ARCHIVES OF TRANSPORT
Volume 46, Issue 2, 2018

ISSN (print): *0866-9546*
e-ISSN (online): *2300-8830*
DOI: *10.5604/01.3001.0012.2098*

EVALUATING THE IMPACT OF LONG CARGO DWELL TIME ON PORT PERFORMANCE: AN EVALUATION MODEL OF DOUALA INTERNATIONAL TERMINAL IN CAMEROON

Monde AMINATOU[1], Yang JIAQI[2], Stephen OKYERE[3]

[1, 2, 3] School of Transportation, Wuhan University of Technology, Wuhan, China
[3] Department of Procurement and SCM, Kumasi Technical University, Kumasi, Ghana

Contact:
1) minet_yasmyne@yahoo.fr, 2) styjq@whut.edu.cn, 3) stephen.okyere@yahoo.com

Abstract:

Create as part of the concession agreement signed by the Container Terminal 28 June 2004 with the port of Douala, Douala international terminal (DIT) Company aims to manage, operate and develop the Port's container handling activity in Douala. This paper investigates the main factors explaining long container dwell times in Douala Port. Using original and extensive data on container imports in the Port of Douala, it seeks to provide a basic understanding of why containers stay on average more than two weeks in port space while long dwell times are widely recognized as a critical hindrance to economic development. It also demonstrates the interrelationships that exist between logistics performance of consignees, operational performance of port operators and efficiency of customs clearance operations. Shipment level analysis is used to identify the main determinants of long cargo dwell times and the impact of shipment characteristics such as fiscal regime, density of value, bulking and packaging type, last port of call, and region of origin or commodity group on cargo dwell time in ports is tested. External factors, such as performance of clearing and forwarding agents, shippers and shipping line strategies, also play an important role in the determination of long dwell times.

Key words:
dwell time, quay crane scheduling, terminal operations, ports, port performance

To cite this article:

AMINATOU, M., JIAQI, Y., OKYERE, S., 2018. Evaluating the impact of long cargo dwell time on port performance: an evaluation model of Douala International Terminal in Cameroon. Archives of Transport, 46(2), 7-20. DOI: https://doi.org/10.5604/01.3001.0012.2098

1. Introduction

The Port of Douala is the largest port in Central Africa in terms of value of cargo handled as well as the number of vessels handled. It also has the largest container terminal in the central part of Africa. (Rallaband, 2013). Dwell time figures have become a major commercial instrument to attract cargo and generate revenues. Port authorities and container terminal operators have increasingly strong incentives to lower the real figure. The average or mean dwell time has usually been the main target indicator for ports in Africa. This statistic is easy to compute and easy to understand. However, because average/mean dwell time in the short and medium term. In Douala, for example, planners set an objective of 7 days at the end of the 1990s, but the dwell time remains over 18 days, despite real improvements for some shippers. Cargo dwell times in African ports are unusually long more than two weeks on average, compared to under a week in large ports in Asia, Europe, and Latin America. Excluding Durban and Mombasa, average cargo dwell time in most ports in Africa is close to 20 days (Refas & Cantes, 2011). The Port of Douala is Cameroon's major port, lying at the head of the Wouriestuary about 30 km from the open sea. Douala is a focal point for both the road and rail systems of the country. Douala possesses the basic infrastructure needed for a port, but the limited depth of water in the long entrance channel is a handicap to port development in view of the trend towards deeper drafts of vessels. Moreover, there is very limited room for expansion because the port is largely hemmed in by the city. The port of Douala moves freight along intraregional corridors in the Central African region (Central Africa Republic and Chad Intermodal Corridors). Its neighboring ports; Port of Owendo (Gabon), Port of Pointe-Noire (Congo), Port of Matabi (Democratic republic of Congo RC) and Port of Luanda (Angola) suffer from high costs of moving goods (twice as much as in southern Africa where distances are significantly longer). Moving a metric ton (tone) of freight from port to hinterland destination costs between $230 and $650 along intraregional corridors in Central Africa compared with $120 to $270 in southern Africa (Kgare, et al., 2011) (Raballand, 2012) in fact, transport costs in Central Africa remain among the highest in Sub-Saharan Africa at $0.11 to $0.26 per ton-km, compared with $0.06 to $0.08 in West Africa (Lomé-Ouagadougou and Cotonou-Niamey) and East Africa (Mombasa-Kigali and Mombasa-Kampala), and ($0.05 to $0.06 in Southern Africa (Durban-Lusaka and Durban-Ndola) (Ocean Shipping Consultants, 2008).

2. Relevant literature review

Before being picked-up and transported to a terminal's mainland or being loaded into a ship container are stacked inside the terminal yard. The performance of transport processes, have nowadays a huge importance in transshipment points, were handling operations are realized, eg. change of mode of transport, consolidation, de-consolidation, etc. Considering the above, these are the nodes in a transport network or logistic distribution network in which the cargo is temporarily stored or transferred into a different direction. At these points, both storage and transport processes are realized. On the one hand there is a concentration of cargo flow and, on the other hand, their distribution on particular types of modes of transport (Jacyna-Golda, 2015)

Dwell Time (DT) is defined as "the total time a container spends in one or more terminal stacks. (Ottjes, et al., 2007). Containers dwell time must be influenced by several factors as gate operations, availability and efficiency of hinterland connections and customs regulations. Consignee, namely the receiver of the goods can be identified as one of the key stakeholders who determine dwell time (DT) since he decides when to pick-up import containers or when to deliver export containers. In addition, it has been found that the stacking area needed is linearly proportional to the average container time in a container terminal (Little, 1961). Attempts have been made to estimate the influence of (DT) in terminal capacity. Specifically, (Hoffman, 1985) developed an equation that estimates the necessary size of the yard as a function of dwell time, the height of the stacked containers, the peak-hour and the total number of containers handled each year.

$$CY = \left(C \cdot A \cdot T\right) \cdot \frac{1+F}{360} \qquad (1)$$

where:
CY - Container yard area (m^2)
C - Expected container volume (TEU)
A - Area (m^2) per container (TEU)
T - Average container dwell time
F - Peaking factor (~20%) ensuring the yard's efficiency

Furthermore, (Dally, 1983) developed a formula that estimates the number of containers a yard can accommodate. This equation uses the number of container ground slots, the mean stacking height and the container dwell time to estimate the annual yard capacity. He also applies a peak factor that usually varies from 1.2 to 1.3. It is expected that the new generation vessels will have an impact on the peak factor that has not yet being determined (Ottjes, et al., 2007).

$$C = \frac{Cs \cdot H \cdot W \cdot K'}{T \cdot F} \quad (2)$$

where:
C - the annual yard capacity (TEU/year)
Cs - Number of ground slots
H - mean profile height
W - Working slots (TEU's) expressed as a proportion (~0.8)
K' - Number of days a year
T - Mean container dwell time in the yard
F - Peaking factor (~20%) ensuring the yard's efficiency

Hence, the average dwell Time plays a crucial role in determining the overall terminal capacity (Chu, et al, 2005) Nowadays, the increased container volumes in combination with the new massive container vessels are demanding bigger terminal capacities. One solution could be the increase of terminal size which, apart from being a very expensive investment, may be not feasible due to space limitations. Consequently, terminal operators are trying to decrease average (DT). In order to do so, they have to determine the main factors that influence the number of days a container stays in the terminal. Nowadays, limited research focusing on quantifying the determinants of (DT) exists.
One of the first researchers of the impact of (DT) on terminal capacity is (Merckx, 2005) who designed a framework that assists terminal operators to optimize terminal capacity, by imposing a number of pricing mechanisms based on different dwell time charging schemes. In addition, (Rodrigue, 2009) discussed how logistic companies that use sea port terminals for their shipments and have limited distribution centers and storage areas fully utilize their free-of-charge time on the terminal's yard. On the other hand, terminal operators react on this practice with the restriction of the dwell time and terminal access. He also proposed that the extension of gate hours on a marine terminal can reduce the container dwell time.
(Huang, 2008) has proven that increased container dwell times lead to more unproductive moves that result in a decrease in the terminal's efficiency in a very costly manner. Some of the main factors influencing DT that were identified in the literature are: 1) the location of the terminal; 2) the efficiency of terminal operations; 3) the implemented port policies such as monetary penalties for delayed shipments or extended gate hours; 4) customs; 5) the freight forwarder or the shipping company; 6) the available hinterland connections; 7) the mode of transport used; 8) the cargo being transferred; and 9) the business relationships developed between the involved parties (Moini et al, 2008) (Rodrigue, et al, 2009). (Moini et al, 2008) applied genetic algorithms to evaluate the main factors affecting the dwell time of containers and measured their impact on the terminal productivity. Furthermore, she highlighted the importance of acquiring data on the landside recipients and on the type of the transported goods. This information is expected to enhance the predictability of the proposed models. In addition ,she established a relationship between truck gate activities and drayage operations at a marine container terminal using both analytical and simulation approaches. By applying data mining techniques, she identified the importance of the abovementioned determinants on the (DT) Towards the same direction (Kourounioti et al., 2015) proposed the development of a methodological framework that combines aggregate and disaggregate models aiming to predict the dwell time of containers in a marine terminal. For this purpose, regression models were developed that showed the influence of a container's consignee and commodity on the DT. In addition, if the exact day a container was to be discharged from the terminal was known in advance, operators would be able to organize the yard appropriately so as to be able to retrieve containers with higher pick-up probabilities more easily, reduce rehandling moves and get full advantage of the available capacity. The importance of this information has also been highlighted in (Zhao et al., 2010) who developed a simulation model to evaluate how to use of information affects the efficiency of marine terminal. The result illustrated that when the day of a trucks arrival was

known in advance there was a substantial decrease of non-productive moves

In order to deal with the lack of informational flow several container port terminal have implemented Truck Appointment Systems (TAS). TAS is mainly a system which books a slot for a certain number (restricted by each terminal's capacity) of binding transactions during a predefined time period (usually one hour). One of the first TAS was implemented on the marine terminals of Los Angeles and Long Beach in order to deal with the issues of traffic congestion and air pollution (Giuliano et al., 2007).

3. Methodology

The summarized reflection is that limited research exists on quantifying the factors influencing DT. It cannot be easily contradicted that knowing when a container will be picked-up from a seaport terminal is expected to assist significantly decision making in a tactical and operational level when designing terminal policies as well as in a strategic level when taking investment decisions.

This paper is to contribute to the question what the effect of the characteristics of terminal operation. The main reason for focusing on container terminals is that the container market is an important market, this last three decades the containerized trade flows have increased rapidly more than sixty per cent of the world cargo transported over sea was carried in containers. The methodology used has been to combine readily available data from the business and port community in Douala, with statistical analysis from data provided by Cameroon Customs and analyzed at World Commerce Organisation headquarters. Cameroon is a specific case since ASYCUDA[1] has been implemented for all customs procedures, from the manifest lodging to the exit note, which enables a very complete follow-up of import processes. This paper disentangles cargo delays imports using comprehensive analysis of original data sets. It uses three types of data:

1. Data collected in Douala Port and Douala International Terminal
2. Information collected in discussions of results with stakeholders in the country.

These analyses have been complemented by interviews with consignees, port operators, clearing and forwarding (C&F)[2] agents and shippers

4. Long dwell time in the Port of Douala

4.1. Differents conponents of Dwell time

Average dwell time is a combination of three Dwell time named operational, transactional and storage dwell times. Storage dwell time seems to have greater contribution than others, which is caused by presence of huge free storage period. Operational dwell time is the time to unload vessels and store containers in yards. It mainly depends on the efficiency of the port and the availability of equipment combined with the level of occupancy of storage facilities. Transactional dwell time mainly concerns the transaction time between the importers/port services and customs procedures. The single most important factor, according to recent studies on dwell time in subsaharan African ports, is the use of the port as storage warehouse by importers or their agents. It seems that importers are taking advantage of the opportunity of free storage given and only consider taking their cargo when the free storage nears expiry (Refas & Cantes, 2011).The components of Cargo dwell Time are explain in the Figure 1 below. In the port of Douala, berth congestion is due to a shortage of capacity, given average berth occupancy of 60 percent. Net crane productivity could be improved through better maintenance of the two gantry cranes, which have not yet reached half of their lifetime. The investment in a third gantry crane is not yet economically justified, but it will be if traffic increases. Efficient dredging could improve berth productivity by extending the availability of berths. As for yard productivity, the main issue today is the very high occupancy rate (88 percent). Physical extension of yard area would be difficult given the shortage of available land in the port outskirts and would require either additional movements or much longer distances between the peers and storage places.

[1] Automated Customs clearance system

[2] We use the acronym C&F agents in this paper to refer to all clearing and forwarding agents namely Customs brokers, Freight brokers, Freight forwarders, etc. NVOCCs and shipping agents will be referred to collectively as shipping agents. In addition, the two largest C&F agents have merged in 2008 but have been considered independent for consistency purpose (the two brands are still in use).

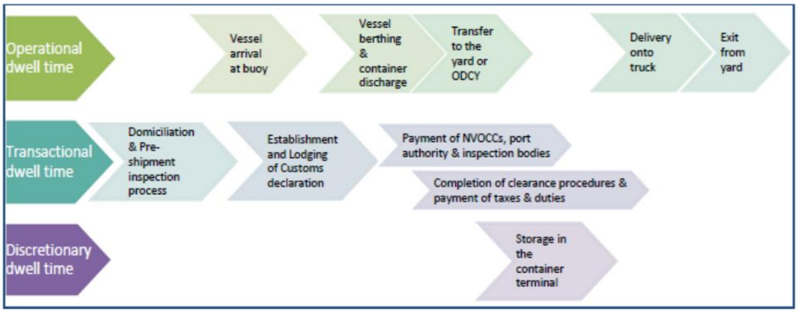

Fig.1. Components of Cargo Dwell time (Source Refas & Cantes, 2011)

The pavement of a small area in the import yard is expected to increase yard capacity by a few hundred TEUs, and the transfer of very long-stay containers and confiscated containers to a separate storage area could also release some capacity.

A substantial increase in capacity is, however, only achievable through investment in a more intensive storage configuration and a transfer from the current reachstacker configuration a straddle carrier configuration (capacity increase of 40 to 50 percent). The layout of the port platform is ill adapted to the physical role of a container terminal (transfer area), and the creation of an independent customs area dedicated to physical or scanning inspections is being discussed.

4.2. The various perception of long cargo dwell time in the port of Douala

Data from the World Bank suggest that delays in ports add roughly 10% to the cost of imported goods, more than tariffs in many cases. Still, Africa is bucking the gloomy trend, and ramping up investments. Cameroon has basically thrown in the towel with Douala, its major port, whose inefficiencies and delays are notorious average cargo dwell time in Douala is 22 days, according to the World Bank. That's five times higher than the one of Durban, twice of the port of Mombasa, 1.5 times of Dar es Salaam. The delays are largely to do with the shallowness of the port of Douala. It's an estuary port that requires constant dredging and has a draught of just 7 metres. It means that small ferries have to be used carry in goods from vessels larger than 15,000 tonnes, which cannot berth at the shallow port. From a national perspective, the issue of dwell time has been specifically identified as a major hindrance to Cameroon economic development for a long time. In November 1997, a dwell time target of 7 days for container imports has been officially defined5. This objective has however not been adopted by all port stakeholder to date notably because it did not take into account shippers and C&F behaviors, as we will demonstrate later. Table 1 shows the alternative of long cargo dwell time definition for Douala port.

Table 1. Alternative Long Dwell Time definitions for Douala Port

Designation	**Stackholder**	**Dwell times objectives**
Global benchmark	All	3 to 4 days
7 days	All/facilitation	21 days
Free time	DIT/DAP	11 days
Desired storage time	Shippers	5 to 31 days
Maximum clearance delay	Customs Administration	90 days
Proposed benchmark	All	11 days

In conclusion long dwell time perception varies according stakeholders. Optimal dwell time perceptions range from 5 to 90 days today in the Port of Douala and a segment approach is to our opinion much more relevant than a standardized objective hardly applicable for all cargo. In this paper we will adopt the 11 days median limit to distinguish between short and long dwell times for two reasons:

- it is DIT's official free time period and is therefore formally adopted by all agents
- we estimate it as the limit value to avoid congestion in the terminal for at least 5 years8.
- We then define three categories to specifically analyze the long dwell time population:
- from 11 days to 30 days: long delay
- from 30 days to 90 days: very long delay
- over 90 Days : abnormal

4.3. Dwell time distribution in Douala port

Container traffic represents about 45% of the total tonnage that transits through the Port of Douala annually[3]. Containers are also the primary mode for Cameroonian exports representing about 75% of total traffic in tons while they account for about 45% of Cameroonian imports Most recent DIT statistics indicate an average dwell time of 19.3 days for the first semester of 2015 while means of 18 days and 20 days respectively have been observed in July and August[4]. Traffic growth has slowed down with the international crisis, but it is expected to increase at a fast pace in the upcoming years. According to customs data, the distribution of dwell time in Douala port is indicated in graph 1

According to recent studies major reason for such delays is that certain public and private actors in the system benefit from such delays. Importers use the ports to store their goods. Customs brokers have little incentive to move the goods because they can pass on the costs of delay to the importers. And when the domestic market is a monopoly, the downstream producer has an incentive to keep the cargo dwell times long as a way of deterring entry of other producers. Another hurdle is that at the Douala port for instance, fiscal pressure seems to play a role in cargo dwell time. The correlation tends to be positive: higher fiscal pressure leads to higher dwell time, with a noticeable exception of duty free items that have a relatively long average dwell time despite the absence of duties. This could be linked to bargaining time between the customs broker and customs agent, a misclassification, a duty free line, or simply the time to furnish additional documents. The net result is inordinately long dwell times, ineffective interventions, and globally uncompetitive industries in African countries.

5. Statistical analysis of determinants of dwell time

Choosing the right method of assessment is not easy and obvious. The multifaceted nature of the functioning of logistic systems often requires complex evaluative solutions. The available qualitative methods require experts to put in the right order the systems attributes, namely the making a decision whether a given property precedes the others, taking into account the given criterion. The quantitative methods, however, in addition to properly arranging the features, provide information, by how much one value is superior to the other (Pavel Foltin, 2015). The automated customs declaration system ASYCUDA has been implemented in Cameroon for all customs procedures, from manifest lodging to issuance of exit bill. This is quite unique in the region and offers significant means to improve customs clearance efficiency. It also provides a consistent database that stakeholders may take advantage of to better understand inefficiencies in the customs duties collection (which is primarily of interest to customs) but indirectly in the whole port clearance processes. We intend here to use of explanation statistic to analyse shipment level data collected through the automated customs declaration system by customs administration and test the assumptions and findings show in table 2

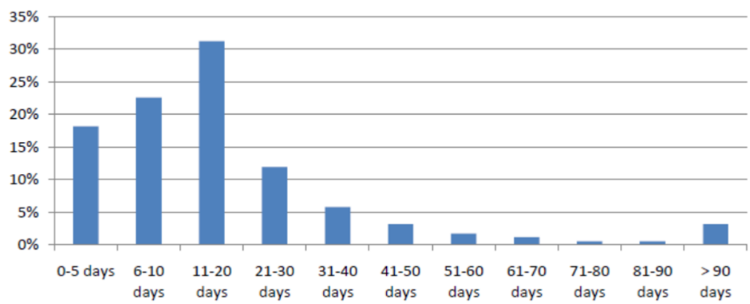

Fig. 2.[5] Dwell time distribution in Douala Port (Cameroonian Custom Data)

[3] Source: Annual statistics, Port Autonome de Douala
[4] Source: DIT (Douala International Terminal)
[5] In addition to the different long dwell times categories observed in Fig 2 there are a few hundred containers that do not appear in statistics which were already in the terminal as of January 1st, 2009 but have not been cleared before December 31st, 2009 (Source: Interview with DIT, October 2010.)

5.1. Continuous distribution

We first attempt to fit the distribution of container dwell times using parametric asymmetric distributions of continuous data with positive values. The analysis of cargo dwell time qualifies as survival analysis since the research output is the expected time at which cargo will exit the port (continuous positive values with right-censoring patterns). Such methods have not been successful however at this stage. Univariate analysis shows for example that standard parametric distributions are not fitting the dwell time data well. Data is processed to try and attempt to reduce some discrete patterns but neither seasonality nor simple stratification improves distribution fit. We also fit a Cox Proportional Hazard (PH) model (Hosmer et al., 2000) a semi-parametric model to Cargo Dwell Time (CDT) with help of covariates identified in earlier sections (e.g. fiscal regime, full-container-load, density of value, cargo type, C&F agents etc.). However, the model assumption of proportional hazard is not satisfied. The main issue at this stage is that CDT data population presents discrete variability patterns that are hardly modeled by parametric or semi-parametric method.

Table 2. Assumptions about determinants of long dwell time

Factor	Type	Impact
Fiscal Regime	Shipment specific	High fiscal pressure leads to high dwell time
Bulking of containers	Shipment specific	LCL containers stay longer in the port
Commodity type	Shipment specific	Commodity category is a crutial determinant
Density of value	Shipment specific	High value leads to higher dwell time
Concentration of C/F marcket	External factor	Dominant C/F players have a low performance
Low volume per operation	External factor	Lack of regularity leads to poor performance
Concentration of shipping flow	External factor	Disruption in ship arrivals leads to discrete behaviors

5.2. Logistic regression analysis of dwell time observation

Continuous models being unsuccessful in modeling CDT data, discrete analysis of CDT is attempted. The objective is to identify which are the most significant determinants of very long and abnormal CDT in the list of variables identified in earlier sections. We transform first the CDT into three discrete levels (categories): (1) CDT less than or equal to 30 days, (2) CDT between 31 and 90 days, and (3) CDT greater than 90 days. An (Ordinal/Multinomial) Logistic regression model is then fitted with the CDT as categorical dependent variable. The objective of logistic regression is to model a dependent variable (DV) in terms of one or more covariates. Logistic regression is used when the DV is categorical. The DV may have two or more categories. For example, default/good (customers), low/medium/high, unsatisfied/satisfied/ very satisfied. Dependent variables (DV) can be ordered (e.g. low/medium/high) or unordered (married/single/others). Ordinary least square cannot be applied to these models as the assumption of normally distributed residuals is not satisfied. Logistic regression is fitted by transforming the DV into log of the odds ratio of being in a particular category for given values of covariates. The odds ratios are used in order to allow linear relationship between log of the odds ratio and covariates (Agresti, 2002) (Long, 1997).

Ordinal Logistic regression model is fitted when categories in DV are ordered and the proportional odds assumption is satisfied (Hosmer et al., 2000) However, in case of CDT levels, this assumption is violated, as we reject the null hypothesis (p-value < 0.05) that location parameters are same across three CDT levels. Hence, we fit a Multinomial Logistic (ML) regression model to CDT levels as proportional odds assumption is not required for this model.

When a DV has M categories, one value of the DV is designated as the reference category. Typically, the first, the last, or the value with the highest frequency is taken as the reference category. The probability of membership in other categories is compared to the probability of membership in the reference category. In order to describe the relationship between the DV and the covariates, the calculation of M-1 equations (sub models), one for each category relative to the reference category is required.

Taking the first category as reference we then have, for $m = 2\ldots M$,

$$\ln \frac{P(Y_i = m)}{P(Y_i = 1)} = a_m + \sum_{k=1}^{k} \beta_{mk} X_{ik} \quad (3)$$

Where X_{ik}, β_{mk}, and a_m are kth covariate (from K number of covariates in this model) for observation i, regression parameter (slope) corresponding to covariate X_k and DV level m, and intercept for DV level m, respectively. For each observation, there will be M-1 predicted log odds, one for each category relative to the reference category.
ML regression model was fitted with CDT levels (1, 2, and 3 with level 1 as the reference category) as a DV and covariates such as fiscal regime, container load (FCL or LCL), density of value, cargo type, container type, C&F agents, Region of origin, and Last port of call. Two sub models are fitted in this ML regression model for every additional category of CDT (CDT <30 days taken as reference).
Model 1: Log odds ratios of CDT between 30 and 90 days with respect to CDT<= 30 days
Model 2: Log odds ratios of CDT> 90 days with respect to CDT<= 30 days

5.3. Interpretation of modeling result

Container type is significant in both sub-models (level 2 vs. level 1 and level 3 vs. level 1). This demonstrates that "last-trip" containers, i.e. those containers that are purchased with cargo at a negotiated rate with shipping line (about $2,000 for a twenty-foot container) are expected to stay longer in the port with a significant confidence level. Last ports of call are also significant in both models. Cargos originating from Dubai for example are likely to stay longer as compared with other ports with a justification that needs to be further investigated.

Table 3. Observed frequencies for CDT data (source Cameroonian customs data, 2009)

		Number of Containers	Marginal Percentage
CDT level	CDT<=30days CDT between 31 and 91days CDT> 90 days	35832 5457 10400	69.3% 10.6% 20.1%
Cargo Container Type	Last trip Others	730 50959	1.4% 986%
Last port of call	Antwerp Dubai Algeciras Singapore Others	7307 1577 17616 5626 19563	14.1% 3.1% 34.1% 10.9% 37.8%
Region of origin	Europe Asia Middle East and Nord Africa Africa Others	28254 13679 3465 3201 3090 20708	37.8% 54.7% 26.5% 6.7% 6.2% 6.0%
Fiscal regime	Over 45.7% (finished goods) 33.7% to 45.7%(semi-finished goods) 22.8%(necessity goods or duty free 0%duty free	5545 13406 7809 4221 1308	10.7% 25.9% 15.1% 8.2% 2.5%
Density of value	Superior to 6500XAF/kg From 1000 to 6500FCFA/kg Inferior to 1000XAF/kg	13079 37302 22296	25.3% 72.2% 43.1%
Full-container-load	LCF	29393	56.9%
Valid	FCL	51689	100.0%
Missing		0	
Total		51689	
Subpopulation		536	

Fiscal regime is also significant: Containers with finished goods and semi-finished goods are expected to have longer dwell time as compared to other categories of goods, which is probably to be linked to the high cost of customs duties that need to be paid as compared to lower fiscal pressure for raw materials for example. Containers with higher density of value are also likely to stay longer than containers with lower density value probably for similar reasons. It is worth noting that the consideration of logistics cost would lead to the inverse relationship since cargo with high density of value are also those with highest inventory costs, which corroborates our earlier comment on low awareness of total logistics cost. To finish with LCL containers are likely to stay longer than FCL containers but they are less likely to be cleared in more than 90 days.
This is probably linked to the more complex clearance process that implies multiple declarations for the same container and multiple payments of customs duties (one for each separate declaration) and generates some delay. This delay is less likely to extend to 90 days since it is very unlikely that all shippers sharing an LCL container face clearance or payment issues that lead to such dwell time. Table 4 below gives the estimated beta parameters using the logistic regression model. Results are very consistent with preliminary conclusions and observed values. In fact for most covariates, the estimated odds ratio is superior to the observed value, which reinforces the pertinence of the use of such model: for some covariate categories such as "Last trip container", "Finished goods" or "Density of value superior to 6500 FCFA/kg" there are 50% more chances or more to be a very long dwell time which would justify a separate treatment in the container yard. To the contrary some categories such as "Last port of call = Singapore", "Region of origin = Europe" or "Region of origin = MENA" have about 40% less chances of being very long dwell time containers than reference. It is more difficult to identify significant categories for abnormal delays but the last trip category or cargo transshipped through Dubai category are much more likely to be abnormal delays and this should add understanding to the abnormal delay issue.

Table 4. Observed and estimated Odds ratio using logistic regression model (Source: Cameroonian Customs data-statistical analysis using SAS Software

	CDT between 31 and 90 days		CDT > 90 days	
	Observed odds ratio	Estimated odds ratio	Observed odds ratio	Estimated odds ratio
Container type = Last trip	1.56	1.74	1.82	1.57
Container type = Others	Ref Cat	Ref Cat	Ref Cat	Ref Cat
Last port of call = Antwerp	0.93	0.84	0.95	0.95[2]
Last port of call = Dubai	1.48	1.30	1.94	1.93
Last port of call = Algeciras	1.02	0.90	0.72	0.72
Last port of call = Singapore	0.80	0.63	0.75	0.73
Last port of call = Others	Ref Cat	Ref Cat	Ref Cat	Ref Cat
Region of origin = Europe	0.60	0.55	1.29	1.08[2]
Region of origin = Asia	0.68	0.69	1.20	1.08[2]
Region of origin = MENA	0.66	0.60	1.28	1.06[2]
Region of origin = Sub-Saharan Africa	0.61	0.67	1.11	0.93[2]
Region of origin = others	Ref Cat	Ref Cat	Ref Cat	Ref Cat
Fiscal regime = Finished goods	1.35	1.51	1.23	1.26
Fiscal regime = Semi-finished goods	1.16	1.23	1.14	1.13
Fiscal regime = Raw materials	0.88	0.98[2]	1.24	1.19
Fiscal regime = Necessity goods or duty free	0.96	1.04[2]	1.06	1.02[2]
Fiscal regime = duty free	Ref Cat	Ref Cat	Ref Cat	Ref Cat
Density of value superior to 6500 FCFA/kg	1.46	1.66	0.87	0.91[2]
Density of value from 1000 to 6500 FCFA/kg	1.12	1.12	1.12	1.13
Density of value inferior to 1000 FCFA/kg	Ref Cat	Ref Cat	Ref Cat	Ref Cat
Full container load	1.56	1.07	1.82	0.93
Less than container load	Ref Cat	Ref Cat	Ref Cat	Ref Cat

6. Examining the impact of application of regression models

The case studies and shipment-level analysis of dwell time presented up show that long dwell times (which account for a large share of containers in terminals) are one of the key issues that need to be addressed (probably across the continent) and are related mostly to factors under the control of shippers. This confirms one of the initial hypotheses of this work, which is that the behaviors and strategies of shippers have an impact on dwell time in ports. The demand by importers for port dwell time beyond the time required to complete port operations and transactions seems to be related mainly to inventory management and the "business model" used (including the extent of informal practices).Due to the fact that demand from importers seems to explain a large part of long-dwell cargo, we present theoretical foundations explaining current demand in Douala port and then present some statistical analysis on firm surveys.

Some Theoretical Considerations

The model examines cost minimization strategies and profit maximization strategies. Coupled with various market structures, it seeks to explain why behaviors that are perceived as irrational, such as leaving cargo in the port, are the best option for an importer.

Cost Minimization Strategies

The application of the cost minimization model presented in appendix Bleeds to the expected conclusion that, because additional dwell time results in additional logistics costs, any market player seeking to minimize its total logistics costs will try to reduce port dwell time. We also reach two secondary conclusions of importance. The first pertains to the impact of dwell time on replenishment time. Our analysis shows that the optimized interval time between reorders is inversely proportionate to dwell time in the port. An inefficient port clearance system with very long clearance time would therefore encourage shippers to replenish their cargo at shorter intervals and to split their annual orders into smaller and more frequent batches for delivery. The second pertains to the arbitrage between different warehousing options. Modern container shipping operations should facilitate the movement of goods along chains, and ports should be nothing more than gateways. In the new paradigm of "warehousing-derived terminalization," port terminals tend to replace warehousing facilities and gradually become strategic storage units. Our analysis shows that companies seeking to minimize total logistics costs will leave their cargo in the port when the financial cost of clearing it outweighs the potential savings from not storing it in private or third-party facilities outside the port. In this situation, there is no incentive to clear the cargo from the port storage area, even if storage costs are high (parking costs plus demurrage fees); the move to cheaper storage facilities outside the port will only occur after cargo has spent a long time stored in the port. shippers might be willing to leave their cargo in the container terminal or in off dock container yards (ODCYs) if they cannot bear the financial cost of paying all port clearance charges and fees in advance. They will not move their cargo until they have sold it and are able to pay these expenses.

Profit Maximization Strategies

Analysis of total logistics costs provides useful insights into the reason why shippers might seek to reduce port dwell times. However, cost minimization does not explain the variety of strategies observed with regard to port dwell time, including the paradoxical situation where shippers are indifferent to long or very long dwell times. The analysis of free competition does not depart from the conclusions of the cost minimization analysis but the analysis of monopolies does provide useful insights into profit maximization strategies. We show first that, despite being a cost setter, a rational monopolist should seek to reduce port dwell times to optimize profits because it is not possible to pass on all cost to the clients without losing sales. In a situation where demand is inelastic to price, modeled through the kinked curve theory, we show that the monopolist is not affected in the short term by higher logistics costs and therefore makes no effort to reduce dwell times. Such a scenario is likely to happen for patterns of cyclical demand that are elastic to price only in the long term (for example, food supplies, drugs, and equipment), while in the short term, there is little demand risk and the monopolist is therefore indifferent to higher logistics costs due to longer dwell times. A third pricing behavior derived from this situation of inelastic demand and observed among monopolistic companies is but the analysis of monopolies does provide useful insights into profit maximization strategies. We show first that, despite being a cost setter, a rational monopolist should seek to reduce port dwell times to optimize profits because it is not possible to pass on all costs to the clients without losing sales. In a situation where demand is inelastic to price, modeled through the kinked curve theory, we show that the monopolist is not affected in the short term by higher logistics cost and therefore make no effort to reduces dwell times. Such a scenario is likely to happen for patterns of cyclical demand that are elastic to price only in the long term (for example, food supplies, drugs, and equipment), while in the short term, there is little demand risk and the monopolist is therefore indifferent to higher logistics costs due to longer dwell times. A third pricing behavior derived from this situation of inelastic demand and observed among monopolistic companies is opportunistic pricing, which explains some paradoxical situations in which companies are willing to suffer from adverse logistics conditions because doing so helps them to justify charging higher markups or holding inventories longer in order to speculate on higher sale prices. Companies seldom operate as pure monopolies, however, and the distribution of market power is more often in the hands of a few firms that is, an oligopolistic situation. We analyze different cases of oligopolies in turn: cartels, leader-followers, price war (Bertrand competition), Nash equilibria–Cournot competition, and kinked oligopoly. All of these situations lead to different behaviors. In a cartel or leader-follower situation, monopolistic pricing strategies are observed. In a price war situation, the market behaves in the same way as in free competition, and companies try to minimize dwell time and logistics costs to secure competitive advantage over other market players. In other situations, the unpredictable consequences of price changes discourage the few market players from undertaking any price move that may unbalance the system; as a consequence, prices are stable despite changing logistics conditions.

6.1. An empirical analysis of demand: lack of competence or purpose

A key factor is the lack of competence and professionalism of small importers and customs brokers, who often don not exercise due diligence in the clearance process. This results in considerable delays in payment and slows down the entire logistics chain. The capacity and professionalism of the private sector have a large effect on the clearing process, even greater than expected. For instance, an analysis of Douala port by a major freight forwarder found that customs procedures cause only 1 percent of all abnormal 20 days or more cargo delays. The same analysis calculated that lack of or erroneous documentation by the importer or delays by the preinspection company are far more time-consuming than customs procedures in total clearance time.

6.2. Empirical evidence in Port of Douala

In Douala, the high level of inventory coverage leads to long port storage times. Using a typical private storage cost of 100XAF per ton per day, we estimate that storage in the port of Douala is cheaper than outside storage for 22 days, meaning 11 days more than the container terminal's free time as long as most shippers do not intend to reduce inventory levels sharply, cargo dwell times will remain very high in the port of Douala.

The situation could improve slightly if shippers were aware of the total logistics costs associated with long cargo dwell times. Few operators include hedging costs or financial charges in their calculation of factory prices, and even fewer envisage actions to reduce dwell times with the objective of reducing inventory levels. As a consequence, dwell time in ports appears simply as an alternative to dwell time in private facilities, and shippers do not undertake a comprehensive analysis of lead time and inventory levels. Shippers who have high inventory coverage (typically two or three months) do not experience a major direct impact on costs because long dwell time are simple an alternative to costly physically limited private storage. However, the situation is radically different for shippers that have low inventory coverage, have just-in-time production processes or handle urgent shipments. In these cases, the direct costs of higher cargo dwell time in port are not offset by savings in private storage costs since cargo is used or sold as soon as it arrives in the shipper's facilities. In other words, storage in port is not perceived as an alternative to storage in private facilities but rather as a pure delay in the supply chain that affects logistics costs and customer service. The direct costs of long dwell times would quickly become prohibitive, especially in terms of lost sales (an estimated 0.5 percent a day).

The contracting patterns of clearing and forwarding (C&F) agents also exhibit some revealing peculiarities. For example, the introduction of a time-efficiency indicator with a weight of 30 percent in the national evaluation framework of C&F agents (Label Qualité des Commissionnaires Agréés en Douane) suggests that shippers are aware of the importance of time efficiency. However, few shippers include compelling time-efficiency terms into their contracts with C&F agents, especially dominant C&F agents who have a very strong supplier power. Those shippers who do include performance conditions in their C&F contracts formulate them in way that leaves room for argument (for example, maximum clearance time on the condition that all documents are submitted correctly and in timely manner by shippers). This is why the largest brokers maintain very high market shares despite poor time performance. Another key factor is that subsidiaries of international trade and industrial firms are often either financially linked with international forwarders or contractually linked to them at the regional or continental level, which does not encourage efficiency at the country level.

There are good reasons to believe that wider recognition of the national broker's label would slowly increase the number of requirements placed on customs brokers, but that shippers would have to replace brokers with whom they have contracted for years. This seems improbable due to very strong patterns of repeat buying (loyalty of shippers).

Another major issue is the availability of cash and the strategies of shippers to reduce their financial exposure. Because of costly trade borrowing and limited import financing tools, shippers are often short of cash in their daily operations, and this is a major hindrance to the reduction of dwell times. The bulk of customs declaration lodging is done in the second or third week after container discharge, even though it takes no longer than three days, on average, to clear customs.

In the first step (the processing of payments), which takes 13 days on average today, processing could be shortened by facilitating the financing of customs dues, because finding the money to pay customs dues is a major reason for delaying this step. Savings in opportunity costs and financial charges associated with delayed clearance are probably underestimated because severe cash constraints and very high opportunity costs sometimes offset high demurrage charges after an extended stay in the terminal.

Some shippers facing extreme cash constraints have no choice but to abandon cargo in the port because they are unable to pay customs dues and clearance charges or can only pay them after part of the shipment has been sold.

7. Conclusion

Cargo dwell time in the port of Douala for containerized imports is very significant. An aggregate analysis shows that cargo dwell time exceeds 20 days for a significant proportion of traffic and average dwell time has been consistently about 20 days in the last 10 years. From a customs clearance standpoint, the two main contributors to long dwell times are time between ship arrival and lodging of declaration, and time between payment of customs dues and gate exit. The payment of customs dues itself and the physical submission of documents seem to be time efficient operations today in Douala thanks to recent reforms. Another approach is to distinguish operational dwell time (physical operations), transactional dwell time (customs clearance) and discretionary dwell time (storage). Data consistently show that operational (2-3 days) and transactional (2-4 days) dwell times are relatively limited and predictable in Douala, which seem to imply that most of the dwell time can be attributed to « discretionary » time by the C&F or the shippers. However, the aggregate analysis of average dwell time is deceptive, and we can list the following specific patterns that justify a shipment-level approach:

- Variance between observations is quite significant which shows that a standardized approach to the cargo dwell time issue in Douala is inappropriate,
- Median value is much lower than mean and the distribution of dwell times has a broad tail which shows that a minority of problematic shipments adversely impact aggregate performance,
- Cargo dwell time distribution is multimodal with a succession of frequency peaks that demonstrate the discretionary behavior of shippers or service providers.
- The usual measures undertaken to reduce port dwell time are relatively limited in number.

These techniques have different impacts on different segments of the distribution fun vnnb`ctionnd thus affect shippers in different ways. An increase in pre arrival processing would have less impact on cargo with long dwell time, for example. What matters most are measures that seek to change the incentives of key stakeholders, especially shipper?

Early conclusions of the shipment level approach are the following:

– Fiscal regime plays an important role in the determination of long dwell time with a positive correlation that tends to show that high fiscal pressure leads to high dwell time in ports,
– Dwell time patterns differ for LCL containers and FCL containers and for standard containers and "last trip" containers where container is purchased with cargo (LCL containers and last trip containers stay longer in the terminal), which means that consolidation and small shippers seem to exhibit longer dwell times (all other things being equal),
– The impact of commodity category is potentially important but can only be approached through aggregate analysis using broad commodity categories derived from first figures of customs HS code. Few categories seem quite problematic with average dwell time exceeding 24 days,
– Cargo density of value, an important characteristic in logistics, also play in important role in the determination of long dwell time: high value leading in general to higher dwell time in port, which may also explain why manufacturing and assembling is difficult to achieve in a port like Douala.

Most of these conclusions were confirmed by multimodal logistic regression results with statistically significant correlation for at least three of these factors (container type, fiscal regime and density of value). Other factors of importance identified through logistic regression modeling are last port of call and region of origin.

Table 5. Usual measures to reduce Dwell Time

Indicator	**Measure**
Operational Dwell Time: Transfer to ODCY infrastructure Investment equipment	Transfer cargo to ODCY Invest in infrastructure (quays, berths) Invest in equipment (cranes, reach sackers, software)
Transactional dwell Time: Pre-arrival Processing Document review Post- clearance inspection Cargo auction	Submit documentation prior to arrival of vessel and decide on required clearance procedure Reduce the additional documentation required when reviewing the declaration and supporting documentation Delay inspection procedures until after the shipment has left the port, including post-clearance audit Reduce time before long-term cargo auctioned
STORAGE Free time Rates Rate escalation	 Reduce free time Increase the level of charges for each period Increase the frequency of escalation of charges

Reference

[1] AGRESTI, A., 2002. Categorical Data Analysis. 2nd ed. New York: John Wiley & Sons.

[2] CHU, C. Y., & HUANG, W. C., 2005. Determining container terminal capacity on the basis of an adopted yard handling system. Transport Reviews, 25(2), 181-199.

[3] DALLY, H. K., 1983. Container Handling and Transport: A Manual of Current Practice

[4] FOLTIN, P., GONTARCZYK, M., ŚWIDERSKI, A., & ZELKOWSKI, J., 2015. Evaluation model of the companies operating within logistic network. Archives of Transport, 36(4), 21-33.

[5] GIULIANO, G., & O'BRIEN, T., 2007. Reducing port-related truck emissions: The terminal gate appointment system at the Ports of Los Angeles and Long Beach. Transportation Research Part D: Transport and Environment, 12(7), 460-473.

[6] HOFFMAN, P., 1985. Container facility planning: A case description. Port management textbook containerization. Institute of shipping economics and logistics.

[7] HOSMER, D. W., LEMESHOW, S., & MAY, S. 2008. Applied survival analysis: Regression Modeling of Time to Event Data. Wiley Blackwell.

[8] HOSMER, D.W. AND LEMESHOW, S., 2002. Applied Logistic Regression.. 2nd ed. New York: John Wiley & Sons,.

[9] HUANG, S. Y., HSU, W. J., CHEN, C., YE, R., & NAUTIYAL, S. 2008. Capacity analysis of container terminals using simulation techniques. International Journal of Computer Applications in Technology, 32(4), 246-253.

[10] JACYNA-GOLDA, I., 2015. Decision-making model for supporting supply chain efficiency evaluation. Archives of Transport , 33(1), 17-31.

[11] KGARE, T., RABALLAND, G., & ITTMANN, H. W., 2011. Cargo dwell time in Durban: Lessons for sub-Saharan African ports. The World Bank.

[12] KOUROUNIOTI, I., POLYDOROPOULOU, A., TSIKLIDIS, C., 2015. Development of a methodological framework for the dwell time of containers in Marine Terminals-First results, In proceeding ICTR.

[13] LITTLE, J. D. C., 1961. A Proof for the Queuing Formula: L = λW. Operations Research, June, Volume 9 Issue 3,(Issue 3,), p. 383–387..

[14] LONG, J. S., 1997. Regression Models of Categorical and Limited Dependent Variables. : Sage.

[15] MERCKX, 2005. The issue of dwell time charges to optimize container terminal capacity,. Cyprus, Limassol.

[16] MOINI N., BOILE M., THEOFANIS S. AND LEVENTHAL W., 2008. Estimating the determinant factors of container DTs at seaports, Maritime Economy and Logistics, 14, 162–177.

[17] OCEAN SHIPPING CONSULTANTS, 2008. Beyond the Bottlenecks: Ports in Sub-Saharan Africa, s.l.: World Bank and the the SSATP.

[18] OTTJES, J. A., VEEKE, H. P., DUINKERKEN, M. B., RIJSENBRIJ, J. C., & LODEWIJKS, G., 2007. Simulation of a multiterminal system for container handling. In Container terminals and cargo systems (pp. 15-36). Springer, Berlin, Heidelberg.

[19] RABALLAND, G., REFAS, S., BEURAN, M., & ISIK, G. 2012. Why does cargo spend weeks in sub-Saharan African ports? Lessons from six countries. The World Bank.

[20] RALLABAND, G., 2013. Why High Dwell Times in African Ports?. World Bank Paper.

[21] REFAS, S., & CANTENS, T., 2011. Why does cargo spend weeks in African ports? The case of Douala, Cameroon. The World Bank.

[22] RODRIGUE, J. P., & NOTTEBOOM, T., 2009. The terminalization of supply chains: reassessing the role of terminals in port/hinterland logistical relationships. Maritime Policy & Management, 36(2), 165-183.

[23] WORLD BANK, 2007. Port Reform Toolkit. Second Edition. ed. s.l.:s.n.

[24] ZHAO, W., & GOODCHILD, A. V. 2010. The impact of truck arrival information on container terminal rehandling. Transportation Research Part E: Logistics and Transportation Review, 46(3), 327-343.