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Parallel Ro-Ro Ferry Networks as an Interregional Trade Facilitation Mechanism: The Case for West Africa (ECOWAS)

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Abstract: Modern Ro-Ro ferry application is developed heavily around the "land bridge" framework supporting trade across large bodies of water. However, state-driven infrastructure projects in Europe and Asia threaten numerous ferry routes. Parallel ferries have often been dismissed as too slow in today's modern and globalised economy. Yet services like Indian Railways Konkan Ro-Ro service have demonstrated, under certain conditions, that the mode can be serviceable away from the technical demands of developed supply chains. Interregional freight movements in West Africa have long faced challenges. Underdeveloped road infrastructure, frequent border delays, high transportation costs, and recent political events have contributed to a relatively low cross-country trade rate of around 15%. This paper investigates the time benefits of parallel Ro-Ro service for ECOWAS, using the framework established by the Konkan. By completing a modern academic survey of the Trans-African Highway Route 7 to demonstrate that parallel Ro-Ro services can be faster and more reliable for road hauliers and cargo owners where primary networks suffer from infrastructure deficits and political interruption, while maintaining critical SME models crucial to local employment.

Keywords: Africa, Ro-Ro ferry, Trans-African highway, Konkan Railway, Parallel transport networks.

1. Introduction

Parallel transport networks offer a robust alternative to road transport by leveraging existing networks, such as rail, or geography, such as bodies of water. However, successful implementation is reliant on a single or combination of factors relating to the deficiencies of the primary route, such as time, cross-border friction, risk; such as safety and security and environmental factors, most of which are not present in more developed economies, and have seen a much slower adaptation and success rate [6]

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with road infrastructure is rarely below the standard of parallel railways. Cost per kilometre, roads are much cheaper to build and can be used more flexibly [2].

Yet, services such as the Konkan Railway's Ro-Ro have provided time benefits to cargo owners of the Western Ghats by utilising existing rail networks to bypass poor and dangerous roads in a geographically complex region.

This example suggests that parallel Ro-Ro networks could succeed where existing infrastructure suffers from deficiencies, such as poor quality, high congestion, low security, or complex cross-border customs facilitation.

The coastal cluster of ECOWAS states is one of the most populated regions in the world. However, less than 10% of trade is interregional. In fact, recent figures for intra-African trade hovered around 17% before the COVID-19 pandemic, compared to 70% for intra-European exports and 60% for intra-Asian exports [12]. Poor infrastructure and implementation of road networks, with large sections of the Trans-African Highway 7 (TH7) system still not paved, primarily from Côte d'Ivoire to Guinea-Bissau [1, 13], coupled with a lack of bilateral cabotage and customs harmonisation [8], delay and restrict the movement of goods and people.

The conditions in West Africa present a transformative opportunity for the parallel Ro-Ro ferry system, due to poor road conditions and policy implementation negatively affecting throughput time and reliability of road freight.

2. Literature Review

Even with various costs and environmental incentives to haulage operators and freight owners, the parallel Ro-Ro ferry networks have been underutilised where time in transit exceeds road time.

Kotowaska [7] defines the principles of longitudinal and transverse parallel networks, but cannot definitively justify a greater use of Ro-Ro vessels outside their mandatory "land bridge" capacity within the EU from an economic and sustainability perspective, given highly developed land infrastructure and the time sensitivity of modern JIT (Just-In-Time) logistics.

Kotowoska [7] also indicates that the deployment of any parallel Ro-Ro ferry service or network should first identify freight corridors where infrastructure or policy slows throughput.

In Japan, the Japan International Cooperation Agency (JICA) note that policies on commercial drive-time slow the movement of end-to-end road freight for SME cargo owners, given that the minimum time to cross the extremities of the mainland by road is around 20 hours. A 12-hour cap on driving means any cargo due for a destination more than 12 hours away is delayed by an additional rest period of up to 12 hours. However, freight between major nodes, such as Osaka and Tokyo, does not fall under this rule. The Japan Long Course Ferry Service Association (Japan's combined ferry operator group) focuses on services where road freight is disadvantaged by caps on drive time; the Tokyo-Kyushu route, which covers the journey in 21 hours, instead of the 12-hour 35-minute plus 8-12-hour rest the road journey would take, without traffic [6].

In India, the Kokan Railway Ro-Ro Rail service provides SME hauliers a major time advantage by cutting out the treacherous mountain passes of the Western Ghats between Kolad and Surathkal. The rail service has seen great success by compressing the transit time that, under best-case simulations, takes 17 hours by road to just 12 hours by rail. This also came with the added benefit of greatly increasing the safety and reliability of freight, no longer exposed to poor road conditions, 2,000-metre drops, theft by bandits or accidents [3, 4, 10, 14].

Understanding the nature of freight is also a critical success factor. Mizutani & Fukuda [9] state, in Japan, one of the first countries to promote a modal shift incentive to its intricate rail network, failed to take into account the operations of SME hauliers and private owners to provide an adequate incentive, resulting in a rise in road freight of 20% since the scheme's introduction in 1987, because the process of unitisation and hub and spoke nodes actually slowed end-to-end freight of SME business owners, who did not require more a truck load of goods or materials in a single shipment.

Yoo [16] identifies that not all road freight is, or can be, containerised, with several truck operators operating units using the more traditional box or pallet trailers, which cannot be easily transferred to intermodal systems.

The Chinese-funded and built SGR freight rail corridor in Kenya failed to attract cargo owners from road transport because the majority of freight movements in the country were for SME businesses, which relied on a complete, end-to-end service. Despite the railway's time advantage of 6 hours compared to 10 hours for the parallel A109, freight sometimes spent hours or even days in Nairobi's Terminal, which hurt end-to-end transit time over a comparatively shorter distance (484 km) than what unitised service would be deployed in developed economies [5, 11].

3. Methodology

Current literature indicates that the critical success factor for a parallel Ro-Ro network is still deeply rooted in time benefits, as most other incentives related to costs, freight risk and environmental concerns are not enough for SME cargo owners, who rely on the convenience of end-to-end services.

Therefore, the objective of this research is to locate and assess the conditions of the road, in this case, the TA7. For primary data, an end-to-end route survey would be best; there are several limitations to such a project, due to time and risk, given the scope and application of the results.

Instead, Primary data collection of road conditions was limited to sections between Lagos and Cotonou (18 to 19 July 2022) and Abidjan to Freetown (8 to 10 June 2022). The remaining route will be assessed using public domain satellite imagery.

Road conditions will be categorised into four classes of road (freeway, highway, paved road, and unpaved roads), with each section given one of 3 grades (good, fair and poor) with a nominal factor in km/h for each based on works by Xing et al. [15] including congestion with five levels (unblocked, basic blocked, mild, moderate, serious). Accuracy is determined by the reliability of the imagery and accompanying literature, if available.

Frontier stoppages will use formula based on the average ($\overline{x_t}$) number of trucks (t) witnessed awaiting customs by a nominal number (n) of inspectors (i) per truck (4 Nigeria, Benin, Togo, Ghana, Ivory Coast) (2 Liberia, Sierra Leone, Guinea, Guinea-Bissau, Gambia, Senegal) by a nominal average inspection time (h) (1 hour)

$$\left(\frac{\overline{x_t}}{n(i)}\right) \cdot h \tag{1}$$

This only applies where definitive information is not available, with inputs relying on first data.

The Gambia Ferry at Banjul has been given a similar formula where the number (n) of ferries (f) and the time it takes for a round trip (h)

$$\left(\frac{\overline{x_t}}{n(f)}\right) \cdot h \tag{2}$$

It is important to note that while the survey identified several crossdocking locations at customs terminals (due to regulations on cabotage), any delays incurred by such operations were not possible to reliably measure and have been redacted from this research.

Ferry times will use nominal data. Speed is assessed at 15 knots while outside port limits, in calm conditions. Port turnaround or dwell times will be given a variable nominal time for all navigation, pilotage, charging and discharging operations, as this is the area which will determine if the benefit could lie with the road or ferry operator. Lebrand [8] mentions an average dwell time for freight at 20 hours, but the model will use periods of 24 and 48 hours for consistency.

The ferry model will be a pure Ro-Ro ferry arrangement, without the ability to carry the tractor unit and driver.

4. Trans-African 7 Route Findings

The survey showed that only 75% of the TA 7 is able to cater for opposing traffic, and 23% of the road remains unpaved, mostly in Guinea and Guinea-Bissau, effectively cutting Dakar from the Eastern ECOWAS. 37% of the driving time (time spent in movement) is in some category of congestion, as none of the major cities along the route has any kind of bypass instrument. 3% of the time at 87 confirmed checkpoints (outside of official customs zones), both legal and illegal.

Average speed across the route ranged from highs of 72 km/h over 334 km between Abidjan and Yamoussoukro to a combined 21 km/h over the 480 km stretch between Lagos and Accra.

Data suggest that the fastest possible transit time between Lagos and Dakar (4007 km) is 21.03 days (519 hours) under the condition that the truck did not stop other than for congestion, border crossings, or confirmed checkpoints.

In fact, 44% of the hypothetical time is spent at borders, with Kandika-Burunduma taking around 26 hours to clear, and Seme-Krake Border taking around 31 hours. Some literature suggests these times to be between 24 and 48 hours [8].

This figure explodes when the Banjul ferry is added, with the average wait time of 150 hours, contributing to 377 hours of stationary time across the route, now 72% of total transit time.

Although the average accuracy for the route is 87%, much of the route was surveyed to an accuracy of 90%. From the Mano River to São Domingos ranged from 65 to 70% where the roads merged into the landscape, and low-resolution images made it difficult to determine conditions. It should be noted that Guinea was experiencing a coup at the time of the survey (June 2022), which restricted access to road traffic from outside the country.

However, the data collected is more than enough to develop a realistic snapshot of time and conditions of the parallel network without the need for extra variables, which only delay the road time more, but are totally dependent on the state of the vehicle and operator, such as refuelling, planned and unplanned maintenance and rest stops.

It should also be noted that night driving outside of urban areas is typically avoided by most operators, given the conditions of the road surface. If night driving was added, it would increase the transit time by 67.5 hours if we consider the maximum sunlight hours in mid-summer, making for 24.4

days. On shorter routes, however, it is impossible to reliably predict where these night stops could fall, as this is again dependent on the state of the vehicle as well as departure time, which can increase time by 11.5 hours or 23 hours for each 12-hour period. Hence, this has also been omitted from the results.

5. Time Benefit Analysis

5.1. Existing Ro-Ro ferries

Both east and west extremities already employ variations of parallel Ro-Ro ferries for passengers and carry-on cargo. The Senegal-based Consortium Senegalais d'Activities Maritimes (COSAMA) uses Ro-Pax ferries for private civilian use between the capital of Dakar and the largest southern city, Ziguinchor, to bypass the customs cluster of Gambia. Cutting the travel time from 24 hours to 14 hours when the Gambia Border is open. The company also operates ferries to Agadir, Morocco, which cuts the journey time from 9 days to 56 hours according to the operator.

Due to the state of the Lagos-Badagry Expressway, an 85 km stretch which takes close to 9 hours to traverse, entrepreneurs have been converting traditional fishing boats into makeshift ferries to transport people and pallet loads between Lagos and Cotonou, which takes around 2 to 3 hours, not including passport controls.

5.2. Potential time advantage of ferry services for stakeholders

In reality, a SOLAS Ro-Ro ferry could transit the route from Lagos to Dakar in around 11 days (SOSP and EOSP, Table 1). However, any time advantage is diminished when factoring in pilotage, dwell times, and other formalities specific to each port of call. For instance, if the time in port exceeds 24 hours, then the average time advantage compared to road transport is 30 hours east and 20 hours west. If the port time is a more generous 48 hours, then the average time loss is 66 hours east and 82 hours west compared to road freight.

If we apply a typical Ro-Pax ferry turnaround time of 6 hours, the average time advantage is 99 hours. However, a Ro-Pax configuration is not viable for freight, as driver and tractor units could spend up to 16 days onboard between Lagos and Dakar.

This rules out an "all-stops" railway-style system from a time perspective. However, when we remove ports within close proximity to one another, the advantage returns.

Once this leapfrogging model is applied to this case, clusters of nodes become more obvious. For instance, a direct ferry from Lagos to Tema, bypassing the nearby ports of Cotonou and Lome, sees the time advantage revert to the ferry by 38 hours after port formalities at 24 hours and 14 hours, with a clearance time of 48 hours. However, the subsequent voyage to Abidjan would lose its time advantage if the combined total dwell time between Lagos, Tema, and Abidjan exceeds 139 hours.

This dwell time is important as the transit times of road and sea are fixed, presuming speed and conditions. The amount of available dwell time or turnaround time at subsequent ports will determine the success factor.

Table 1 - *Amount of time available from outbound customs processes to SOSP to EOSP to the end of customs processes before the time benefit is lost for most viable port combinations*

Route	Road time (hours)	Sea time (hours)	Time available for customs before advantage is lost (hours)	When a nominal 24-hour average is applied at both ends (hours)
Lagos-Tema	76	14	62	-14
Lagos-Abidjan	117	29	88	40
Lagos-Monrovia	192	59	133	85
Lagos-Freetown	216	75	141	93
Lagos-Conakry	233	78	155	107
Lagos-Dakar	518	104	414	366
Tema-Abidjan	43	17	26	-22
Tema-Monrovia	116	46	70	22
Tema-Dakar	442	91	351	303
Abidjan-Conakry	116	49	67	19
Abidjan-Dakar	401	75	326	278
Dakar-Bissau	233	17	216	168
Dakar-Freetown	302	29	273	225
Dakar-Monrovia	326	47	279	231

From Lagos to Tema, freight would need to clear OPL and customs in less than 48 hours at each port. This rules out a pure Ro-Ro vessel between:

- Lagos-Cotonou
- Cotonou-Lome
- Cotonou-Lagos
- Cotonou-Lome
- Cotonou-Tema
- Cotonou-Abidjan
- Lome-Cotonou
- Lome-Tema
- Lome-Abidjan
- Tema-Cotonou

- Tema-Lome
- Tema-Abidjan
- Abidjan-Monrovia
- Monrovia-Abidjan
- Monrovia-Freetown
- Monrovia-Conakry
- Freetown-Monrovia
- Freetown-Conakry
- Freetown-Bissau
- Conakry-Monrovia
- Conakry-Freetown
- Conakry-Bissau
- Bissau-Freetown
- Bissau-Conakry
- Bissau-Banjul
- Banjul-Bissau

Ports along the middle of the route, such as Monrovia and Freetown, would see time advantage of between 83 and 93 hours with direct connections to the major economic ports in Lagos and 239 and 244 hours from Dakar and at a 24-hour turnaround and 183 and 220 hours from Dakar, when the turnaround is and well time are 48 hours each.

The Banjul ferry creates an anomaly in the results, as the almost 3-day wait to cross means any ferry from Dakar west has a time advantage until Lome.

6. Conclusion

The coastal nature of many of the ECOWAS states and short distances between markets present an opportunity for parallel Ro-Ro ferry networks, a concept previously dismissed as a viable alternative to road networks in developed countries because of the slower speeds and high competition from railways and intermodal networks, neither of which are factors in West Africa.

Road freight in the region indeed suffers from wide inefficiencies from a combination of road conditions, customs protocols and congestion, culminating in a hypothetical best time of more than 21 days.

Even when considering generous transit times for road hauliers, the Ro-Ro ferry does see a time advantage under certain operating conditions when competing with the TA 7. This advantage is primarily observed when utilising a leapfrog model, where the vessel bypasses markets in close vicinity to each other. This is particularly beneficial to port clusters in Southwest Africa, like Monrovia and Freetown. Simulated movements in and out of Dakar saw major time benefits as it bypasses the Banjul ferry, which the survey concluded can add up to 3 days of stationary time due to the limitations of that ferry's operations.

The Ro-Ro model also maintains the SME haulier model and end-to-end freight model, which drives local employment and economies in the absence of large manufacturing operations.

But it is not fully established how this model can hold up economically. While a snapshot shows potential, further studies into the cost-benefits for cargo owners, road hauliers, and the ship operator would be beneficial to any future proposals.

It should be noted that existing passenger services operating in the area may incentivise investigation of the use of Ro-Pax vessels on shorter routes, where dwell times would be much shorter.

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