ANALYSIS OF THE RELATIONSHIP BETWEEN VESSEL CALLS AND PORT PIER CAPACITY IN THE PORT OF DURBAN IN SOUTH AFRICA

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1. Introduction

Durban serves as the premier trade gateway port to landlocked countries and occupies a focal point in transport and logistics chain generating more than 60% of the combined revenue of South Africa's eight ports as a major role contributor to the economy. The purpose of his research is to find an approach for the port to meet capacity demand by establishing and quantifying required cargo terminal capacity in terms of infrastructure. With the aim to analyse capacity constraints aligned to vessel calls, projected volume growths and future capacity demands for all commodities with the view to expand port capacity. Forecasting of cargo volumes and demand capacity were included to ensure capacity requirements are according to precise projections. Regarding port congestion, container vessel port time was analysed to measure time spent by vessels in the port. The research considerers not only capacity expansions in containers but incorporates all major commodities of the port excluding navy, passenger and fishery. The attributes analysed are the main features that quantify the proposed capacity required to meet demand.

2. Port Capacity

Port capacity and its utilization in various stages of ship movements such as anchorage, berthing, yard and intermodal links are an important measure for port performance [2]. Ship turnaround time referred to as time spent at anchorage, berthing and non-working time, which is the time spent in port by vessels, is the indicator that exposes capacity constraints when congestion manifests due to vessels spending time at anchorage and onshore. Also considered is the operational capacity refers to the amount of cargo the port can handle in given space of time [1]. Recent studies demonstration how capacity is measured with considered attributes, however most studies focus on container cargo only. Capacity is categorised as three types i.e. Design capacity, Installed/Operational capacity and Latent capacity, however operational and latent capacity were the attributes considered for the research.

2.1 Latent capacity analysis

Latent capacity is defined as follows: Lc = Installed Capacity/Design Capacity - 100%

$$Lc = \frac{Ci}{Cd} - 100\% \quad \text{...} (1)$$

Lc = Latent capacity/ annum
Ci = Installed capacity/annum
Cd = Design capacity/annum

Table 1 shows container and dry bulk to have no latent capacity, demonstrating a concern on continuous congestion for the terminals respectively. Although break-bulk and ro-ro cargo demonstrated slight latent capacity, it is considered to be negligible and non-usable as terminal utility rate exceeding 80% -90%. In addition, once berth capacity utilisation exceeds 70% of available capacity, it is understood to be more costly to handle additional trade through the port, indicating how capacity is the critical factor in port planning, affected by prolonged port and dwelling time. Liquid bulk revealed a usable significant latent capacity although volumes exceed operational capacity.

Table 1: Capacity status quo

Cargo type	Design Capacity per annum	Installed Capacity per annum	Latent capacity
Container (TEU'S)	3,020,000	3,020,000	0.0%
Dry Bulk (Tonns)	11,000,000	11,000,000	0.0%
Break Bulk (Tonns)	4,000,000	3,800,000	5.0%
Liquid Bulk (Kl)	21,000,000	11,000,000	47.6%
Ro-ro (Units)	520,000	480,000	7.7%

2.2 Cargo volumes

A 12 year period annual cargo volume growth was defined using the Compound Annual Growth Rate using the formula:

$$\mathbf{CAGR} = \left(\frac{\mathit{Ending\ value}}{\mathit{Beginning\ Value}}\right)^{\left(\frac{1}{\mathit{Number\ of\ years}}\right)} - \mathbf{1} \quad \text{......}(2)$$

Table 2 shows all cargo volumes to be inclining except for breakbulk cargo that shows a steep decline although latent capacity is seen to be available. There is no information regarding the cause of decline, however it is noted that some break bulk cargo might had been containerized and were accounted for in container cargo. With larger vessels, it is understood that larger amount of cargo is carried. Therefore, the bigger the vessels the more volume it carries.

Table 2: Volume trends

Cargo type	2001 Throughput	2013 Throughput	CAGR (2001-2013)
Container (TEU's)	1,228,493	2,660,146	6.65%
Dry Bulk (Tonns)	5,818,480	10,443,959	5.00%
Break Bulk (Tonns)	6,911,144	3,380,546	-5.79%
Liquid Bulk (Kl)	19,830,331	25,132,543	1.99%
Ro-ro (Units)	89,407	501,456	15.45%

3. Vessel Calls

3.1 Vessel movements

The ability of a port to handle cargo economically and on time determines in part whether vessels and cargo are attracted to the port. A five years review of vessel call is shown in table 3. The trend shows a significant number of vessels decreasing year to year respectively due to transformation of larger vessels [3], while cargo volumes continues to increase. Figure 1 demonstrates a trend regarding vessel movements. The number of movements is related to the number of arrivals, departures and shift respectively. Therefore that the lesser the number of arrivals the lesser the vessel movements.

Table 3: Vessel movement trends

Year	Movements	Arrivals	Departures	Shift
2011	9463	4229	4215	945
2012	8819	3975	3975	844
2013	8945	3967	3982	967
2014	8741	3935	3910	842
2015	8610	3946	3946	690

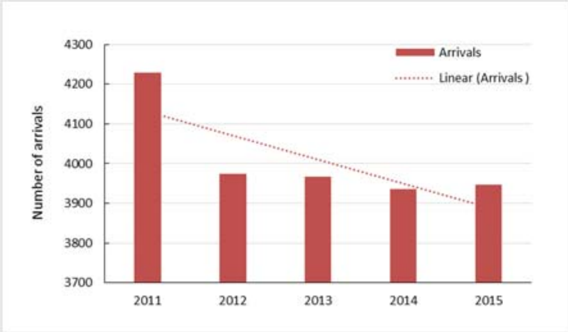

Figure 1: Annual vessel call trends

3.2 Container vessel time

Table 4 and figure 2 show time spent in the port reveals anchorage time improving by almost a day, however ship turnaround time increases by insignificant hours showing congestions on container terminals during operations. Vessel port time is calculated to be an average of 4 days improving slightly by 16 hours. Table 3 further displays container vessel trend that decreases over the four year period while increasing from 2013 and 2014.

Table 4: Container vessel time trend

Year	Time at anchorage (hrs)	Ship Turnaround time (hrs)	Vessel port time time (hrs)	Vessel movements
2011	63	45	108	2907
2012	61	53	114	2308
2013	57	58	115	2335
2014	41	51	92	2416
Average	**55.5**	**51.8**	**107.3**	
Average in days	**2**	**2**	**4**	
Increase/decrease	**22**	**6**	**16**	**491**

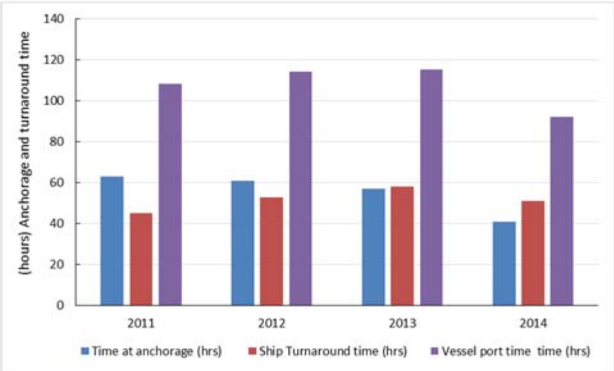

Figure 2: Container vessel time in port

4. Projected cargo volumes and capacity demand

4.1 Forecast capacity demand

Table 5 shows the demand capacity rising progressively for all cargo types except for containers and liquid bulk that indicate a substantial hike, giving an indicating of the amount having to meet projected cargo volumes.

Table 5: Future capacity demand

Cargo type	Year			
	2017	2020	2024	2043
Container (TEU's)	2,981,321	3,434,675	4,091,637	8,803,080
Dry Bulk (Tonnes)	10,780,616	9,620,644	10,332,673	12,826,294
Break Bulk (Tonne	3,178,208	3,422,882	3,780,742	4,916,608
Liquid Bulk (Kl)	8,105,675	8,719,295	9,432,147	43,531,729
Ro-ro (Units)	537,977	578,279	639,975	718,611

4.2 Forecast Volume Growth

The continuous trend of larger vessels was taken into consideration where forecasted values are concerned. Table 6 shows the values are used to determine the number of terminals required in respect of cargo type.

Table 6: Forecasted volumes

Cargo type	Estimated volume growth rate	Year			
		2017	2020	2024	2043
Container (TEU's)	4.20%	3,107,050	3,498,538	4,086,293	6,123,656
Dry Bulk (Tonnes)	0.50%	10,652,838	10,814,660	11,030,953	12,062,772
Break Bulk (Tonnes)	0.40%	3,434,634	3,475,850	3,531,463	3,799,734
Liquid Bulk (Kl)	N/A	25,132,543	25,132,543	25,132,543	25,132,543
Ro-ro (Units)	2.80%	557,619	604,459	672,158	936,720

5. Analysis

The number of terminals required to meet projected cargo volumes was defined as:

$$Nc = \frac{Vf}{Co} \quad \text{.........} (3)$$

$$Nd = \frac{Vf}{Co} \quad \text{.........} (4)$$

$$Nb = \frac{Vf}{Co} \quad \text{.........} (5)$$

$$Nl = \frac{Vf}{Co} \quad \text{.........} (6)$$

$$Nr = \frac{Vf}{Co} \quad \text{.........} (7)$$

Where **N** is the number of terminals required, **Vf** = forecasted cargo volumes and **Co**= current operational capacity, measured per unit per annum. Nc, Nd, Nb, Nl and Nr represent each cargo type, container, dry-bulk, break-bulk, liquid-bulk and ro-ro respectively.

6. Results

6.1 Terminal requirements

Table 7 shows results of the number of terminals required to meet projected capacity demand. With the knowledge of latent capacity and cargo volume trends, the required number of terminals per cargo type was calculated using estimated capacity demand from 2017 until 2043 and currently installed capacity, both considered with cargo unit type per annual. Based on both variables, containers, liquid-bulk, and ro-ro were found to require two terminals per commodity while dry-bulk and break-bulk were found to require only one terminal per commodity. The forecasted capacity over the next 30 years is projected to be able to meet the forecasted volumes with an overview of additional capacity required. With projected cargo volumes, the demand capacity aligned to the number of required terminals established, figure 3 proves that demand capacity will be met.

Table 7: Summary of results

Cargo type	Forecasted volume 2043	Demand capacity 2043	Installed Capacity	No. of terminals
Container (TEU's)	6,123,656	8,803,080	3,020,000	2
Dry Bulk (Tonns)	12,062,772	12,826,294	11,000,000	1
Break Bulk (Tonns)	3,799,734	4,916,608	4,000,000	1
Liquid Bulk (Kl)	25,132,543	32,719,258	21,000,000	2
Ro-ro (Units)	936,720	718,611	520,000	2

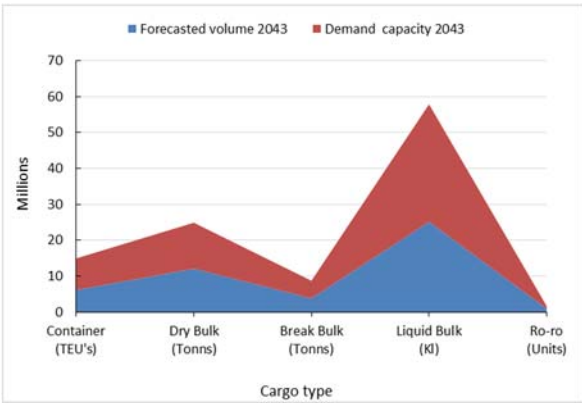

Figure 3: Demand capacity and volume forecasts

6.2 Vessel movements

Table 8 and figure 4 show that containers vessels were found to record the most movements followed by general cargo, bunker, tanker, car carrier, and coal respectively. The results verify that Durban in the primary container port as the highest number is recorded. Although vessel movements fluctuate in figure 4, the trend in figure 1 shows that movements decrease as over time, indicating that the movements increase or decrease in respect of the number of arrivals.

Table 8: Some types of vessels calling for the port

Reason	Year				
	2011	2012	2013	2014	2015
Bunker	1601	1688	1392	1240	1428
Container	2907	2308	2335	2416	2320
Tanker	429	229	752	691	916
General Cargo	1858	1608	2020	1813	1648
Car carrier	681	718	833	720	681
Coal	196	194	236	314	228

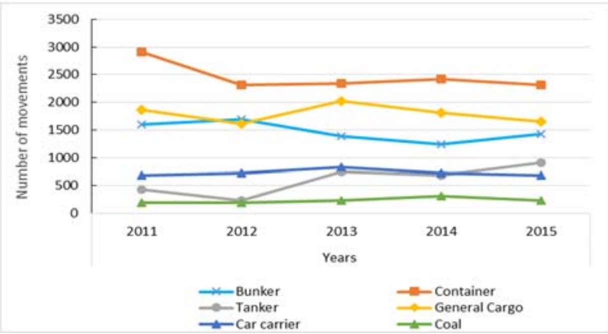

Figure 4: Number of movements per vessel type

7. Conclusion

From the results obtained in this study the conclusions is that:

- The measured terminals required will be adequate for the future demand capacity based on predicted cargo volumes and future demand capacity.
- All cargo types require additional capacity in medium to long term infrastructure planning based on projected demand and volumes, except for containers and dry-bulk and should be prioritized under short term planning to avoid additional port congestion.
- In addition, the capacity expansion will promote efficiency and enhance port performance. Liquid bulk volumes are depended on potential major projects although volumes are expected to grow whether the proposed projects materialize.

- The next generation of vessels being larger in size are concluded to have a significant effect on decreasing number of vessels destined for the port, particularly for containers and break bulk cargo due to the transformation.
- With the knowledge that vessels calling for the port are driven by the port capacity and its developments, trade primarily relies on the economy of the country in line with market demand and on well progression of the ports main attributes.
- As containerization of breakbulk cargo is expected to grow, we can conclude that volumes can decrease over time and would be encountered in container volumes. With the rapid growth experienced in containers, this transformation will create excessive volume growth.
- Moreover, adding or expanding capacity insures good hinterland connections and efficient terminal operation.

8. References

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[4] Ding Yi-Zhong: Throughput Capacity of a Container Terminal Considering the Combination of the Types of Arriving Vessels, Vol 15(1), pp 124-128, 2010