FORECASTING SOUTH AFRICAN CONTAINERS FOR INTERNATIONAL TRADE: A COMMODITY-BASED APPROACH

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ABSTRACT

The most common approach used internationally for forecasting international trade containers is models based on the correlation between container trade and economic growth. While the strong historical correlation is indisputable, this paper argues that there will be saturation in the propensity to containerise as all the suitable volumes of the underlying commodities shift to containers over time. In addition, the link between freight transport and GDP will decouple as more sustainable approaches to economic development, and therefore freight transport, are necessitated by economic and environmental realities. A commodity-based model, taking into account the underlying drivers of containerisation, is proposed here as a more realistic forecast of container demand. This could have a material impact on how large-scale investment decisions are directed.

INTRODUCTION

The container shipping industry and the related sea/land interface require major capital investments (Gregg-Macdonald, 2011). The exponential growth in the containerisation of freight (Garratt, 2006; Rodrigue, 2007; US Department of Transportation, 2011) therefore dictates the development of an appropriate forecasting model for South Africa's demand for international trade container capacity to inform infrastructure investments.

The challenges in forecasting container demand is however evident from recent history. In 2005, Singh (2005:15,18) forecast that demand for container port capacity will outstrip supply by 2012 and that a doubling of global port capacity will be required between 2005 and 2012. However, in 2010 overcapacity still existed (Neylan, 2010:50). (Disconcertingly, Ocean Shipping Consultants [2011] forecast overcapacity in most European container ports up to 2020, initiated by the fall-out of the 2008 recession. This reality has not necessarily filtered through to 'on-going and planned investments'.) World container traffic grew from 150 to 163 million TEUs between 2008 and 2010, and no significant growth is forecast for 2011 (Neylan, 2010:25). Using Gardiner's (2007:4) TEU number for 2006 (128 million TEUs), growth between 2006 and 2011 is expected to be a mere 30%, far below the expected doubling (Singh, 2005) between 2007 and 2012. Gardiner's (2007:49) forecast in 2007 for 2012 was 223.7 million TEUs, 63 million TEUs more than what will probably be achieved (or an error factor of 40%).

Container demand is prone to many uncertainties, such as weather conditions, port/surface transport interfaces, seasonality and the condition of the labour force (Bilegan, Craininc & Gendreau, 2007:2). These determinants are however short-term issues that are often considered in forecasting models, whereas long-term approaches which analyse underlying drivers are more difficult to find. The problem is that in times of major infrastructure spend in the developing world, and even in the developed world where infrastructure spend is attempted as a stimulus (*The Economist*, 2010), underlying determinants over far longer periods should be considered. (Port Investor [2011] estimates that total port infrastructure investment requirements in Asia, Africa and Latin America exceed 1 trillion USD.)

Many of the competition issues prevalent in studies such as for Hong Kong (Fung, 2001), which is situated close to other East-Asian super ports, are not valid for South Africa. Here, an integrated network of ports has the same owner, and is managed by the same authority, who has to satisfy total future demand with integrated port planning. This facilitates forecasting, but also increases responsibility because no alternative to poor planning exists. (Competition from Maputo and Walvis Bay is acknowledged, but these volumes are negligible compared with total port volumes in South Africa, and are expected to remain so over the next couple of decades – for Walvis Bay refer to JICA, 2010:60; for Maputo refer to Mpumalanga Department of Public Works, Roads and Transport, 2009:101.)

In this paper, the shifts in drivers of containerisation are discussed, followed by the current common approaches to forecasting container demand. A new container demand forecasting technique for South Africa is proposed as well as how to overcome the related data challenges. The results of the container demand forecast for South Africa are presented, followed by concluding remarks.

GROWTH DRIVERS OF DEMAND FOR TRADE CONTAINERS

Specialisation

Abonyi and Van Slyke (2010:S2,S3) identify four drivers of production globalisation, namely policy liberalisation, capital mobility, increasing competition and accelerating technological change in transport, telecommunications and information technology. Pienaar (2005:2) confirms that 'sustained economic development and growth is dependent upon productive regional specialisation … and the consequent exchange of goods, services and information'.

Trade is stimulated because specialisation increases productivity and reduces costs (Ballou, 2004:2). Specialisation therefore drives production globalisation, and transport ability sustains it. The net result of this state of affairs is that transport growth will outstrip GDP growth. This can be seen for Europe over the period 1995–2004, as illustrated in Figure 1.

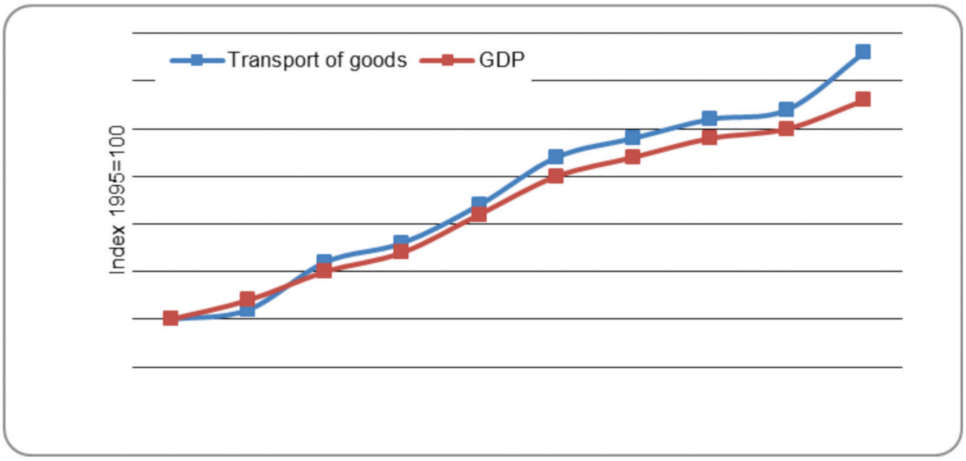

Figure 1: Growth in goods transport outstripping GDP growth in Europe between 1995 and 2004 (Ponthieu, 2008)

However, a (un)natural limit for the trend exists in as far as the consolidation of production technology and resources are concerned (resulting in supply often being significantly geographically displaced from demand), which should decouple the link between transport growth and GDP growth over the medium to long term (Koppen, 1995; Rodrigue, 2007). New factors have however emerged that could reduce the gap in the short-to-medium term, i.e. the carbon footprint of transport, increasing scepticism about GDP growth as the key indicator of wealth and declining cheap energy sources. Sustainable Aotearoa New Zealand (2009:39), an NGO promoting sustainability, forecasts a scenario for 2025 where manufacturing will be more localised unless it is more 'strongly sustainable' to import, and then importation will be from manufacturers where, *inter alia*, the transportation of input of goods is limited. This will significantly impact freight transport flows.

Propensity to containerise – trade growth faster than GDP growth

Over the past 30 years, growth in global container flows significantly outperformed global GDP growth, as is illustrated in Figure 2.

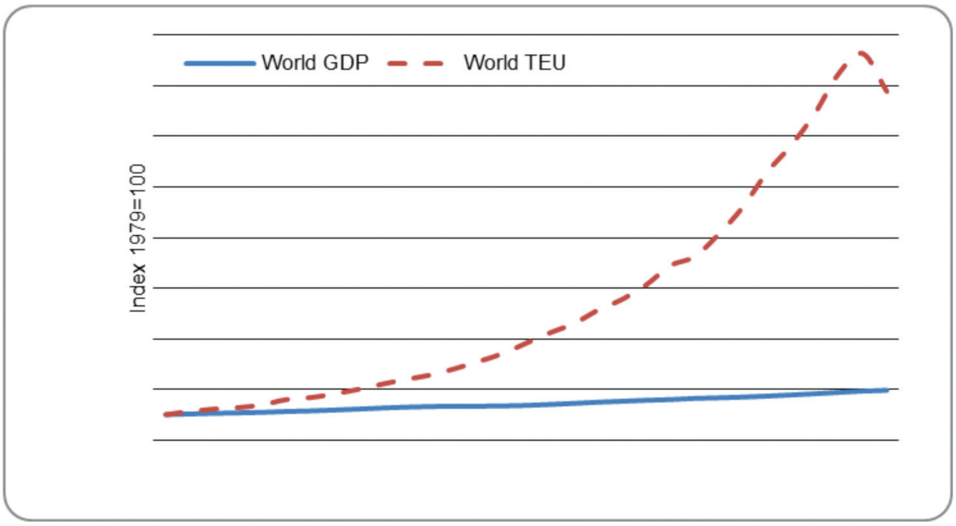

Figure 2: Growth in global container flows outstripping GDP growth over the last three decades (GDP data from IndexMundi, 2011; TEU data from Sooredoo, 2011)

However, a review of individual countries reveals that container growth in developing countries has been much higher than in developed countries over the same period. One reason for this is that the containerisation trend started earlier in the developed world, pointing to a natural slowing down of containerisation over time. At some stage, the trend to containerise commodities should therefore slow down to the global trade growth pattern. This phenomenon can be seen in Figure 3 for India and Brazil, representing developing economies versus the UK and the USA, representing developed economies.

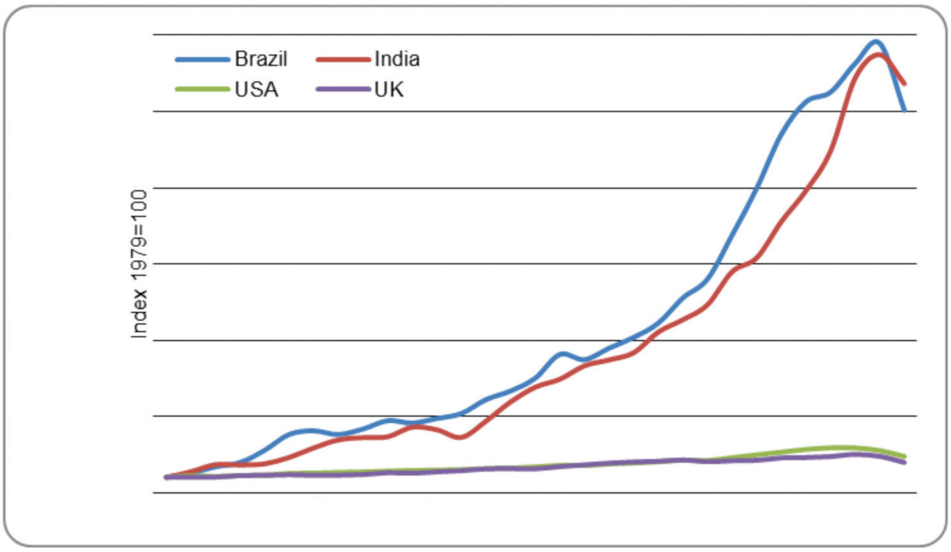

Figure 3: Relationship between GDP and TEU growth for developing and developed countries (GDP data from IndexMundi, 2011; TEU data from Sooredoo, 2011)

FORECASTING TECHNIQUES FOR TRADE CONTAINER DEMAND

The historical correlation between container traffic growth and GDP growth is indisputable (Garratt, 2006). The most common approach to forecasting trade container demand is therefore the strong belief that it is 'ultimately driven by economic growth' (UNESCAP, 2007:28). The underlying assumption in the UNESCAP forecast is that, for the decade up to 2017, 'the structural relationships between growth in container trade and economic growth will remain basically unchanged'. The basis of their analysis was consequently expectations of future economic growth (UNESCAP, 2007:28). The Department of State and Regional Development of New South Wales (2011), responsible for container forecasts for Melbourne, Sydney, Brisbane, Fremantle and Adelaide, also bases dramatic intermodal growth on globalisation and world economic growth, which is forecast to remain constant over the next 20 years.

The United Nations forecast is for a global outcome, but some major ports such as Rotterdam (where commodities are considered) and New York (where the 'economic wellbeing of surrounding hinterland states' as well as foreign trade volumes are considered) (Dagenais & Martin, 1987:1) developed more complex forecasting models. Gosasang, Chandraprakaikul & Kiattisin (2010:1) refer to Japan International Cooperation Agency's (JICA) forecast reports of 1994, which forecast volumes of import/export containers at Bangkok Port by using the technique of regression analysis on the two variables population and gross domestic product (GDP). They propose a neural networks method for predicting the container throughput at Bangkok Port, but still consider domestic GDP, world GDP, the exchange rate (compared with the US dollar), population, inflation rate, interest rate and the fuel price as underlying variables.

Fung (2001:15) adopts a forecasting model that considers price sensitivity and service competitiveness between the competing ports of Hong Kong and Singapore, with GDP growth as a given. He concludes that 'the demand for container handling services is derived from the demand for imports, as the resultant market shares of container handling services is gripped by different regions inevitably becoming a mirror image of the relative competitiveness of their exports. When the markets of the two ports overlap, the market shares will depend on the prices they charge and on how well they meet the needs of the shippers and shipping lines' (Fung, 2001:18-19). Wilson and De Vuyst (2007:10) also emphasise inter-port competition in the USA and highlight a common mistake entailing a belief that certain forecasts relating to the improvement of efficiency levels will correlate with growth, while port competition is ignored.

As developing nations are on the threshold of major infrastructure investments, greater accuracy is required. In addition, the sub-Saharan African region receives more foreign aid than any other region in the world, and the wise spending of this aid should become an increased focus for global aid givers and the receiving economies (De Bod & Havenga, 2010:89-92).

Lam, Pan, Seabrooke and Hui (2004:142), in addressing the ever-present issue of forecasting demand for the world's busiest container port, Hong Kong, proposed in 2004 that explanatory factors (such as population, trade values of imports/exports, and GDP) that affect freight movements should be re-analysed since the relationship between these and freight movements was determined in 1997. They reason that changes in the economic environment 'might cause their relationship to no longer be valid, and hence a reanalysis is needed'.

In forecasting container throughput for Indonesia to support the case for the building of a new port, Syafizi, Kuroda and Takebayashi (2005), however, include container throughput, GDP, population, and exports and imports as model variables and assume that the statistical structure of the model will not change substantially in the future. Wilson and De Vuyst (2007:10-11) maintain that 'rather than modelling individual or even multiple commodities, we explicitly recognise that the supply and demand for container shipments is a market of its own, regardless of the contents of the containers'. However, the authors do list as an outstanding issue the 'non-identity of container content' and concede that the reason their model excludes commodities is because the content of containers is unknown. They go on to state that 'there has been an increase and shift in commodities shipped by containers' and suggest that 'somehow this will have to be captured in the model specification' (Wilson & De Vuyst, 2007:28,34). Garratt (2006) refers to the slower growth rate of containerisation due to the 'maturing of the containerisation of commodities'.

In this paper, the inevitable saturation in the propensity to containerise is illustrated as a potentially more important explanatory factor in forecasting container demand than usually considered. The research strategy to achieve this is described in the following section.

RESEARCH STRATEGY

In this paper, a container demand forecast, based on commodity-level export and import-volume forecasts, as well as the propensities of the commodities to be containerised, is proposed. The methodology is therefore driven by information on container content, forecasts of long-term growth in demand for this content, and 'fitting' these to maximum propensities to containerise.

Sourcing information on container content through mega-sampling

Due to resource constraints, South Africa's port authority stopped capturing information on container content from shipping line manifests, which is one of the main causes of the poor planning of trade container capacity. Various methods have been attempted since 2006 by the authors to rectify this problem.

The first attempt involved deriving information on container content from the difference between imports and exports (per commodity) as contained in customs data (which should reflect total imports and exports), and available National Ports Authority (NPA) data per commodity, which excludes containers. It was unfortunately proven that no sensible result could be obtained from this exercise. It would seem that for various possible reasons (and this is a topic for further investigation) information on either one or both sides of the equation was recorded incorrectly or coded in different ways. These reasons could include human error, coding errors, value-to-volume translation errors or a combination of several of the aforementioned. The next attempt involved surveying freight forwarders and logistics service providers, but poor response rates and unreliable data also led to difficulties in solving the container content question.

Eventually, in 2009, the shipping lines were requested to submit their original raw manifest data and, after considerable persuasion, data on the content of 66% of all import and export containers was recorded. This sample of 1 311 853 full TEUs is by far the most reliable source of commodity information that could be established. The database includes two calendar years' data (2008 and 2009), including *inter alia* total weight of the contents, the number of TEUs and content information, enabling a robust analysis. The detailed commodity data was classified into commodity groups to enable matching with the GDP data. The data will be updated annually for the first couple of years to establish the robustness of the process and the results, and thereafter the plan is to update it every three years to determine shifts in the propensity to containerise certain commodities. This, in turn, will enable a validation and refinement of the methodology proposed in this paper.

It was established that the commodities most suitable for containerisation fall into two broad categories:

- perishables, including agricultural products such as fruit, meat, and dairy; and
- break-bulk, including mainly palletised manufacturing-sector consumer goods.

Once the historical content of trade containers was known, the supply and demand for all commodities had to be forecast (to ensure all future containerisable commodities were incorporated). This was followed by translating supply and demand into flows to determine import and export flows.

Forecasting economic growth and deriving freight flows

The detail of the freight modelling methodology is beyond the purpose of this paper, but will be described briefly. For further insight, please refer to Havenga (2007).

In order to refine domestic freight-flow forecasting in South Africa, disaggregated supply and demand data, based on an input-output model (I-O model) of the economy, was used.

(South African ports are far more hinterland ports than transhipment ports, meaning that surface freight flows, which are derived from the I-O model, play an important part in import/ export demand.) The I-O model was used to calculate the output per sector by taking into account the interrelationships in the economy. For the purposes of freight-flow analysis, the I-O model was disaggregated into 356 magisterial districts and 65 commodity groups.

A combination of forecasting techniques was used to determine future supply and demand for these commodity groups. These include expert consensus for agricultural and mining commodities, correlated with macroeconomic forecasts at the industry level. For validation, results were compared to historical trends. For manufacturing, standard forecasting models from a major bank were used. These forecasts are the results of an elaborate system of quantitative analyses coupled with, and to some extent controlled by, a qualitative evaluation of each sector's unique characteristics. A 30-year forecast is updated annually, with yearly results for the first five years and thereafter a 10-, 15- and 30-year forecast. Finally, the forecasts are verified by a set of independent economists.

Economic forecasts, even at the sub-sectoral level, are normally expressed in monetary terms. For this reason, most of the modelling is done in monetary terms. However, to facilitate transport analyses, it is more practical to express production magnitudes in volumetric terms. The supply and demand components of the I-O table were converted from monetary to volumetric terms using a rand-per-ton ratio. This enables the generation of total supply and demand volumes (in tons) that ultimately need to be transported on South Africa's transport network.

Gravity modelling principles were applied to determine freight flows. Gravity-based approaches are based on the premise that trade flows between origins and destinations are determined by measures of supply and demand, and a measure of transport resistance (Krygsman, 2006; Havenga, 2007).The measure of transport resistance refers to a transport cost variable for overcoming the spatial discrepancy between supply and demand locations. For the purposes of this research, a distance decay function was used as a transport resistance measure.

The forecast for all flows, including import and export commodities, was thus established, leading to the next step of determining the propensity of import and export commodities to be containerised in the future.

Propensity to containerise

The extent to which containerisable commodities have been containerised had to be determined, i.e. are there commodities that could be in containers, but are still being transported as bulk or break-bulk freight. The current containerisation per commodity was determined, based on the non-containerised bulk volumes from detailed commodity knowledge obtained from the NPA's database, and the containerised volumes as received from the shipping lines (described previously). Assumptions for the percentage of each commodity that can potentially be containerised in the forecast years were then developed, based on the sampled data to date and through discussions with industry experts. The shifts were captured as a cumulative, gradual change over time. This process was repeated for all 64 commodity groups. The current containerisation of import/export commodities, as well as the containerisation at the end of the forecast period, is provided in Table 1. More research can be undertaken on 1) the propensity to increase the containerisation for each commodity group per year, and 2) whether a ceiling value of less than 100% needs to be set for certain commodity groups.

Table 1: Percentage containerisation per commodity for 2009 and 2040 (sorted according to 2009%)

Break-bulk	2009	2040
Cement	21%	17%
Ferrochrome	25%	24%
Iron & steel basic industries	28%	60%
Ferromanganese	30%	33%
Wood & wood products	32%	52%
Industrial chemicals	38%	54%
Food & food processing	52%	95%
Other chemicals	59%	94%
Non-ferrous metal basic industries	63%	63%
Machinery & equipment	90%	97%
Transport equipment	93%	99%
Paper & paper products	94%	96%
Other manufacturing industries	96%	99%
Non-metallic mineral products	97%	100%
Motor vehicle parts & accessories	97%	100%
Rubber products	99%	100%
Metal products excl. machinery	100%	100%
Electrical machinery	100%	100%
Bricks	100%	100%
Furniture	100%	100%
Textiles & clothing	100%	100%
Tobacco products	100%	100%
Pharmaceuticals & toiletries	100%	100%
Cotton	100%	100%
Printing & publishing	100%	100%

Perishables	2009	2040
Citrus	69%	100%
Vegetables	91%	100%
Deciduous fruit	94%	100%
Dairy	100%	100%
Livestock (slaughtered)	100%	100%
Subtropical fruit	100%	100%
Viticulture	100%	100%

Based on the proposed forecasting methodology, the differential between GDP and container forecasts will shrink over time as the propensity to containerise reaches saturation. The benefit of this methodology is that although container growth will outperform GDP growth and/or trade growth in the medium term, once commodities reach their respective ceiling values for containerisation, the growth of containerisation will have to be limited to GDP growth and/or trade growth.

RESEARCH RESULTS

Propensity to containerise

The combined percentage of containerisation for the industry groups most likely to be containerised – i.e. break-bulk and perishable industry groups – in 2009, was 48% for exports and 69% for imports respectively.

On analysing the remaining 52% of export commodities not yet containerised, 76% belongs to four commodity groups that were considerably containerised already, and possibly could be containerised further in future but some of them might achieve a ceiling less than 100% due to weight complexities, i.e. iron and steel, and wood. Table 2 shows these commodity groups, the current percentage containerised, and the remaining non-containerised bulk tons.

Table 2: Commodity groups, percentage containerised and bulk tons for exports (2009)

Commodity	% Containerised	Sum of bulk tons
Iron and steel basic industries	28%	2 749 901
Wood and wood products	28%	2 428 099
Ferrochrome	24%	1 766 885
Industrial chemicals	31%	1 237 578

Performing the same analysis for the remaining 31% of import commodities not yet containerised, 84% belongs to four commodity groups that were already considerably containerised, as shown in Table 3. Processed foods and chemicals are expected to approach 100% containerisation in the short-to-medium term.

Table 3: Commodity groups, percentage containerised and bulk tons for imports (2009)

Commodity	% Containerised	Sum of bulk tons
Food and food processing	42%	1 922 850
Iron and steel basic industries	39%	499 809
Other chemicals	66%	393 182
Industrial chemicals	53%	374 232

The number of future containers is calculated by multiplying the total import and export volumes (tons) by the percentage containerisation predicted, and then dividing the tons containerised by the average weight per TEU for imports and exports respectively. The resultant container growth rate versus the GDP growth rate over the forecast interval is shown in Table 4, indicating that the differential is shrinking over time.

Table 4: GDP growth, container forecast and difference per forecast interval

Year	GDP growth	Container growth	Difference
2010	2.88%	5.70%	2.82%
2011	3.00%	5.44%	2.44%
2012	4.05%	4.62%	0.57%
2013	4.05%	4.49%	0.44%
2014	4.05%	4.80%	0.75%
2015	4.05%	4.74%	0.69%
2020	3.87%	4.79%	0.92%
2025	3.69%	4.42%	0.73%
2040	3.69%	4.12%	0.43%

The increase in containerisation also provides a better understanding of expectations regarding future freight volumes for bulk terminals. Although outside the scope of this paper, break-bulk handling volumes are expected to decline, or at best be stagnant, due to most of the growth being taken up by containers.

Container volume forecast

Figure 4 compares the results of the proposed commodity-based approach to the results of three extrapolated forecasts from the same base data. The extrapolation was done by using container growth rates for the past 10, 20 and 30 years respectively. The container numbers based on the approach described in the methodology still outperform GDP growth over the 30-year forecast.

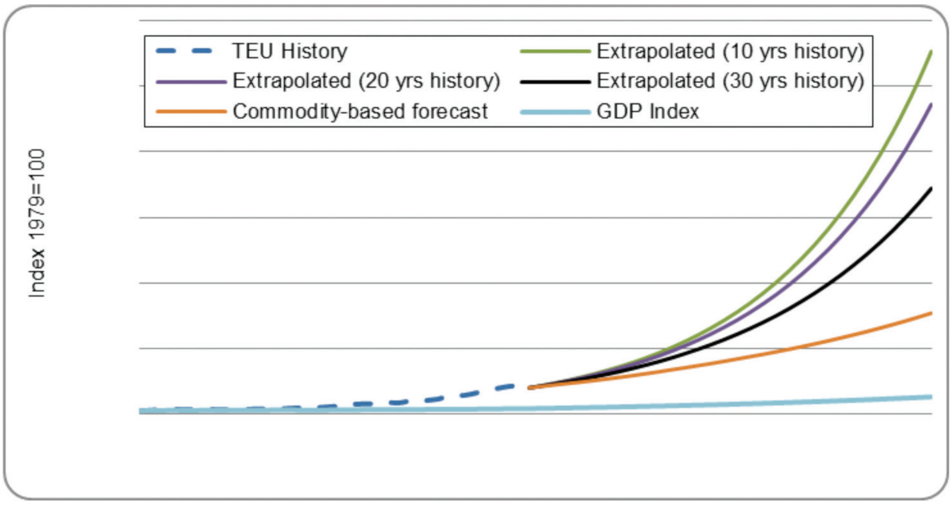

Figure 4: Extrapolated container forecasts versus commodity-based forecast

The extrapolated forecasts would create a potential overestimation of required port capacity for container handling by 300% for the 20-year extrapolation, compared with the commodity-based forecast. This shows the potential danger of planning and investing in infrastructure based on extrapolating historic trends for containers.

To test the risk that the propensity to containerise could be faster than expected, and that the commodity-based forecast might therefore be too conservative, another forecast is added for 100% containerisation of all suitable commodity groups by 2039 (excluding bulk iron ore, coal, and manganese exports, and crude oil and petroleum imports which can confidently be excluded from containerisation). Although many other commodity groups can probably also not be completely containerised, this assumption indicates the upper ceiling and also the overestimation of the extrapolated forecasts. The ceiling forecast is still significantly lower than extrapolated forecasts (Figure 5).

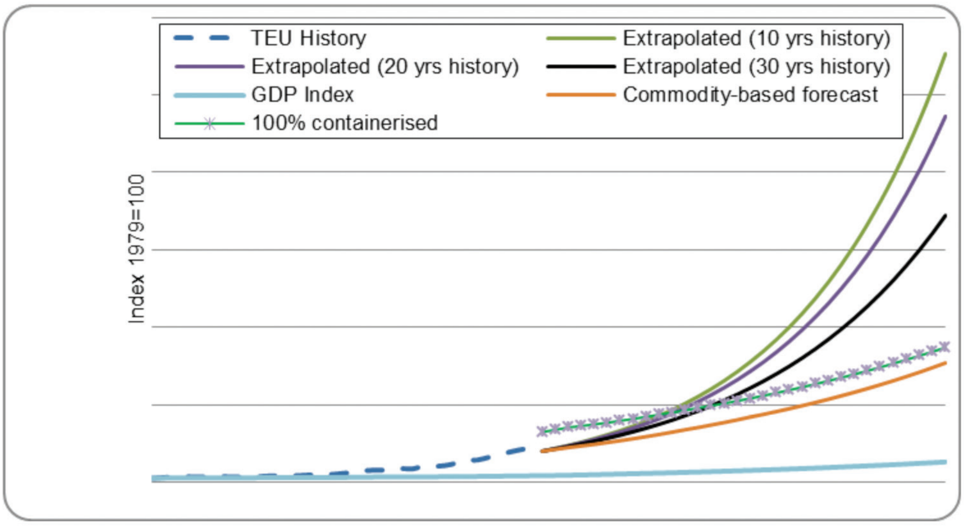

Figure 5: Extrapolated container versus commodity-based forecast with ceiling container volumes

FINDINGS

The most conservative extrapolated forecasts have been shown to require infrastructure capacity of double what is actually required based on the actual container content forecasts. Even if all commodities can be containerised, the former approach to forecasted historic container trends have been proven to be too optimistic, and new approaches should be followed.

Forecasts of trade container demand over the past decade have shown significant deviations from actual demand. When analysing container contents and current containerisation trends, containerisation is already maturing, limiting the future growth of containerisation. A container forecasting approach based on the underlying commodities' future propensities toward containerisation is therefore proposed. This potentially more realistic forecast yields, at its ceiling value, a forecast below the most conservative extrapolation. While further research is proposed, the results of this research should serve as a cautionary input into large-scale infrastructure investments. The results of the model are currently applied by the national port operator to direct decisions regarding significant investment in port container- and bulk-handling terminals. Informed decisions are critical since they will have medium- to-long-term repercussions for the development of other logistics infrastructure, industry location decisions and hinterland development.

Recommendations to South African port authorities would be to consider the actual contents of containers, by capturing the actual content, and move away from their view that 'a box is a box'. Port authorities have access to detailed container contents through shipping manifests, and thus can plot historic container content trends. A higher level of accuracy in container forecasting could be achieved if the forecast is based on historic container contents and the underlying commodity trade forecasts.

More research is suggested in the following areas: 1) understanding discrepancies between customs and National Ports Authority data; 2) the propensity to increase containerisation for each commodity group per year; and 3) ceiling values of less than 100% for certain commodity groups. Ideally, the forecasts should also include a scenario that takes into account the changing global landscape, incorporating *inter alia* the potential trade impact of the shift to ethical consumption (with specific reference to localisation of consumption where possible), as this could have a material impact on the need for freight logistics infrastructure.

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