THE DEVELOPMENT OF A PERFORMANCE MEASUREMENT SYSTEM FOR THE SOUTH AFRICAN CONTAINER SHIPPING INDUSTRY

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ABSTRACT

Globalisation is dependent on efficient supply chains and a variety of transport systems. South Africa participates in the world's economy with an extensive container shipping industry, as well as a road/rail/air distribution system. One of the aims of this research study was to develop a measurement system, or model, that may assist in measuring the performance of a container shipping service, from the time a ship arrives in the harbour, through the process in the container depot until the container arrives at the final customer for imports, and the other way round for exports. The objective was to develop a performance index that would assist management in assessing and/or improving the current system. It is a global phenomenon that inefficiencies cannot be eliminated by a single organisation; it requires the cooperation of all the parties in a supply chain.

In the South African container shipping industry as represented in this article by the Cape Town Container Terminal (CTCT), the emphasis currently is on customer and supplier relationships in the supply chain. In order to be meaningful, and in support of and of benefit to the whole chain, it needs to be measured. The performance measurement system (PMS) developed in this study can be used to improve supply chain efficiency. The research was conducted through questionnaires and interviews with CTCT role players as well as relevant stakeholders. Finally, two case studies were identified that illustrate the proposed application of a PMS. The PMS was applied to the CTCT and two of its shipping corridors. The results of this study may be useful to practitioners and researchers in the field of service supply chains.

INTRODUCTION

Problem statement

Cho, Lee, Ahn and Hwang (2012) found that: 'Despite the increasing attention to the service supply chain management by both practitioners and academics, the performance measurement of service supply chains still remains unexplored. Most service firms realise that, in order to evolve an efficient and effective service supply chain, service supply chain management needs to be assessed for its performance.' In recent decades, services have become extremely important in world economies. The service economy has always been the driving force of the economic growth of every developed nation (Giannakis & Louis, 2011). Indeed, the transformation of industrialised economies from a manufacturing base to a service orientation is a continuing phenomenon (Smith, Karwan & Markland, 2007). However, despite the importance of services and the increasing servitisation of world economies, services lag behind in performance when compared to manufacturing (Van Ark, O'Mahony & Timmer, 2008). One of the reasons for this is that most of the successful manufacturing organisations have an opportunity to achieve higher performance in pursuit of supply chain management (SCM), which is a common practice across manufacturing industries. From both the practical and the academic standpoint, the emphasis in SCM is still strongly skewed towards the manufacturing sector (Boonitt & Pongpanarat, 2011). This is because effective SCM can lead to a lowering of the total amount of resources required to provide the necessary level of customer service to a specific segment and to improving customer service through increased product availability and reduced order cycle time while reducing costs (Banomyong & Supatn, 2011). The differences between service supply chains and the more traditional manufacturing supply chains are described as follows: 'In service supply chains, human labour forms a significant component of the value delivery process and while physical handling of a product leads to standardised and centralised procedures and controls in manufacturing supply chains, in services this is not entirely possible as many of the decisions are taken locally and the variation and uncertainties in outputs are higher because of the human involvement' (Sengupta, Heiser and Cook, 2006).

The above research clearly shows that SCM performance measurements are lacking in the service industry, including in the container industry. The shortcomings and inefficiencies in this industry, within the South African context and more specifically in the Cape Town area, were discussed in a focus group on 23 March 2010. The group included managers and staff working for shipping lines, the container terminal operator, transporters and freight forwarders. Specific inefficiencies were listed as those that have the most impact on the container shipping supply chain. Some of the inefficiencies that are common in South Africa, particularly in the Western Cape, are (Transnet, 2010):

- Little priority is assigned to investment in ports and container terminals.
- Inter-modal facilities and inland terminals are inefficient.
- The lack of capacity within ports and on the roads causes congestion.
- The industry is unpredictable.
- Labour is unpredictable due to strikes and union demands.

Objective of this study

The planning managers of the Cape Town Container Terminal (CTCT) voiced a need to ascertain the role of the terminal in the shipping supply chain, with emphasis on measuring the efficiency of such a supply chain. The objective of this study was to research and evaluate the shortcomings and inefficiencies that exist within the local container shipping supply chain with a view to determining which areas need to be improved. The data will be used as input to a measurement system. A performance measurement system (PMS) will be developed as an outcome of this study. The validity of the model will be tested through case studies of two different 'corridors'. Throughout the study, the definition of a corridor proposed by Douma and Kriz (2003) was used: 'We define a transportation corridor as a geographic area between two points, linking multiple centres, and moving people and freight. This definition includes both the transportation infrastructure (e.g., the roadbed, rails and stations) and the new and existing development that surrounds that infrastructure.'

Recent developments in the industry

Containerised trade has changed significantly since the 1960s. At the 5th Asean Ports and Shipping Conference it was shown that 60% of world trade is containerised, and that the percentage shows an upward trend (Johari, 2007: 4). On the assumption that the increase in containerised cargo will result in an increase in the level of traffic at the world's ports, container handling terminals need to prepare for the increase. Shipping lines aim to ship a container at the lowest cost by using larger vessels and by making use of economies of scale. Container terminal operators are under pressure to operate at high productivity levels and to turn vessels around in the shortest possible time. There is still significant room for improvement within this industry, probably best illustrated when comparing South Africa's logistics cost as a percentage of GDP, at 13.5% in 2009, with that of the United States of America, at 7.7% (Havenga, Simpson, Van Eeden, Fourie, Hobbs & Braun, 2010). Similarly, the Logistics Performance Index (LPI) survey done by the World Bank in 2010 showed that South Africa was ranked 28th (out of 155 countries) with regard to international logistical competitiveness (Saslavsky, Shepherd, Ojala, Mustra & Arvis, 2010).

RESEARCH STRATEGY

The literature study was divided into three phases:

1) Studying the container shipping industry and the planned developments in South Africa
2) Studying the shipping supply chain framework
3) Studying PMSs that have been developed and that are used in different industries

Performance measurement systems (PMSs)

Much emphasis has been placed on how supply chains are being managed and how effective they are. Firms strive to achieve strategic objectives, and the importance of having an integrated supply chain with stable and close relationships with suppliers and customers has grown. Supply chain management is applying 'a total systems approach to managing the entire flow of information, materials, and services from raw materials suppliers through factories and warehouses to the end customer' (Chase, Jacobs & Aquilano, 2006: 406). According to Frohlich and Westbrook (2001: 186), 'the effective integration of suppliers into product value/supply chains will be a key factor for some manufacturers in achieving the necessary improvements to remain competitive. Integration with customers allows a manufacturer to know exactly what the needs of his customers are and to respond quickly to changes to those needs'. Although referring to manufacturing, the concepts are just as important in services.

Existing performance management systems

In this study it was found that there are many proposed measurement systems for supply chains with those based on fuzzy Analytical Hierarchical Process (AHP) probably being the most popular or most often referred to (Chan, 2003; Nooral Haq & Kannan, 2006; Ganga & Carpinetti, 2011), but there is no single measurement system used universally in the container industry. An often-used measurement method is to list the important and measurable attributes and to use a tick-box mechanism to ascertain compliancy or otherwise. Services are difficult to visualise and measure, and the diversity of the services sector makes it difficult to develop a unifying services framework (Ellram, Tate & Billington, 2004), as confirmed by Cho, *et al*. (2012). To obtain objectives or ensure continuous improvement, the performance of the processes must be measured, and a process cannot be managed if its performance cannot be measured (Neely, Adams & Kennerley, 2002).

Based on the current study, a PMS was developed using the analytical hierarchical approach. The AHP was used to develop a model to measure elements of a multi-criteria decision-making supply chain. The AHP, developed by Saaty (1980, 1990: 9), is a commonly used tool for solving multi-criteria decision-making problems. It provides a framework for coping with multiple-criteria situations involving quantitative and qualitative aspects. It first breaks down the complex problem into a hierarchy of different levels of elements, then uses a measurement method to establish priorities among the elements, and lastly synthesises the priorities of elements to establish the final decision. The applicability of the AHP in this instance is best illustrated in the words of Kinra and Kotzab (2008: 289), who said: 'The AHP approach shall result in an illustrative model that assesses the capabilities of individual nations in their ability to sustain top class supply chain management practices, institutions and infrastructure.'

The AHP is a method for formalising decision-making when there are a limited number of choices, but each has a number of attributes and some of these attributes are difficult to formalise. It provides a structured framework for setting priorities on each level of the hierarchy using pairwise comparisons, a process of comparing each pair of decision factors at a given level of the mode for their relative importance with respect to their parent.

The AHP adopts six generic steps to determine the priorities of the attributes:
1) Structure a problem as a hierarchy or as a system with dependence loops.
2) Elicit judgments that reflect ideas, feelings or emotions.
3) Represent these judgments with meaningful numbers.
4) Use those numbers to calculate the priorities of the elements of the hierarchy.
5) Synthesise the results to determine an overall outcome.
6) Analyse the sensitivity to changes in judgment.

This methodology is used to prioritise various elements and can be used to assign weights to each of the key performance indicators (KPIs) that were identified for the container supply chain. Finally, the measurement system was tested in two case studies to confirm the validity of the model and results. The information required to populate the PMS was collected in four ways: questionnaires, interviews, a focus group and research based on the available literature.

DEVELOPMENT PROCESS

Data collection

Two questionnaires were sent to representatives working in the South African container shipping industry and the results were used as input to the development of the PMS model. The first questionnaire requested information on the performance measurement of suppliers, customers and the organisation's own operation. The questionnaire was sent to 133 managers in the South African shipping industry, mainly covering the shipping lines, container terminals, trucking companies and port authority, and 31 were completed. The 31 completed questionnaires covered most of the supply chain partners and were used as a first sample and input to the model. The low number of completed questionnaires was deemed acceptable, as the model allows for adaptation during its development period.

Approximately 50% of the represented organisations actively measure supplier performance. Some of the measurements for suppliers are lead time, dedicated capacity of truckers to a shipping line, minimum notice time for a trucking company, accuracy of invoicing, response time to queries, delays, cost and productivity. All the representatives felt that their suppliers assisted in problem-solving by jointly coming up with solutions, and most felt that their communication with suppliers was good. Some of the internal operations measurements listed by participants included vessel productivity (container terminals); on-time delivery (trucking companies); down time; man hours lost; equipment delays; truck turnaround times; and productivity losses due to delays. The majority of the participants did not measure internal capacity utilisation, especially the utilisation of human resources, although container ports do focus on equipment utilisation rates, and shipping lines measure capacity utilisation of vessels. Most trucking companies stated that they did not measure utilisation specifically, but that they endeavoured to keep their trucks busy and on the road as much as possible. Measurements regarding customer satisfaction included customer feedback (verbal and written); the accuracy of information provided; performance measurement of customer representatives; claims processing; and reduction in claims.

The second questionnaire was sent to 91 role players in the fruit export industry, and 26% of those representatives responded. Internal performance measurements in these companies focus mainly on fruit quality, but this is something that is affected throughout the supply chain. Financial returns, market access and market share are also main focus areas of organisations in the fruit export industry. Six of the logistics companies also measure the accuracy of their volume forecast to that of the shipping lines. Supplier measurements are based on two key measurements: time and temperature. The time for various links in the chain is measured by exporters, for example the scheduling and timing of land transport, dock handling, sea freight and overseas harbour clearing are the critical stages for which time is measured. Temperature discrepancy throughout the chain is an important aspect that needs to be measured in order to manage this inefficiency and eliminate it from the chain. The level of integration between the various organisations in a supply chain needs to be measured so that improvements in this area can be tracked. Currently there is no measurement that specifically measures the level of integration in this industry. All of the industry role players were requested to perform a monthly survey to determine the level of integration of each organisation with its suppliers and customers. The survey rated each of the following integration activities for both the suppliers and the customers on a level from 1 (no integration) to 5 (extensive integration) (Frohlich & Westbrook, 2001: 198):

- access to planning systems
- sharing of production plans
- joint EDI access/networks
- knowledge of the organisation's capacity levels
- weekly/monthly meetings to discuss performance levels.

Key Performance Areas/Key Performance Indicators (KPAs/KPIs)

The KPAs that were identified by the Centre for Supply Chain Management (CSCM) at Stellenbosch University are process efficiency, availability, customer service, economic utility, capacity utilisation and asset productivity (CSCM, 2011). Specific KPIs for the different stakeholders, as well as the respective targets to be achieved, are shown in Table 1.

Table 1: Popular and possible KPIs for the PMS derived by management

Container Terminal KPIs		Shipping Line KPIs		Rail Operator KPIs		Trucking Company KPIs	
KPIs	**Target**	**KPIs**	**Target**	**KPIs**	**Target**	**KPIs**	**Target**
Average vessel turnaround time	40 hours	Idle time	5%	On-time arrival (average minutes delayed)	184 minutes	On-time delivery	2 hours
Truck turnaround time (in gate to out gate)	30 minutes	Level of integration	Level 5	On-time departure (average minutes delayed)	238 minutes	Level of integration	Level 5
Rail turnaround time	2 hours	Customer service index	85%	Level of integration	Level 5	Customer service index	85%
Level of integration	Level 5	Value of claims	0	Rail trucks availability	100%	Idle time	5%
Customer service index	85%	Total vessel slot utilisation	95%	Locomotive availability	85%	Value of claims	0
Value of claims	0			Customer service index	85%		
Percentage of budgeted volumes achieved	100%			Value of claims	0		
Stacking capacity utilisation	65%						

Development of the PMS

The PMS for the container shipping industry was developed in Excel (available from the authors) (see Figure 1). The PMS includes the entire process, from transportation to and from the container terminal via road or rail, to the activities at the container terminal, to the shipping line's portion of the supply chain. The system can be adapted to include more detailed, commodity-specific measurements. Targets and actual figures are captured monthly and the entire year's data can be viewed in graphical form. This approach is crucial to identify emerging trends in the industry. Each supply chain managing party should review the KPIs regularly and make the necessary changes. The weight assigned to each KPI is as per the AHP described earlier.

TESTING THE MODEL

Case study 1: BMW Rosslyn

BMW opened its first foreign plant in Rosslyn, South Africa in 1973 (BMW, 2007). The Rosslyn plant currently produces the BMW 3 Series model, both for the local and export markets. Mediterranean Shipping Company (MSC) has had an agreement with Transnet Port Terminals for the past ten years that states that the BMW containers will be afforded priority status. Normally, once the containers are placed in the stacking area with the rest of the imports, for safety reasons they cannot be extracted until all the discharge work has been completed. In BMW's case, the only stipulation by Transnet Port Terminals is that these containers be stowed together on the vessel so that they can be discharged consecutively. This allows for all the containers to be transported to the train consecutively, which increases resource utilisation of the rail system. The agreement also states that the BMW containers must receive preference and that rail wagons should be readily available at all times to transport the containers upon discharge (Hendricks, personal communication, 2010). This cuts approximately 24 hours from the total 'normal' supply chain process.

Applying the measurement system to BMW Rosslyn

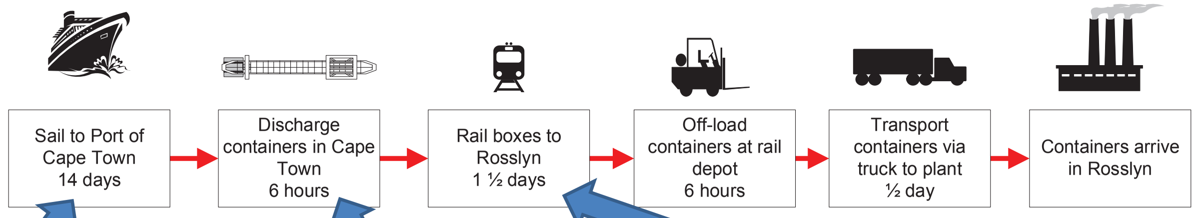
Currently there is no integrated measurement system that focuses specifically on the performance of the BMW corridor, as the various entities involved do not have a tool to benchmark their performance. This PMS will assist the different entities to identify possible problem areas. The organisations should then collaborate to solve specific problems or challenges. Figure 1 shows the BMW PMS. As the dashboard shows, the BMW supply chain was 79% efficient in July 2011. This efficiency level will be tracked on a monthly basis to see whether the performance can be maintained or improved. During the month in Figure 1, the shipping line achieved a performance level of only 60%. This was due to excessive delays along the chain. The idle time accumulated to eight hours during this month, which is more than the allowable five hours' delay. The total vessel slot utilisation was also below target, at 79%. This impacted heavily on the efficiency of the supply chain. The only other KPIs that did not achieve the target during this month were the volume throughput achieved at the container terminal and the rail truck availability at the rail operator. Both these KPIs are only marginally under target and should be investigated to determine their impact. The rest of the KPIs at the container terminal and rail operator exceeded their targets.

PERFORMANCE MEASUREMENT SYSTEM

Monthly Input Sheet

MONTH: July 2011 **Corridor efficiency** 79%

CLIENT: BMW



Shipping Line Measurements	Unit	Goal	Weight	Target	Actual
Idle time	hours	min	60%	5	8
Customer service survey index	%	max	10%	80%	85%
Total vessel slot utilization	%	max	17%	95%	79%
Level of integration	level	max	7%	5	3
Cost of claims	R	min	6%	0	0
Total efficiency			100%	90%	60%

Container Terminal Measurements	Unit	Goal	Weight	Target	Actual
Average vessel turnaround time	hours	min	38%	40	40
Rail turnaround time in port	hours	min	19%	2	4
Customer service survey index	%	max	11%	85%	86%
Throughput per month	TEU's	max	13%	100%	94%
Stacking capacity utilization	%	min	6%	60%	24%
Level of integration	level	max	7%	5	3
Cost of claims	R	min	6%	0	0
Total efficiency			100%	90%	78.8%

Rail Operator Measurements	Unit	Goal	Weight	Target	Actual
% On-time departure	minutes	min	29%	184	180
% On-time arrivals	minutes	min	23%	238	170
Rail trucks availability	%	max	13%	100%	98%
Locomotive availability	%	max	16%	85%	90%
Customer service survey index	%	max	6%	85%	85%
Level of integration	level	max	7%	5	3
Cost of claims	R	min	6%	0	0
Total efficiency			100%	90%	96%

Figure 1: BMW inbound supply chain performance measurement dashboard, developed in Excel

Case study 2: The South African fruit industry

The fruit export industry was chosen as a second case study because of the high volumes of fruit that are exported annually from the CTCT. Fruit exported from South Africa comprises mainly citrus, deciduous and subtropical fruit (South African Agriculture, 2010). Fresh fruit is transported mainly by road due to the uncertainties associated with the SA rail network (Brown, personal communication, 2010). The prevailing congestion on the roads (at least into Cape Town) in turn increases the risk of breaking the cold chain. Reefer containers that are transported for short distances to the ports are sometimes not plugged into a power source. This poses a severe risk as any delays on the road may leave the reefer containers without power for extended periods and the quality of the fruit may be affected.

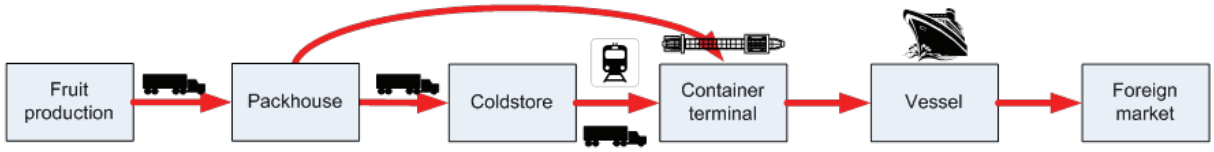
Applying the PMS to the fruit export industry

The fruit export industry currently does not have a PMS in place that covers the entire corridor. Each organisation measures its own internal performance and, in some instances, measures the performance of its direct clients and suppliers. This industry is in need of a system that is transparent, measures the correct aspects of the chain and attracts the participation of all or most of the big role players in the fruit export industry. Each organisation should be required to submit its performance data. The data can be handled confidentially, so that only the party responsible for the management of the PMS will work with the unrefined data. Average figures for the fruit export industry can be made available to all participating organisations instead of only specific organisation-based statistics.

The export of reefer containers has a few additional measurements when compared to other corridors. The continuation of the cold chain is one of the main focus areas where reefer containers are concerned. Temperature deviations should therefore be added as a measurement item in the PMS for this corridor. If there are parties or processes within the supply chain that are responsible for breaking the cold chain and affecting the quality of the export fruit, the PMS will assist in identifying them. The KPI that measures the total value of claims will also cover all damages to reefer containers and the cargo inside the container, while the temperature deviation KPI will ascertain how often the cold chain is broken and where the most temperature anomalies occur. The electronic on-board memory on most reefers stores temperature data so that historical data can be retrieved to determine whether the cold chain was maintained en route. Figure 2 shows the PMS, with problem areas or KPIs that were not reached highlighted in red.

PERFORMANCE MEASUREMENT SYSTEM
Monthly Input Sheet

MONTH:	July 2011	Corridor efficiency	81%
CLIENT:	Fruit Export Industry		



Rail Operator Measurements	Unit	Goal	Weight	Target	Actual
% On-time departure (average minutes delayed)	minutes	min	29%	184	180
% On-time arrivals (average minutes delayed)	minutes	min	20%	238	170
Rail trucks availability	%	max	13%	100%	98%
Locomotive availability	%	max	19%	85%	90%
Customer service index	%	max	6%	85%	85%
Level of integration	level	max	7%	5	3
Cost of claims	R	min	6%	0	0
Total efficiency			100%	90%	98%

Container Terminal Measurements	Unit	Goal	Weight	Target	Actual
Average vessel turnaround time	hours	min	45%	40	40
Rail turnaround time in port	hours	min	16%	2	4
Customer service index	%	max	11%	85%	86%
Throughput per month (% budget achieved)	TEU's	max	13%	100%	94%
Stacking capacity utilization	%	min	6%	60%	24%
Level of integration	level	max	7%	5	3
Cost of claims	R	min	8%	0	0
Total efficiency			107%	90%	87.2%

Trucking Company Measurements	Unit	Goal	Weight	Target	Actual
On-time delivery (average minutes delayed)	minutes	min	53%	120	180
Idle time	%	max	28%	80%	85%
Customer service index	%	max	8%	100%	88%
Level of integration	level	max	6%	5	3
Cost of claims	R	min	5%	0	0
Total efficiency			100%	90%	71%

Shipping Line Measurements	Unit	Goal	Weight	Target	Actual
Idle time	hours	min	61%	5	8
Customer service index	%	max	9%	80%	85%
Total vessel slot utilization	%	max	17%	95%	79%
Level of integration	level	max	7%	5	3
Cost of claims	R	min	6%	0	0
Total efficiency			100%	90%	57.7%

Figure 2: The performance measurement dashboard of the fruit export industry, developed in Excel

Validation of the PMS

The PMS was presented to various managers working at the CTCT, Transnet Freight Rail and Transnet National Port Authority, trucking company owners as well as vessel agents working for different shipping lines. A total of 23 individuals attended the presentations. The BMW example was explained, along with the benefits of implementing such a system. After the presentation the attendees were asked to complete a short survey containing four statements with which they agree or disagree. The average score for each of the statements was close to 4 of a possible 5 (see Table 2). This means that the individuals who completed the survey were of the opinion that the PMS included most of the relevant KPIs, and that the PMS would have a positive impact on their organisation as well as on the industry.

Table 2: Survey results – average score per statement

	Statement	Average score per statement
1	The performance measurement system includes all the KPIs that need to be measured	3.9
2	The performance measurement system will promote integration between organisations	3.7
3	The performance measurement system will positively impact my organisation	4.3
4	The performance measurement system will positively impact the industry	3.6

CONCLUSION

In all studies of supply chains it is crucial that integration and participation be paramount. In order to promote integration, managers need to understand what the challenges are and how to work towards overcoming them. Business processes must be implemented in the various organisations along the supply chain to achieve a common goal. The aim of the PMS is to bring organisations closer together, and for them to work towards a common goal. The main requirement to successfully implement the PMS is commitment and participation by the organisations. The respective supply chain managers should pass on the information to the team driving the PMS to enable the development of an industry standard. It will benefit all the organisations concerned if they have a benchmark to measure their performance. The PMS developed during this study will point managers to where gaps can be identified jointly, and to areas where improvement will have the greatest impact.

This PMS is a dynamic model in the sense that it allows for changes to priorities and weights. The managing body needs to review the system regularly. The KPIs may change as the focus of the supply chain changes, and the weight assigned to each KPI will change as priorities change within the chain. It is up to supply chain managers to judge the importance of each. The research provides practitioners with managerial insights into the following aspects:

- considering and reconsidering the priorities of KPIs in the container shipping supply chain
- identifying opportunities to improve the process
- becoming aware of possibilities of applying the model to other parts of their organisations.

All over the world, organisations are striving towards better supply chain integration. Waller, visiting Professor in International Supply Chain Management at Cranfield School of Management indicates that 'The supply chain lies no longer with the individual company. We have been taught how to compete, but no-one has taught us how to work together' (Emmet & Crocker, 2006). This is where the focus should lie within the next five to ten years: to improve and put the necessary systems in place to sustain improved supply chain collaboration by South African container depots.

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Table of acronyms

AHP	Analytical Hierarchical Process
CSCM	Centre for Supply Chain Management
CTCT	Cape Town Container Terminal
KPA	Key Performance Area
KPI	Key Performance Indicator
LPI	Logistics Performance Index
PMS	Performance Measurement System
SCM	Supply Chain Management