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Analyses of stevedoring productivity in Australia's five major container ports[1]

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Abstract

Bureau of Infrastructure, Transport and Regional Economics (BITRE) has published quarterly statistics on the net crane rate as a measure of container port terminal productivity at Australia's five major container port terminals since the mid 1990s. This paper uses various methods (including regression analysis) to analyse the net crane rate and other measures of productivity. It constructs a new indicator: TEUs exchanged per hour a vessel spends at berth which is a broader measure than the Waterline measures of productivity as it includes in the calculation time when cranes are non-operational. Total time a vessel spends at berth is of interest to shipping companies and other customers of container port terminals. With this broader measure of container port terminal productivity as a reference the paper shows that stevedoring productivity with respect to handling containers has improved significantly between 1996 and 2009 a period which has witnessed total containers handled increase by a factor of 2.8; TEUs handled by a factor of 3.4; ship visits increase by 20 per cent with vessel size increasing in many cases by a factor of 2. Important drivers of this productivity have included: crane intensity—the number of cranes working on a vessel on average; increased vessel size; increased trade volume measured as number of TEUs per vessel visit; and increased share of 40 foot containers in the total number of containers handled.

1. Introduction

Recent literature on Australian container port efficiency has focused on comparisons between container port terminals with the aim of producing a league table ranking of container port terminals. Examples of this literature include Tongzon (2001), Australian Bureau of Industry Economics (1993, 1995), Productivity Commission (1993. 1995) and BITRE (2009). Tongzon (2001) used 1996 port data and applied data envelope analysis to provide an efficiency measurement for four Australian ports (Melbourne, Sydney, Brisbane and Fremantle) and twelve other international ports. Australian Bureau of Industry Economics (1993, 1995) and BITRE (2009) have compared ports using a selection of indicators.

This paper differs from these earlier analyses in that its aim is not the construction of a league table of container port terminals by level of performance, rather the better understanding of what drives performance at an individual container port terminal, over time. The paper introduces a new measure of productivity using vessel level data. While it would have been informative for comparative purposes to construct this measure using estimates of crane rates (containers exchanged per hour per crane) these data are not available for

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individual vessels. Data at the vessel level, on Twenty foot equivalent units (TEUs) exchanged per hour per crane can be computed from available data and these are the estimates used to construct the new measure of productivity based on vessel level information.

TEUs exchanged are used as the measure of work performed. The containers exchanged at a port terminal are of varying length (for example, 20-foot, 40-foot, 45-foot, 48-foot and 53-foot). The use of TEUs standardizes the measure of work performed across the five ports each of which has a different mix of containers by container length.

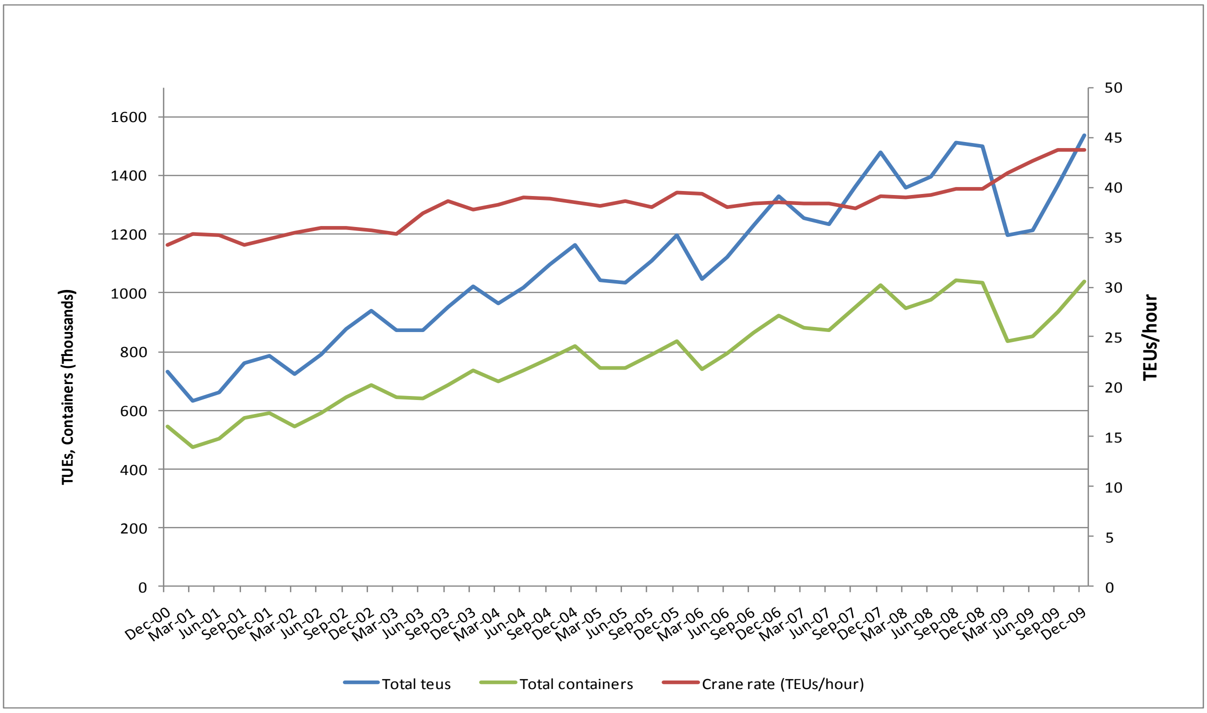
Crane rate (TEUs exchanged per hour per crane) measures the productivity of capital at a port terminal. This is the total TEUs handled divided by the elapsed crane time where elapsed crane time is defined as the total allocated crane hours, less operational and non-operational delays. The crane rate gives the total number of TEUs lifted onto and off ships per hour per crane. Total productivity is determined by a number of factors including the crane rate, the crane intensity (that is, the number of cranes on average working a ship) and the mix of containers handled at a port terminal.

Figure 1 plots the crane rate (average over five Australian container ports), TEU and container throughput at the five major Australian container ports between December quarter 2000 and December quarter 2009. An important motivation for this paper is to explain the factors that have contributed to changes in productivity at the five ports over the last 50 or so quarters.

While Figure 1 and elsewhere in the paper use is made of 'Five ports'-- the aggregation of data over the five individual ports the core analysis is undertaken at the level of either a vessel or an individual port. Aggregating over five ports obscures much of the variation in the data at the lower levels.

Figure 1: Five ports: Total TEUs and containers handled and crane rate (TEUs per hour),

December quarter 2000 to December quarter 2009



Source: BITRE Waterline series, various years

2. Analysis of Waterline measures of productivity

BITRE's Waterline journal publishes three main measures of stevedoring productivity. This section describes these measures and undertakes a more detailed analysis of two of them.

Vessel working rate (TEUs handled per hour of elapsed labour time) — is a single factor (labour) measure of stevedoring productivity at the wharf. It is estimated as the total TEUs handled divided by the elapsed labour time in hours. For a given worker, the elapsed labour time is estimated as the difference between the time when a worker first boards the ship and the time when he/ she last leaves the ship, less the time when a worker has not worked.

Crane rate (TEUs handled per hour of elapsed crane time) — is a single factor (capital) measure of stevedoring productivity at the wharf. It is estimated as the total TEUs handled divided by the elapsed crane time in hours. Elapsed crane time is defined as the total allocated crane hours, less operational and non-operational delays (see BITRE, 2010 for details).

The two partial measures of productivity of labour and capital are commonly used to measure single factor productivity at container port terminals. Examples of their use in the literature include Sanchez et al 2002), Pacific Maritime Association (1999) and Committee on productivity of marine port terminals (1986).

Ship rate (TEUs loaded on or unloaded off a ship per hour)— is computed as the product of the crane rate and an estimate of the number of cranes working on a vessel (the so-called crane intensity) is not a stand-alone measure of productivity since it is derived from the net crane rate. It measures how fast containers are being loaded onto and off loaded from a vessel. This measures the combined stevedoring productivity of capital and labour. The ship rate has risen over the sample period due to a steady increase of the number of cranes working a ship at a container terminal.

Hanh Dam Le-Griffin and Murphy (2006) argued that the following seven factors affect productivity at a container port terminal. Three of the seven factors are under the control of a stevedoring company. The first of these is capital resources invested—approximated by crane intensity. It is expected that as capital resources invested increase, stevedoring productivity increases and thus this factor is likely to be associated with a positive coefficient in the estimation equation (1) below. Another important factor is labour input—measured as elapsed labour time. It is expected that as labour productivity improves less labour time is required for a given task which in turn suggests that this factor is likely to be associated with a negative coefficient in the estimation equation (1). Terminal configuration and lay-out affects productivity at a port terminal. While there is no data on this variable it is likely not to change by much over time and in the analysis below it is considered that these factors are captured in the constant term.

Four factors are beyond the control of a stevedoring company. The first of these is trade volume—measured as TEU throughput per vessel visiting a container port terminal. It is expected that increased trade volume is likely to lead to improved productivity. Trade mix—approximated by the per cent of containers handled that are 40 foot containers is likely to be associated with a positive coefficient in the estimation equation (1). Increased average size of vessel—the average gross registered tonnage for vessels visiting a container port terminal is expected to lead to improved productivity. Lastly the ratio of import to export containers is relevant because it determines the number of empty containers at a port terminal, but it is not included in equation (1) at this stage due to lack of data.

A linear regression equation (1) is estimated and used to assess the relationship between these factors and two performance measures: the crane rate and the vessel working rate.

For each container port terminal the following relationships are estimated:

$\ln(y_i)$ = Constant

$+a_{1i}$*ln (crane intensity)

$+ a_{2i}$*ln (elapsed labour time)

$+ a_{3i}$*ln (gross registered tonnage per vessel visiting a port)

$+ a_{4i}$*ln (per cent of containers that are 40 foot containers)

$+a_{5i}$ ln (TEUs per ship visit) + e_i ------------ (equation 1)

where y_i is a stevedoring performance measure; i = (the crane rate, the vessel working rate) and e is an error term. Ordinary least squares estimates of the regression coefficients in equation (1) are summarised in Table 1 and Table 2.

<u>The intercept</u>

The intercept in each of the port-specific equations is a proxy for factors like terminal configurations which the port has control over but which do not change by much over time. The estimated intercept differs between ports reflecting the known differences between ports due to topography and geography.

In the crane rate equation the intercept is significant for Fremantle, Melbourne and Sydney. In the vessel working rate equation the intercept is significant in all equations. The largest value is for Sydney at 6.15 in the crane rates equation and 5.39 in the vessel working rate equation. The smallest significant estimate is for Adelaide ranging in value from 0.68 in the crane rates equation to 1.9 in the vessel working rate equation

Table 1: Relationship between the net crane rate and selected drivers of stevedoring productivity, by container port terminal

Dependent variable		Crane rate equation				
Port		Brisbane	Sydney	Melbourne	Adelaide	Fremantle
Intercept	Estimate	ns	6.15	2.40	ns	3.34
	SE		1.12	0.64		0.69
	P-value	0.46	0.00	0.00		0.00
Crane Intensity	Estimate					
	SE					
	P-value					
	VIF					
Elapsed Labor Time	Estimate	-0.33	-0.46	-0.28	Ns	-0.23
	SE	0.12	0.05	0.04		0.09
	P-value	0.01	0.00	0.00		0.01
	VIF	4.76	1.20	1.02		1.24
Average Vessel GRT	Estimate	0.73	ns	0.19	0.12	0.19
	SE	0.15		0.04	0.06	0.05
	P-value	0.00		0.00	0.07	0.00
	VIF	5.21		5.33	3.92	4.18
40ft Container Proportion	Estimate	0.67	0.83	0.25	Ns	0.34
	SE	0.22	0.14	0.08		0.10
	P-value	0.00	0.00	0.00		0.00
	VIF	20.42	11.09	12.12		10.19
Average TEU Exchanged	Estimate	ns	ns	0.23	0.21	ns
	SE			0.06	0.08	
	P-value			0.00	0.01	
	VIF			17.39	8.04	
DW Statistic	Estimate	0.5934	0.8603	1.5614	0.23	0.9024
	P-value	0.0000	0.0000	0.0184	0	0.0000

Notes:

1. 'ns = not statistically significant. SE are standard errors for estimates.
2. A blank indicates the variable was not included in the estimated equation. SE stands for standard errors for estimates.
3. DW: The Durbin-Watson statistic is a measure of autocorrelation in the residuals from the model fit. Values significantly less than 2 are evidence that the residuals are positively autocorrelated; that is. there is time-dependence in the response variable which is not captured by the explanatory variables in the model.
4. VIF: The Variance Inflation Factor is a measure of multicolinearity in the explanatory variables. It is the factor by which the variance of the parameter estimate for a variable is inflated due to its correlation with the other explanatory variables. Values greater than 5 are typically taken as evidence of multicolinearity.

Source: BITRE estimates based on data from Port Authorities and stevedoring companies

Table 2: Relationship between the vessel working rate and selected drivers of stevedoring productivity, by container port terminal

Dependent variable		Vessel working rate equation				
Port		Brisbane	Sydney	Melbourne	Adelaide	Fremantle
Intercept	Estimate	3.13	5.39	4.70	1.86	4.51
	SE	1.35	0.96	1.00	0.53	0.70
	P-value	0.02	9.02E-07	0.0	0.001	4.64E-08
Crane Intensity	Estimate	0.70	0.43	0.70	0.54	‘ns
	SE	0.18	0.16	0.20	0.16	
	P-value	0.00	0.01	0.00	0.00	
	VIF	5.34	3.44	15.10	1.72	
Elapsed Labor Time	Estimate	-0.27	-0.38	-0.20	ns	-0.43
	SE	0.1	0.05	0.07		0.11
	P-value	0.0	0.00	0.00	0.15	0.00
	VIF	4.8	1.28	1.32	5.42	1.90
Average Vessel GRT	Estimate	‘ns	‘ns	0.29	‘ns	‘ns
	SE			0.06		
	P-value			0.00		
	VIF			5.45		
40ft Container Proportion	Estimate	0.27	0.94	0.90	‘ns	0.30
	SE	0.14	0.12	0.13		0.10
	P-value	0.06	0.00	0.00		0.00
	VIF	20.87	11.65	16.10		10.40
Average TEU Exchanged	Estimate	‘ns	0.20	-0.24	0.25	0.30
	SE		0.08	0.10	0.08	0.10
	P-value		0.01	0.03	0.00	0.00
	VIF		9.60	19.30	11.19	38.70
DW Statistic	Estimate	1.0268	1.1099	1.5610	0.5283	1.2
	P-value	0.0000	0.0000	0.0146	0.0000	0.0

Notes:

1. ‘ns = not statistically significant. SE are standard errors for estimates.
2. A blank indicates the variable was not included in the estimated equation. SE stands for standard errors for estimates.
3. DW: The Durbin-Watson statistic is a measure of autocorrelation in the residuals from the model fit. Values significantly less than 2 are evidence that the residuals are positively autocorrelated; that is. there is time-dependence in the response variable which is not captured by the explanatory variables in the model.
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Source: BITRE estimates based on data from Port Authorities and stevedoring companies

<u>The crane intensity</u>

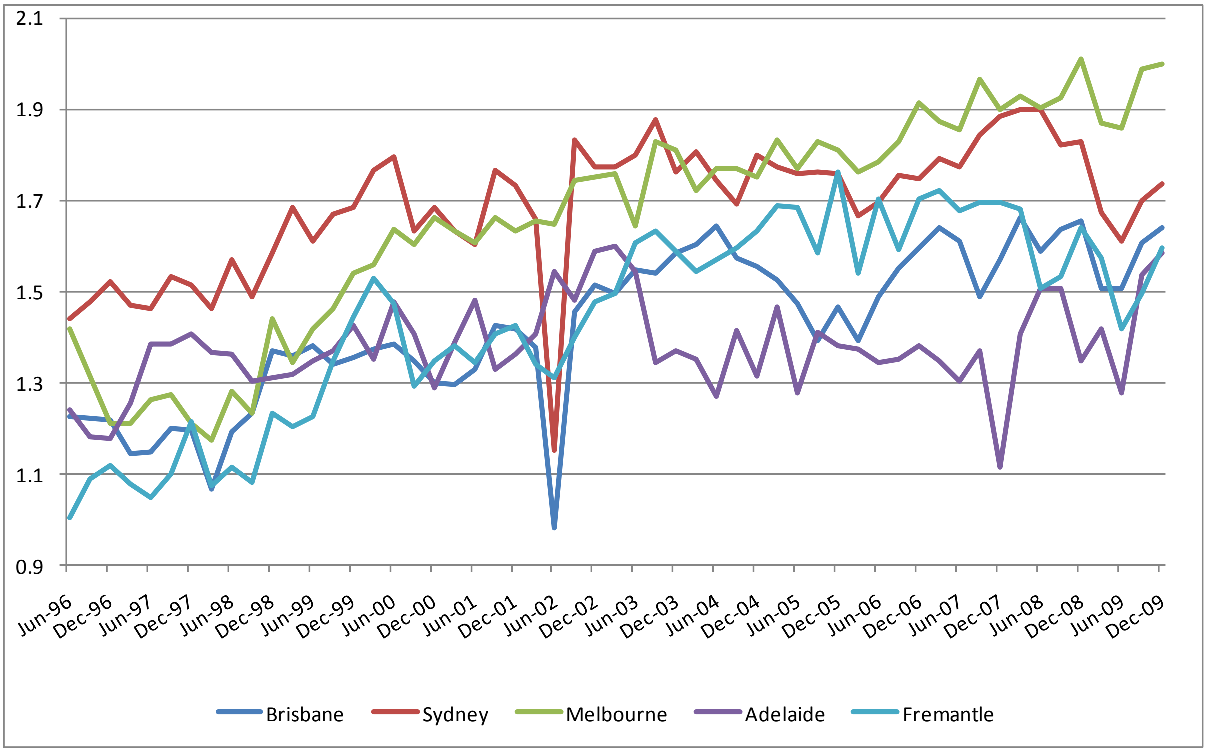
The crane intensity is computed in Waterline by dividing the total number of allocated crane hours by the elapsed time from labour first boarding the ship to the labour last leaving the ship. This provides an estimate of the number of cranes that did work a ship in a particular quarter. The variable is excluded from the 'net crane rate' equations.

Figure 2 show the crane intensity for all port terminals increasing from just over one in 1996 to close to 2 in 2009. The coefficient for this factor is expected to be positive. The coefficient for crane intensity is

- 0.7 for Brisbane and Melbourne;
- 0.54 in Adelaide;
- 0.43 for Sydney; and
- Statistically insignificant for Fremantle.

These estimates suggest that a 1 per cent change in crane intensity is likely lead to less than 1 per cent change in stevedoring productivity. These estimates probably underestimate the contribution of cranes to stevedoring productivity because they do not adjust for quality change in crane technology over time. For example the introduction of a post panama crane which is more productive than a 1960s technology crane may lead to the reduction in the number of cranes working a ship.

Figure 2 – Crane intensity (average number of cranes working a vessel) at container port terminals: Brisbane, Sydney, Melbourne, Adelaide and Fremantle: June quarter 1996 to December quarter 2009



Source: Figures are constructed by BITRE from data supplied by port authorities.

Elapsed labour time

The general result is that an increase in elapsed labour time, other things constant, leads to a reduction in stevedoring productivity. In the 10 equations estimated the coefficient is negative, as expected. From Table 1 and 2 the largest coefficient for elapsed labour time is for Sydney ranging from -0.37 (vessel working rate equation) to -0.46 (crane rate equation) followed by Brisbane -0.3 (in both the vessel working rate and crane rate equations). The variable is not significant for both equations for Adelaide.

Gross registered tonnage per vessel visiting a container port terminal

Figure 3a to 3e show for each of the container ports the dramatic shift in the mix of vessels from predominantly small size vessels (less than 25, 000 GRT) in January to June 1996 to predominantly large vessels (greater than 35 000 GRT) July to December 2009..

Brisbane—From Table 3 the period January to June 1996 to July to December 2009 has been one of strong growth for Brisbane's container port as shown in the growth of the task handled at the port. The number of container vessels visiting the port grew by a factor of 1.5. In1996, the majority of ships visiting Brisbane were between 6 500 and 25 000 GRT. By 2009 larger ships, those between 30 000 and 40 000 GRT dominate (Figure 3a).

Sydney—is Australia's second largest container port. From Table 3 the period January to June 1996 to July to December 2009 the number of container vessels visiting the port grew by a factor of 1.3. In the period January to June 1996, the majority of ships visiting Sydney were below 25 000 GRT (Figure 3b). In the period July to December 2009 the majority of vessels visiting the port were over 25 000 GRT.

Melbourne: During the period January to June 1996 to July to December 2009, Melbourne, Australia's largest container port, had the number of container vessels visiting the port grow by a factor of 1.1. In January to June 1996, the majority of ships visiting Sydney were below 25 000 GRT with the smallest ship visiting having less than 4 000 GRT. In the period July to December 2009 the vessels of tonnage lower than 25 000 GRT represented only a small percentage of ships visiting the port (Figure 3c). These small vessels serviced short range freight or provided feeder services.

Adelaide: In the period January to June 1996 to July to December 2009 the Port of Adelaide which is the smallest container port of the five ports witnessed the number of container vessels visiting the port grow by 10 per cent. In January to June 1996, there were only 41 ships in the UCC category visiting Flinders Ports, many of them in the 17 000 GRT category. In July to December 2009 only seven vessels in the GRT less than 25 000 category visited the port. The majority of ships visiting the port was around 40 000 GRT, with one very large ship of 66 280 GRT (Figure 3d).

Fremantle: Between January to June 1996 July to December 2009 the Port of Fremantle witnessed the number of container vessels visiting the port decrease by 10 per cent. In the period January to June of 1996, of the 296 ships visiting Fremantle 96 were dedicated container ships (UCCs) in the rather narrow range of 15 000 to 20 000 GRT. By July to December of 2009, the majority of ships visiting Fremantle were between 30 000 and 53 000 GRT (Figure 3e).

From Table 1 and Table 2 an increase in the average size of vessels visiting a container port terminal is associated with increased productivity. Vessel size is estimated to have the biggest impact at the Port of Brisbane where a 1 per cent change in vessel size is estimated to lead to up to a 0.7 per cent improvement in stevedoring productivity. Vessel size is also estimated to be important for the Port of Melbourne and Fremantle where it has a coefficient of 0.19 (crane rate equation)—about a quarter of the size of the coefficient for Brisbane.

Vessel size is insignificant for Sydney and Adelaide in the crane rate equation and in the vessel working rate equation it is insignificant for all five container ports.

Figure 3a– Container vessel calling at port by size, Brisbane

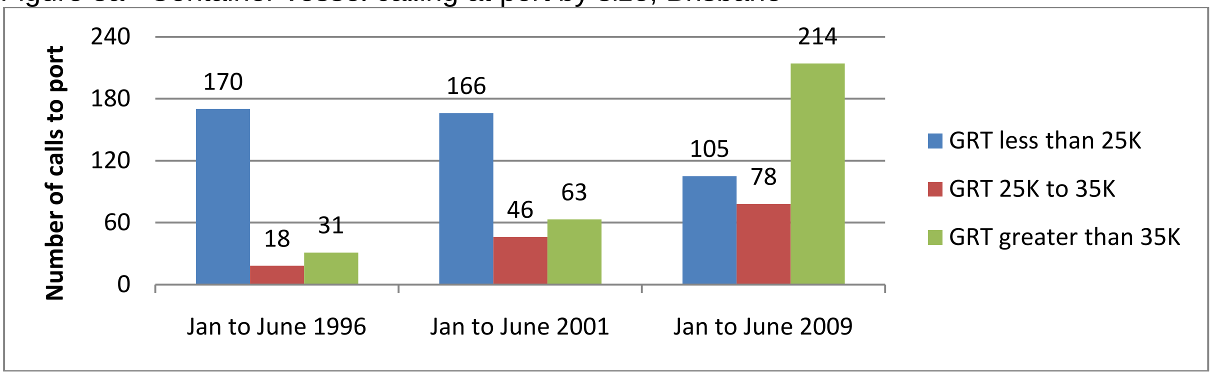


Figure 3b – Container vessel calling at port by size, Sydney

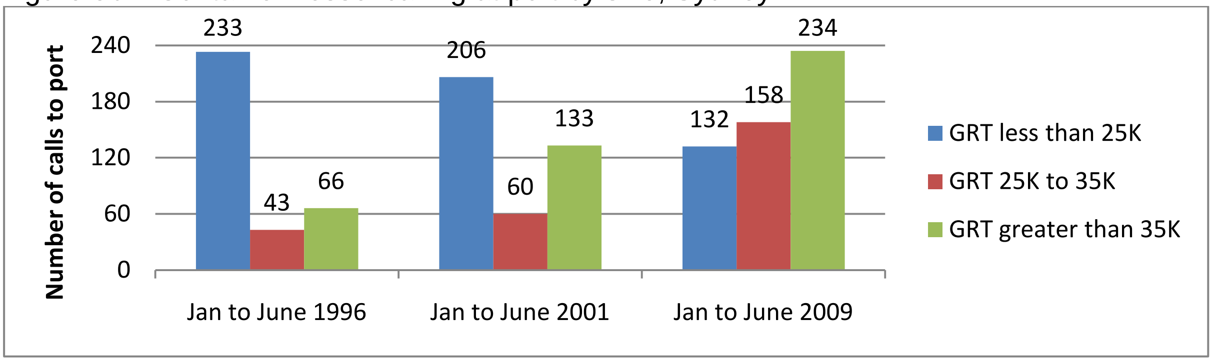


Figure 3c – Container vessel calling at port by size, Melbourne

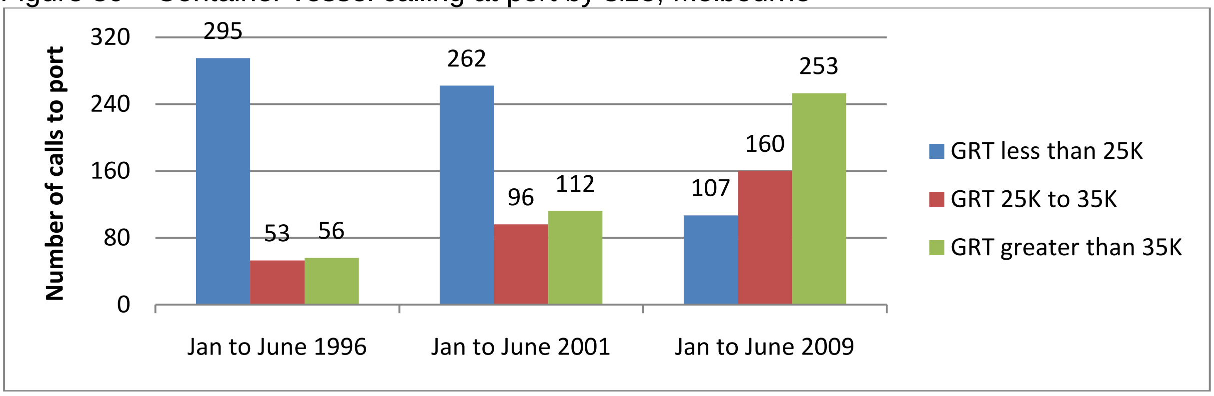


Figure 3d – Container vessel calling at port by size, Adelaide

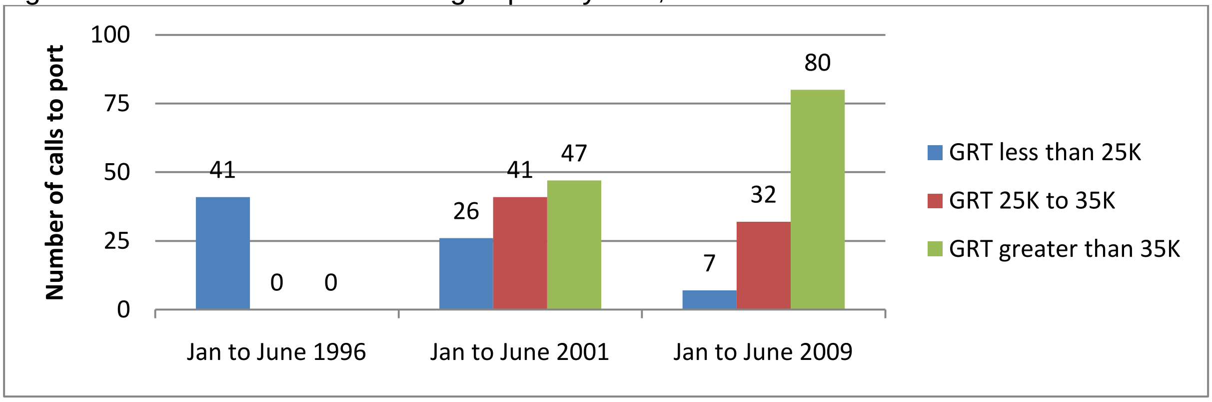
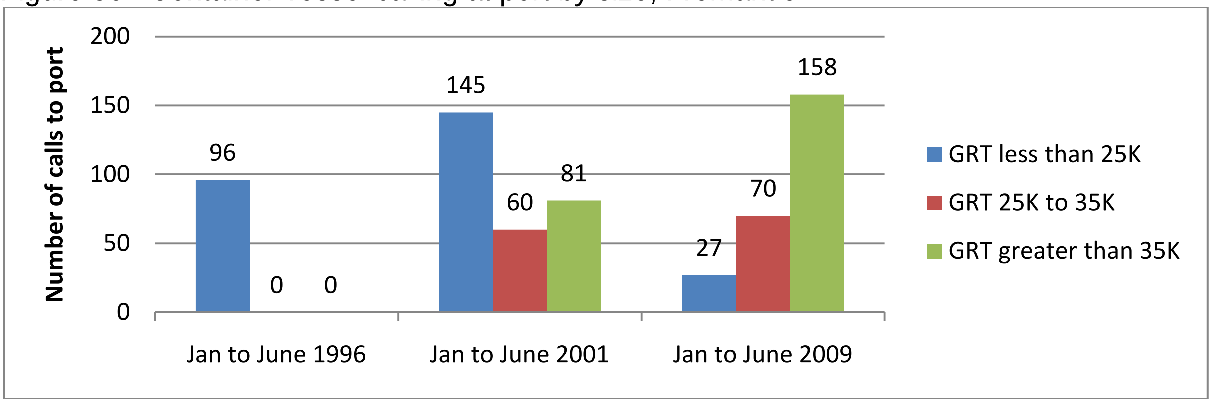


Figure 3e– Container vessel calling at port by size, Fremantle



Source: Figures are constructed by BITRE from data supplied by port authorities

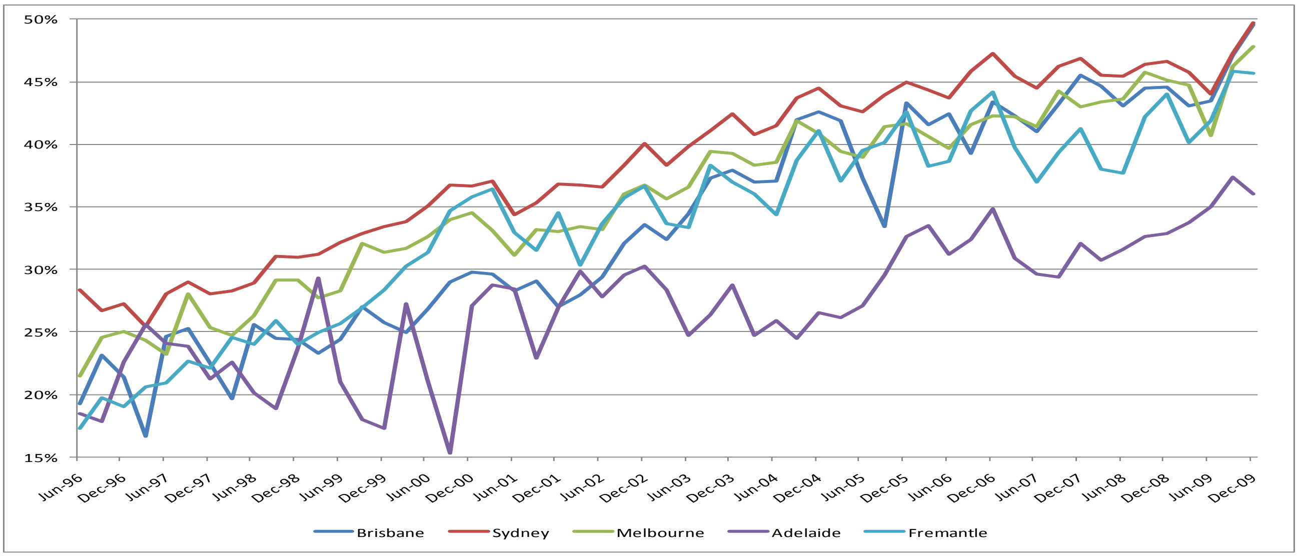
<u>Trade mix: the percentage of containers that are 40 foot containers</u>

Figure 4 shows that between January to June 1996 and July to December 2009 there has been a gradual increase in the percentages of containers that are 40 foot containers:

- For Brisbane from 19.2 % to 49.5 %
- For Sydney from 28.3 % to 49.7 %
- For Melbourne from 21.4 to 47.8 %
- For Adelaide from 14.4 % to 35.9; and
- For Fremantle from 17.2 % to 45.6

From Table 1 and Table 2 it is estimated that a 1.0 per cent increase in the percentage of containers that are 40-footers leads to the largest productivity improvement of up to 0.93 per cent in Sydney Ports. Melbourne is next with estimated productivity improvement of up to 0.90 per cent followed by Brisbane with an estimated 0.67 per cent increase in productivity. The coefficient for this factor is smaller for the smaller ports--about a 0.3 per cent increase in productivity in Fremantle; and insignificant in Adelaide.

Figure 4: 40 foot containers as a percentage of containers handled at container port terminals: Brisbane, Sydney, Melbourne, Adelaide and Fremantle: June quarter 1996 to December quarter 2009



Source: Figures are constructed by BITRE from data supplied by port authorities

<u>Trade volume: TEUs per ship visit</u>

Figure 5a to 5e show the rapid increase in the median TEUs exchanged per vessel from 1996 to 2009. It is estimated that a 1.0 per cent increase in trade volume per ship visiting a container port terminal on average led to the largest impact in Fremantle (0.3 per cent) followed by Port of Adelaide (0.24 per cent) and Sydney (0.19 per cent). This variable is not significant for Brisbane, Fremantle and Sydney in the crane rate equation.

Figure 5a – Median TEU exchanged per vessel, Brisbane

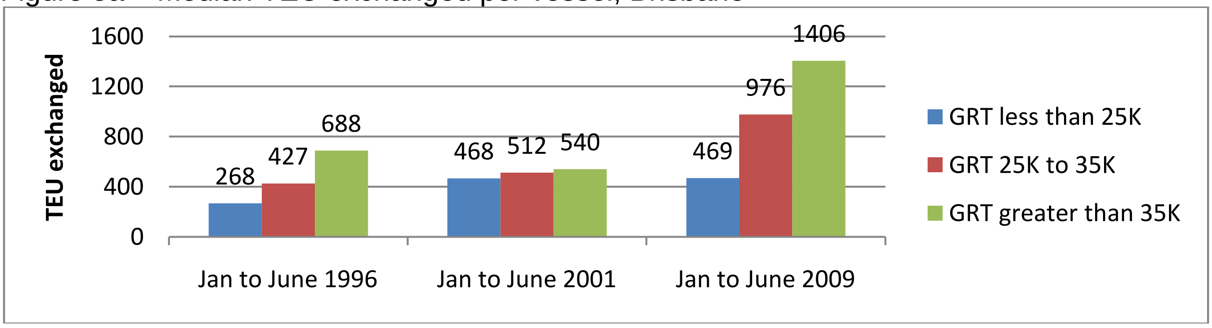


Figure 5b – Median TEU exchanged per vessel, Sydney

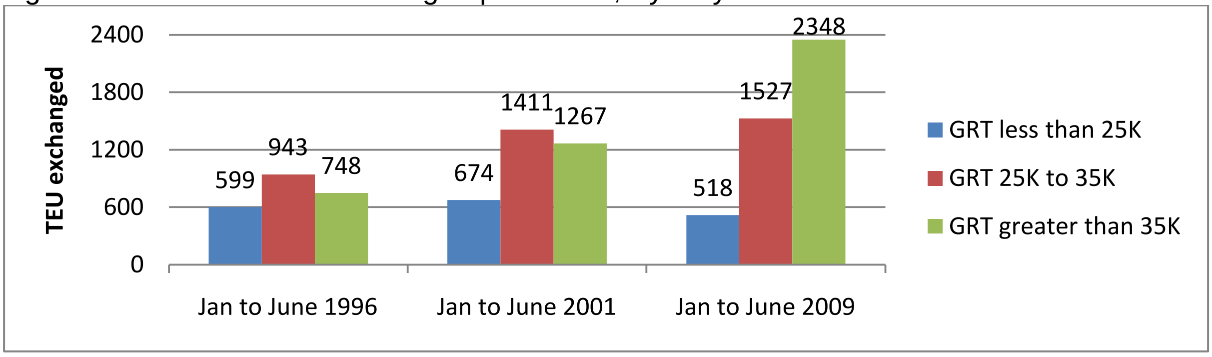


Figure 5c – Median TEU exchanged per vessel, Melbourne

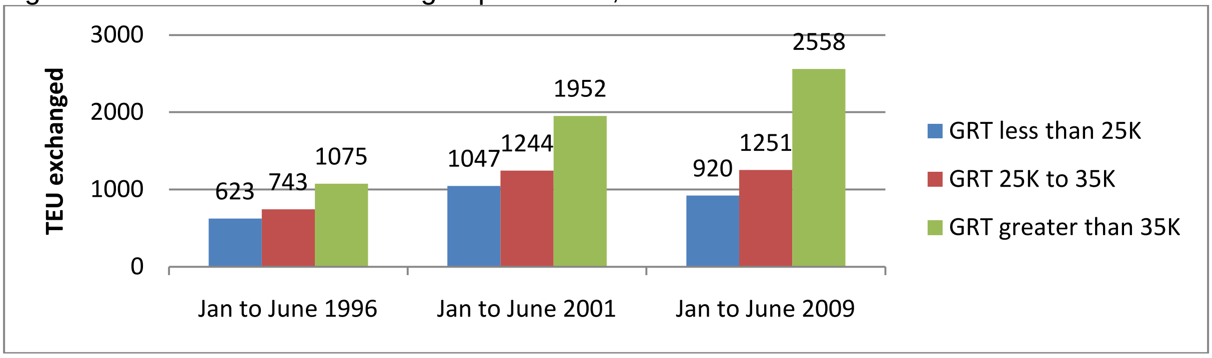


Figure 5d – Median TEU exchanged per vessel, Adelaide

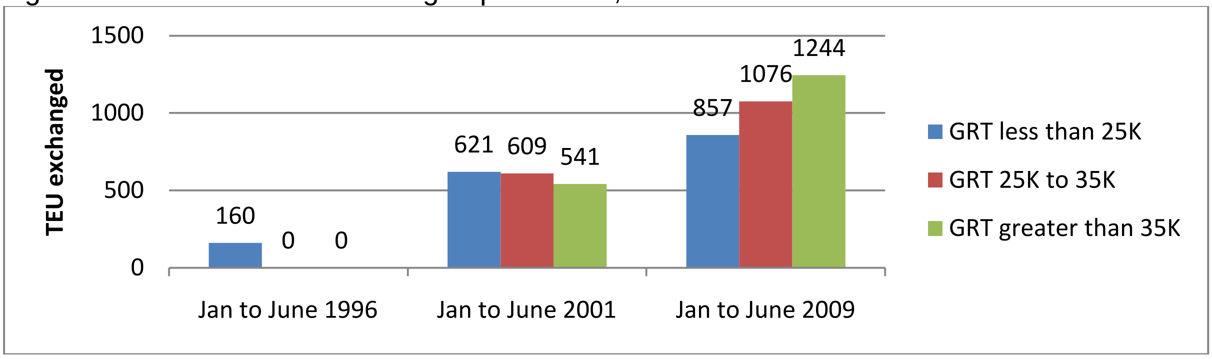
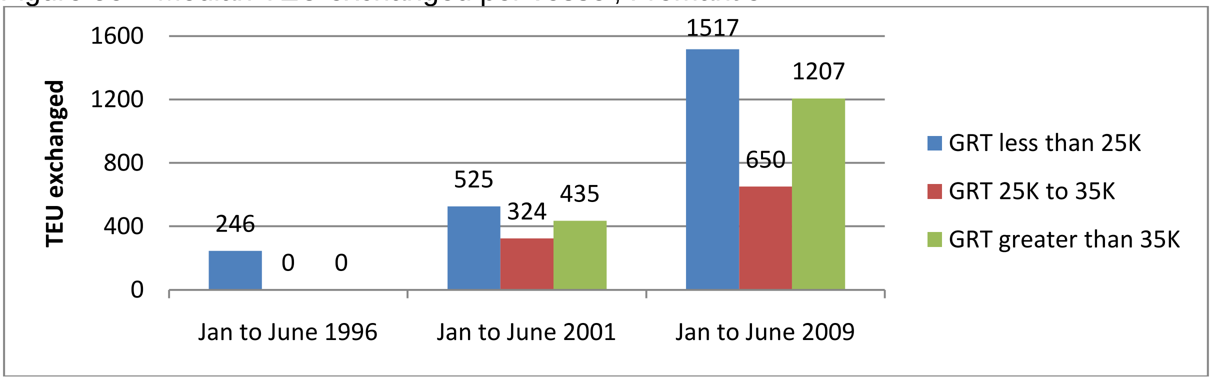


Figure 5e – Median TEU exchanged per vessel, Fremantle



Source: Figures are constructed by BITRE from data supplied by port authorities

Further research

Two lines of interest could be pursued in the future. One extension could address a criticism of using a constant elasticity formulation as we have done in equation (1) which is that it implicitly assumes that responsiveness is constant from any base point. However, the different characteristics of the ports and ship profile are likely to influence productivity. In the future we propose to test alternative functional forms (perhaps using a Box-Cox transformation function) and let the data determine the appropriate functional form (using the log-likelihood ratio to select the best fit functional form). Another line of investigation would involve pooling port data to determine what factors have significant differential impacts by port.

3. A new broad measure of container port terminal productivity

This section introduces a new measure of container port productivity.

The number of TEUs per hour a vessel spends at berth — is a measure of container port terminal productivity which is broader encompassing more than stevedoring tasks. Ships spend time at specialised container handling berths performing simultaneously various necessary operations in addition to loading and unloading containers. These other tasks include waiting for stevedores to commence or finish their work, taking bunker, food and water supplies, undertaking maintenance work, waiting for delivery of services by various port agents. If these services are not delivered at the time when container handling is completed, the ship has to stay longer at the berth. Unfortunately information about the how a vessel uses each hour of time spent by container ships at berth is not readily available.

The number of TEUs per hour a vessel spends at berth is given by "number of TEUs exchanged by a container ship" divided by the total time spent at berth by a vessel.

This measure is likely to be less than the net crane rate (the number of TEUs per hour of elapsed crane time) for those vessels whose visits at a port involve more tasks than the straightforward loading and unloading of containers. Furthermore, the more focused (on loading and unloading of containers) a vessel visit is, the closer this measure is to the ship rate.

For each container port terminal, three 6 months time periods are covered: January-June 1996, January-June 2001 and July-December 2009. For each vessel visiting a port in a six months period, data on TEUs exchanged and the time spent at berth are used to estimate the number of TEUs exchanged per hour a vessel spends at berth. The vessels are sorted in ascending order of 'TEUs per hour at berth. Thus vessels close to zero on the x-axis have low values for 'TEUs per hour at berth' because they spend a longer time than necessary for loading/unloading at berth. Similarly the vessels at the maximum end of the x-axis have high values of TEUs per hour at berth.

Cumulative distributions

For each port terminal we construct a cumulative distribution of the vessels handled and their corresponding estimate 'TEUs per hour at berth'. The percentage of vessels is plotted on the x-axis and the 'TEUs per hour at berth' on the y-axis. The cumulative distributions are presented in Figures 6a to 6e. In each one of the ports there is an upward shift in the cumulative distribution curves over time. Upward shifts in the cumulative distribution curve for 'TEUs per hour a vessel spends at berth' represents productivity improvements.

Comparing the estimate of the number of TEUs per hour spent at berth with the crane rate provides insights in changes in productivity at a container port terminal. Such a comparison yields estimates of the 'Per cent of TEUs handled below crane rate'. This comparison is provided in the shaded column in Table 3.

Figures 6a to 6e and Table 3 show that the percentage of vessels for which the TEUs per hour a vessel spends at berth is less or equal to the crane rate drops in each of the five container port terminals as follows:

- For Brisbane from about 60 per cent in January to June 1996 to about 22 per cent in July to December 2009:
- For Sydney from about 56 per cent in January to June 1996 to about 31 per cent in July to December 2009:
- For Melbourne from about 46 per cent in January to June 1996 to about 11 percent in July to December 2009:
- For Adelaide from about 80 per cent in January to June 1996 to less than 40 per cent in July to December 2009:
- For Fremantle from about 70 per cent in January to June 1996 to just over 30 per cent in July to December 2009:

These changes are broad indicators of improved productivity at container port terminals. Figure 7 shows the median counts of TEUs handled per hour at berth for three snapshots at each of the five container port terminals. The rest of the section summarises the key impressions from the distributions for each of the five major container port terminals.

Figure 6a – Cumulative distribution of TEU exchanged per vessel hour at berth, Brisbane

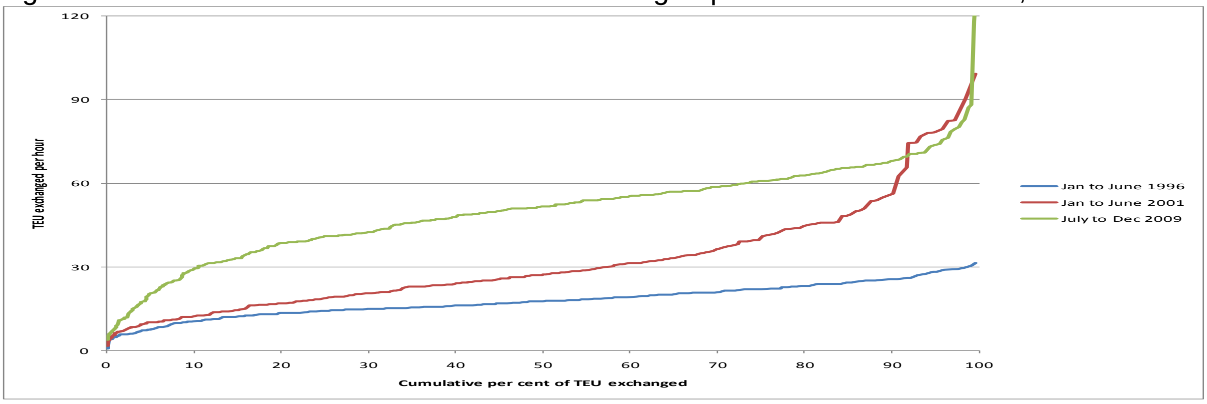


Figure 6b – Cumulative distribution of TEU exchanged per vessel hour at berth, Sydney

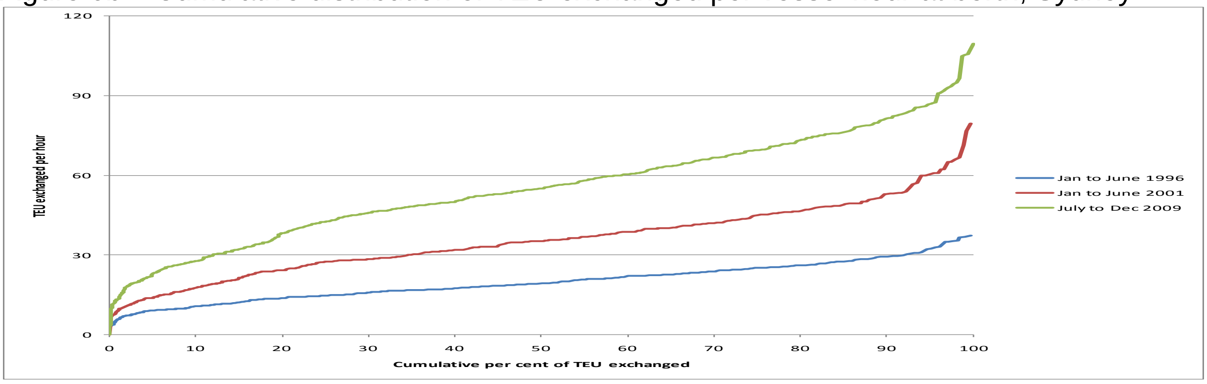


Figure 6c – Cumulative distribution of TEU exchanged per vessel hour at berth, Melbourne

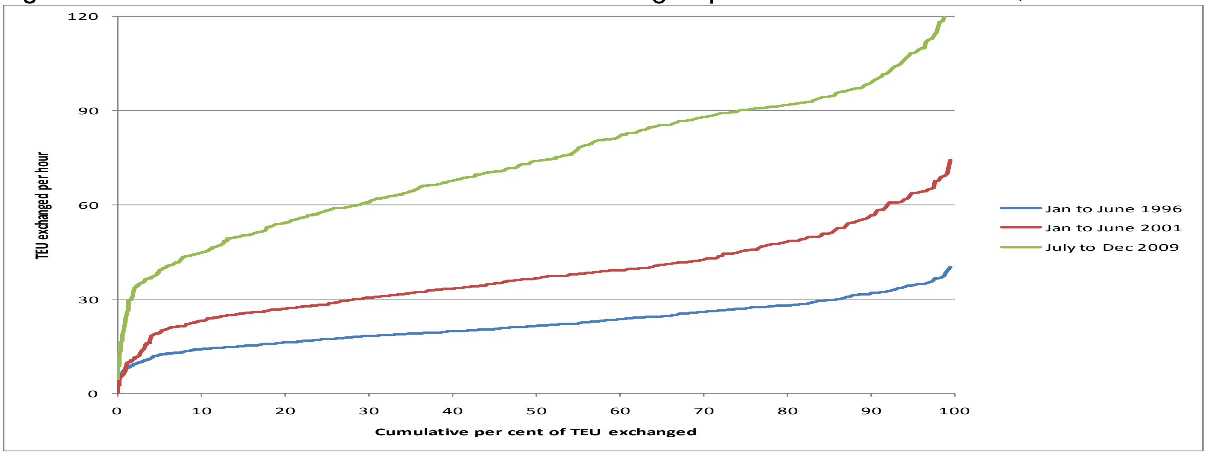


Figure 6d – Cumulative distribution of TEU exchanged per vessel hour at berth, Adelaide

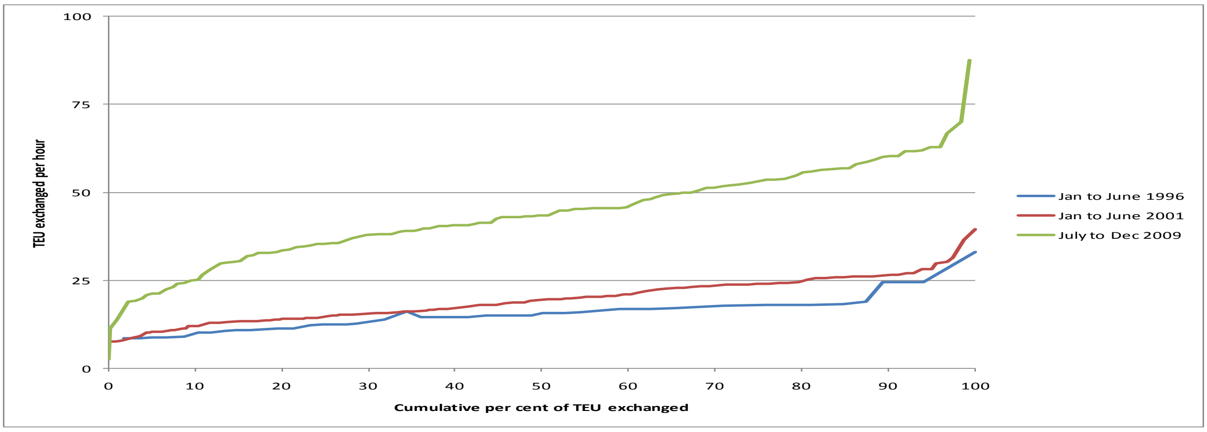
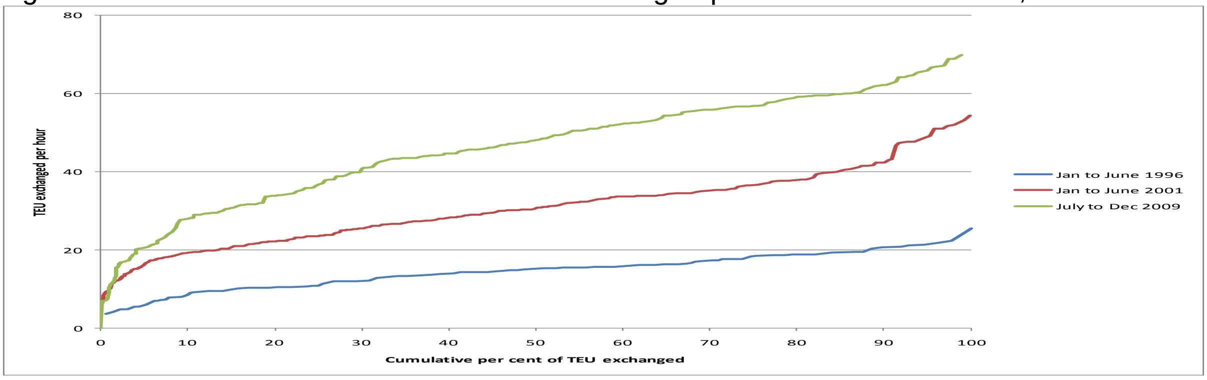


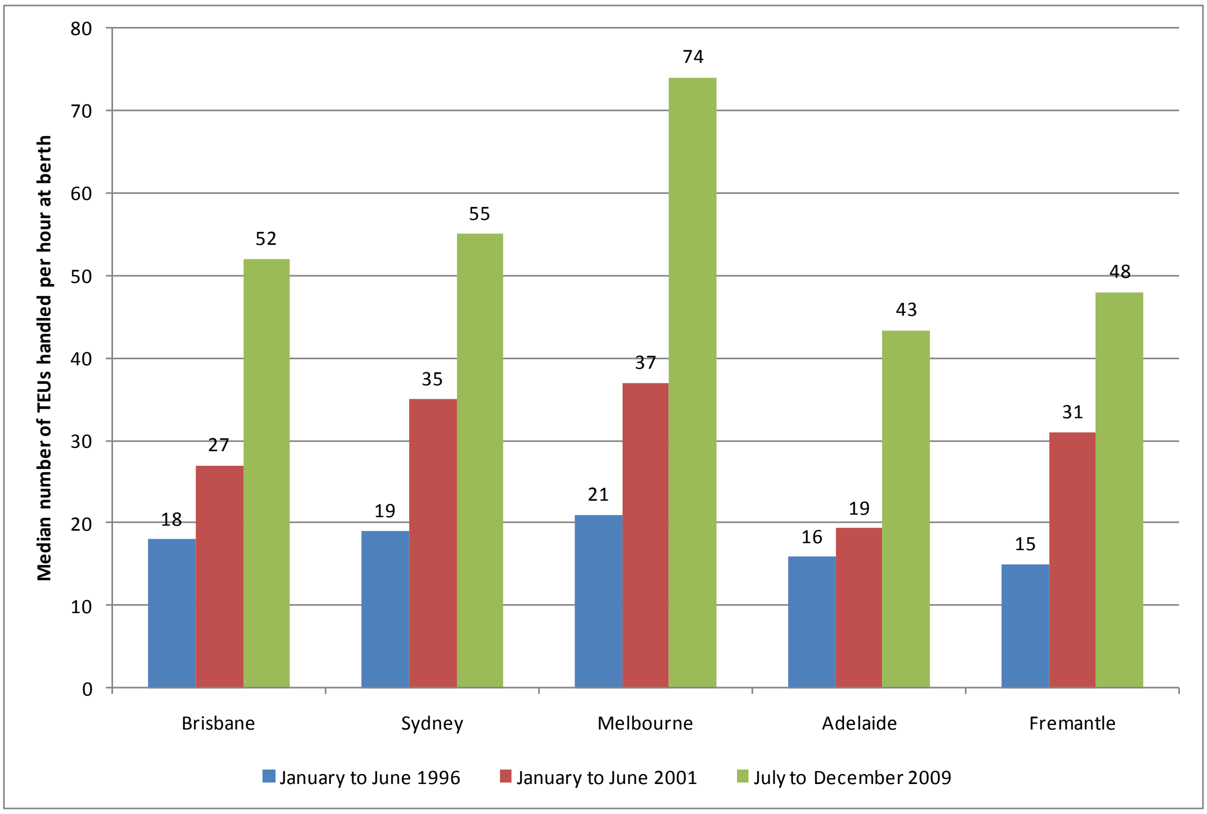
Figure 6e – Cumulative distribution of TEU exchanged per vessel hour at berth, Fremantle



Source: Figures are constructed by BITRE from data supplied by port authorities

Brisbane: Table 3 shows that from January to June 1996 to July to December 2009 total containers handled at the terminal grew by a factor of 4.2; Total TEUs handled at the terminal grew by a factor of 5.3; all the productivity indicators at the container port terminal improving by a factor of at least 2 during this period. From Table 3 and Figure 6a in the period January to June of 1996, the reported crane rate was nearing 20 TEUs per hour and about 60 per cent of all TEUs were handled below the crane rate. The Waterline crane rate for the port in 2009 was 40.4 TEUs per hour and about 22 per cent of TEUs handled during that period was below the crane rate.

Figure 7: Median counts of TEUs handled per hour at berth at Brisbane, Sydney, Melbourne, Adelaide and Fremantle: Jan to June 1996 Jan to June 2001 and July to December 2009



Source: Constructed by BITRE from data supplied by port authorities

Table 3: The changing size of the task and performance at Australia's container port terminals January-June 1996, January-June 2001 and July-December 2009

Size of task at container port terminals				Performance measures at container port terminals				
	All ships handled at the port	Total containers	Total TEUs	Per cent of TEUs handled at rates below the crane rate	Crane rate	Vessel working rate	Ship rate	Median number of TEUs handled per hour at berth
FIVE PORTS								
(A) Jul-Dec09	1 872	1 971 076	2 899 743	ne	43.7	61.8	77.3	ne
(B)Jan-Jun 01	1 600	974 834	1 295 329	ne	35.3	38.2	53.8	ne
(C)Jan-Jun 96	1 575	697 531	851 636	ne	20.8	23	27.7	ne
(A)/(C)								
	1.2	2.8	3.4		2.1	2.7	2.8	
BRISBANE								
(A) Jul-Dec09	390	321 370	476 825	23.9	40.4	50.4	64.8	52
(B)Jan-Jun 01	355	148 031	190 674	68.4	35.3	29.9	46.3	27
(C)Jan-Jun 96	257	77 063	90 045	61.3	19.9	21	24.4	18
((A)/(C)								
	1.5	4.2	5.3		2.0	2.4	2.7	2.9
SYDNEY								
(A) Jul-Dec09	555	677 876	1 007 245	32.6	43.2	58	73.7	55
(B)Jan-Jun 01	403	300 966	408 343	50.8	34.3	38.9	55.3	35
(C)Jan-Jun 96	422	231 873	294 328	58.6	19.7	22.9	27.9	19
(A)/(C)	1.3	2.9	3.4		2.2	2.5	2.6	2.9
MELBOURNE								
(A) Jul-Dec 09	549	669 320	984 335	12.2	47.1	77.3	93.4	74
(B)Jan-Jun 01	429	344 399	455 012	46.2	35.5	41.5	57.4	37
(C)Jan-Jun 96	490	275 150	333 795	49.1	21.4	24.8	30	21
(A)/(C)	1.1	2.4	2.9		2.2	3.1	3.1	3.5
ADELAIDE								
(A) Jul-Dec 09	118	105 132	143 684	24	35.3	46.8	55.1	43
(B)Jan-Jun 01	114	50 979	65 559	97	33.4	43.7	48	19
(C)Jan-Jun 96	110	29 856	34 758	94	21.5	26.4	27	16
(A)/(C)	1.1	3.5	4.1		1.6	1.8	2.0	2.5
FREMANTLE								
(A) Jul-Dec09	260	197 378	287 654	49.3	43.8	48	66.8	48
(B)Jan-Jun 01	299	130 459	175 741	78	37.8	34.7	51.1	31
(C)Jan-Jun 96	296	83 589	98 710	96.2	22.4	18	22.9	15
(A)/(C)	0.9	2.4	2.9	2.7	2.0	2.7	2.9	3.2

Source: BITRE Waterline Journal, various issues

Sydney: Table 3 shows that the net crane rate, the vessel working rate and the ship rate grew respectively by factors of 2.2, 2.5 and 2.6 between January to June 1996 and July to December 2009. From Figure 6b, in the period January to June of 1996, the reported crane rate was 19.7 TEUs per hour and about 58.6 per cent of all TEUs were handled below that rate. The lowest number of TEUs per hour spent in berth were noted for ships of around 8 000 GRT but the fast handling rates of above 30 TEUs per hour in berth were achieved when handling the container ships of 50 000 GRT and higher. In the period January to June of 2001, the number of small vessels in the range of 10 000 to 20 000 GRT visiting the port decreased. The reported crane rate at 34.3 was much higher than in the previous period but still about 50.8 per cent of all TEUs were handled below the crane rate. The largest container carriers were processed at very high speeds as reflected in the associated estimates of ‘the number of TEUs per hour a vessel spends at berth’. The crane rate for the port in 2009 was 43.2 TEUs per hour and about 22 per cent of TEUs handled in that period were handled at rates below the crane rate.

Melbourne: Between January to June 1996 to July to December 2009 total containers and TEUs handled at the Port of Melbourne grew respectively by factors of 2.4 and 2.9. The net crane rate, the vessel working rate and the ship rate grew respectively by factors of 2.2, 3.1 and 3.1 over the same period (Table 3). From Figure 6c, in January to June of 1996, the reported crane rate for Port of Melbourne was 21.4 TEUs per hour and about 49.1 per cent of all TEUs were handled below that rate. The lowest number of TEUs per hour spent in berth were noted mainly for smaller ships, the faster handling rates of above 30 could be accessed by larger vessels. In January to June of 2001, UCC container vessels as small as 5 500 GRT still visited Melbourne but the crane rate reported increased to 35.5 TEUs per hour and about 46.2 per cent of TEUs were handled at rates below the crane rate. In the period January to July of 2009 the crane rate reported was 47.1 TEUs per hour and only 12.2 per cent of TEUs were handled in the Port of Melbourne at rates lower than the crane rate. At the same time, about 25 per cent of TEUs were handled at about 95 TEUs per hour spent in berth and all these ships exceeded 40 000 GRT (with the exception of one ship below 30 000 GRT).

Adelaide: All the productivity indicators at the container port terminal improved by at least 60 per cent during the study period. In January to June of 1996, the reported crane rate was 21.5 TEUs per hour and about 94 per cent of TEUs at the port were handled at rates (TEUs handled per hour in berth) which were below the crane rate (Table 3 and Figure 6d). In July to December of 2009, the crane rate was 35.3 TEUs per hour and about 24 per cent of TEUs handled during that period was below the crane rate.

Fremantle: Table 3 shows that for Fremantle, total containers handled at the terminal grew by a factor of 2.4 and Total TEUs handled at the terminal grew by a factor of 2.9 and all the productivity indicators at the container port terminal improved by a factor of at least 2 during this period. Table 3 and Figure 6e further show that in the period January to June of 1996, the reported crane rate was 22.4 TEUs per hour and 96.2 percent of TEUs were processed at rates (TEUs handled per hour spent in berth) below the crane rate. TEUs per hour. In the period July to December of 2009, the crane rate was 43.8 TEUs per hour and about 49.3 per cent of TEUs handled during that period was below the crane rate. The fall in the percentage of TEUs processed at rates (TEUs handled per hour spent in berth) below the crane rate from 96.2 per cent to 49.3 is an indicator of strong productivity improvement at the port.

4. Conclusions

This paper finds that key drivers of stevedoring productivity over the recent past include:

- Crane intensity—the number of cranes working a ship, on average, has increased;
- Vessel size—for ships visiting each of the five container ports has increased; this increase in vessel size has been part of the justification for increased crane intensity;
- Trade mix measured by the per cent of containers that are 40 foot containers—larger containers while heavier, reduce the number of moves required to complete the TEU exchange per ship visit; and
- Average TEUs exchanged per vessel visit.

More importantly the paper introduces a new measure of productivity 'TEUs per hour spent in berth' providing the connection between time in berth and overall turnaround times for container ships and is broader than the traditional "net" measures of productivity --vessel working rate, crane rate and ship rate. This measure includes time required for performing other port tasks in addition to container movements.

The integration of tasks from when crane/container movements is completed and the other tasks needs to be well synchronized to improve container port productivity. The discussion above illustrates that use of container berths in general has been improving in major Australian ports between 1996 and 2009.

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