Forecasting Container Traffic at the Port of Fremantle

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Abstract:

This paper uses a survey based methodology to forecast container exports through the port of Fremantle. A survey was carried out to obtain information expected volumes of containers exports for two years ahead by type of container and destination. Respondents were asked to assign a degree of confidence to their responses on projected volumes. This data was used in a simulation to develop confidence interval estimates for the survey based forecasts. The survey based forecasts were compared with the results of standard time series forecast method based on past trends in container volumes. The advantage of the survey method is that it can provide more detail on destinations. By repeating the survey annually the potential exists to compare the survey forecast with the actual outcome. This will enable the survey based method to be refined.

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Introduction

This paper develops a method for forecasting the number of containers needed to accommodate exports through the Port of Fremantle

Such forecasts are an important aspect of the planning needed to ensure that an adequate container service exists. The forecasting is by volume, type and destination of containers for two years ahead. The method used is based on a shipper's survey and is designed to be implemented every year to generate rolling two year forecasts. Eventually by comparing the survey predictions with the actual outcomes, the survey based forecasting will be able to be refined.

Methodology

The methodology used breaks the analysis into distinct components

Forecasting container exports is broken down into two modules,

- a survey module, and

- a time series reference module

A time series model is developed based on past data records from the Port according to volumes of containers and cargo types. This is a relatively standard business forecasting approach using time series analysis. Ranges of uncertainty are provided for the forecasts. This forecast can be revised as new actual data is recorded over time.

The mean forecasts and the associated confidence intervals form the "reference" for the survey results. This time series reference is totally objective in its use of past data on container exports, but cannot use industry information, including expectations, or trends.

The survey module is the most detailed part of the exercise. A list of shippers of major commodities was prepared in conjunction with representatives from the Fremantle Port Authority, the Department of Transport and industry. Shippers were issued with the survey form shown at the end of this paper. Data was collected on their recent shipments of containers and their expectations about future container volumes by cargo type. For each respondent, information was collected on the last three years so that the coverage of the survey could be checked by comparing the survey results with the actual port records for those years.

In addition to their expected number of containers in total, respondents were asked to detail the destinations for their containers and to provide an assessment of the likelihood that the actual number would exceed or fall below their best guess. This has enabled assessment of the inherent variability in the survey forecasts.

Survey results have been compared with the time series benchmark projections. The survey uses more information than the time series analysis, and should have lower error bounds. If the survey results are to be used in planning, then it is necessary to ascertain the degree of consistency between the two and to monitor any trend for the survey to be systematically above or below the time series projection.

Trends in Export Container Traffic

The trend in container numbers is shown in Table 1. Full containers as TEUs have increased from 28,708 to 83,641, an increase of 191% at an average annual rate of growth of 7.4% per annum. Total TEUs have increased from 32,224 to 98,683 at an average annual rate of growth of 7.8% per annum. These data were used as the benchmark for the time series forecast. They are graphed in Figure 1.

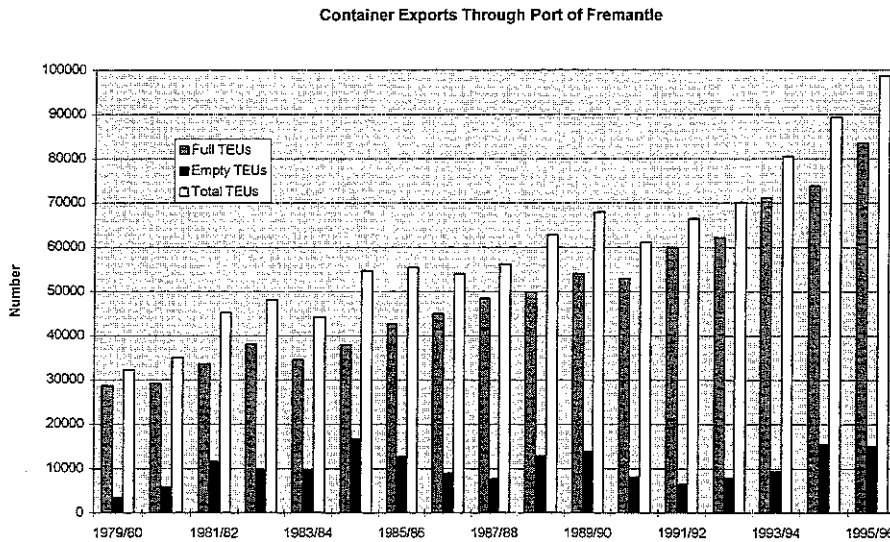**Figure 1: Trends in container exports for Fremantle, 1979/80 - 1995/96**

Container Exports Through Port of Fremantle

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Table 1: Fremantle container exports (TEUs) 1979/80 - 1995/96

	Full TEUs	% Change	Empty TEUs	% Change	TOTAL TEUs	% Change
1979/80	28708		3516		32224	
1980/81	29182	1.65%	5840	66.10%	35022	8.68%
1981/82	33711	15.52%	11629	99.13%	45340	29.46%
1982/83	38259	13.49%	9829	-15.48%	48088	6.06%
1983/84	34566	-9.65%	9682	-1.50%	44248	-7.99%
1984/85	38013	9.97%	16719	72.68%	54732	23.69%
1985/86	42828	12.67%	12682	-24.15%	55510	1.42%
1986/87	45054	5.20%	9016	-28.91%	54070	-2.59%
1987/88	48536	7.73%	7705	-14.54%	56241	4.02%
1988/89	49904	2.82%	12852	66.80%	62756	11.58%
1989/90	54081	8.37%	13848	7.75%	67929	8.24%
1990/91	53032	-1.94%	8097	-41.53%	61129	-10.01%
1991/92	59989	13.12%	6443	-20.43%	66432	8.68%
1992/93	62232	3.74%	7939	23.22%	70171	5.63%
1993/94	71191	14.40%	9373	18.06%	80564	14.81%
1994/95	73933	3.85%	15453	64.87%	89386	10.95%
1995/96	83641	13.13%	15042	-2.66%	98683	10.40%
AARG, 1979/80 - 1995/96	7.39%		10.18%		7.75%	

Time Series Forecast of Container Exports

A time series analysis was applied to the data in Table 1 to determine a benchmark for the next few years. The time series forecasts capture the pattern of variability that has actually occurred between the years in the data. The forecasts and their associated upper and lower bounds based on both 70% and 95% confidence levels are shown in Table 2. The forecasts are based on a simple ARIMA (1,2,1) process.

Table 2: Time series forecast for container exports, 1996/97 to 1999/00

Year	Forecast Full TEUs	Lower Bound 70%	Upper Bound 70%	Lower Bound 95%	Upper Bound 95%
1996/97	*87182*	81959	92738	77240	98404
1997/98	*94251*	87823	101149	82066	108246
1998/99	*100249*	92119	109097	84936	118324
1999/2000	*107405*	97768	117992	89331	129136

The projected TEUs for 1996/97 are 87182. The lower bound based on 95% for this forecast is 77240. The upper bound is 98404. Therefore based on the past pattern of variability in this data, we are 95% certain that the number of containers will be between 77240 and 98404. For 1997/98 the expected number of TEUs is 94251 with a range of 82066 to 108246.

The time series projection can be extended as far out as we desire. The further we extend it the wider the error bounds become. The use of the period to 1999/2000 is consistent with the use of the model as a test benchmark for the survey results discussed below.

As new data becomes available, the forecasts can be revised (for example when 1996/97 data is available) and in this way a set of rolling forecasts can be produced with which to compare the survey results.

The time series forecast and associated error bounds are shown in Figure 2

**Survey Results: Aggregate Container Forecasts**

The complete survey form is available in Economic Research Associates (1997). The data sought in the survey included container number by type and destination and tonnes shipped. A summary of the results is given in Table 3.

It was noted above that the time series forecast, whilst objective, cannot take advantage of all available information on the industry. The survey has the ability to use relevant industry information, including expectations, but is a more subjective approach

In implementing the survey account must be taken of the relationship between the sample and the ultimate market to be forecast. For the current study this involved two steps. First, the survey was concentrated on major export commodities accounting for around 75% of full export containers. Second, the actual survey response accounted for

around 63% of all export containers associated with the specified group of major commodities covered by the survey.

Figure 2: Forecasts for container exports - time series projections

Export Container Forecasts, Fremantle, 1996/97 to 1999/2000
(Full TEUs)
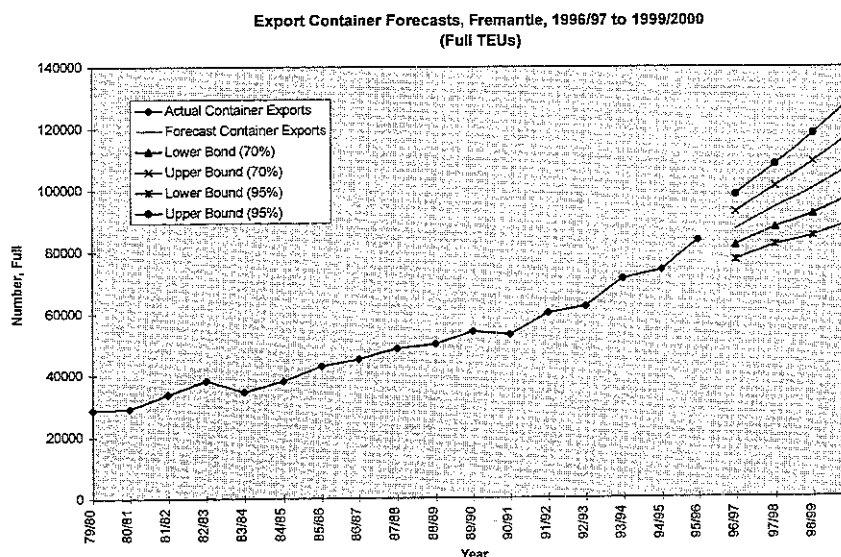
Reflecting this, the final forecast of container exports involves;

- scaling up the sample survey results to the sampling frame of all major commodity exports covered by the survey. This allows for survey non response.

- scaling up the total forecast for all major commodity exports covered by the survey to the total container exports for the port. This allows for sampling frame incomplete coverage.

Table 3: Survey results, aggregate containers

Year	Container Type					Total Containers as TEUs	
	20D	20R	40D	40R	Other	Tonnes	
93/94	24646	1622	2743	322	1769	395994.5	34167
94/95	25854	2102	2512	680	1918	425310.5	36258
95/96	25553	2138	2883	692	1851	439167.0	36692
96/97*	27383	2086	3704	800	1625	487086.0	40102
97/98*	26952	2199	4094	842	1466	458221.0	40489

* = forecast years

The survey concentrated on a specific group of commodities as set down in Table 4.

Table 4: Commodity Groupings in Survey

COMMODITY CATEGORY	Y93/94 TEU	Y94/95 TEU	Y95/96 TEU	Y96/97 TEU	Y97/98 TEU
ALE,BEER etc	318	280	286	300	310
ALUMINA	335	816	979	1290	1290
BARLEY	430	412	451	495	550
BRICKS, TILES	1944	2076	2398	3000	3475
CEMENT	250	350	400	300	350
CORK AND WOOD MANUF	3241	3430	3531	4025	4266
FISH,CRUSTACEANS INCL. FROZEN SEAFOOD	121	94	109	106	106
FRESH FRUIT&VEGS	1245	2459	2483	2660	2863
FRESH MEAT&CHILLED MEAT	940	958	969	970	970
HAY, CHAFF & FODDER	3608	2742	3186	3980	4360
HIDES ANDSKINS	200	250	300	350	400
LOGS AND TIMBER	120	132	144	144	144
LUPINS	362	354	285	400	430
MALT	2998	3370	3497	3920	4180
MINERAL SANDS	357	991	584	637	642
NICKEL,MATTE, REFINED AND INTERMEDIATE	3230	3320	3150	3275	3300
NON FERROUS PRODS-SILICON	1288	1205	1240	1374	1328
OATS, STOCK FEED	123	219	255	260	256
OTHER CEREALS(PULSES)	0	37	16	25	30
OTHER FOOD PREPS	18	0	0	12	6
PAPER PRODS & WASTE PAPER	368	356	551	600	600
SILICA SANDS	0	0	0	20	0
SLAG DROS	242	288	380	215	185
TALC	0	0	0	0	400
TITANIUM DIOXIDE	3000	3500	3500	3500	3800
WHEAT	0	232	97	100	100
WOOL	9429	8387	7901	8144	8154
TOTAL	34167	36258	36692	40102	42495

Table 5 shows the survey total containers as TEUs as a percent of the actual port exports for those commodity classifications in the survey for the three years for which the two overlap. The survey coverage for the three overlap years averages around 60%. Applying this percentage to the survey projected TEUs for 1996/97 and 1997/98 gives projected

Table 5: Survey TEUs as a percent of actual exports and two year survey forecasts for surveyed commodities

Year	Total TEUs from Survey	Actual TEUs from Port Data	Percentage
1993/94	34167	51423	66.44%
1994/95	36258	57250	63.33%
1995/96	36692	70698	51.90
1996/97*	40102	67152	59.72%
1997/98*	40489	67800	59.72%

* = forecast years

In order to compare the survey forecasts with the time series projections we need to allow for the fact that the survey data does not cover all container export commodities. Table 6 shows the aggregate container forecasts derived from the survey. For the overlap years the commodities included in the survey accounted for, on average, 79% of all container exports. Applying this percentage to the survey results gives a total TEU forecast of 85285 for 1996/97 and 86108 for 1997/98. This compares to the time series projections of 87182 for 1996/97 and 94251 for 1997/98. These are within the 95% standard uncertainty bounds in the time series forecasts with the survey result above the lower level of the narrower 70% confidence bound for 1996/97 and just below the lower level of the 70% bound for 1997/98.

The survey results fall further below the time series projection in 1997/98. The average annual rate of growth in containers over the period used in the time series forecast was 7.4% and this rate is reflected in the time series forecast numbers. In effect the survey shows a lower rate of growth than this. Total TEUs from the survey are projected to grow 3% over two years from 1995/96 to 1997/98. Total TEUs based on the time series forecast are expected to grow by 12.7% over the same period.

Container forecasts by type

The survey sought data on the number of containers by type. This is shown in Table 7. The final column shows the scaled forecast of total containers produced in previous tables. Applying this scaling factor to the distribution of containers across container types gives the results in Table 8. This table shows, for example, that of a forecast of 67800 containers covering the specified commodities in the survey for the year 1997/98,

45132 are expected to be 20D containers. This table assumes that the pattern of exports will be the same for the total containers as that revealed for the survey containers. The Table 8 data is presented in Figure 3 for the year 1996/97.

Table 6: Aggregate container forecasts based on survey results

Year	Total TEUs	Survey TEUs	Percent
1993/94	71191	51423	72.23%
1994/95	73933	57250	77.28%
1995/96	83641	70698	84.53%
*1996/97**	*85285*	*67152*	*78.73%*
*1997/98**	*86108*	*67800*	*78.73%*

* = forecast years

Table 7: Containers by type - survey results for specified commodities

Year	20D	20R	40D	40R	Oth	Total Survey	Actual Port Total
93/94	24646	1622	2743	322	1769	34167	51423
94/95	25854	2102	2512	680	1918	36258	57133
95/96	25553	2138	2883	692	1851	36692	70698
*96/97**	*27383*	*2086*	*3704*	*800*	*1625*	*40102*	*67152*
*97/98**	*26952*	*2199*	*4094*	*842*	*1466*	*40489*	*67800*

* = forecast years

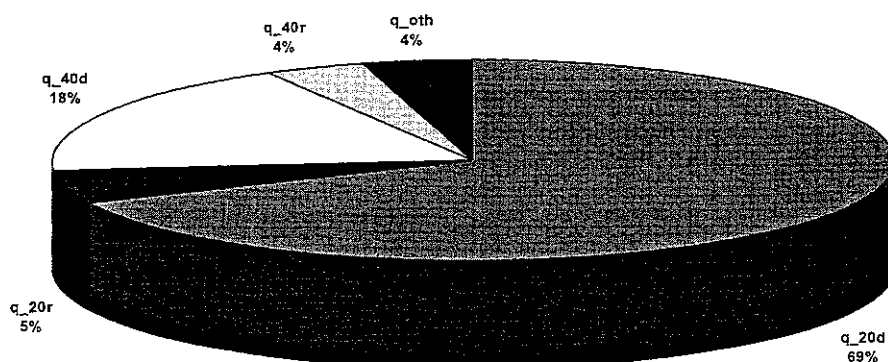**Figure 3: Forecasts of export containers by type for 1996/97.**

Table 8: Aggregate container forecasts by container type for specified commodities included in survey

Year	20D	20R	40D	40R	Other	Total
93/94	37093	2441	8257	969	2662	51423
94/95	40739	3312	7916	2143	3022	57133
95/96	49235	4119	11110	2667	3566	70698
96/97*	45854	3493	12405	2679	2721	67152
97/98*	45132	3682	13711	2820	2455	67800

* = forecast years

Container Forecasts by Destination

Each survey respondent was asked to assess the destination of the containers that they were expecting to use for exports in each of the next two years. The full details of the listed countries are shown in Economic Research Associates (1997). For the year 1996/97, the distribution across the broad destination areas is shown in Figure 4. Estimates numbers of containers by destination by year were obtained by applying the distribution of the survey responses across destinations to the aggregate container forecasts for the surveyed commodities. It is only applied to the container forecast for the commodities in the specified areas covered by the survey because it seems inappropriate to impute a similar destination distribution to the remainder of the containers

Details of survey results for containers broken down across container destination, container type and commodity are included in the report appendices.

Assessing Variability in Survey Forecasts

Surveys typically result in a single number or point estimate for forecast years. In the current study each respondent provided as estimate of their future container exports for 1996/97 and 1997/98. This is a single number estimate.

However respondents arrived at their final estimates, they are nevertheless estimates and contains some legitimate variability. It was thought important in the current study to obtain some indication of the inherent variability in the survey forward estimates. There are a number of reasons for doing this. First the benchmark projections based on the time series forecast contain confidence bounds that capture the inherent uncertainty in the projections. These bounds increase as you project further out. Incorporating a variability element into the survey forecasts allows for a more meaningful comparison.

Second, it is important to understand the strength with which the respondent estimates are held This is an element in judging the usefulness of the survey results. Finally, as the survey is repeated in subsequent years and feedback is provided to respondents, it may be important to assess whether respondents are narrowing their range of uncertainty

Figure 4: Destination of container forecasts, 1996/97.
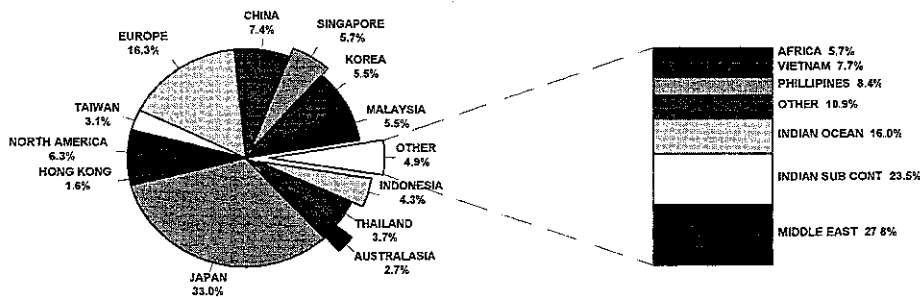
To assess the variability, each survey respondent was asked to indicate a degree of confidence in the forecasts they provided for 1996/7 and 1997/98 They were asked to do this by allocating 100 points across a range of over/under percentage deviations from their best estimate so that the spread of points reflected their degree of confidence. The range was from -30 percent to +30 percent in increments of 10 percent. Therefore a respondent was confronted with the following range of possible deviations from their best estimate ;

-30%	-20%	-10%	0%	+10%	+20%	+30%

Each respondent then had 100 points to allocate across these deviations in a way that reflected their degree of confidence in their estimates. For example if the points were allocated as follows:

0	0	0	100	0	0	0

the respondent is allocating the whole 100 points to the 0% deviation thereby indicating complete confidence in their estimate.

If they allocated the points as follows:

0	0	12	75	13	0	0

the respondent is interpreted as being 75% certain that their best estimate is "spot on" (zero % deviation expected) with it being equally likely that the deviation will be -10% or +10%.

The data provided by the points allocations was used to represent the variability in the form of a general distribution for each commodity group with the range;

-40% (min)	-30%	-20%	-10%	0%	+10%	+20%	+30%	+40% (max)

with individual probabilities in the form;

0	P(-30)	P(-20)	P(-10)	P(0)	P(+10)	P(+20)	P(+30)	0

For example, using the points allocation illustrated above these probabilities would be;

0	0	0	.12	.75	13	0	0	0

The distributions were used in a simulation of the possible forecast outcomes. Every respondent had a distribution of the kind just described. The simulation samples combinations of estimate and probability across respondents to produce a distribution of container forecast values. This distribution of possible aggregate forecast outcomes is determined and this can be used to assess the likely variation in the forecasts based on the survey.

The distribution produced from this simulation exercise for the total containers from the survey is shown in Figure 5 and in Figure 6. The results are presented in Table 9.

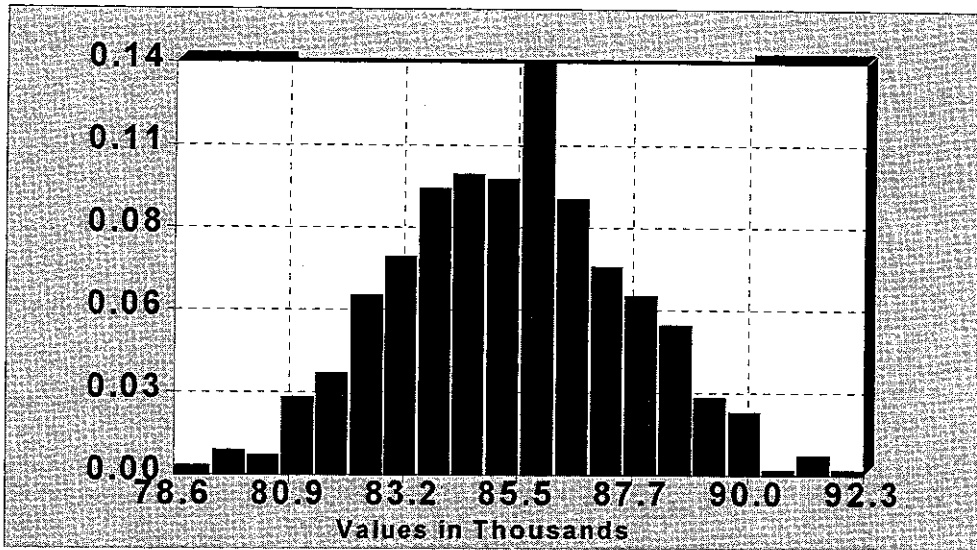**Figure 5: Distribution of total containers (TEUs) for 1996/97 based on survey results**

Figure 6: Distribution of total containers (TEUs) for 1997/98 based on survey results
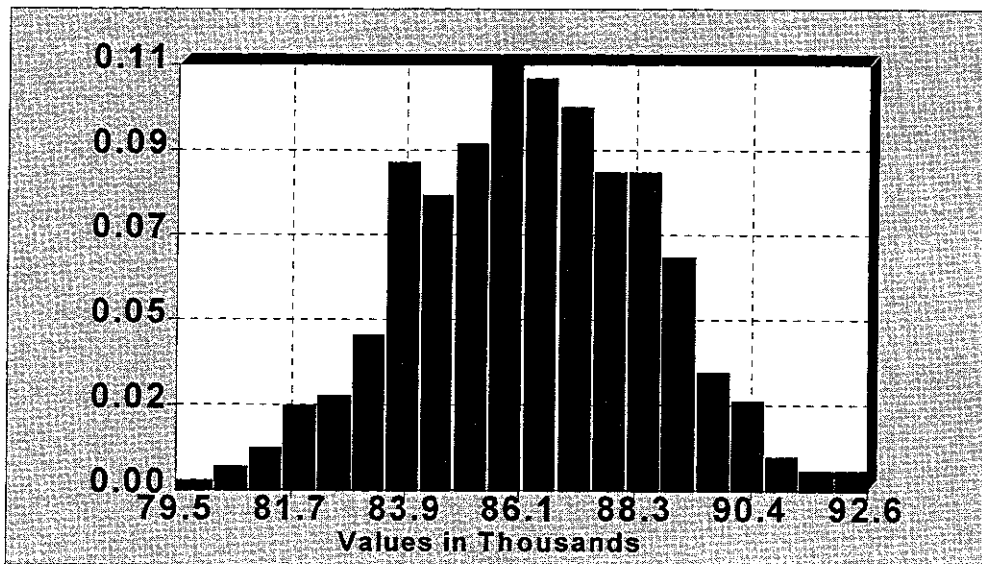
Table 9: Forecast variability based on survey data

	Aggregate for Surveyed Commodities			Aggregate for All Commodities		
Year	Minimum	Mean	Maximum	Minimum	Mean	Maximum
1996/97	61925	67130	72660	78647	85257	92281
1997/98	62629	67851	72922	79541	86173	92614

The mean for 1996/97 is 67130 for the surveyed commodities with a range of 10600 from 62000 to around 72600. Scaling this to the overall total gives a forecast of 85260 with a range of around 13700 from a minimum of 78600 to a maximum of 92300.

The mean for 1997/98 is 67851 for the surveyed commodities with a range of 10300 from 62600 to around 72900. Scaling this to the overall total gives a forecast of 86170 with a range of around 13100 from a minimum of 79500 to a maximum of 92600.

Table 10 shows the comparison of the forecast and variability for the aggregate container numbers (TEUs) based on a variation of 1 standard deviation which is around a 70% confidence bound. As already noted the survey estimates are less than the time series forecast, more so in the 1997/98 year. In addition the standard deviation is smaller for the survey in both. The survey can be interpreted as giving;

- a lower growth projection than the time series forecast and,

- a narrower range of uncertainty around the projected number of containers.

Table 10: Comparison of survey and time series for aggregate TEU forecasts

	Aggregate Forecast for all Commodities from Time Series			Aggregate Forecast for All Commodities from Surveys		
Year	Lower Bound 70%	Mean	Upper Bound 70%	Lower Bound 70%	Mean	Upper Bound 70%
1996/97	*81959*	*87182*	*92738*	*82957*	*85257*	*87557*
1997/98	*87823*	*94251*	*101149*	*83907*	*86173*	*88439*

The combination of the survey and time series techniques allows this to be put into perspective. The survey is not highlighting any significant jump in volumes from the current level. Note also that the level of export containers fluctuates on a yearly basis (see Table 1) and the survey may be picking up a slower growth period within this fluctuating pattern

Over time the repeating of the survey on an annual basis will allow a refinement of approach In particular;

- as the actual outcomes are recorded the time series forecast can be revised. This is a relatively mechanical task.

- as the actual is compared to the survey an understanding will be formed as to whether the survey consistently understates actual outcomes and how well it captures the inherent year on year fluctuations This can then be a basis in future for adjusting the survey forecasts

References

Economic Research Associates Pty Ltd and Data Analysis Australia Pty Ltd. (1997) *Forecasting Container Traffic at the Port of Fremantle.* A Report Prepared for the Department of Transport.