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AUSTRALIA'S SEABORNE CONTAINERISED FREIGHT

FORECASTS TO 2010-11

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FOREWORD

This study analyses and forecasts trends in the usage of containers for the carriage of Australia's seaborne freight over the period 2001–02 to 2010–11. The study also estimates the proportion of 40-foot containers used in Australia's inbound and outbound seaborne trade and assesses the implications of their increasing use over time.

The study was carried out by Johnson Amoako under the supervision of Joe Motha, Deputy Executive Director. Liz Berryman provided some assistance during the early part of the study.

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EXECUTIVE SUMMARY

The analysis carried out in this study using econometric modelling suggests that combined Australian containerised imports and exports are expected to increase at an average annual rate of 5 per cent over the forecast period (2001–02 to 2010–11). In absolute numbers, this represents about 3.8 million import and export containers expected to be handled in 2010–11 compared with 2.2 million in 2000–01.

The study forecasts that domestic containers will increase at an average annual rate of about 8 per cent over the forecast period. In this study, 'domestic containers' comprise transhipment containers (import containers that are discharged at an Australian port and then transhipped to another Australian port) and local containers (containers carried on the coastal trade; that is, from one Australian port to another). This relatively high growth rate is expected because the larger ships entering the liner trade will not be able to berth at some ports, thereby increasing the number of transhipped containers. This rapid growth rate, if realised, would add considerably to pressure on road and rail links between ports.

The study has also reviewed the relative proportions of 40-foot and 20-foot containers. These proportions affect total container numbers, the efficiency of intermodal transfers and pressure on port facilities and connecting road and rail links. The proportion of 40-foot containers currently handled at all Australian ports is around 31 per cent (the average for the five major ports is about 33 per cent). The most likely forecast is that the proportion for all ports would average around 35 per cent during the forecast period.

However, under the high-growth scenario for 40-foot containers, their proportion would rise to up to 56 per cent during the forecast period. In this case, there would be a three-fold increase in 40-foot containers handled in the next decade (from about 700 000 currently to up to 2.1 million by 2010–11). However, under this scenario, total container movements would rise at a much lower rate, reaching around 2.8 million in 2010-11. The proportion of 40-foot containers is therefore an important issue in the planning and provision of port, road and rail infrastructure.

As with any forecast, these results are based on a number of assumptions. In this case, the assumptions involve Australia's economic growth rates and those of its major trading partners. The key economic factors are Australia's gross domestic product (GDP), trade weighted index (TWI) and the GDPs of OECD or G7 countries. The extent of availability of empty containers can also have some effect on containerised exports.

CHAPTER 1 INTRODUCTION

Container trade is central to liner shipping and waterfront activities and therefore commands the attention of governments, the shipping industry and shipping researchers.

There are approximately 69 commercial and semi-commercial ports located around the Australian coastline (including Tasmania) and three ports on surrounding islands (figure I.1 in appendix I). About 30 of these ports handle containers (appendix I table I.1).

Over 50 per cent of Australia's trade by value is currently carried in containers. The containerised share of Australia's international trade is expected to increase as greater quantities of cargoes traditionally shipped in bulk such as coal, grain and salt are shipped in containers. Australia's major container trading partners are East Asia, Europe, Japan, North Asia, New Zealand, North America, and South East Asia. Australia's container imports are largely manufactured goods such as machinery and chemicals, whereas container exports tend to be commodities such as meat, cereals and dairy products (Productivity Commission 1999). Australia's export trades have a far greater weight utilisation of containers than the import trades (Baker 1996).

The quantities of containers loaded and discharged at a port and ship size are prime drivers of port infrastructure investment, as port authorities seek to improve efficiency by faster ship turnaround times.

This study provides a broad perspective of the current container trade and identifies future trends. The perspective is broad in the sense that the analysis is carried out at the national level rather than for individual ports. The study provides aggregate forecasts of container quantities by using two different methods: dynamic econometric modelling and multivariate autoregressive modelling. The two methods have been applied to sets of data obtained from different sources.

Most empirical studies focus on trade volumes in mass tonnes, and where the studies focus on containers handled, they often include double-handled containers. The double handling situation arises mainly as a result of ships not calling at all ports, thereby generating transhipment containers. As larger ships are likely to call at fewer ports, transhipment of containers will increase. An implication of this trend is that it will affect the accuracy of forecasts of container movements.

This study focuses on actual container quantities (boxes), rather than mass tonnes exported or imported[1], and in so doing is able to model the impact of increasing use of 40-foot containers and innovative technologies such as collapsible containers. Although trade volumes may be rising, increasing use of larger containers could actually result in a decline in total container numbers. This issue is of importance to port planners, as it may dictate different types of investments.

[1] In this study, import and export containers handled exclude containers for transhipment and re-stow

CHAPTER 2 CONTAINER TRADE

The first domestic container operation in Australia commenced in 1964. Shipping of containerised cargo to international destinations commenced in 1969. Two consortia operated the international services: Overseas Containers (Australia) Ltd (OCAL) and Trans-Ocean Containers Ltd (TOC)—the Australian subsidiary of Associated Containers Transportation (ACT). In late 1969, the Australian National Line introduced container services to Japan and Britain (BTE 1982). During 1976–77, after a decade of containerisation in Australian ports, about 654 000 TEUs were handled at the five major ports (table 2.1). Of these, about 60 000 TEUs (about 9 per cent) were transhipped—in other words, they were handled more than once through the ports. The twenty-foot equivalent unit (TEU) is the common measure of container size and refers to a standard 20-foot container. Other sizes—including 40-foot containers—are all commonly expressed in TEUs.

TABLE 2. 1 IMPORT AND EXPORT CONTAINER THROUGHPUT (TEUs), 1976–77

Port	*Full import*	*Empty import*	*All import*	*Full export*	*Empty export*	*All export*	*Total*
Melbourne	144 243	5 699	149 942	126 519	27 425	153 944	303 886
Sydney	138 493	2 519	141 012	66 267	45 127	111 394	252 406
Brisbane	18 582	2 791	21 373	27 939	63 22	34 261	55 634
Adelaide	3 312	29	3 341	3 648	1 74	3 822	7 163
Fremantle	11 650	1 246	12 896	16 484	5 250	21 734	34 630
Five ports	316 280	12 284	328 564	240 857	84 298	325 155	653 719

Source BTE (1982)

Table 2.2 shows that during 2000–01 the container throughput at the five major ports was 3.3 million TEUs—an increase of nearly 400 per cent during the last 25 years. Adelaide Fremantle and Brisbane have experienced the greatest growth, with Adelaide averaging 70 per cent per year over this period. By comparison, Melbourne and Sydney have had more modest annual growth rates, averaging 13 and 12 per cent respectively. These five ports have collectively accounted for between 89 and 95 per cent of the container throughput of Australian ports (table I.1 in appendix I). The high levels of growth experienced by Adelaide, Fremantle and Brisbane are unlikely to be repeated in the next decade.

TABLE 2. 2 CONTAINER THROUGHPUT (TEUS), 2000–01

Port	*Full import*	*Empty import*	*All import*	*Full export*	*Empty export*	*All export*	*Total*	*% change 1976–77 to 2000–01*	*% change annual*
Melbourne	571 177	98 394	669 571	523 519	123 575	647 094	1 316 665	333	13
Sydney	491 689	19 905	511 594	306 099	171 274	477 373	988 967	292	12
Brisbane	153 486	74 575	228 061	194 173	30 805	224 978	453 039	714	29
Adelaide	38 008	21 059	59 067	63 294	10 875	74 169	133 236	1760	70
Fremantle	136 494	47 582	184 076	125 574	44 494	170 068	354 144	923	37
Five Ports	1 390 854	261 515	1 652 369	1 212 659	381 023	1 593 682	324 6051	397	16

Source BTRE *Waterline.*

Containerised shipping is entering a new period of growth. This time the growth is expected to be driven largely by the containerisation of traditionally non-containerised bulk cargo such as grain and coal. In the case of grain, if trade liberalisation were to affect centralised grain marking, there would be potential for the development of small niche markets and these would be better served by container shipping. However, the growth rates are not expected to match those indicated earlier.

Melbourne, Sydney and Brisbane have consistently had a relatively greater share of the container trade. Melbourne exchanged the largest number of TEUs (1 316 665 or 41 per cent of total Australian throughput) in 2000–01, followed by Sydney (988 967 or 30 per cent). Their shares are set to increase further, given the trend in vessel sizes. It is inevitable that the larger vessels will not be able to call at some ports. Containers that would normally be discharged at most ports by relatively smaller ships would be discharged at a few ports that can handle the larger ships.

Containerisation International (November 2000) reported that the largest vessel deployed in the Australian trade has a capacity of 3 450 TEU and this was set to increase to 4 100 TEU following P&O Nedlloyd and partner Contship Containers placing orders for larger vessels to be deployed in 2002. The first such 4 100 TEU vessel in the Australian trade was commissioned on 10 July, 2002.

A 4 100 TEU vessel is unlikely to be able to call at all ports without additional and expensive port investment. Figure 2.1 shows the world trend in vessel sizes. It is clear that in the medium to longer term, as these vessel are deployed in the Australian trade, some port calls are likely to be discontinued even with additional port infrastructure investment because of a port's physical limitations, such as depth and landside handling infrastructure. However, the penetration of larger vessels into the Australian trade is likely to be slow because of the relatively small container volumes involved.

Another development that is facilitating container trade is the increasing adoption of electronic commerce. The widespread adoption of e-commerce can generate substantial savings. Communication and administrative costs could be reduced significantly, particularly if the technology provides the customer with access, information and schedules to manage booking, financial transactions, and container tracking, including facilities for diverting containers in transit. The adoption of these technological advances translates into cost savings and price reductions, thereby stimulating demand for containerised trade. Trade that has not been amenable to containerisation because of cost factors would become attractive when costs decrease sufficiently.

Containerised freight will therefore continue to be an important part of Australia's export and import trade. Table 2.3 shows the relative importance of containerised trade in comparison with bulk (non-liner) commodities.

TABLE 2. 3 RELATIVE SHARES OF LINER AND BULK TRADE

	Liner		*Non- liner*		*All*		*% Liner by*	
Year	*k/tonne*	*$b*	*k/tonne*	*$b*	*k/tonne*	*$b*	*Value*	*Volume*
1999	34 001	86	462 098	55	496 100	141	61	7
2000	32 125	93	508 775	79	540 900	172	54	6
2001	38 144	111	515 500	75	553 644	185	59	7

Source BTRE unpublished data.

CONTAINERISATION

Globally, the extent of containerisation is increasing each year with the continuing transfer of bulk, breakbulk[2] and general cargo into containers (Crisp 2000a, Haralambides et al 2000, Porter 2001). Some vehicle types, particularly specialist, high-specification and customised cars are carried in containers (DTLR 2001). Australian products and commodities traditionally handled in bulk, such as grain, rice, salt and briquettes have been containerised.

Containerisation of exports from Australia is increasing for a number of reasons, including the advantage of being able to control product quality and condition, the ability to deliver small volumes direct to the point of demand, and the low blue-water container rates[3] (Crisp 2000a).

According to Haralambides et al (2000), approximately 80 per cent of containerisable global cargo has been containerised and it is expected that this

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[2] Breakbulk refers to non-bulk cargo that is not containerised. It can include unitised cargoes as well as miscellaneous goods in boxes, bales, cases or drums—for example, assembled cars, steel coil and timber. Bulk cargo refers to cargo (such as coal, mineral ores, oil or wheat) that is carried loose, taking up the shape of the ship's hold. It is handled by direct application of conveyors, grabs, pumps, and elevators (Productivity Commission 1998b).

[3] Blue water freight rates include pilotage, towage, mooring and unmooring charges and 'over the rail' stevedoring costs at Australian ports (Productivity Commission 1998a).

proportion will rise to about 95 per cent in the next few years as a result of more general cargo being made suitable for containerised transport.

Porter (2001) suggests that the expected expansion of the containership fleet in the near future and surplus ship capacity could result in more low-value commodities being containerised.

Containerisation is not an option for items such as light poles, large farm machinery and newspaper rolls, given the length or weight of these items.

Globally, it is estimated that container carriage grew by 162 per cent in the 1990s, compared with 126 per cent in the 1980s[4]. The steep increase was due to a number of factors, including economic growth, greater use of transhipment, the increasing containerisation of breakbulk and bulk cargoes, and growth in general cargo volumes (Gardiner 2001).

World container port throughput is forecast to grow from 170.3m TEUs in 1997 to 271.3m TEUs by 2005—an increase of almost 60 per cent (Drewry Shipping Consultants Ltd 1998). World container port throughput was at 231 million TEUs in 2000.

20- AND 40-FOOT CONTAINERS

Australia's import trade is dominated by 40-foot containers, while exports are mainly in 20-foot containers[5] (Chinnery 2001a). As a result of this imbalance, it is common for shipping companies based in Australia to have a surplus of 40-foot containers and a shortage of 20-foot containers (Baker 1996).

Australia's dense export cargoes also affect the use of 40-foot containers, since the weight of a 40-foot container filled with dense cargo can exceed the capacity of cargo handling equipment (Productivity Commission 1999).

The 20-foot containers are generally more difficult to load and unload, as they are loaded on and off ships built with 40-foot cells. This slows the rate at which 20-foot containers can be loaded or unloaded, because crane drivers are able to use only one cell guide (Productivity Commission 1998b).

Chinnery (2001b) notes that a major change is on the way in the North American trade with the switch to 40-foot equipment. For Australia, the main implications of the change to 40-foot containers relate to road haulage restrictions in some parts of the country. This may mean having to partially unload containers on the wharf or carry containers with reduced payloads.

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[4] These figures are based on port throughput compiled by Drewry Shipping Consultants.

[5] The 20-foot container has a capacity of up to 26 tonnes for heavy cargoes, and the 40-foot container has a capacity of 30 tonnes and is designed for light cargoes (Baker 1996).

EMPTY CONTAINERS

Australia's trades are affected by the movement of empty containers. In Australia, from January to June 2001, the number of empty TEUs exchanged by the five ports[6] were 141 024 (imports) and 169 114 (exports) (BTE 2001a). The difference in the number of empty containers carried on outward journeys compared with inward journeys is because Australia exports denser cargoes than it imports, and vessel deadweight limitations.

In contrast to import cargoes, a relatively high proportion of Australia's exports require shipping in refrigerated containers. As a result, it is necessary to import large numbers of empty refrigerated containers into Australia, as many of Australia's imports cannot be carried in refrigerated containers. Empty dry containers are carried from Australia for subsequent use in other trades (Productivity Commission 1999).

Containers are not locked into specific trades: when a container becomes free it can be used wherever demand is greatest (Baker 1996). However, moving empty containers is a costly exercise for container ships. The cost of moving empty containers around the world has been estimated as exceeding US$25 billion per year[7] and could exceed US$50 billion by 2010 on present trends (Jarman 1999). Gardiner (2001) suggests that the number of annual empty movements may reach 100 million TEU by 2010.

Though the cost of moving empty containers has been reduced by improvements in the logistics of empty container movements, further cost reductions will be achievable if collapsible 20-foot containers are introduced. The use of collapsible containers will enable shipping lines to fit three such containers in each standard container slot (Flower 2001).

Although container lessors have 'one-way deals' with shipping lines to transfer boxes from their surplus areas in the US and Europe to Australia, 'many shipping lines would now claim that freight rate levels do not warrant the extra cost of positioning empties back to Australia again. Leasing companies, also say that they cannot afford to keep large idle stocks here' Chinnery (2001a).

The costs associated with the provision of land storage and wharf facilities to accommodate empty containers around the world have been estimated at billions of dollars (Jarman 1999).

SHIP SIZE

The size of container ships has grown. In 1969, the Europe to Australia container service had the capacity to stow 1 100 TEUs. As noted earlier, the

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[6] The five ports refer to container ports in Melbourne, Sydney, Brisbane, Adelaide and Fremantle.

[7] April 1999 estimate.

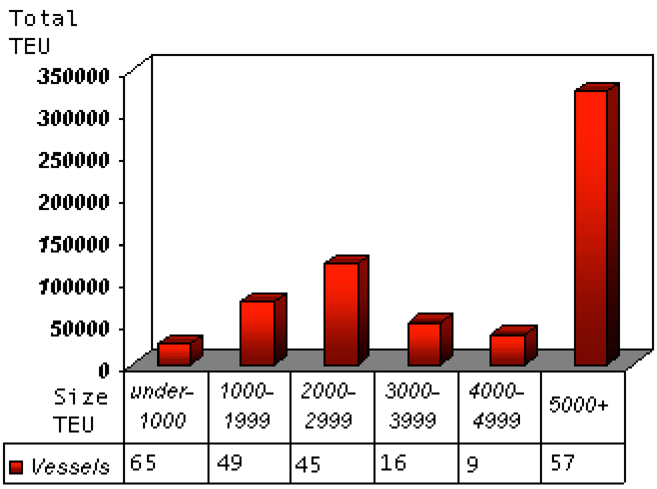
biggest ship now serving the Australian trade has a container capacity of 4 100 TEU.

Trade in overseas containers is largely handled by fully cellular ships[8] with some roll on–roll off vessels also used. The size of container ships entering Australia is influenced by a number of factors including:

- water depths of Australia's ports;
- outreach of cranes;
- number of containers that have to be moved through the port in a very short time; and
- amount of terminal space required to stack containers for loading and unloading.

The 4 100/4 200 TEU vessels being introduced by P&O Nedlloyd and Contship Containerlines will affect up to five key services to and from Australia and New Zealand. According to Crisp (2000b), Adelaide and Melbourne may have to be dropped from the schedule given potential port depth problems.

FIGURE 2.1 Vessel Deliveries by Size range in 2001



Source *Containerisation International*, February 2002

Although container ships have reached a capacity of 7 060[9] TEUs (figure 2.1), the volumes of Australian trade do not currently warrant ships of this size.

[8] Fully cellular ships are defined as purpose-built container ships equipped with 40-foot cell guides below deck as a minimum, but are not regarded as fully cellular if used for mixed cargoes of containers and general cargo.

[9] Refers to the Maersk Line (Haralambides et al 2000).

According to Baker (1996), if 6 000-TEU ships entered Australian trades, there would have to be an offsetting factor—such as reduced frequency (which would not be beneficial to Australia's trading task)—to balance capacity and to ensure cost-efficient slot utilisation. Haralamdides (2000) outlines some of the characteristics a port should possess to receive such vessels:

- Sufficient channel depth
- Good proximity to markets
- Established processing facilities with sufficient storage
- Modern cargo handling equipment
- Good transport linkages to hinterland markets
- Large breakwaters
- Reinforced piers
- Sufficient space for future expansion

The use of larger ships involves overall cost considerations: the cost of transhipment and inland transport constraints and costs could outweigh any gains from mainline shipment.

Developments in vessel sizes highlight the need for trade analyses that focus on import and export volumes—excluding transhipment within Australia—because these reflect the actual size of the trade.

CONTAINER MANUFACTURERS

Containers are manufactured in a number of countries, China being the dominant producer. In 1998, China's container production reached almost 1 million TEU. This figure compares with 100 000 TEU built by factories in South East Asia, 115 000 TEU from North East Asia (Taiwan, South Korea and Japan), 160 000 TEU from Europe, 38 000 TEU from the Americas and 50 000 from other regions (Foxcroft 1999).

This distribution of production could change if a container involving innovative technology is widely adopted. An Australian company based in Brisbane announced in 2001 that it is developing a folding container and were marketing the concept. The company claims that three folding containers (when folded) can fit into the slot occupied by a standard 20-foot empty container. The folding containers would help to remedy the imbalance between inward and outward containers at a relatively lower cost. Several Australian container ports and export hubs suffer from severe container imbalances and shippers ultimately bear the cost of re-positioning empties. Firms adopting the new container could increase their own efficiency as well as the efficiency of their customers while reducing costs along the entire transport chain.

As the foldable units can also be carried on road and rail transport vehicles, the same re-positioning benefits would apply on land as at sea. It should be noted that, as in the case of many other new technologies, costs are saved in some areas and increased in others. In this case, additional costs are likely to be incurred in the provision of extra resources to fold and unfold containers at both ends of a trip. The time required for this operation would be critical. It is too early to speculate about the extent of uptake as the concept has yet to move from the drawing board to the manufacturing plant.

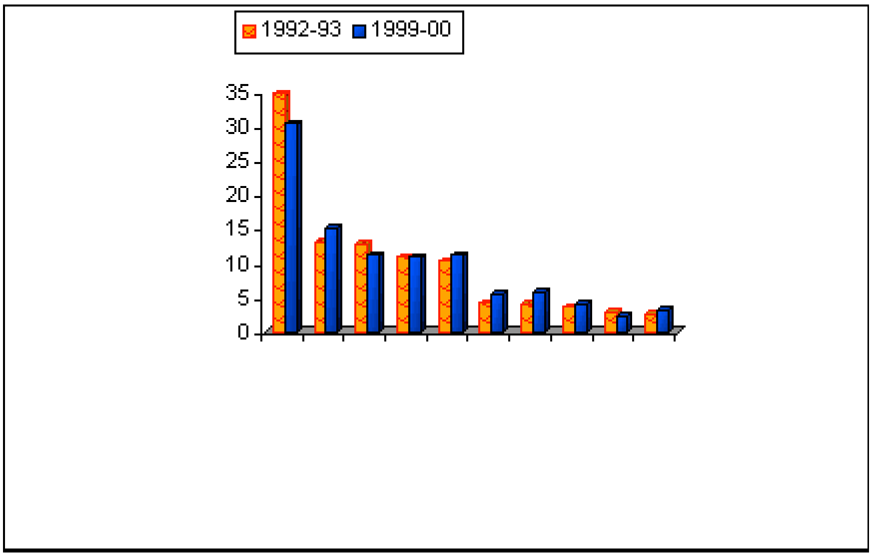
CHAPTER 3 ECONOMIC OUTLOOK

This chapter provides a general commentary on the economies of Australia's major trading partners. It draws largely on reports of the OECD and Access Economics. A global picture is needed to put Australia's prospects for international trade in perspective.

One of Australia's longest and most successful periods of sustained growth occurred in the 1990s. The growth was largely attributable to policies that fostered Australia's integration with the global economy. Consequently, exports rose as a share of national income—a percentage point growth in exports was accompanied by 0.5 per cent growth in the Australian economy. This surge in exports also boosted imports. For example, during the 1992–93 financial year, exports (by value) amounted to about $49 billion. By the end of the 1999–00 financial year it had risen to $78 billion—an increase of 60 per cent over the eight year-period. Similarly, during the same period, imports had risen from $43 billion to $77 billion—an increase of 78 per cent.

Figures 3.1 and 3.2 show the geographic distribution of export and import markets. The growth also demonstrates the robustness of the Australian economy, as it occurred during a period that saw the Asian financial market meltdown, the near collapse of the information and communication technology (ICT) sector and a slowdown in the global economy. Australia was one of the few economies in the region to have endured the shocks without significant adverse impact.

FIGURE 3.1 EXPORT MARKET SHARES BY REGION—1992–93 AND 1999–2000



Source BTRE and ABS

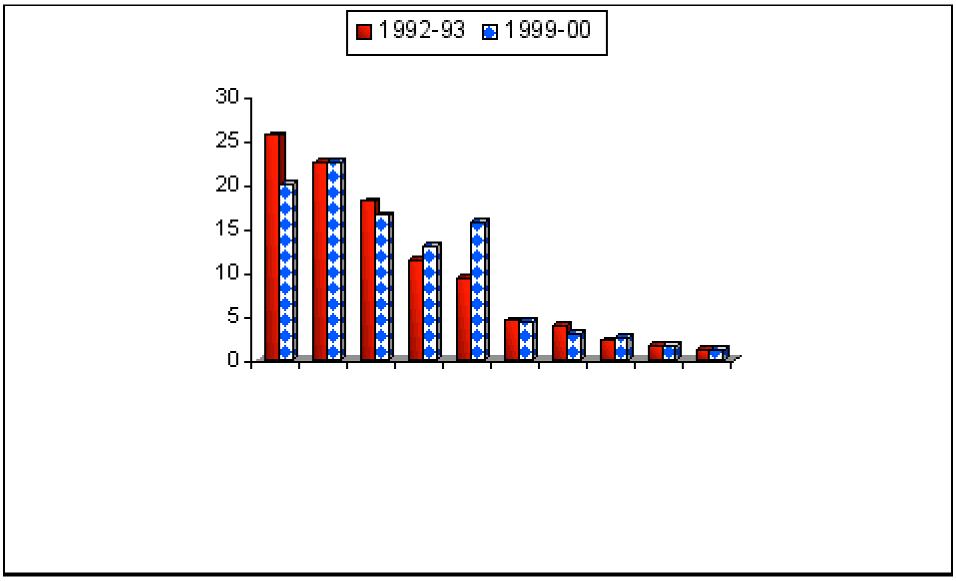


FIGURE 3. 2 IMPORT MARKET SHARES BY REGION—1992–93 AND 1999–2000

Source BTRE and ABS

Will the growth trend continue after September 11, 2001?

The events of September 11, 2001 and their aftermath have touched most economies. Australia is a small player in the global economy, with trade driving less than a quarter of economic activity. So far there is little evidence that September 11 has had any short-term impact on the Australian economy. Signs are now emerging of global recovery.

Growth momentum is returning to the OECD area as the causes of the recent slowdown dissipate. Analysts believe that reductions in excess inventory appear to be well advanced in many countries. The collapse of investment in information and communication technologies is generally giving way to a cautious recovery. Confidence has returned more rapidly than previously expected in the wake of the September 11 events, especially in the USA.

Economic policies have provided a strong impetus, with low real interest rates helping to boost consumer spending and fiscal policy supporting demand growth. OECD GDP growth is expected to accelerate gradually, reaching nearly 2 per cent in 2002 and 3 per cent in 2003 (table 3.1). The USA is leading the upturn. Rapid and forceful monetary action, together with fiscal expansion, helped bring about renewed growth from late 2001. A gradual strengthening in business investment is expected to underpin the recovery in the second half of 2002 and into 2003.

Output in Europe stagnated in the second half of 2001, with depressed household confidence and spending. European economic activity is predicted to remain sluggish in the first half of 2002 but should gather pace thereafter as capital spending recovers and the effects of the upturn in the United States is felt through higher European exports.

OECD analysts believe that beyond the short-term rebound, policy decisions are needed to make European economies more productive and increase growth, even though progress has been made in some areas. In labour markets, steps were taken to reduce the tax burden on the low skilled, but progress is still needed in some OECD countries.

TABLE 3.1 SEASONALLY ADJUSTED ECONOMIC PROJECTIONS

Period	*2001*	*2002*	*2003*
Real GDP	*% changes from previous period*		
United States	1.2	2.5	3.5
Japan	-0.4	-0.7	0.3
Euro area	1.6	1.3	2.9
European Union	1.7	1.5	2.8
Total OECD	1.0	1.8	3.0

Source OECD (2002)

In Japan, exports are responding to exchange rate depreciation and the revival of global demand, inventories have fallen to more normal levels, and economic activity is expected to stop contracting in the near future. However, OECD analysts contend that any growth in output is likely to remain very anaemic. Investment demand will continue to be depressed by banking sector problems and corporate restructuring, while households, faced with rising unemployment and longer-term pension uncertainties, will be reluctant to increase their spending. Deflation appears to have become entrenched, although it is expected to stabilise at its present moderate pace. The effect of exchange rate depreciation is being offset by rising unemployment and a significant output gap.

Activity in non-OECD countries as a group is likely to accelerate, the Asian economies having weathered the downturn well. Growth in China is expected to remain around 7 per cent and activity in the Asia-Pacific region as a whole is set to strengthen as the high-tech investment cycle turns up. Overall, the recovery both inside and outside the OECD area is likely to boost world trade growth from 2.5 per cent in 2002 to over 9 per cent in 2003.

Implications for transportation

Following the September 11, 2001 attacks, the US transportation system was subject to severe disruptions largely resulting from increased security measures. The most severe disruption occurred at the land border between the US and Canada where, on average, half a million vehicles and $1.4 billion in bilateral trade cross each day. The long delays involved in border crossings had an adverse impact on the operations of firms. Several factories on both sides of the border had to shut down because of the disruption of just-in-time supply chains. With improved security arrangements, the movement of trucks across the border has returned to near-normal levels.

More stringent security measures and various surcharges have affected the cost of freight transport by sea and air. For international sea shipments, increased costs and longer waiting times have resulted from procedural requirements, more frequent Coast Guard inspections and tugboat escort regulations. For air freight, higher airport security costs at airports have led to security levies, higher insurance premiums, and war surcharges for certain regions.

Air freight rates were about 10 per cent higher in late 2001 than before the attacks. However, maritime shipping rates increased by 5 to 10 per cent on average in the two weeks following the attacks but fell thereafter. Given the sharp decline in aggregate demand observed in the US since 2000 and the drop in fuel costs following the attacks, a greater reduction in shipping costs should have occurred. However, the fact that such a reduction in costs has not occurred despite lower fuel costs and under-utilised freight capacity, suggests that underlying transportation cost elements such as insurance are likely to have increased.

More stringent security measures have been advocated at borders. The US Coast Guard has proposed to the International Maritime Organisation various measures for preventing acts of terrorism against shipping. Containerised cargo accounts for 60 per cent of the volume of international trade. Following recommendations by the US Customs Service, it is expected that increased security measures for containers will be introduced at the ten large ports that account for nearly half the containers shipped to the United States. This initiative would involve improved procedures and technology, requiring significant capital investment in ports, ships and containers.

A key implication of the commentary in this chapter is that the world economy is recovering. This is likely to provide a boost to Australian exports and imports. However, a factor that could constrain smooth trade flows to some degree is the form and extent of security measures that Australia's trading partners are likely to impose at their borders.

CHAPTER 4 DATA USED FOR FORECASTING

DATA SOURCES

Sources of data for analysing and forecasting containerised imports and exports include the BTRE's International Cargo Statistics database, data from the BTRE's *Waterline* publication and DOTARS' data on stevedoring activities.

International Cargo Statistics

This is a detailed unpublished database on Australian imports and exports compiled by the Australian Bureau of Statistics (ABS) and provided to the BTRE. Variables in the database that are relevant to this study are liner cargo imports and exports. Liner cargo is largely transported in containers. However, a small proportion of liner cargo (about 5 per cent in mass tonnes) is not containerised, mainly because the configuration of such cargoes is not amenable to containerisation. For the purpose of this study, International Cargo Statistics is the database that has sufficient data for robust analysis. The data used cover the September 1994 quarter to June 2001 quarter and are in the form of quantities of imports and exports, allowing separate econometric analysis of imports and exports.

The database does not provide numbers of containers used in cargo movement and the throughput of empty containers—data required for estimating the proportion of 40-foot containers used. Because of this limitation, forecasts in mass tonnes have to be converted to container numbers. However, this database was used for the econometric analysis, as a key advantage was the adequate amount of available data.

Waterline data

Data for port productivity estimates published in BTRE's *Waterline* are obtained from port authorities and stevedoring companies. There is a gap in the stevedoring companies' data between 1992 and 1993. The *Waterline* database provides information on the number of TEUs handled at the five major ports, including empty TEUs. The stevedoring companies' data cover containers handled by the three major companies (Patrick, P&O Ports and CSX World Terminals), constituting about 85 per cent of the TEUs handled at the five major ports. The database also provides an indication of the proportions of 20- and 40-

foot containers handled. This information is of considerable importance in estimating future growth in 40-foot container movements.

The database does not have information on local re-stow and transhipment containers (these allow for the exclusion of double handling and local container movements) and is limited to the five major ports (the five ports account for between 89 and 97 per cent of container trade by cargo volume). The stevedoring companies' data do not distinguish between imports and exports—required to construct separate models. The *Waterline* data were used in the analysis to develop models to convert mass tonnes carried to TEUs, TEUs to number of containers, and ratios of loaded containers to empties.

DOTARS database

This database meets all the requirements for use in forecasting except that it is limited by sample size, thereby constraining robust econometric analysis.

In the near future, when sufficient data have been collected, this will be the ideal data source for forecasting container movements. The data are in a monthly format, providing more data points. However, the economic variables that are used in the modelling are either presented quarterly or in an annual format, meaning that the monthly data have to be aggregated into quarters. This step reduces the sample size for analytical purposes, since the monthly data cover a period of only two years (from February 1999 to June 2001). The 24 data points therefore reduce to 8 (8 quarters).

Because of the inadequate sample size, this data set could not be used for the econometric analysis. However, the data set was considered to be adequate for use in multivariate time series analysis and forecasting—an approach gaining popularity among researchers (Veenstra & Haralambides 2001). These data were also used to develop a model to estimate the proportion of containers that are handled at the ports more than once.

Economic data

Economic literature and empirical work (for example, Stopford 2002, Benetatos et al 1997, BTCE 1991 and BTE 1988) postulate links between economic variables and international cargo flows. The links generally suggest that trade flows (imports and exports) flourish in times of world and national economic growth or prosperity. After all, trade is at the heart of economic activity. This means that economic indicators can be used to explain and predict imports and exports. These economic variables include gross domestic product (GDP), currency exchange rates, household disposable income, GDP per capita, freight rates and commodity prices

GDP and foreign exchange rates were sourced from the ABS and Access Economics. They include aggregate GDP, GDP per capita and household disposable income for Australia, G7 countries, OECD countries, Japan, EU15 countries, the USA and UK and are presented in quarters. Although quarterly estimates are generally less detailed and less reliable than the annual estimates, they have a very important role in economic analysis. First, they are more up-to-date than annual accounts, so they provide a more timely indicator of the direction in which an economy is heading. Second, they enable a more detailed analysis to be made of the behaviour of economies around turning points in the business cycle (annual accounts tend to hide the pattern of growth around turning points to some extent, because peaks or troughs in economic activity generally cut across years). The foreign exchange rates include the Australian trade weighted index and the Australian dollar versus the US, Euro, Yen and UK pound.

Freight rates and commodity prices can also affect the volume of trade flows. For example, if freight rates are very high it would make trade in low value products unprofitable. Similarly, low commodity prices may reduce exporters' margins and thereby discourage exports. However, experts believe container traffic growth is more likely to come from cargoes that are currently not transported in containers. Data on these variables were not collected for this study.

There are other qualitative factors such as economic policy, trade policy (e.g. tariffs, quotas and trade liberalisation) political strategy and technological change that have a bearing on trade flows. Some of these effects may be short- to medium-term, while others may have long term effects. For example, technological innovations, such as the collapsible container described earlier, will generally have medium to long term impacts. To a large extent, these impacts are incorporated in the economic indicators and would therefore be reflected in the forecasts. Appendix III provides the data set described in this section

CHAPTER 5 METHODOLOGY AND FORECASTS

What is a forecast?

Since economic and business conditions vary over time, business leaders and policy makers must find ways to prepare for effects that such changes will have on their operations or the activities at which policies are directed. Forecasting provides a means of understanding and preparing for future events.

A forecast is a prediction about the future based on a set of justifiable assumptions. A forecast will not necessarily predict the future accurately, and sophisticated mathematical models may not necessarily generate more accurate forecasts than simpler models. If using a forecast is likely to have significant implications, forecasters will generally try to provide decision-makers with an indication of how reliable they expect the forecast to be, by providing a forecast range, a scenario analysis, or an expected distribution.

Forecasting, therefore, is simply a qualified view about the future and may need to be updated periodically. Generally speaking, the accuracy of forecasts decline as the period over which they are made increases.

Issues in forecasting

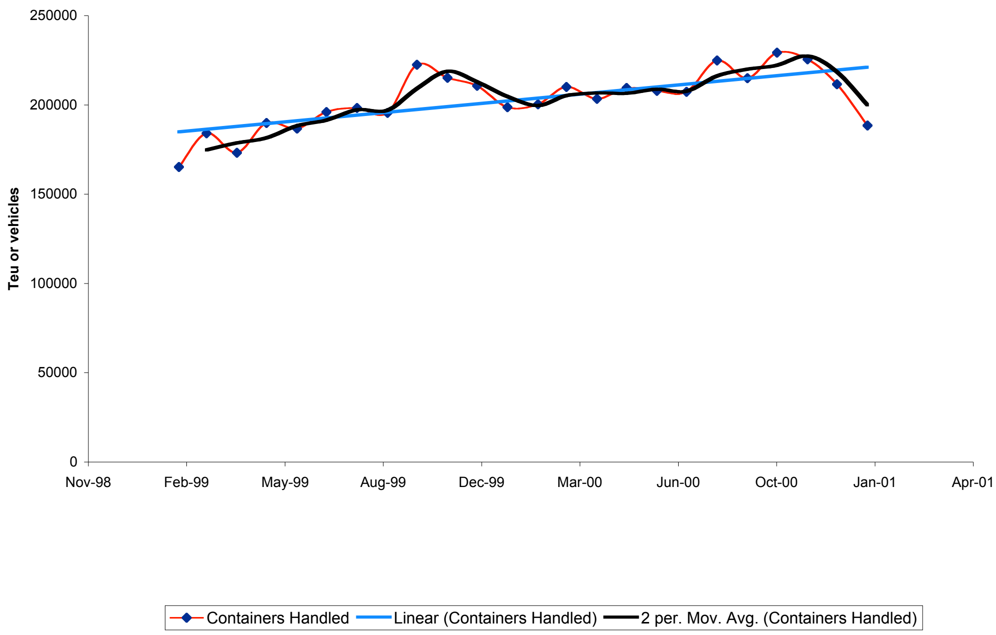
There are basically two approaches to forecasting: qualitative and quantitative. The approach adopted in this paper is quantitative. Quantitative forecasting methods can be subdivided into two types—time series and causal—and both approaches are used in this paper. Causal forecasting methods involve the determination of factors that relate to the variable to be predicted. The causal method used is referred to in this paper as econometric analysis.

Time series comprise a set of numerical data collected at regular periods over time, such as those described in chapter 4. The basic assumption underlying time-series analysis is that the factors that have influenced patterns of activity in the past and present will continue to do so in more or less the same manner in the future. The major aims of time-series analysis are to identify and isolate these influencing factors for predictive purposes as well as for planning and control. A detailed description of the Autoregressive Integrated Moving Average (ARIMA) method is in appendix III.

The first step in the use of time series analysis is the examination of the series to determine the trend that fits the series and to select the appropriate model to be used.

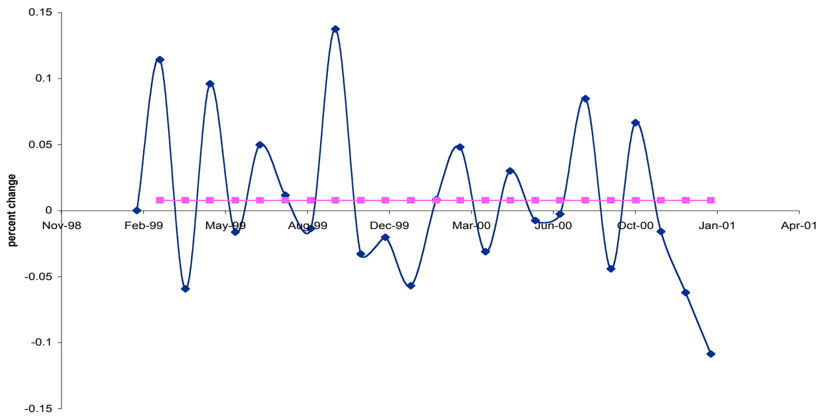
Figure 5.1 shows a simple linear forecast of containers on which alternative forecasts (univariate ARIMA time series analysis) have been superimposed. An examination of the graphs would suggest that the linear trend model does not adequately describe the behaviour of the series. This is further illustrated in figure 5.2, which shows the percentage change in container throughput over the same period. It is clear that the increase in throughput is not constant over time. This provides a clue that models other than linear models need to be investigated to fit the data series.

FIGURE 5.1 TREND ANALYSIS OF CONTAINERS HANDLED



Source BTRE

FIGURE 5. 2 TREND ANALYSIS—PERCENTAGE CHANGES



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As discussed in chapter 4, the ABS international cargo statistics provide the appropriate sample size for a detailed and advanced modelling technique to be used. The next section discusses the econometric modelling technique used in this analysis.

ECONOMETRIC METHODOLOGY

An important question that must be asked when applying a technique to economic data concerns the correspondence between the technique employed and the economic relationships under consideration. It is therefore imperative that care be taken to ensure the correspondence between the choice of technique in modelling and the expected results.

Key issues addressed in this paper are the determination of future growth rates in container movements and whether growth in 40-foot container trade will be sufficient to influence the direction of port development. Econometric modelling can be used to predict trends in container flows by considering how factors that influence cargo movements are likely to impact on these flows.

Container movements are essentially a direct result of cargo flows, which depend on the economic activities occurring within the areas of origin and destination of the cargo.

Until the 1990s, the US, Japan and Germany used gross national income (GNI)[10] as the main measure of economic activity. However, now the key measure of

[10] GNI is a term, which has replaced Gross National Product (GNP) see for example The Economist (2000).

economic activity is GDP, which is used by all the major industrialised countries. The quantities of Australia's exports and imports have some form of relationship with Australia's GDP and those of its trading partners. Similarly, the exchange rate of the Australian dollar to the currencies of Australia's trading partners would have a bearing on the quantity and timing of imports and exports. The model developed in this Working Paper explores these dynamic relationships.

A dynamic econometric model—Polynomial Distributed Lag (PDL)[11]—has been adopted for this modelling [for details see Gujarati (1995)]. This technique incorporates both short and long run components of the data set. This means that the impact on imports and exports of the economic (explanatory) variables felt in the short and long term are measured and reflected in the structural part of the model. To illustrate: if the value of the Australian dollar declines relative to the US dollar, Australian exports would become cheaper and Australian imports more expensive. The impact of the lower value of the dollar on import and export quantities will be felt shortly after the lower dollar value occurs (short term) as well as in subsequent periods (long term). This makes economic sense because trade contracts are usually entered into long before delivery occurs. That is, there is a delayed effect (lag) which the dynamic models capture. Standard static econometric models do not capture these lags. An alternative model (multivariate ARIMA) has also been used for comparative purposes.

As well as the dynamic structure of the model, careful attention has been given to the univariate and multivariate stochastic properties of the data set under consideration. Time series data present some special problems for econometricians. Most empirical work based on time series data assumes that the underlying time series are stationary. Time series data are said to be stationary if their mean value and variance do not vary systematically over time. If the time series data are non-stationary, a very high [R^2][12] may be obtained, although there may be no meaningful relationship between the variables being regressed. If the time series variables exhibit strong trends (sustained upward or downward movements), the high R^2 observed would be due to the presence of the trend, not the true relationship between the variables. In econometric terms, the relationship is described as spurious.

The usual remedy in such a situation is to simply estimate the model in first differences. This practice, however, results in model misspecification, since first differences essentially nullify the information concerning the long-term relationship between variables. Cointegration analysis addresses this problem. Should the relationship be cointegrated, the short and long run relationship discussed above is retained. In this analysis, both the univariate and

---

11 For example, $Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \ldots \beta_k X_{t-k} + u_t$

12 R^2 , Coefficient of determination is a measure of goodness of fit that is, it measures the proportion of the total variation in Y (export or import) explained by the regression model.

multivariate properties have been examined using augmented Dickey-Fuller (1984) and Phillips-Perron (1988, 1990) tests.

MODELLING

The econometric modelling has been undertaken in two steps: imports and exports were modelled separately and the outputs of both models combined to obtain total throughput. Each model was tested to ensure that it conformed to statistical properties and economic theory. The best-fit model based on 'total R^2'[13] was used to forecast container cargo flows for a ten-year period.

The data set used was sourced from the ABS international cargo statistics (seasonally adjusted quarterly time series). As discussed earlier, the data set is compiled in mass tonnes and does not indicate the quantity of containers, which is the objective of the forecast. It should be noted that exports and imports used in this analysis do not equate to Australia's total exports and imports. It is only the exports and imports that are shipped in containers (liner shipping) that are the focus of analysis. A high proportion of these exports and imports can be classified as manufactured or value added products.

To convert the forecast of mass tonnes into numbers of containers, a separate model was developed using the *Waterline* DOTARS data sets. The model takes account of the impact and growth of 40-foot containers. This model was then used to convert the forecast of mass tonnes into numbers of containers.

Export model and forecast

Economic theory posits that, if Australia's trading partners' economies are growing (measured by GDP) and the value of the Australian dollar is relatively low, it would boost Australian exports. Conversely, a declining trading partner's economy and a relatively strong Australian dollar would precipitate export decline. The trading partner's GDP is represented by the G7[14] aggregate GDP and the trade-weighted index (TWI)—an index of the exchange rate of Australia's major trading partners—which represents the relative strength or weakness of the Australian dollar in the model.

Examination of the plot of economic data covering the period of the analysis reveals that the G7's real GDP has been growing steadily, while the Australian exchange rate has been declining. Imports were used as a proxy for 'imported containers' and introduced into the model as an explanatory variable. Australian exports in containers are to an extent influenced by the number of empty containers available. Empty containers are largely the result of import containers whose contents have been emptied. For example, the *Daily*

[13] Total (adjusted) R^2 is a measure of how well the next value can be predicted using the structural part of the model and the past values of the residuals (as used in the SAS program). The regression R^2 and total R^2 should be the same when there is no autocorrelation correction (OLS regression).

[14] The Group of seven countries comprises Canada, France, Germany, Italy, Japan, UK and US.

Commercial News of September 9, 2001 in commenting on the slump in exports, attributed one of the causes to a shortage of incoming containers for loading export cargo. Imports are therefore used as a proxy for containers and introduced into the export model as an explanatory variable. The model is of the form:

$$\ln y_t = \alpha + \sum_{i=0}^{4} \beta_i \ln x_{t-i} + \sum_{i=0}^{3} \beta_i \ln z_{t-i} + \varepsilon_t$$

Where

y_t is predictand in time t and is total exports

α and βs are regression coefficients

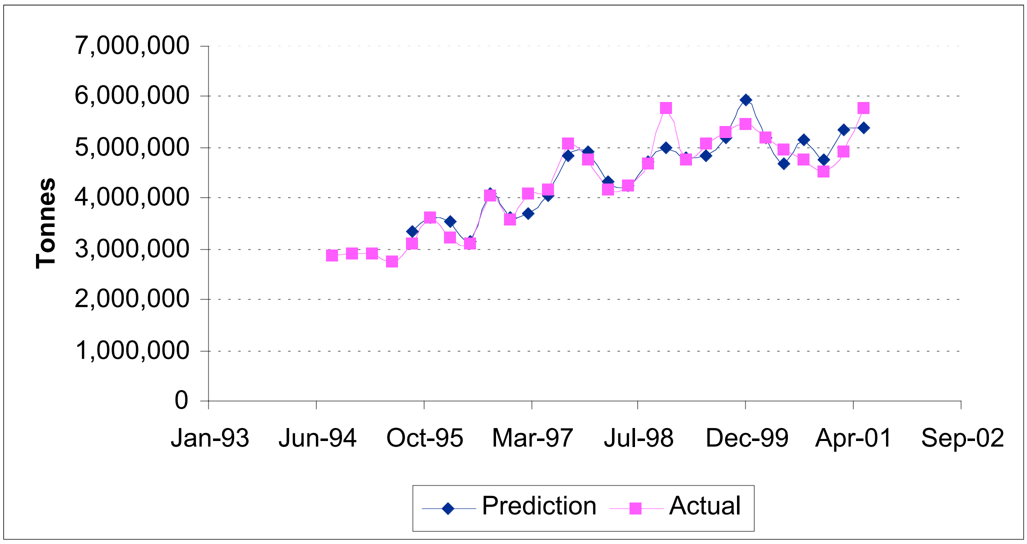
x_t is predictor in time t and is GDP of G7 countries

z_t is predictor in time t and is import containers

ε is an error term

The best-fit dynamic export cargo model (loglog) was with G7's real GDP and 'import containers'. Real TWI was statistically not significant and had the wrong sign. The model's total R^2 was 0.89. The model's statistical properties including short and long run coefficients and the univariate test for stationarity and multivariate test for cointegration are shown in appendix III. Figure 5.3 shows the graph of the model's output and provides a pictorial indication of how well the model predicts future container flows. The export forecast (in mass tonnes) is shown in table II.2 in appendix II.

FIGURE 5. 3 MODEL FOR EXPORTS (TONNES)



Source BTRE

Import model and forecast

If both the Australian economy as measured by real GDP and the dollar are strong, imports will be expected to rise; that is, demand for goods will increase. In particular, if the dollar is strong relative to the trading partner's, imports would be expected to be less expensive. The regression coefficients for both GDP and the trade-weighted index in such a situation are expected to have positive signs. A dummy variable was introduced to capture the effect leading up to, and including, the period of the Sydney Olympics. The model was constructed in loglog form and is of the form:

$$\ln y_t = \alpha + \sum_{i=0}^{1} \beta_i \ln x_{t-i} + \sum_{i=0}^{3} \gamma_i \ln z_{t-i} + \varepsilon_t$$

Where

y_t is predictand in time t and is total imports

α and βs are regression coefficients

x_t is predictor in time t and is Trade Weighted Index (TWI)

z_t is predictor in time t and is Australia's GDP

ε is an error term.

The SAS program written to run this model is in appendix II.

The best-fit dynamic cargo imports model was with Australia's real GDP and real TWI. The model's total R^2 was 0.88. The model's statistical properties are shown in appendix III. Figure 5.4 shows the graph of the model's output and provides a pictorial indication of how well the model predicts future container flows. The forecast of imports in mass tonnes is as shown in table II.1 in appendix II.

As discussed in chapter 4, the DOTARS data set was not adequate for econometric analysis. However, it contains monthly figures for actual containers handled at all ports and was deemed sufficient for multivariate ARIMA forecasting. These data are perhaps the most accurate and reliable in terms of actual containers handled at all ports, although imports and exports are not differentiated. Therefore, this forecast, which uses an alternative source of data, provides a basis for checking the accuracy of the econometric forecast involving the conversion to containers. This modelling also provides the means of separating double handled containers from total containers handled. The output of this forecast is shown in tables II.3 and II.4 and tables II.1 and II.2 of appendix II. Figure 5.5 shows the plot of actual containers handled and forecasts. The best model was determined on the basis of its root mean square error (RMSE).

FIGURE 5. 4 MODEL FOR IMPORTS (TONNES)

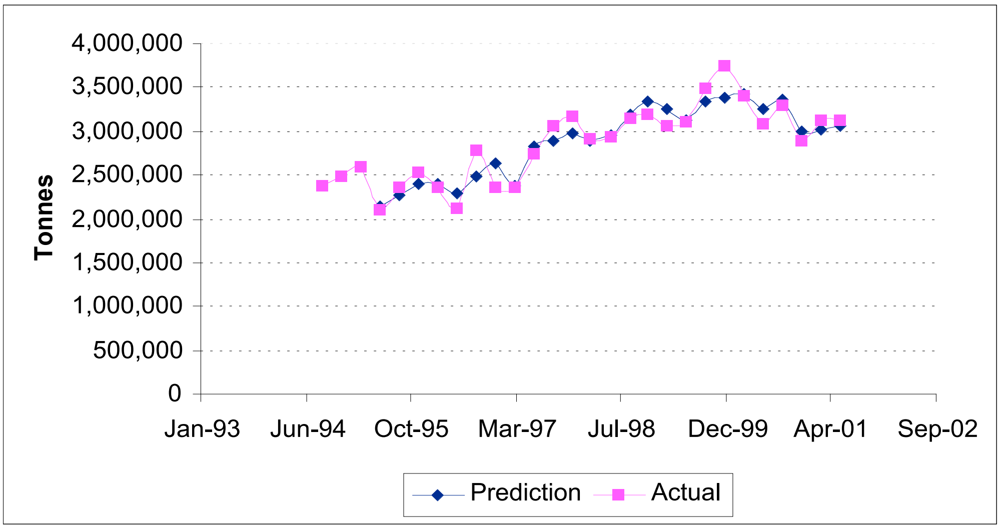


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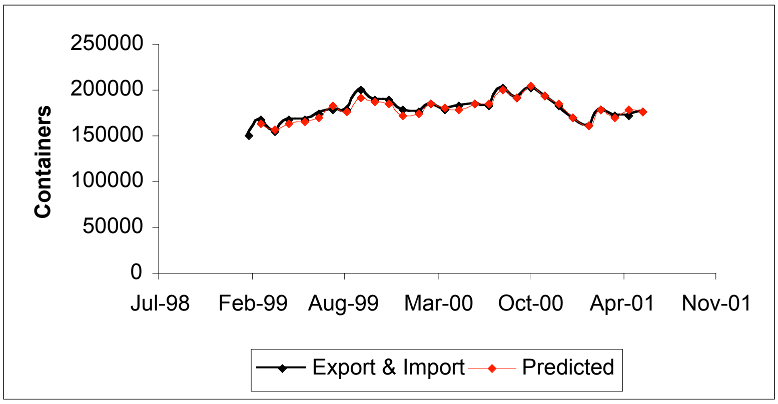
FIGURE 5. 5 ARIMA MODEL FOR EXPORTS AND IMPORTS (CONTAINERS)



Source BTRE

All the models described were developed for base case, lower case and upper case forecasts based on confidence intervals and different container loading capacities (13 tonnes for a fully loaded container in the base case, 14 tonnes in the lower case and 12 tonnes in the upper case).

DERIVATION OF CONTAINER QUANTITIES

As discussed earlier, the econometric modelling generated forecasts in mass tonnes of cargo. However, the focus of this paper is not on cargo throughput per se, but on the number of containers handled, particularly the separation of double handled containers from containers for actual imports and exports. The number of containers handled and ship sizes are the prime movers of port infrastructure investment. Translating total mass tonnes into container numbers helps to project future port needs. Ideally, historical data on containers moved should be the data used for econometric forecasting. However, as discussed earlier, available data in that format have a number of limitations. The econometric modelling forecast in mass tonnes is converted to number of containers, both fully loaded and empty, and the proportions of 40-foot containers are then determined.

It is also necessary to project the growth in 40-foot containers. Increasing mass tonnes of imports and exports may not necessarily translate into increasing numbers of containers, particularly if larger containers are used. If increasing use of larger containers does affect container numbers substantially, it may affect the nature of port infrastructure investment as well as any policy instruments involving container numbers.

The first step in the analysis was to convert tonnes to TEU's. Vessels are usually loaded with both 20-foot and 40-foot containers and possibly other container sizes as well. There is no way of knowing from the data what the usual proportions are (20-foot versus 40-foot). One approach is to assume that all are 20-foot equivalents. In theory, 20-foot containers are able to hold 20 tonnes or more. However, due to various cargo configurations, the maximum weight is rarely achieved. Industry often uses figures between 12 and 18 tonnes per TEU. Haralambides et al (2000) used 13 tonnes. In this study, the average weight per TEU has been assumed to be 13 tonnes in the base case, and 12 tonnes and 14 tonnes in the upper and lower case respectively. The conversion from tonnes to TEU (base case) is therefore:

TEU = mass tonnes /13

The second step involved the conversion of the estimated TEU's into containers using BTRE's *Waterline* data. The data contain historical records of TEU's and the actual numbers of containers. The following model was developed from the data:

Containers = 40059 + 0.7060TEU

(P value <.0001).

This model was used to convert the estimated TEUs into containers.

Since three TEUs are equivalent to one 20-foot container and one 40-foot container or three 20-foot containers, this relationship is developed further using the following equation to transform the estimated containers into 20- and 40-foot containers.

$$\square = \frac{\square\square\square}{\square}$$

where Y is 40ft container proportion, X is total TEUs and K is total containers.

Another alternative to the above derivation of 40-foot proportions was to forecast separately using the historical 40-foot proportion data and then apply the forecasted proportions to the estimated containers by period. Both approaches were used. For the forecast period, the 40-foot proportion ranges between 31 and 35 per cent of total container flows.

Empty containers

Because of the imbalance in trade (imports and exports) there is usually a need to supplement fully loaded containers with empty containers in either direction. The ABS data used for the analysis and forecast reflect loaded containers only. Therefore, to estimate the total number of containers using ABS data requires a separate analysis and forecast of empty containers which is then added to the forecasted number of loaded containers. The *Waterline* data discussed earlier contain information on loaded and empty TEU's arriving and departing. The following functional relationship was developed:

$$\text{Empty} = -524 + 0.226\,\text{TEU}$$

(p value <0.0001)

The above container/TEU equation was applied to derive the number of empty containers.

Table 5.1 presents the results of the mass tonnes forecast conversion to containers. For ease of presentation, they have been transformed to annual figures and are comparable with the forecast obtained from ARIMA modelling using the alternative data discussed above and shown in table 5.2.

Transhipment analysis

The need to separate transhipment containers from the total number of containers may be questioned, because what drives port investment is the volume of containers passing through the port irrespective of whether they are local or transhipment containers. While this is generally the case, it is also important, from a policy perspective, to estimate the future volume of actual expected containerised imports and exports (that is, excluding double handling and re-stow containers). For example, the Federal government's stevedoring levy scheme applies levies to import and export containers, excluding double handled containers (that is, transhipment containers). With the expected increase in the use of larger ships, it is inevitable that transhipment containers will increase proportionally. This increase could distort forecasts by indicating high growth rates when, in fact, forecasts are inflated by increased double handling.

The DOTARS data contain information that enables estimation of the proportions of transhipped containers. These proportions were projected over the forecast period using the ARIMA model. The results show that transhipment and re-stow containers add about 1.5 per cent to the annual growth rate forecast.

TABLE 5.1 IMPORTS AND EXPORTS CONTAINER FORECAST USING ECONOMETRIC MODEL—NUMBER OF CONTAINERS (MILLIONS)

	Base Case	*Lower Case*	*Upper Case*
Year	*Import & export*	*Import & export*	*Import & export*
2000/01	2.184		
2001/02	2.394	1.701	3.309
2002/03	2.650	2.049	3.404
2003/04	2.656	2.040	3.364
2004/05	2.831	2.164	3.633
2005/06	2.989	2.263	3.897
2006/07	3.147	2.357	4.170
2007/08	3.304	2.447	4.452
2008/09	3.461	2.532	4.743
2009/10	3.616	2.612	5.042
2010/11	3.770	2.687	5.351

a. *Note C*ontainers include empties

Source BTRE

TABLE 5.2 IMPORTS AND EXPORTS CONTAINER FORECAST USING ARIMA —NUMBER OF CONTAINERS (MILLIONS**)**

	Base case			*Lower case scenario*			*Upper case scenario*		
Year	*All Containers*	*Import & export*	*Domestic*	*All Containers*	*Import & export*	*Domestic*	*All Containers*	*Import & export*	*Domestic*
2000/01	2.484	2.184	0.299						
2001/02	2.599	2.270	0.330	2.390	2.152	0.239	2.809	2.388	0.420
2002/03	2.677	2.305	0.372	2.377	2.143	0.234	2.976	2.467	0.510
2003/04	2.786	2.383	0.403	2.431	2.189	0.242	3.140	2.577	0.564
2004/05	2.869	2.424	0.445	2.468	2.207	0.261	3.269	2.640	0.628
2005/06	2.973	2.497	0.476	2.536	2.259	0.277	3.411	2.735	0.676
2006/07	3.060	2.542	0.518	2.589	2.288	0.301	3.530	2.796	0.734
2007/08	3.161	2.612	0.550	2.661	2.342	0.320	3.661	2.882	0.779
2008/09	3.250	2.660	0.590	2.723	2.376	0.346	3.778	2.943	0.834
2009/10	3.350	2.727	0.623	2.797	2.430	0.367	3.902	3.024	0.879
2010/11	3.440	2.777	0.663	2.864	2.469	0.395	4.017	3.086	0.931

b. *Note C*ontainers include empties

c. Domestic containers comprise transhipment containers (import containers that are discharged at an Australian port and then transhipped to another Australian port) and local and re-stow containers (containers carried on the coastal trade; that is, from one Australian port to another and containers moved temporarily to re-position on ship).

Source BTRE

FORECAST RESULTS

Results for the base case indicate that actual import and export container throughput (excluding double handling and local containers) will increase at an average annual rate of 5 per cent over the period 2001–02 to 2010–11. In absolute numbers, this represents about 3.8 million direct import and export containers by 2010–11, compared with 2.2 million in 2000–01.

On the other hand, the multivariate ARIMA analysis predicts that combined import and export containers will grow at an annual average rate of 2.3 per cent. All containers (import, export and domestic) are predicted by this model to grow at an annual rate of 3.8 per cent—that is, 1.5 per cent higher than the forecast growth for the combined import and export containers. The ARIMA model also forecasts that transhipment and local containers will grow by 8.1 per cent. This level of growth is expected because the larger ships entering the liner trade will be able to call at a limited number of ports. The lower growth forecast (2.3 per cent) applies to the short term, given the limited range (two years) of data used.

Comparing forecast growth with historical growth

Analysis of the historical container data—measured in container numbers and TEUs—published in BTRE's *Waterline* data indicate that annual container growth rates (including transhipment or double handled containers) since 1993 have averaged about 8.5 per cent. However, the container growth rate is not a true reflection of actual import and export growth as it includes double handled containers.

The mass tonnes data, however, indicate that annual growth has averaged about 4.3 per cent over the same period. The mass tonnes closely reflect actual imports and exports. Therefore, the expected growth over the forecast period of 2.3 or 5 per cent by the two models used is realistic.

To test the reliability and accuracy of the forecasts, the forecast for the first year was compared with actual results. The forecasts were derived from available data on containers handled up to June 2001. The actual number of containers handled during 2001–02 became available before the completion of the study. Table 5.3 shows actual and forecast container numbers.

TABLE 5. 3 COMPARISON OF FORECAST AND ACTUAL CONTAINERS—ARIMA MODEL

	Import & export containers —Actual (millions)	*Import & export containers —Forecast (millions)*	*All containers—Actual (millions)*	*All containers—Forecast (millions)*
2000–01	2.184	na	2.484	na
2001–02	2.268	2.270	2.594	2.6
Growth rate (%)	3.9	3.9[a]	4.4	4.4[a]

Note *Note* na not applicable

Note a The forecast growth rate was calculated from the forecast number of containers handled in 2001-02 and the actual number handed in 2000–01.

Source Source BTRE

Although the forecasts in table 5.3 are based on data for only one year, they nonetheless demonstrate the accuracy of the models used.

Gardiner (2001) forecasted that world container movements measured in TEUs would increase from the present figure of about 230 million TEUs to 400–600 million TEUs by 2010. The lower bound of 400-million TEUs was predicated on economic events that would lead to a decline in the major economies. The events of 11 September 2001 occurred after the forecasts were published, suggesting that Gardiner's lower scenario forecast of 400 million TEUs is more likely to eventuate.

Australia's share of the world TEU market is about 1.3 per cent. The BTRE forecast indicates that, at the end of the decade, Australia's share will be almost steady at about 1.3 per cent. The BTRE forecast is therefore consistent with Gardiner's lower bound growth estimate.

As with any forecast, these results are based on a number of assumptions about Australia's economic growth and that of its major trading partners. The key economic factors are Australia's gross domestic product (GDP), trade weighted index (TWI) and GDP of OECD or G7 countries. The availability of empty containers can also have some effect on containerised exports.

Barring unexpected major economic setbacks, the BTRE believes that these forecasts are robust, even in the context of pessimistic world economic forecasts.

Some container growth in Australia is likely, as greater quantities of bulk commodities such as grain, salt and coal are being containerised for shipment to certain niche markets.

CHAPTER 6 IMPACT OF 40-FOOT CONTAINERS

SENSITIVITY ANALYSIS

The base case analysis discussed in the preceding chapters are based on 40-foot container proportions varying between 31 and 35 per cent of total containers over the forecast period 2001–02 to 2010–11.

Compared with 20-foot containers, 40-foot containers are cost-effective for importers and exporters and are easier to load onto, and unload from, ships with 40-foot cells. The introduction of the Waterfront Redundancy Scheme ($12 per 20-foot or 40-foot container) may also have provided incentives for shippers to use the larger containers.

A growth projection using time series data for 40-foot containers suggests that 40-foot container proportions could increase to 56 per cent over the forecast period. This high growth scenario is achievable, but very unlikely during the forecast period, given the large investment already made in 20-foot containers and some constraints in transport infrastructure.

Nevertheless, the sensitivity analysis uses the high growth scenario of 40-foot containers reaching 56 per cent, with an average of 45 per cent over the forecast period. In carrying out the sensitivity analysis, different container load weight configurations were used together with the higher 40-foot container proportions of up to 56 per cent.

Table 6.1 shows the effect of the increasing proportion of 40-foot containers over the forecast period. Figure 6.1 shows forecasts for combined import and export containers (20-foot and 40-foot). The upper line represents the base case forecast and the lower line represents the forecast incorporating the high growth scenario for 40-foot containers.

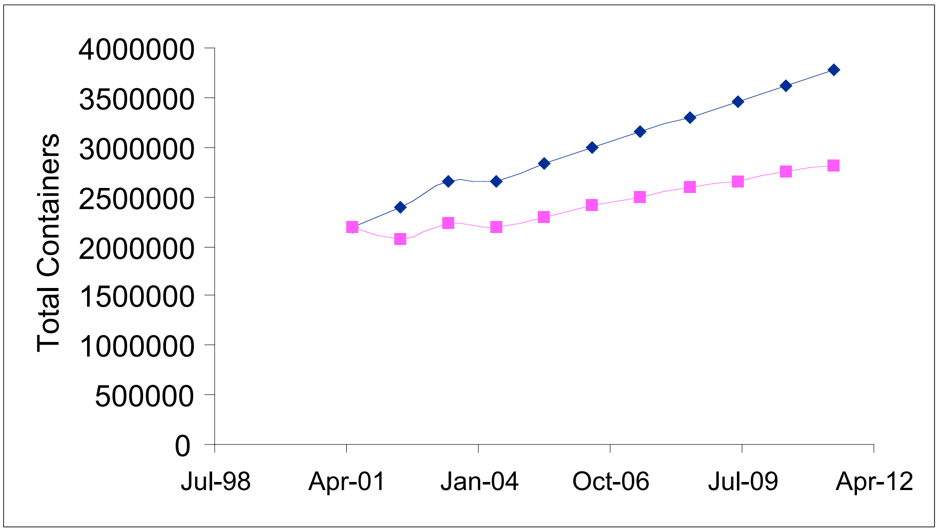
If the uptake of 40-foot containers turns out to be up to 56 per cent, there could be up to a three-fold increase in 40-foot containers handled in the next decade (from about 700 000 currently to up to 2.1 million by 2010–11). This means that the number of larger and heavier containers transported domestically by road and rail would also increase substantially. The forecast growth in overall containers and the expected increase in the proportion of 40-foot containers are, therefore, important considerations in the planning and provision of port, road and rail infrastructure.

TABLE 6.1 FORECAST IMPACT OF 40-FOOT CONTAINERS (MILLIONS)

Year	*Import & Export*	*40-ft impact*	*Containers reduced*
2001–02	2.394	2.074	0.320
2002–03	2.650	2.238	0.412
2003–04	2.656	2.200	0.456
2004–05	2.831	2.300	0.531
2005–06	2.989	2.409	0.580
2006–07	3.147	2.488	0.659
2007–08	3.304	2.590	0.715
2008–09	3.461	2.663	0.798
2009–10	3.616	2.755	0.861
2010–11	3.770	2.821	0.949

Source BTRE

FIGURE 6.1 CONTAINER GROWTH FORECASTS



Note Note: The upper line represents the base case forecast and the lower line represents the forecast incorporating the high growth for 40-foot containers

Source BTRE

APPENDIX I CONTAINER TRADE AND PORTS

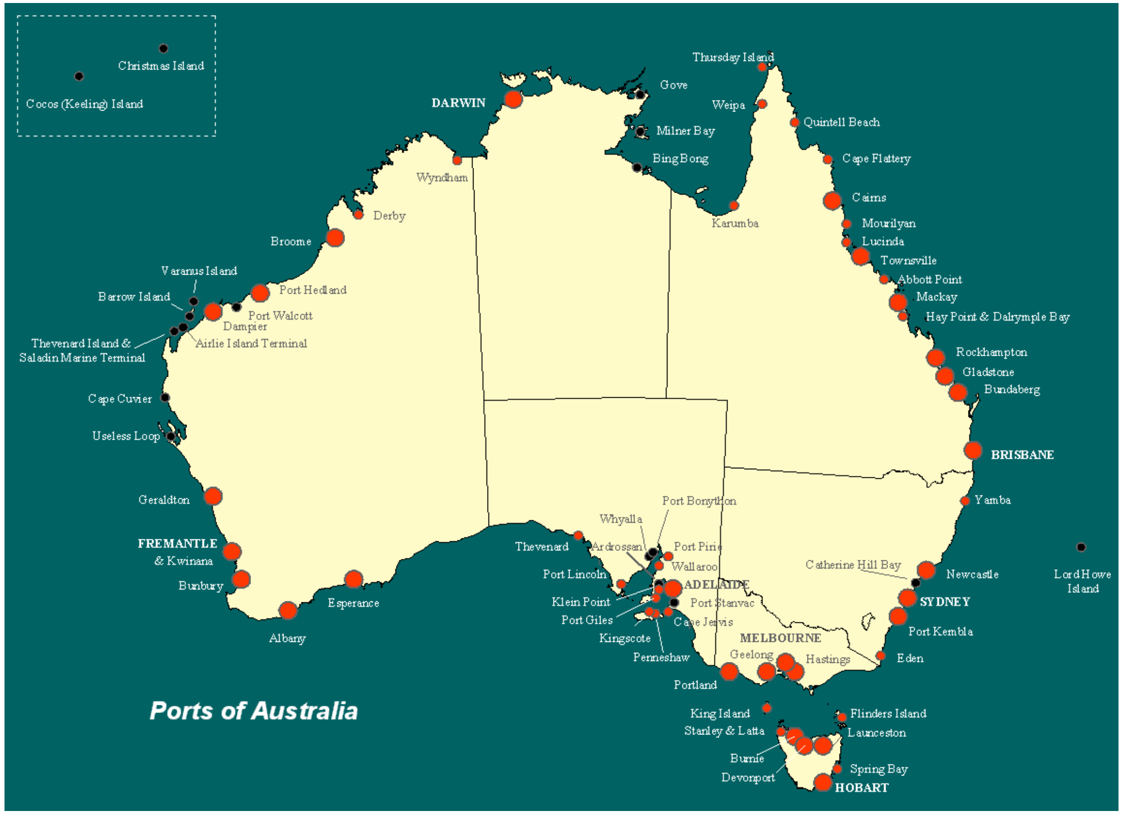
TABLE I. 1 2000–01 CONTAINERISED TRADE (TEU's)

Port	*Imports Full*	*Empty*	*All Imports*	*Exports Full*	*Empty*	*All Exports*	*Total*	*% of Total*
Melbourne	573 348	99 504	672 852	525 106	124 723	649 829	1 322 681	0.36
Sydney	493 345	19 522	512 867	306 071	171 716	477 787	990 654	0.27
Brisbane	153 494	74 584	228 078	194 440	30 811	225 251	453 329	0.12
Fremantle	136 526	47 582	184 108	44 506	125 613	170 119	354 227	0.10
Adelaide	36 395	20 597	56 992	63 762	10 975	74 737	131 729	0.04
5 Port Total	**1 393 108**	**261 789**	**1 654 897**	**1 133 885**	**463 838**	**1 597 723**	**3 252 620**	**0.89**
Burnie	46 871	15 345	62 216	71 726	6 630	78 356	140 572	0.04
Devonport	59 663	8 054	67 717	41 333	19 987	61 320	129 037	0.04
Launceston	5 144	10 673	15 817	18 237	518	18 755	34 572	0.010
Townsville	4 197	6 585	10 782	10 978	907	11 885	22 667	0.006
Newcastle	537	3,851	4,388	8,736	40	8,776	13,164	0.004
Cairns	606	6 001	6 607	5 818	324	6 142	12 749	0.004
Darwin	3 343	22	3 365	878	2 019	2 897	6 262	0.002
Gladstone	321	2 135	2 456	3 300	2	3 302	5 758	0.002
Port Pirie	967	2 193	3 160	2 950	55	3 005	6 165	0.002
Toll Geelong	2 298	0	2 298	1 845	0	1 845	4 143	0.001
Rockhampton	1 682	0	1 682	1 943	6	1 949	3 631	0.001
Hobart	344	901	1 245	437	0	437	1 682	0.000
Broome	455	0	455	0	353	353	808	0.000
Port Kembla	188	0	188	387	0	387	575	0.000
Port Hedland	103	0	103	0	0	0	103	0.000
Yamba	0	0	0	8	0	8	8	0.000
Total	1 519 827	317 549	1 837 376	1 302 461	494 679	1 797 140	3 634 516	100
5 Port %	**92**	**82**	**90**	**87**	**94**	**89**	**89**	

Note Nine other small ports recorded no containers handled

Source AAPMA and BTRE estimates.

FIGURE I. 1 PORTS OF AUSTRALIA



Source AAPMA

APPENDIX II IMPORTS AND EXPORTS FORECASTS—ECONOMETRIC MODEL

TABLE II. 1 IMPORTS FORECAST (TONNES)

Date	*Prediction*	*Lower*	*Upper*	*Actual*
Sep-94				2 377 000
Dec-94				2 490 000
Mar-95				2 578 000
Jun-95	2 148 970	1 795 156	2 348 412	2 102 000
Sep-95	2 270 048	1 897 649	2 484 214	2 343 000
Dec-95	2 385 947	2 040 979	2 542 798	2 517 000
Mar-96	2 394 027	2 078 440	2 512 114	2 349 000
Jun-96	2 285 405	1 983 263	2 477 532	2 118 000
Sep-96	2 489 120	2 162 084	2 595 620	2 786 000
Dec-96	2 640 399	2 278 994	2 608 541	2 356 000
Mar-97	2 372 456	2 050 316	2 665 244	2 360 000
Jun-97	2 821 404	2 427 216	2 975 755	2 732 000
Sep-97	2 889 954	2 517 616	2 882 731	3 058 000
Dec-97	2 974 308	2 585 890	3 023 176	3 175 000
Mar-98	2 880 958	2 501 930	3 101 216	2 907 000
Jun-98	2 957 911	2 571 296	3 214 793	2 936 000
Sep-98	3 192 167	2 768 821	3 321 617	3 145 000
Dec-98	3 342 719	2 889 781	3 441 257	3 194 000
Mar-99	3 261 677	2 812 105	3 460 079	3 064 000
Jun-99	3 132 922	2 705 539	3 309 711	3 109 000
Sep-99	3 331 836	2 892 112	3 375 597	3 479 780
Dec-99	3 381 143	2 928 959	3 508 508	3 751 050
Mar-00	3 430 080	2 974 473	3 669 528	3 399 790
Jun-00	3 255 056	2 824 825	3 615 406	3 090 140
Sep-00	3 363 463	2 905 515	3 555 602	3 287 890
Dec-00	2 995 072	2 544 019	3 109 764	2 892 620
Mar-01	3 006 695	2 562 612	3 231 760	3 122 190
Jun-01	3 061 971	2 606 925	3 352 781	3 114 560
Sep-01	3 230 053	2 782 016	3 525 696	
Dec-01	3 024 954	2 593 773	3 281 950	
Mar-02	3 121 871	2 648 523	3 296 739	
Jun-02	3 240 682	2 733 412	3 477 478	

TABLE II.1 (CONT.) IMPORTS FORECAST (TONNES)

Date	*Prediction*	*Lower*	*Upper*
Sep-02	3 666 183	3 071 626	4 011 252
Dec-02	3 751 185	3 145 449	4 090 179
Mar-03	3 713 001	3 108 794	4 034 392
Jun-03	3 613 831	3 048 297	3 857 911
Sep-03	3 653 224	3 079 973	3 914 554
Dec-03	3 698 945	3 116 677	3 970 676
Mar-04	3 753 220	3 160 829	4 028 451
Jun-04	3 805 609	3 203 372	4 087 636
Sep-04	3 854 564	3 242 942	4 147 647
Dec-04	3 904 268	3 282 856	4 207 963
Mar-05	3 956 176	3 324 437	4 268 890
Jun-05	4 008 237	3 365 998	4 330 677
Sep-05	4,059,682	3 406 917	4 393 314
Dec-05	4 111 385	3,447,882	4,456,602
Mar-06	4 163 805	3 489 263	4 520 472
Jun-06	4 216 493	3 530 684	4 584 974
Sep-06	4 269 187	3 571 947	4 650 157
Dec-06	4 322 103	3 613 232	4 715 996
Mar-07	4 375 398	3 654 667	4 782 445
Jun-07	4 428 963	3 696 154	4 849 484
Sep-07	4 482 695	3 737 611	4 917 120
Dec-07	4 536 640	3 779 078	4 985 354
Mar-08	4 590 859	3 820 610	5 054 176
Jun-08	4 645 334	3 862 189	5 123 569
Sep-08	4 700 026	3 903 784	5 193 525
Dec-08	4 754 936	3 945 396	5 264 041
Mar-09	4 810 084	3 987 044	5 335 112
Jun-09	4 865 471	4 028 728	5 406 732
Sep-09	4 921 084	4 070 440	5 478 894
Dec-09	4 976 919	4 112 178	5 551 592
Mar-10	5 032 980	4 153 944	5 624 821
Jun-10	5 089 269	4 195 741	5 698 578
Sep-10	5 145 781	4 237 567	5 772 858
Dec-10	5 202 513	4 279 420	5 847 657
Mar-11	5 259 467	4 321 302	5 922 969
Jun-11	5 316 640	4 363 213	5 998 793

TABLE II. 2 EXPORTS FORECAST (TONNES)

Date	*Prediction*	*Lower*	*Upper*	*Actual*
Sep-94				2 867 000
Dec-94				2 924 000
Mar-95				2 917 000
Jun-95				2 742 000
Sep-95	3 331 532	2 727 453	3 679 854	3 109 000
Dec-95	3 598 647	2 953 678	3 962 207	3 621 000
Mar-96	3 547 858	2 937 456	3 848 692	3 216 000
Jun-96	3 142 704	2 600 779	3 387 527	3 125 000
Sep-96	4 088 691	3 369 299	4 544 487	4 056 000
Dec-96	3 629 492	2 962 254	3 971 380	3 564 000
Mar-97	3 684 541	3 010 020	4 133 697	4 082 000
Jun-97	4 067 133	3 372 867	4 375 072	4 187 000
Sep-97	4 839 040	3 986 405	5 279 400	5 077 000
Dec-97	4 905 618	4 055 587	5 455 517	4 747 000
Mar-98	4 336 646	3 614 917	4 677 685	4 168 000
Jun-98	4 227 702	3 528 749	4 607 249	4 239 000
Sep-98	4 712 637	3 937 333	4 987 075	4 681 000
Dec-98	4 987 554	4 170 712	5 252 472	5 776 000
Mar-99	4 805 248	4 010 789	5 077 627	4 741 000
Jun-99	4 822 706	4 045 245	5 006 629	5 081 000
Sep-99	5 186 803	4 341 941	5 682 240	5 299 900
Dec-99	5 925 276	4 918 754	6 380 036	5 476 800
Mar-00	5 176 938	4 295 128	5 726 130	5 175 500
Jun-00	4 662 042	3 830 864	5 183 072	4 965 900
Sep-00	5 152 272	4 251 749	5 553 774	4 771 200
Dec-00	4 747 001	3 904 758	5 205 022	4 509 700
Mar-01	5 340 522	4 346 003	6 142 697	4 930 060
Jun-01	5 378 424	4 335 690	6 121 869	5 798 020
Sep-01	6 098 705	4 395 471	8 038 121	
Dec-01	5 734 351	3 922 577	7 814 551	
Mar-02	5 611 564	3 905 050	7 865 359	
Jun-02	5 670 243	4 267 523	7 097 162	
Sep-02	6 224 303	5 037 423	7 089 154	
Dec-02	6 345 780	5 139 990	7 127 561	
Mar-03	6 156 171	4 955 857	7 016 771	
Jun-03	5 799 181	4 676 734	6 569 843	
Sep-03	5 861 735	4 742 892	6 623 379	
Dec-03	6 016 667	4 881 585	6 757 635	
Mar-04	6 195 712	5 020 670	6 980 623	
Jun-04	6 303 600	5 095 020	7 128 482	
Sep-04	6 394 382	5 153 925	7 268 152	
Dec-04	6 485 809	5 212 825	7 404 904	
Mar-05	6 579 094	5 272 597	7 548 223	
Jun-05	6 675 874	5 334 143	7 695 270	

Table II.2 (CONT.) EXPORTS FORECAST (TONNES)

Date	*Prediction*	*Lower*	*Upper*
Sep-05	6 769 426	5 392 077	7 841 780
Dec-05	6 862 681	5 448 982	7 988 289
Mar-06	6 956 171	5 505 316	8 136 973
Jun-06	7 050 231	5 561 241	8 287 479
Sep-06	7 143 308	5 615 505	8 438 722
Dec-06	7 235 950	5 668 596	8 590 782
Mar-07	7 328 426	5 720 742	8 744 252
Jun-07	7 420 791	5 771 953	8 899 091
Sep-07	7 512 604	5 821 871	9 054 952
Dec-07	7 603 917	5 870 552	9 211 807
Mar-08	7 694 835	5 918 086	9 369 844
Jun-08	7 785 377	5 964 477	9 529 095
Sep-08	7 875 399	6 009 606	9 689 451
Dec-08	7 964 863	6 053 445	9 850 869
Mar-09	8 053 781	6 096 010	10 013 397
Jun-09	8 142 155	6 137 299	10 177 060
Sep-09	8 229 933	6 177 268	10 341 834
Dec-09	8 317 072	6 215 886	10 507 697
Mar-10	8 403 554	6 253 141	10 674 652
Jun-10	8 489 363	6 289 022	10 842 711
Sep-10	8 574 469	6 323 506	11 011 869
Dec-10	8 658 840	6 356 570	11 182 119
Mar-11	8 742 450	6 388 198	11 353 460
Jun-11	8 825 275	6 418 374	11 525 894

TABLE II.3 FORECASTS OF TOTAL CONTAINER THROUGHPUT—ARIMA MODEL

Month	*Model Data*	*Date (six monthly)*	*Total containers*	*Predict*	*Upper*	*Lower*
1/02/99	165 290	1/03/99	899 374	725 689	777 508	673 869
1/03/99	184 191	1/07/99	1 238 512	1 228 310	1 306 040	1 150 581
1/04/99	173 242	1/01/00	1 230 220	1 220 126	1 274 642	1165 610
1/05/99	189 885	1/07/00	1 313 556	1 315 251	1 358 161	1 272 341
1/06/99	186 766	1/01/01	1 170 282	1 174 572	1 217 481	1 131662
1/07/99	196 073	1/07/01		1 306 232	1 383 697	1 228 767
1/08/99	198 337	1/01/02		1 293 205	1 424 918	1 161493
1/09/99	195 618	1/07/02		1 399 170	1 548 411	1 249 930
1/10/99	222 517	1/01/03		1 277 541	1 427 801	1 127 282
1/11/99	215 167	1/07/03		1 408 509	1 574 151	1 242 866
1/12/99	210 800	1/01/04		1 377 434	1 566 238	1 188 630
1/01/00	198 778	1/07/04		1 487 554	1 686 582	1 288 526
1/02/00	200 412	1/01/05		1 380 973	1 582 192	1 179 755
1/03/00	210 043	1/07/05		1 508 476	1719 682	1 297 270
1/04/00	203 472	1/01/06		1 464 853	1 690 856	1 238 851
1/05/00	209 562	1/07/06		1 577 862	1 811 598	1 344 127
1/06/00	207 953	1/01/07		1 481 744	1 718 557	1 244931
1/07/00	207 373	1/07/07		1 606 838	1 851 410	1 362 266
1/08/00	224 945	1/01/08		1 554492	1 809 836	1 299 148
1/09/00	214 990	1/07/08		1 669 509	1 931 381	1 407 637
1/10/00	229 297	1/01/09		1 580 665	1 846 196	1 315134
1/11/00	225 367	1/07/09		1 704 085	1 976 190	1 431 980
1/12/00	211 584	1/01/10		1 645 673	1 926 264	1 365 082
1/01/01	188 548	1/07/10		1 762 086	2 048 502	1 475 671
1/02/01	183 929	1/01/11		1 678 300	1 968 711	1 387 889
1/03/01	204 585					
1/04/01	196 321					
1/05/01	198 125					
1/06/01	198 774					

d. *Note* Includes transhipment and local containers.

Source BTRE

TABLE II. 4 FORECASTS OF EXPORT AND IMPORT CONTAINERS—ARIMA MODEL

Month	*Model Data*	*Date (six monthly)*	*Actual export & Importt*	*Predict*	*Upper*	*Lower*
1/02/99	149 554	1/03/99	805 418	646 867	694 220	599 515
1/03/99	166 355	1/07/99	1 107 926	1 093 489	1 161422	1 025 556
1/04/99	154 615	1/01/00	1 085 810	1 076 498	1 121 210	1 031 786
1/05/99	167 990	1/07/00	1 156 291	1 158 240	1 192 035	1 124 446
1/06/99	166 904	1/01/01	1 028 127	1 032 232	1 066 026	998 437
1/07/99	174 662	1/07/01		1 147 894	1 194 456	1 101 332
1/08/99	177 820	1/01/02		1 121 963	1 193 680	1 050 246
1/09/99	177 589	1/07/02		1 209 792	1 290 554	1 129 030
1/10/99	199 81	1/01/03		1 094 850	1 175 998	1 013 702
1/11/99	189 294	1/07/03		1 210 391	1 301 358	1 119 425
1/12/99	189 280	1/01/04		1 172 699	1 275 528	1 069 870
1/01/00	177 306	1/07/04		1 264 189	1 372 152	1 156 227
1/02/00	176 739	1/01/05		1 159 454	1 268 181	1 050 727
1/03/00	184 399	1/07/05		1 271 818	1 386 684	1 156 951
1/04/00	178 926	1/01/06		1 225 267	1 348 007	1102 527
1/05/00	183 559	1/07/06		1 319 516	1 446 009	1 193 022
1/06/00	184 881	1/01/07		1 222 468	1 350 071	1 094 866
1/07/00	183 245	1/07/07		1 332 438	1 464 581	1 200 295
1/08/00	201 363	1/01/08		1 279 216	1 417 202	1 141229
1/09/00	191 029	1/07/08		1 375 541	1 516 622	1 234 461
1/10/00	203 038	1/01/09		1 284 285	1 426 745	1 141 824
1/11/00	194 044	1/07/09		1 392 452	1 538 587	1 246 317
1/12/00	183 572	1/01/10		1 34 204	1 484 970	1 183 437
1/01/01	168 862	1/07/10		1 432 094	1 585 590	1 278 598
1/02/01	160 948	1/01/11		1 345 199	1 500 270	1 190 127
1/03/01	178 660					
1/04/01	171 602					
1/05/01	172 068					
1/06/01	175 987					

e. *Note* Excludes transhipment and local containers.

Source BTRE

APPENDIX III MODELLING DETAILS AND RESULTS

AUTOREGRESSIVE MODELLING

Values of a series of data at particular points in time are often highly correlated with the values that precede and succeed them. A first-order autocorrelation refers to the magnitude of the association between consecutive values in a time series. A second-order autocorrelation refers to the magnitude of the relationship between values two periods apart. Thus, a *p*th-order autocorrelation refers to the magnitude of the correlation between values in a time series that are *p* periods apart. The autoregressive modelling method provides a means of using the potential autocorrelation features in the data series to obtain a better historical fit of the data and to make useful forecasts of their future behaviour. A modelling approach in the SAS/ETS User Guide is described below.

Autoregressive Integrated Moving-Average (ARIMA)

The ARIMA procedure in SAS analyses and forecasts equally spaced univariate time series data using the autoregressive moving-average (ARIMA) model. An ARIMA model predicts a value in a response time series as a linear combination of its own past values, past errors (also called shocks or innovations), and current and past values of other time series.

The ARIMA approach was popularised by Box and Jenkins, and ARIMA models are often referred to as Box-Jenkins models. The general transfer function model employed by the ARIMA procedure was discussed by Box and Tiao (1975). When an ARIMA model includes other time series as input variables, the model is sometimes referred to as an ARIMAX model. Pankratz (1991) refers to the ARIMAX model as 'dynamic regression'.

General notation for ARIMA models

ARIMA is an acronym for autoregressive integrated moving average. The order of an ARIMA model is usually denoted by the notation ARIMA(p,d,q), where

p is the order of the autoregressive part

d is the order of the differencing

q is the order of the moving-average process

If no differencing is done ($d = 0$), the models are usually referred to as ARIMA(p,q) models.

Notation for pure ARIMA models

$$W_t = \mu + \frac{\theta(B)}{\phi(B)} a_t$$

Mathematically, the pure ARIMA model is written as

Where

μ

t indexes time, W_t is the response series Y_t or a difference of the response series

is the mean term

$\phi(B)$

B is the backshift operator; that is, $BX_t = X_{t-1}$

is the autoregressive operator, represented as a polynomial in the back shift

$\phi(B) = 1 - \phi_1 B - \ldots - \phi_p B^p$

operator:

is the moving-average operator, represented as a polynomial in the back shift operator:

$\theta(B) = 1 - \theta_1 B - \ldots - \theta_q B^q$

a_t is the independent disturbance, also called the random error.

For simple (nonseasonal) differencing, $W_t=(1-B)^d Y_t$. For seasonal differencing $W_t=(1-B)^d(1-B^s)^D Y_t$, where d is the degree of nonseasonal differencing, D is the degree of seasonal differencing, and s is the length of the seasonal cycle. For example, the mathematical form of the ARIMA(1,1,1) model

Model constant term

$$\phi(B)(W_t - \mu) = \theta(B)a_t$$

The ARIMA model can also be written as

$$\phi(B)W_t = const + \theta(B)a_t$$

or

where

$$const = \phi(B)\mu = \mu - \phi_1\mu - \phi_2\mu - \ldots - \phi_p\mu$$

Thus, when an autoregressive operator and a mean term are both included in

$$\phi(B)\mu$$

the model, the constant term for the model can be represented as

THE DISTRIBUTED LAG MODEL

The SAS procedure for PDL regression estimates regression models for time series data in which the effects of some of the regressor variables are distributed across time. The distributed lag model assumes that the effect of an input variable X on an output Y is distributed over time. If the value of X at time *t* is changed, Y will experience some immediate effect at time *t*, and it will also experience a delayed effect at times *t*+1, *t*+2, and so on up to time *t*+*p* for some limit *p*.

The regression model in SAS can include any number of regressors with distribution lags and any number of covariates. (Simple regressors without lag distributions are called covariates.) For example, the two-regressor model with a distributed lag effect for one regressor is written:

$$y_t = \alpha + \sum_{i=0}^{p} \beta_i x_{t-i} + \gamma z_t + u_t$$

Here, x_t is the regressor with a distributed lag effect, z_t is a simple covariate, and u_t is an error term.

The distribution of the lagged effects is modelled by Almon lag polynomials. The coefficients b_i of the lagged values of the regressor are assumed to lie on a polynomial curve. That is,

$$b_i = \alpha_0^* + \sum_{j=1}^{d} \alpha_j^* i^j$$

$d(\leq p)$

where

s the degree of the polynomial. For the numerically efficient estimation, the PDL regression procedure uses orthogonal polynomials.

The PDL regression as used in SAS supports endpoint restrictions for the polynomial. That is, the estimated polynomial lag distribution curve can be constrained so that b_{-1}=0 or b_{p+1}=0, or both. Linear restrictions on the parameter estimates for the covariates can also be imposed.

A minimum degree and a maximum degree for the lag distribution polynomial can be specified, and the procedure fits polynomials for all degrees in the specified range. (However, if distributed lags are specified for more that one regressor, a range of degrees for only one of them can be specified.)

The SAS program compiled to forecast imports is given below.

SAS program

```
data econ;
set xmt.ownfcst2;
*rtwi=rtwif; TWI=twif; rgdpa=rgdpaf; usd=usdf;
rgdpg7=rgdpg7f;
run;

data regall;
set xmt.qrtdata ; *(obs=28 keep= date export sexport import
simport);
run;
data regdata;
merge econ regall ; by date;  run;
/*transforming variables to log */
data regdat2;
set work.regdata;
```

```
if date in ( 15249, 15341, 15431) then
rgdpaf=(rgdpaf*0.99); /*adjusting forcast by 2 %)*/
limp=log(import);
LTWI=log(TWIf);
LRTWI=log(RTWIf);
LRgdp7=log(rgdpG7f);
lgdpa=log(rgdpaf);
/* including dummy variable)*/
format date comma12.;
Dummy=Date;
If Dummy
in(14153,14245,14335,14426,14518,14610,14701,14792) then
dummy=1; else dummy=0;
run;
/* stationarity test*/
proc arima data= regdat2 (obs=28);
identify var =lgdpa stationarity=(ADF=(0,1,2)) minic; /*ADF
Dickey fuller lag 0,1& 2. (2,5)=lag 2 & 5)*/
identify var =ltwi stationarity=(PP=2) minic; /*PP phillip
Perron lag 0-2*/
identify var =limp stationarity=(ADF=(2,5));
/*note Minic=minimum info cretrion-identify how
stationarity should be corrected
run;

/*Actual model of equation*/
Proc pdlreg data=regdat2;
Model limp=ltwi(1) lgdpa(3,2) /nlags=2
covb partial itprint coef dwprob
method= ML
slstay=0.05
converge=0.05 maxiter=15;
output out= Work.CC2 residual=resid
predicted=forecast
lcl=lower uclm=upper
alphacli=0.05
alphaclm=0.05;
run;

/*Testing for Cointegration using residual
proc arima data= CC2;
identify var =resid stationarity=(ADF=(0,1,2));
run;
data DD2;
set work.CC2;
/*transform log to numbers if analysis is loglog*/
*if lsimp>1 then do;
Limpt=exp(Limp);
*end;
```

```
forecast=exp(forecast);
upper=exp(upper);
lower=exp(lower);
run;

data EE2;
set work.DD2 (keep=Date forecast upper lower limpt);
format date YYQC6.;  /*reverting date to formal quarter
date;*/
run;

proc print data=EE2;
run;
/*Ploting results of modellinh*/
goptions reset=(axis, legend, pattern, symbol, title,
footnote) norotate
hpos=0 vpos=0 htext= ftext= ctext= target= gaccess=
gsfmode= ;
 goptions device=WIN  ctext=blue
graphrc interpol=join;
axis1
color=blue
width=2.0;
axis2
color=blue
width=2.0;
axis3
color=blue
width=2.0;

proc gplot data=EE2;
plot (limpt forecast upper lower ) * Date / overlay
haxis=axis1
vaxis=axis2
frame;
run;
```

STATISTICAL PROPERTIES OF THE MODELS

Statistical properties of the imports model

SSE	0.0696	*DFE*	17
MSE	0.004	*Root MSE*	0.064
SBC	-49.812	*AIC*	-59.56
Regress R-Square	0.922	*Total R-Square*	0.88
Durbin-Watson	2.208	*Pr < DW*	0.55
Pr > DW	0.45		

f. Pr < DW is p value for testing positive autocorelation and Pr > DW is p value for testing negative autocorelation

g.

Estimate of lag distribution

Variable	*Estimate*	*Standard Error*	*t Value*	*Approx Pr > |t|*
Constant	1.10	1.5134	0.73	0.477
TWI(0) short run	**-0.12**	**0.295**	**-0.41**	**0.687**
TWI(1)	0.56	0.2774	2.02	0.060
Sum (Long run)	**0.44**		**1.98**	**0.065**
GDP(0) short run	**8.018**	**2.208**	**3.63**	**0.002**
GDP(1)	1.016	1.9003	0.53	0.600
GDP(2)	-3.036	1.8238	-1.66	0.114
GDP(3)	-4.136	2.3915	-1.73	0.102
Sum (Long run)	**1.862**		**12.28**	**<.0001**

The above model can be written as:

$$import_t = 1.10 - 0.12 twi_t + 0.56 twi_{t-1} +$$

$$8.02 gdp_t + 1.02 gdp_{t-1} - 3.04 gdp_{t-2} - 4.14 gdp_{t-3}$$

Augmented Dickey Fuller Unit Root Test (cointegration)

Type	*Lags*	*Rho*	*Pr < Rho*	*Tau*	*Pr < Tau*	*F*	*Pr > F*
Zero Mean	0	-26.6824	<.0001	-5.37	<.0001		
	1	-30.9285	<.0001	-3.72	0.0007		
	2	-158.472	0.0001	-3.96	0.0004		
Single mean	0	-26.6783	<.0001	-5.25	0.0004	13.79	0.001
	1	-30.9441	<.0001	-3.63	0.0129	6.59	0.0206
	2	-161.573	0.0001	-3.87	0.0079	7.48	0.007
Trend	0	-26.6925	0.0011	-5.13	0.002	13.17	0.001
	1	-30.9587	<.0001	-3.52	0.0606	6.26	0.0868
	2	-150.402	0.0001	-3.72	0.0428	7.14	0.0538

Statistical properties of the exports model

SSE	0.0861	*DFE*	14
MSE	0.00615	*Root MSE*	0.078
SBC	-35.061	*AIC*	-46.84
Regress R-Square	0.90	*Total R-Square*	0.89
Durbin-Watson	2.01	*Pr < DW*	0.34
Pr > DW	0.66		

h. Pr < DW is p value for testing positive autocorelation and Pr > DW is p value for testing negative autocorelation

i.

Estimate of lag distribution

Variable	*Estimate*	*Standard Error*	*t Value*	*Approx Pr > |t|*
Constant	-11.256	4.3934	-2.56	0.0226
GDP-G7(0) short run	**-0.759**	**2.2376**	**-0.34**	**0.7396**
GDP-G7(1)	-0.193	1.1606	-0.17	0.8702
GDP-G7(2)	0.372	0.1779	2.09	0.055
GDP-G7(3)	0.938	1.03	0.91	0.3779
GDP-G7(4)	1.503	2.1059	0.71	0.487
Sum (Long run)	**1.862**		**2.09**	**0.055**
Import container(0) short run	**1.038**	**0.1999**	**5.19**	**0.0001**
Import container (1)	-0.075	0.2056	-0.36	0.7207
Import container (2)	-0.063	0.1913	-0.33	0.7487
Import container (3)	-0.335	0.2107	-1.59	0.1337
Sum (Long run)	**0.565**		**1.67**	**0.1163**

Augmented Dickey Fuller Unit Root Test (cointegration)

Type	*Lags*	*Rho*	*Pr < Rho*	*Tau*	*Pr < Tau*	*F*	*Pr > F*
Zero Mean	0	-24.4839	<.0001	-4.97	<.0001		
	1	-19.9947	0.0003	-3.01	0.0044		
	2	-33.2733	<.0001	-2.98	0.0048		
Single Mean	0	-24.4415	0.0002	-4.83	0.0008	11.79	0.001
	1	-19.963	0.0019	-2.93	0.0576	4.31	0.0909
	2	-33.87	<.0001	-2.93	0.0589	4.36	0.0888
Trend	0	-24.4778	0.0027	-4.72	0.0053	11.15	0.001
	1	-19.9859	0.0164	-2.86	0.1931	4.09	0.418
	2	-31.845	<.0001	-2.89	0.1851	4.38	0.3666

Augmented Dickey Fuller Unit root test (univariate) ARIMA model

Total import and export data unit root test significance probability is 0.0004, indicating that (at 0.05 significance level) a stationary series is likely. Total containers handled significance probability is 0.0002. Again, the conclusion (at 0.05 significance level) is that a stationary series is likely.

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