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Strategic Interaction amongst Australia's East Coast Ports*

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Strategic Interaction amongst Australia's East Coast Ports

Abstract:

Australia's principal container ports, located in its state capitals, are owned and operated by state authorities that largely return profits from port operations to state governments. Since they govern the volumes of trade in most merchandise, they command immense influence over the openness and flexibility of the national economy. In this study, we estimate the elasticities of substitution between services of ports in Brisbane, Sydney and Melbourne. We also examine the pricing of port services to estimate the extent of their interaction, from which we derive conjectural variations parameters to assess the actual and potential levels of price collusion. The results confirm that there is considerable potential for destructive oligopoly behaviour and that pricing by the apparently isolated Port of Melbourne has been effectively controlled by price-cap regulation. The services of the ports of Sydney and Brisbane are comparatively substitutable, however. Although their regulation appears to be less restrictive, this substitutability appears to result in some level of competition, which aids in the control of pricing.

1. Introduction

Australia's principal container ports are located in its state capitals. They are owned and operated by state authorities that largely return profits from port operations to state governments. Since they govern the volumes of trade in most merchandise, they command immense influence over the openness and flexibility of the national economy. The ports of the east coast are operated by the Port of Melbourne Corporation, the Sydney Ports Corporation and the Port of Brisbane Corporation. They are the largest players in the Australian container ports industry and together they hold market shares totalling approximately 80%[1]. Although these ports tend to serve different hinterlands, land transport networks are sufficiently extensive that their markets overlap. It might therefore be assumed that their pricing decisions affect their respective throughput volumes both through their influence over total trade flows and via substitution between ports.

In this study we use data on quantities exchanged in ports, prices charged for their services and final demand by state[2] to estimate pair-wise elasticities of substitution between the services of East Coast ports. We also derive conjectural variations parameters to measure the extent of price collusion between ports. These estimates are

[1] According to data supplied by the Association of Australian Ports and Marine Authorities (AAPMA) the market shares in containerised trade in financial year 2004/2005, measured in both full and empty Twenty Foot Equivalent Units (TEUs), exchanged were: Port of Melbourne- 36.9%, Sydney Ports- 26.6%, Port of Brisbane- 14.0%, Port of Fremantle- 9.0%, Others- 13.5%.

[2] Final demand is a measured proxy for state GDP.

put into a wider modelling framework to back out estimates for overall demand elasticities for port services and, subsequently, draw conclusions about the ports' optimal pricing behaviour in the absence of regulation. Our main finding is that elasticities of substitution are quite small and hence that there is considerable scope for use of the monopoly power in the container ports industry.

Among the studies of oligopolistic markets based on the conjectural variations approach the benchmark is a paper by Iwata (1974). He studied firm behaviour in the Japanese flat glass industry in the period from 1956 to 1965. Brander and Zhang (1990) applied the notion of conjectural variations to the set of duopoly airline routes in the United States while a similar approach was used by Bresnahan (1987) to study the American automobile industry in the 1950's. Another line of research in this area has been aimed at estimating the elasticities of substitution between imported and domestically produced goods (the so-called Armington elasticities). For Australia, these were estimated by Alaouze, Marsden and Zeitsch (1977) as part of the project financed by the Industries Assistance Commission. Welsch (2006) studied Armington elasticities for France during 1970-1997 and found that, while initially the level of substitutability between home production and imports was rising for most commodity groups, it consistently fell after the 1980s. The explanation offered for this was that, following trade liberalization in the 1970s, imports provided closer substitutes for home production. However, with the passage of time, free trade induced intra-industry specialization that led to home production having different structures and increased differentiation from imports so the level of substitutability started to decline.

Our approach is different from these previous studies primarily because it focuses on estimating the elasticity of substitution for varieties distinguished not by country of production but by firm. Also, our elasticities are part of a larger modelling framework, enabling us to draw conclusions about the pricing behaviour of the firms in the container port sector in Australia. The paper is organized as follows. Section 2 offers a brief introduction to the market structure of Australia's East Coast port sector, Section 3 presents a generic model of a price interacting oligopoly with firm specific differentiated products. Section 4 describes the data. Elasticities of substitution and conjectural variations parameters are estimated in Sections 5 and 6 respectively. These estimates are then used to draw inferences about mark-ups charged which are discussed in Section 7. Section 8 concludes.

2. Australia's East Coast Ports

Ports play a very important role in Australian trade since 98% of internationally exchanged goods are shipped through them. In fiscal year 2004/05 Australian ports handled about 700 million tonnes of trade out of which 576 million tonnes were exports and 121 million tonnes were imports. Although containerised throughput comprises only 6.8% of total throughput in terms of mass tonnage (4.4% in exports and 18.3% in imports) its unit value is usually much higher than that of bulk cargo so that more than half the value of shipped merchandise is containerised[3].

Among ports handling containers, those in Melbourne, Sydney and Brisbane are the largest players with respective shares of 37, 27 and 14 per cent of total containerised trade in Australia. At the same time, they are by far the largest market players on the East Coast with the next biggest competitor, the port in Newcastle, having only a 0.2 per cent share in the market[4]. Our focus is therefore on the three East Coast ports, each of which is managed and operated by a separate state- owned corporation: the Port of Melbourne Corporation (created out of a merger between the Melbourne Port Corporation and the Victorian Channel Authority in July 2003), the Sydney Ports Corporation and the Port of Brisbane Corporation.

Furthermore, starting from 1995, the Port of Melbourne is subject to regulation by the Essential Services Commission (ESC, until 2001 the Office of the Regulator General). According to the Port Services Act of 1995 the ESC has a prerogative to regulate the prices of the following "prescribed" services within the port of Melbourne:

- the provision of channels for use by shipping
- the making available of berths, buoys or dolphins in connection with the berthing of vessels
- the provision of short term storage or cargo marshalling facilities in connection with the loading or unloading of vessels at adjacent berths, buoys or dolphins[5].

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[3] The Bureau of Transport and Regional Economics (BTRE) published data indicate that the average value of container cargoes in Australia's sea-borne exports and imports during 1999-2000 was approximately $3,000 per tonne. This was roughly twice the average value of general and roll-on-roll-off cargoes (when combined), ten times the average value of liquid bulk cargoes, and as much as 45 times the average value per tonne of dry bulk cargoes. See BTRE Information Paper 47, Table 4.7.

[4] All the figures used here are based on data for fiscal year 2004/05 gathered from the Association of Australian Ports and Marine Authorities (AAPMA) web page trade statistics http://aapma.org.au/tradestats/, accessed March- June 2006. Other large container ports include the Port of Fremantle (9.0% share), Tasmanian ports: Port of Devonport and Burnie Port as well as the Port of Adelaide (all of them with shares between 3 and 4%).

[5] These "prescribed" services were subject to price-cap regulation. See: *Essential Services Commission-Regulatory Framework, http://www.esc.vic.gov.au/ports88.html accessed March- June 2006.*

The regulatory authority for the Port of Brisbane Corporation is the Queensland Competition Authority formed under the Queensland Competition Authority Act of 1997. Its obligations in relation to ports include access regulation and "investigating and monitoring of prices for ports declared for monopoly prices oversight".[6] Consequently, the regulatory framework for the Port of Brisbane Corporation is much more "light-handed" and does not include price-caps. The port of Sydney is still more lightly regulated. The Sydney Ports Corporation is not supervised by any formal regulatory authority.

3. Price-Interacting Oligopolists

Consider an economy with *i=1,N* industries that are in turn made up of n_i companies respectively. As we are concentrating here on the services sector it is assumed that all supply comes only from domestic producers – there can be no imports of port services. Consumers choose the quantity of each generic product *i*. Their objective, when choosing the bundle $(C_1, C_2, ..., C_N)$, is to maximize their utility,

(1) $$U(C_1, C_2, ..., C_N) = \prod_i^N C_i^{\alpha_i}$$

subject to the income constraint

(2) $$GNP = \hat{P}_1 C_1 + ... + \hat{P}_N C_N \ ,$$

where $\hat{P}_i$ is an index of the varietal prices of generic service, *i*.

In the second step consumers decide on the varietal composition of their consumption of each generic good - they choose the quantities consumed coming from different firms. They are assumed to sub-aggregate product varieties of different firms with the elasticity of substitution, σ_i. For each generic good *i* they choose $C_{i1}, ..., C_{in_i}$ so as to minimize the expenditure:

(3) $$\hat{P}_i C_i = p_{i1} C_{i1} + ... + p_{in_i} C_{in_i}$$

where $\hat{P}_i C_i$ is determined in the first step, subject to the *CES* composite condition:

(4) $$C_i = \left(\sum_{j=1}^{n_i} \beta_{ij} C_{ij}^{-\rho} \right)^{-1/\rho} .$$

[6] Queensland Competition Authority- Ports, http://www.qca.org.au/ports/ accessed March- June 2006.

where $\hat{P}_i$ is formulated as a *CES* composite price index of services supplied by firms in sector *i*:

(5) $$\hat{P}_i = \left[s_{i1} p_{i1}^{(1-\sigma_i)} + ... + s_{in_i} p_{in_i}^{(1-\sigma_i)}\right]^{1/1-\sigma_i} .$$

and s_{ij} is the market share of firm *j* in sector *i* while σ_i is the elasticity of substitution between varieties supplied by different firms in sector *i*.

The first step is just the standard consumer problem with Cobb-Douglas utility. This yields the familiar Marshallian demands for the generic goods:

(6) $$C_i = \alpha_i \frac{GNP}{\hat{P}_i} ,$$

where α_i is the reference expenditure share of sector *i*. Solving for the second step leads to expenditure shares of companies within the sector:

(7) $$s_{ij} = \frac{p_{ij} C_{ij}}{\hat{P}_i C_i} = \beta_{ij}^{\sigma} \left(\frac{p_{ij}}{\hat{P}_i}\right)^{1-\sigma} .$$

This in turn allows the formulation of the demand function for the product variety *j* in sector *i*:

(8) $$C_{ij} = \frac{s_{ij} \alpha_i GNP}{\hat{P}_i} \left(\frac{p_{ij}}{\hat{P}_i}\right)^{-\sigma_i} .$$

With this demand function in mind, we can proceed to find the elasticity of demand for the products of firm *j* in sector *i*. In order to do this, we first derive the expression for the demand response $\frac{\partial C_{ij}}{\partial p_{ij}}$:

(9) $$\frac{\partial C_{ij}}{\partial p_{ij}} = s_{ij} \alpha_i GNP \frac{\partial}{\partial p_{ij}} \left[\hat{P}_i^{-1} \left(\frac{p_{ij}}{\hat{P}_i}\right)^{-\sigma_i} \right] =$$
$$= s_{ij} \alpha_i GNP \left[(-1) \hat{P}_i^{-2} \frac{\partial \hat{P}_i}{\partial p_{ij}} \left(\frac{p_{ij}}{\hat{P}_i}\right)^{-\sigma_i} + \hat{P}_i^{-1} (-\sigma_i) \left(\frac{p_{ij}}{\hat{P}_i}\right)^{-(1+\sigma_i)} \frac{\hat{P}_i - p_{ij} \frac{\partial \hat{P}_i}{\partial p_{ij}}}{\hat{P}_i^2} \right]$$

where

$$\frac{\partial \hat{P}_i}{\partial p_{ij}} = \frac{\partial}{\partial p_{ij}}\left[\left(s_{i1}p_{i1}^{(1-\sigma_i)} + ...+ s_{in_i} p_{in_i}^{(1-\sigma_i)}\right)^{1/1-\sigma_i}\right] =$$

(10) $$= \left[(1-\sigma_i) s_{ij} p_{ij}^{-\sigma_i} + \sum_{k\neq j} s_{ik}(1-\sigma_i) p_{ik}^{-\sigma_i}\mu_{ij}\right]\frac{1}{1-\sigma_i}\left(s_{i1}p_{i1}^{(1-\sigma_i)} + ...+ s_{in_i} p_{in_i}^{(1-\sigma_i)}\right)^{1/1-\sigma_i -1}$$

$$= s_{ij} p_{ij}^{-\sigma_i}\left(1+(n_i-1)\mu_{ij}\right)\hat{P}_i^{\sigma_i}$$

where μ_{ij} is the conjectural variations parameter that reflects the expectation of firm *j* in industry *i* as to the reactions of other firms to a marginal increase in its price ($\mu_{ij} = \frac{\partial p_{ik}}{\partial p_{ij}}$ for every $k \neq j$). Substituting (10) into (9) we have that:

(11)

$$\frac{\partial C_{ij}}{\partial p_{ij}} = s_{ij}\alpha_i GNP\left[-s_{ij}\left[1+(n_i-1)\mu_{ij}\right]p_{ij}^{-2\sigma_i}\hat{P}_i^{2(\sigma_i-1)} - \sigma_i p_{ij}^{-\sigma_i-1}\hat{P}_i^{\sigma_i-1} + \sigma_i s_{ij}\left[1+(n_i-1)\mu_{ij}\right]p_{ij}^{-2\sigma_i}\hat{P}_i^{2(\sigma_i-1)}\right]$$

$$= GNP\alpha_i s_{ij}^2(\sigma_i-1)\left[1+(n_i-1)\mu_{ij}\right]p_{ij}^{-2\sigma_i}\hat{P}_i^{2(\sigma_i-1)} - s_{ij}\alpha_i GNP\sigma_i p_{ij}^{-(1+\sigma_i)}\hat{P}_i^{\sigma_i-1}$$

From this (and substituting (8) for C_{ij}) we can derive the expression for the elasticity of demand ε_{ij} :

(12)

$$\varepsilon_{ij} = \frac{\partial C_{ij}}{\partial p_{ij}}\frac{p_{ij}}{C_{ij}}$$

$$= \frac{\hat{P}_i}{s_{ij}\alpha_i GNP}\left(\frac{p_{ij}}{\hat{P}_i}\right)^{\sigma_i} p_{ij}s_{ij}\alpha_i GNP\left[s_{ij}(\sigma_i-1)\left[1+(n_i-1)\mu_{ij}\right]p_{ij}^{-2\sigma_i}\hat{P}_i^{2(\sigma_i-1)} - \sigma_i p_{ij}^{-(1+\sigma_i)}\hat{P}_i^{\sigma_i-1}\right]$$

$$= s_{ij}(\sigma_i-1)\left[1+(n_i-1)\mu_{ij}\right]p_{ij}^{1-\sigma_i}\hat{P}_i^{-(1-\sigma_i)} - \sigma_i$$

$$= -\sigma_i + s_{ij}(\sigma_i-1)\left[1+(n_i-1)\mu_{ij}\right]\left(\frac{p_{ij}}{\hat{P}_i}\right)^{1-\sigma_i}$$

As all producers are the unique suppliers of their product varieties, each of them finds it optimal to behave like a monopolist in its product market. Therefore prices charged by them should satisfy the Lerner condition:

(13) $$p_{ij} = \frac{v_{ij}}{1+\frac{1}{\varepsilon_{ij}}},$$

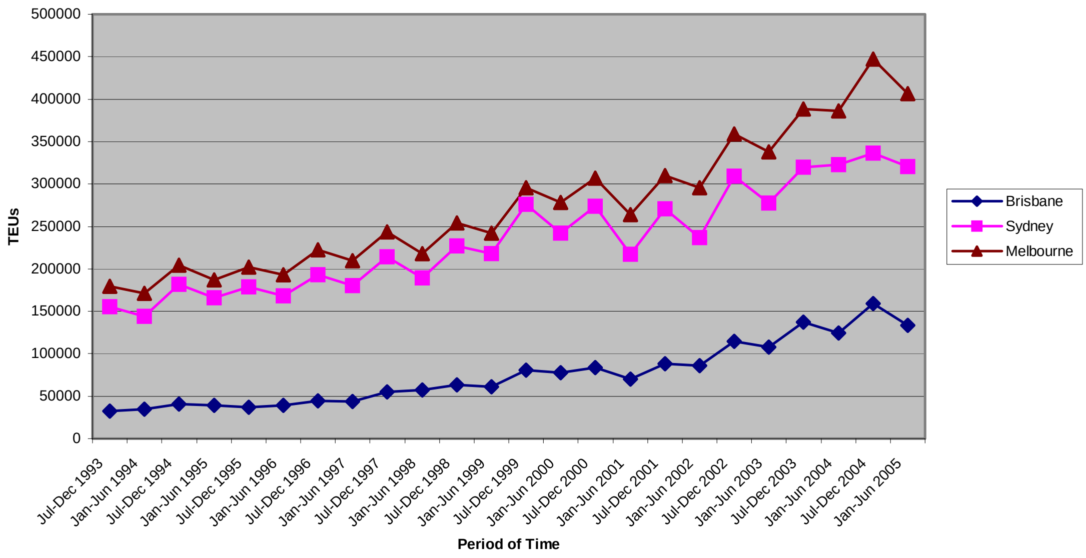
where v_{ij} is the average variable cost for producer *j*.

Expressions (12) and (13) are then employed as follows. We first estimate the pair-wise elasticity of substitution, σ_i , between services of ports in Brisbane, Sydney and Melbourne and, by examining pricing behaviour directly, the conjectural variations parameters (μ_i). We then use equation (12) to estimate the overall demand elasticity for the services of each port. Finally, we apply equation (13) to see the implications of our estimates for optimal pricing behaviour of ports authorities in the absence of regulation.

4. Data Description

The data for the number of containers in Twenty Foot Equivalent Units (TEUs) exchanged and fees charged by the ports comes from the *Waterline* magazine published by the Bureau of Transport and Regional Economics (BTRE). It is published semi-annually and covers the period from July 1993 to June 2005, yielding altogether 24 observations. Data on state final demand[7] was gathered from the Thomson Financial Datastream database while figures on Australian GDP and imports were obtained from the Australian Bureau of Statistics (ABS).

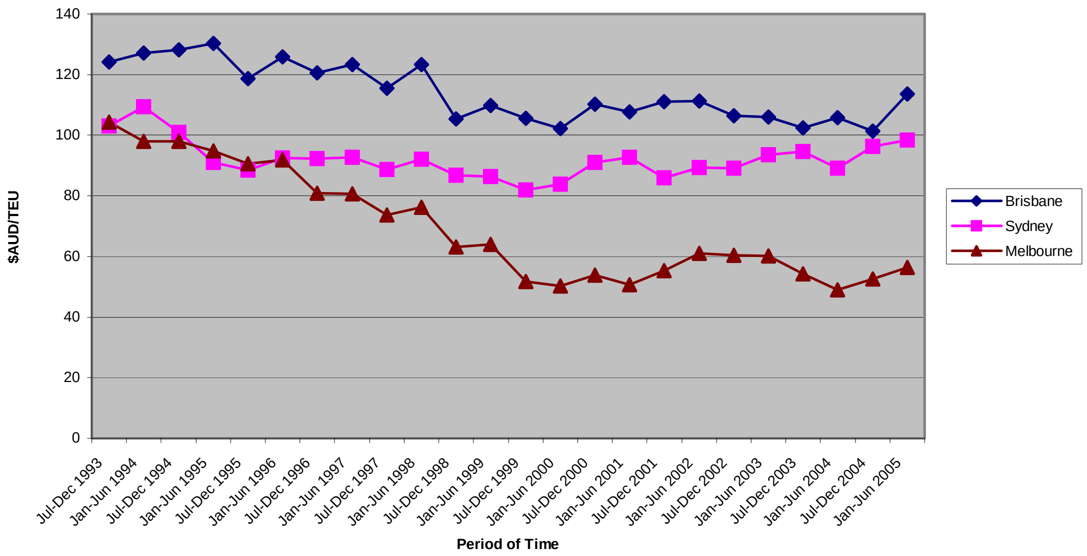
Figure 1: Number of full containers imported through the port



Source: Waterline, issues 1-39, Tables "Non-financial performance indicators, selected Australian ports", Full import.

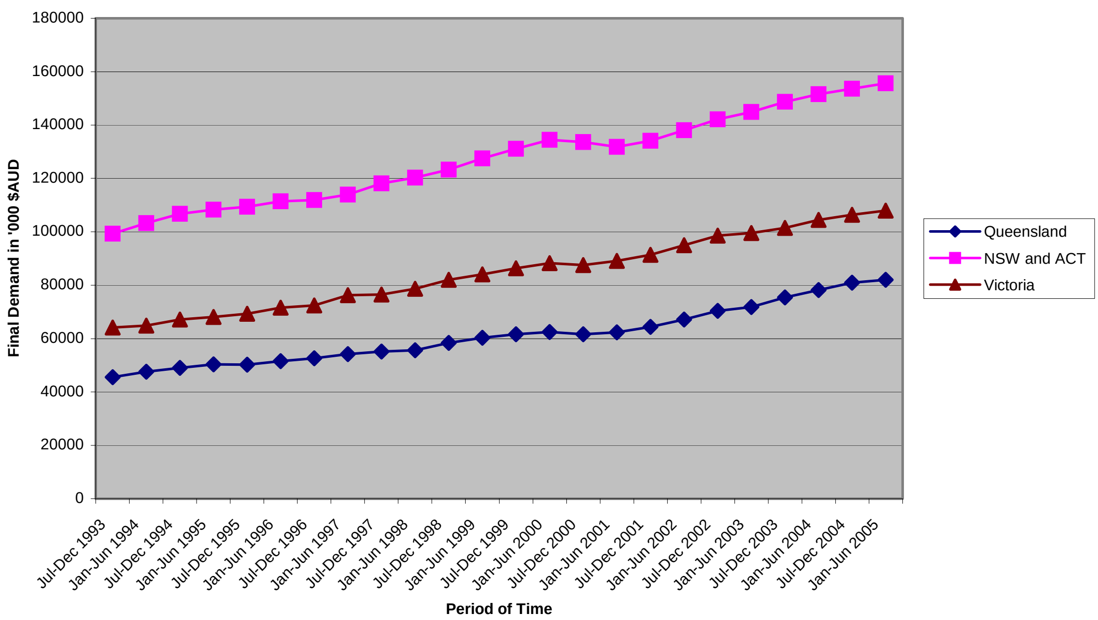
[7] Final Demand = Household Final Consumption Expenditure + Government Final Consumption Expenditure + Private Gross Capital Formation + Public Gross Capital Formation. See Australian Bureau of Statistics (ABS), *Components of State Final Demand.*

Figure 2: Total Port and Related Fees Charged on Loaded Imports



Source: Waterline, issues 1-39, Tables "Port and related charges for ships in the 15,000- 20,000 GT range", Total port and related charges ($/TEU)- Loaded imports

Figure 3: Final demand* in the ports operational areas



* Final Demand = Household and Government Final Consumption Expenditure + Private and Public Gross Fixed Capital Formation.
Source: Thomson Financial Datastream, aggregated on the basis of quarterly data for the following series: AU Final Demand- New South Wales, AU Final Demand- ACT, AU Final Demand- Queensland and AU Final Demand- Victoria. All of them are constant price, seasonally adjusted series.

Figures (1) to (3) present trends in import volume, prices charged and final demand that can be attributed to ports' operational areas (Queensland to the Port of Brisbane, NSW and ACT to Sydney, Victoria to Melbourne). All of the ports in the study showed a considerable reduction in fees charged in the early period - from 1993 until the first half of 2000 - with stable or gradually increasing charges from the year 2000 on. The sharpest drop in charges occurred in the Port of Melbourne where they declined by around 50% between 1993 and 2000.

In spite of this remarkable drop in charges it was the Port of Brisbane that exhibited the most impressive growth in the number of imported containers- during the sample period the number of full containers imported (in TEUs) via Brisbane quadrupled while at the same time there were rises of 126% and 106% in Melbourne and Sydney respectively. The rapid expansion of Brisbane's port activity was clearly associated with the comparatively rapid growth of the Queensland economy - total final demand rose there by 80% during the sample period with growth figures for Victoria and combined NSW and ACT being respectively 68 and 57%.

5. Estimating Elasticities of Substitution

The first step is to estimate the elasticities of substitution between service varieties. As the ports are at different distances from one another and lie in different geographical regions it is very unlikely that the elasticity of substitution between them would be the same for all 3 ports under study. As a result, the following analysis provides an estimation of "pair-wise" elasticities of substitution for all combinations: Brisbane- Sydney, Brisbane-Melbourne and Sydney- Melbourne.

Firstly, however, we need to use the theory developed in Section 3 to derive an equation that is readily estimated. By combining equations (8) and (6), and dropping subscript *i* (the ports sector) for convenience, we arrive at the expression:

(14) $\frac{C_j}{\hat{C}} = s_j \left(\frac{p_j}{\hat{P}} \right)^{-\sigma}$ where $\hat{C}$ is total demand for the services of the ports sector, *i*.

Assume, first, that all demanded quantity is readily supplied by firms. Then, to account for the effects of changes in overall income and in trade policy we incorporate in the equation (state) GDP[8] as well as the quotient of imports to national GDP as a measure

[8] GDP of Queensland for the Port of Brisbane, of NSW for Sydney Ports and Victoria for the Port of Melbourne as these are the primary areas served by these ports

of openness of the Australian economy.[9] With these incorporations, the share of the output of services by port *j* in the pair-wise sum of port services supplied is:

$$(15) \qquad \frac{q_j}{\hat{Q}} = k\left(\frac{p_j}{\hat{P}}\right)^{-\sigma}\left(\frac{y_j}{\hat{Y}}\right)^{\eta}\left(\frac{M}{\hat{Y}}\right)^{\gamma},$$

where σ is the elasticity of substitution between services of the two ports in question, y_j is the GDP contribution of hinterland region *j*, $\hat{Y}$ is total GDP contribution of the two state hinterlands, *Y* is national GDP and *M* is national imports. After taking natural logarithms, this relationship collapses to the following:

$$(16) \qquad \ln\left(\frac{q_j}{\hat{Q}}\right) = \ln(k) - \sigma\ln\left(\frac{p_j}{\hat{P}}\right) + \eta\ln\left(\frac{y_j}{\hat{Y}}\right) + \gamma\ln\left(\frac{M}{Y}\right)$$

which might be readily estimated as:

$$(17) \qquad \ln\left(\frac{q_{jt}}{\hat{Q}_t}\right) = \beta_0 + \beta_1\ln\left(\frac{p_{jt}}{\hat{P}_t}\right) + \beta_2\ln\left(\frac{y_{jt}}{\hat{Y}_t}\right) + \beta_3\ln\left(\frac{M_t}{Y_t}\right) + \varepsilon_{jt} \ ,$$

where $\hat{\beta}_1$ provides an estimate for $-\sigma$.

Quantities in equation (17) denote the number of full TEUs imported through a port while prices are the sum of all cargo-based and ship-based fees charged by the port for imports of a representative TEU container.[10] Since every regression was run for a "pair" of ports, $\hat{Q}_{ti}$ - the total number of full TEUs imported always denotes the total number of full TEUs imported through *both* ports in a given pair. Consequently, it differs for every regression. Similarly, $\hat{P}_i$ is always a composite of prices charged by both ports in a pair while $\hat{Y}_i$ is the sum of state GDPs of both ports in question[11].

Stationarity issues

According to Augmented Dickey-Fuller stationarity tests, some of the series used in estimation of equation (17) were $I(1)$ (these were: relative quantities exchanged and relative prices charged for the Melbourne- Sydney pair and relative state GDPs for the Brisbane-Sydney pair). This finding contradicts the usual econometric intuition

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[9] Openness of Australian economy is measured as the ratio of imports to GDP in a given year

[10] Ship-based fees include charges for conservancy, pilotage, towage, mooring/unmooring, berth hire and the charge based on a ship's tonnage. Cargo-based charges include wharfage, harbour dues and berthing. In some instances prices for imports and exports are not the same. *Waterline, issues 1-39, Tables "Port and related charges for ships in the 15,000- 20,000 GT range"*.

[11] It is then the sum of Qld and NSW GDPs when the ports of Brisbane and Sydney are considered and sum of NSW and Vic GDPs for a Sydney- Melbourne pair.

whereby variables that are shares or in other ways bounded variables [variables with possible values restricted to closed sets like $(0;1)$] are most commonly assumed to be stationary. In case of the 3 time series in question, however, a failure to reject the null hypothesis of a unit root was most likely caused by the structural break in the quantities and prices series around the year 2000, when the prices charged in Melbourne relative to Sydney levelled off after a period of a sharp decline causing a reversal in the relative quantities exchanged trend as well. The same story is true for the relative Brisbane-Sydney state GDPs series where around the year 2000 the GDP in Queensland started to grow steadily (relative to GDPs of NSW and ACT) after a period of rather stable relative growth until the year 2000. In view of this, we assume that results from ADF tests suggesting non-stationarity in these series were due to structural breaks and in further discussion all variables are treated as if they were stationary[12].

Regression results

On the presumption that the quotients in (17) are all stationary, all regressions were performed in the levels. Two complications arise in the estimation. First, quantities and prices are determined simultaneously in (17), so consistent estimates required the use of instrumental variables for the prices. The instrument for p_{ij}^{t} was chosen to be its lagged value, p_{ij}^{t-1}. Second, as (3) shows, σ_i is actually required in the calculation of $\hat{P}_i$. An iterative procedure is therefore adopted with the initial value of σ_i taken to be -2. In each case the estimator of σ_i quickly converged and was independent of the initial value chosen.

Anomalous results arise for the Brisbane- Melbourne pair in that the estimators for β_1 are positive and statistically significant. This is contradictory to economic intuition and to our definition in Section 3. It suggests that the ports of Brisbane and Melbourne are too far apart for the users to substitute between them, especially considering that there is another port midway between them. In what follows, therefore, only results for the Brisbane-Sydney and Sydney-Melbourne pairings are discussed.

[12] Another argument enforcing this line of thinking is that residual series from all 4 regressions in levels pass safely stationarity tests and are all found to be stationary. This suggests that regressions in levels give us reliable estimates for the elasticity of substitution between services of ports. Special thanks for clearing out this issue are due to Heather Anderson from the School of Economics, Australian National University.

Table 1 summarizes the results of regression (17) for all pair-wise combinations of ports[13]. The results suggest that the sensitivity of shipping agents to differences in port fees is not high. It seems that port fees are most influential when agents decide between the ports of Brisbane and Sydney, where the elasticity of substitution is close to *–1* (keeping all other things equal, a 1% increase in a port fee in one of these ports is expected to result in an average decrease of a market share in containerised imports by 1%). For the ports of Sydney and Melbourne fees do not appear to play an important role as the elasticity of substitution for this pair is about *–0.1*. One possible explanation for this may be that many ships call at more than one port. Those calling at Sydney also exchanged goods at other ports on the east coast while ships calling at Melbourne were arriving along the southern coast of Australia, calling also at Fremantle and perhaps Adelaide. By this reasoning the low elasticity of substitution between Melbourne and Sydney would be caused by the fact that ships calling at these ports were actually serving different regions, with Sydney the key East Coast port while Melbourne is recognised as the main port of the Southern Coast.

One of the major reasons behind the continuous growth in Brisbane's market share in recent years has been Queensland's comparatively rapid economic growth. The regression results suggest that, keeping other things equal, a 1% expansion in the share of Queensland in Australia's overall output resulted in an average growth in market share of the Port of Brisbane by 3%. This local GDP effect in explaining containerised imports in the Brisbane-Sydney pair was also the only significant effect in regression (17) at the 5% confidence level. The fact that all coefficients relating to fees charged by ports proved to be insignificant indicates that the results should be interpreted with caution, though the comparative weakness of the substitution estimates might also be due to the limited number of observations.

6. Estimates for price collusion

Estimates for conjectural variations parameters, μ_{ij}, can be obtained directly by studying the relationships between prices charged by the three ports under study (Figure 2), recalling that:

(18) $$\mu_{ij} = \frac{\partial p_{ik}}{\partial p_{ij}} \text{ for every } k \neq j .$$

[13] For detailed e-VIEWS output for all regressions please see Appendix 2.

All of the price series are non-stationary and $I(1)$, however[14]. Applying Johansen's cointegration test procedure to pairs of price series confirms that there is no cointegration between both pairs of price series of interest (Brisbane and Sydney as well as Sydney and Melbourne)[15]. In view of this, consistent estimates for the conjectural variations parameters can be found by performing regressions with differenced prices. The following is the regression equation for the Brisbane-Sydney and Sydney-Melbourne pairs:

(19) $$\Delta p_{kt} = \beta_0 + \beta_1 \Delta p_{jt} + \varepsilon_t$$

Table 2 summarizes the results obtained. All of these estimates are statistically insignificant and give rather low estimates for conjectural variations parameters. By itself, this suggests that, "pair-wise" at least, there is no significant Brisbane-Sydney or Sydney-Melbourne collusion in prices. On the other hand, the Johansen cointegration test indicates a strong relationship between the prices charged in Brisbane and Melbourne. For this pairing, the estimated conjectural variations parameter is of the order of 0.7. The explanation of this phenomenon may have to do with similarities between the regulatory regimes to which Brisbane and Melbourne ports are subjected. Since pricing by the port of Sydney is not regulated in the same manner, its prices appear to move independently.

7. Elasticity of Demand and Mark-Ups Charged

Now that estimates are available of both the elasticities of substitution and the conjectural variations parameters we can use equation (12) to calculate elasticities of demand faced by each port. Bearing in mind that the ports are considered in pairs, and so $\hat{P}$ is a pair-wise CES price index, we obtain:

(19) $$\varepsilon_i = -\sigma + s_i\left(\sigma - 1\right)\left(1 + \mu_i\right)\left(\frac{p_i}{\hat{P}}\right)^{1-\sigma},$$

[14] ADF tests for unit roots are presented in Appendix 4. As all price series appear to exhibit a downward trend a time trend was added to the test regression. The number of lags for the differenced dependent variable was chosen on the basis of the Bayesian Information Criterion (BIC).

[15] The very same cointegration test procedure indicates strong cointegration between prices charged in Brisbane and Melbourne, however. This result means that, "econometrically", there is a long-run relationship between prices charged at Brisbane and Melbourne. It is certainly an interesting finding, especially given that the results from the previous section indicate that the markets of the ports of Melbourne and Brisbane do not overlap and there is no direct competition between them. However strange this finding might seem, it has a relatively easy explanation: starting from mid-1990s both ports of Brisbane and Melbourne were subject to price regulation (price-cap regulation for Melbourne and price monitoring in Brisbane) which pushed their prices down. To the present, prices charged in Sydney have not been regulated and therefore they do not exhibit any correlation to prices charged at other ports.

where the s_i are shares, within the pairing, averaged throughout the sample period.[16] The average elasticities of demand follow as listed in Table 3.[17]

In this case we assume that the only competitor of Brisbane in container services is Sydney which is also Melbourne's only competitor. Because Sydney has two competitors, Melbourne and Brisbane, the overall elasticity of demand it perceives could be larger than that indicated here. Given these elasticities, the Lerner formula (equation 13) can be used to derive optimal mark-up ratios.

(20) $m_i = \dfrac{p_i}{v_i}$, and from (13), $m_i = \dfrac{1}{1+\dfrac{1}{\varepsilon_i}}$.

That for Brisbane turns out to be 9.6, while those for the other ports are outside the theoretical range of the model.[18] These results suggest that the market interactions between the three ports are weak and that each has considerable monopoly power. Regulation clearly plays a key role in pricing by all three ports. The only departure from this to emerge is that the services of the ports of Brisbane and Sydney are the most substitutable and hence that measurable competition exists between them. This implies that, while the regulation of the Port of Melbourne needs to be very restrictive, substitutability between Brisbane and Sydney could allow less restrictive regulation of at least one of these ports.

To assess the power of the regulatory frameworks under which each port operates we have estimated the actual mark-up ratios charged by them. A difficulty with this is the separation of recurrent fixed costs, which may be comparatively high in the lower-volume ports. Comparisons between ports might therefore be less robust than those over time. Our best estimates of the mark-up ratios are listed in Table 4 for the financial years 2001/02 through to 2004/05.[19] They range from 1.7 for the port of Melbourne to 3.3 for Brisbane. The results suggest that relatively strict regulation in case of the Port of Melbourne Corporation has brought desirable outcomes in the form of the steady fall in mark-ups throughout the period of study. Indeed, Melbourne seems at the moment to be the most competitive port on the east coast. Mark-ups charged by

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[16] The average shares throughout the sample period are as follows: Brisbane in Brisbane-Sydney 0.2318, Sydney in Brisbane-Sydney 0.7682, Melbourne in Melbourne-Sydney 0.5385, Sydney in Melbourne-Sydney 0.4615.

[17] Subscript *b_bs* means "Brisbane in Brisbane- Sydney pair", *s_bs* means "Sydney in Brisbane- Sydney pair" and so on.

[18] The Lerner formula given by equation (13) returns negative mark-ups for elasticities of demand, ε_i , with smaller absolute value than -1.

[19] For a detailed description of our method and calculations please see Appendix 1.

the Sydney Ports Corporation were, on the other hand, continuously increasing. Among the large ports on the east coast Brisbane managed to maintain the highest level of mark-ups charged, though this could be explained by Brisbane's considerably smaller volume and therefore its (likely) higher recurrent fixed costs. Clearly, regulation of port service pricing plays a critical role in all three of these Eastern States.

8. Conclusion

Elasticities of substitution between the services of Australia's East Coast ports are estimated to be quite low - around *–1* between services of ports of Brisbane and Sydney and around *–0.1* between those of the ports of Sydney and Melbourne. The possible reasons for this are:

- large distances between ports which make it unprofitable to use services of another port even if differences in fees charged by ports are substantial
- long-term arrangements that most of shipping lines sign with port authorities
- restrained competition among shipping lines which might prevent them from adjusting to differences in prices charged by ports
- separation between the Southern and Eastern shipping routes, rendering port substitution costly
- estimation difficulties that could bias the estimated elasticities downward.

The low elasticities of substitution imply that, even without price collusion by port authorities, varietal elasticities of demand are small and optimal oligopolistic mark-ups over average variable cost are very large. The fact that actual mark-ups are well below these levels is a testament to regulation, particularly in the case of the port of Melbourne. The measurable substitutability between Brisbane and Sydney, combined with the weaker price regulation to which the port of Brisbane is subjected, may act to restrain mark-ups in those ports.

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Table 1: Summary of regression results from the elasticity of substitution equations

Equation	Estimator for σ_i	Std error, σ_i estimator	Estimator for η_i	Std error, η_i estimator	Estimator for γ_i	Std error, γ_i estimator
Brisbane in Brisbane-Sydney pair	-1.163	1.176	3.201	1.677	1.190	0.270
Sydney in Brisbane-Sydney pair	-0.777	1.023	2.553	0.920	-0.325	0.073
Melbourne in Melbourne-Sydney pair	-0.108	0.087	0.441	0.386	-0.213	0.101
Sydney in Melbourne-Sydney pair	-0.111	0.119	0.955	0.716	0.228	0.122

Source: Regression results reported in the text.

Table 2: Summary of regression results from the conjectural variations equations

Equation	Estimator for μ_i	Std error, μ_i estimator
Brisbane in Brisbane-Sydney pair	0.268	0.203
Sydney in Brisbane- Sydney pair	0.206	0.149
Melbourne in Melbourne-Sydney pair	0.422	0.223
Sydney in Melbourne-Sydney pair	0.346	0.183

Source: Regression results reported in the text.

Table 3: Estimated demand elasticities for port services

Equation	Estimator for ε
Brisbane in Brisbane-Sydney pair, ε_{b_bs}	-1.116
Sydney in Brisbane- Sydney pair, ε_{s_bs}	-0.981
Melbourne in Melbourne-Sydney pair, ε_{m_ms}	-0.704
Sydney in Melbourne-Sydney pair, ε_{s_ms}	-0.745

Source: Equation (12) and the regression results reported in the text.

Table 4: Estimated Actual Mark-Up Ratios Charged by Ports

Port/ Year	2001/02	2002/03	2003/04	2004/05
Melbourne	2.49	2.23	1.70	1.98
Sydney	2.09	2.39	2.57	2.64
Brisbane	3.34	2.85	3.08	N/A

Source: Annual Reports: Port of Melbourne Corporation (Melbourne Port Corporation) 2002/03, 2003/04, 2004/05; Sydney Ports Corporation 2002/03, 2003/04, 2004/05; Port of Brisbane Corporation 2002/03, 2003/04. See Appendix 1 for detailed methodology and calculation.

Appendix 1: Calculation of mark-ups for the Sydney Ports Corporation, Port of Melbourne Corporation and Port of Brisbane Corporation

Port of Melbourne Corporation

Year	2002	2003	2004	2005
Total Revenue from ordinary activity (TR)[1]	83.4	90.2	101.8	124.6
Costs (excl. borrowing, capital opportunity costs[2] & depreciation)[3]	35.3	42.5	62.9	66.3
Variable Costs (VC)[4]	33.5	40.4	59.8	63.0
Mark-ups (TR/VC)	2.49	2.23	1.70	1.98

Average mark-up: 2.10

Sydney Ports Corporation

Year	2002	2003	2004	2005
Total Revenue from ordinary activity (TR)[1]	106.4	119.7	132.4	147.1
Costs (excl. borrowing, capital opportunity costs[2] & depreciation)[3]	53.7	52.6	54.3	58.7
Variable Costs (VC)[4]	51.0	50.0	51.6	55.8
Mark-ups (TR/VC)	2.09	2.39	2.57	2.64

Average mark-up: 2.42

Port of Brisbane Corporation

Year	2002	2003	2004
Total Revenue from ordinary activity (TR)[1]	96.4	106.9	108.9
Costs (excl. borrowing, capital opportunity costs[2] & depreciation)[3]	30.4	39.5	37.3
Variable Costs (VC)[4]	28.9	37.5	35.4
Mark-ups (TR/VC)	3.34	2.85	3.08

Average mark-up: 3.09

[1] Revenues from ordinary activity
[2] Capital opportunity costs were calculated as the value of infrastructure, property, plant and equipment times the reference rate of return (equal to 5.5%).
[3] This includes expenses from ordinary activities, excluding borrowing costs, capital opportunity costs and depreciation and amortisation expenses.
[4] Variable costs are set as equal to 0.95 of "Costs" as it was assumed that 5% of costs not already excluded were also fixed costs.

Appendix 2: E-views output from regressions for Ports of Brisbane and Sydney

Dependent Variable: LOG(SHAREBRISB_BS_FULLIMP)

Method: Two-Stage Least Squares

Date: 12/07/05 Time: 11:08

Sample (adjusted): 1994S1 2005S1

Included observations: 23 after adjustments

Instrument list: C LOG(RELPRBRISB_IT2_BS_IMP(-1))
LOG(RELY_BRISB_BS) LOG(OPENNESS_GS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.302933	1.500106	-0.868560	0.3959
LOG(RELPRBRISB_IT2_BS_IMP)	-1.162617	1.176328	-0.988344	0.3354
LOG(RELY_BRISB_BS)	3.200879	1.676767	1.908959	0.0715
LOG(OPENNESS_GS)	1.190325	0.270051	4.407785	0.0003

R-squared	0.912530	Mean dependent var	-1.466362
Adjusted R-squared	0.898719	S.D. dependent var	0.178349
S.E. of regression	0.056759	Sum squared resid	0.061210
F-statistic	64.37734	Durbin-Watson stat	2.100237
Prob(F-statistic)	0.000000		

Elasticity of substitution in the composite price taken to be -1.164.

$$\hat{\ln}\left(\frac{q_{ijt}}{\hat{Q}_{it}}\right) = -1.303 - 1.163\ln\left(\frac{p_{ij}}{\hat{P}_i}\right) + 3.201\ln\left(\frac{y_{ij}}{\hat{Y}_i}\right) + 1.190\ln\left(\frac{imp}{Y}\right)$$

(1.500) (1.176) (1.677) (0.270)

Dependent Variable: LOG(SHARESYD_BS_FULLIMP)
Method: Two-Stage Least Squares
Date: 12/07/05 Time: 12:35
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments
Instrument list: C LOG(RELPRSYD_IT3_BS_IMP(-1))
LOG(RELY_SYD_BS) LOG(OPENNESS_GS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.686363	0.557331	3.025784	0.0070
LOG(RELPRSYD_IT3_BS_IMP)	-0.776927	1.022697	-0.759684	0.4568
LOG(RELY_SYD_BS)	2.553299	0.920027	2.775244	0.0121
LOG(OPENNESS_GS)	-0.325298	0.073433	-4.429847	0.0003

R-squared	0.934624	Mean dependent var	-0.268466
Adjusted R-squared	0.924301	S.D. dependent var	0.055793
S.E. of regression	0.015351	Sum squared resid	0.004477
F-statistic	87.19747	Durbin-Watson stat	2.184998
Prob(F-statistic)	0.000000		

Elasticity of substitution in the composite price taken to be -0.777.

$$\hat{\ln}\left(\frac{q_{ijt}}{\hat{Q}_{it}}\right) = 1.686 - 0.777\ln\left(\frac{p_{ij}}{\hat{P}_i}\right) + 2.553\ln\left(\frac{y_{ij}}{\hat{Y}_i}\right) - 0.325\ln\left(\frac{imp}{Y}\right)$$

(0.557) (1.023) (0.920) (0.073)

Appendix 3: E-views output from regressions for Ports of Sydney and Melbourne

Dependent Variable: LOG(SHAREMELB_MS_FULLIMP)
Method: Two-Stage Least Squares
Date: 12/07/05 Time: 13:57
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments
Instrument list: C LOG(RELPRMELB_IT2_MS_IMP(-1))
LOG(RELY_MELB_MS) LOG(OPENNESS_GS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.417959	0.388976	1.074509	0.2961
LOG(RELPRMELB_IT2_MS_IMP)	-0.108396	0.086706	-1.250155	0.2264
LOG(RELY_MELB_MS)	0.440882	0.385765	1.142877	0.2673
LOG(OPENNESS_GS)	-0.212659	0.101090	-2.103650	0.0490

R-squared	0.458035	Mean dependent var	-0.619053
Adjusted R-squared	0.372461	S.D. dependent var	0.022374
S.E. of regression	0.017724	Sum squared resid	0.005969
F-statistic	5.975772	Durbin-Watson stat	1.809396
Prob(F-statistic)	0.004785		

Elasticity of substitution in the composite price taken to be -0.108.

$$\hat{\ln}\left(\frac{q_{ijt}}{\hat{Q}_{it}}\right) = 0.418 - 0.108\ln\left(\frac{p_{ij}}{\hat{P}_i}\right) + 0.441\ln\left(\frac{y_{ij}}{\hat{Y}_i}\right) - 0.213\ln\left(\frac{imp}{Y}\right)$$

(0.389) (0.087) (0.386) (0.101)

Dependent Variable: LOG(SHARESYD_MS_FULLIMP)
Method: Two-Stage Least Squares
Date: 12/07/05 Time: 14:08
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments
Instrument list: C LOG(RELPRSYD_IT2_MS_IMP(-1))
LOG(RELY_SYD_MS) LOG(OPENNESS_GS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.965242	0.592713	-1.628516	0.1199
LOG(RELPRSYD_IT2_MS_IMP)	-0.111493	0.118664	-0.939568	0.3592
LOG(RELY_SYD_MS)	0.954902	0.716198	1.333293	0.1982
LOG(OPENNESS_GS)	0.227503	0.122272	1.860620	0.0783

R-squared	0.457620	Mean dependent var	-0.773792
Adjusted R-squared	0.371981	S.D. dependent var	0.026664
S.E. of regression	0.021131	Sum squared resid	0.008484
F-statistic	5.796447	Durbin-Watson stat	1.800017
Prob(F-statistic)	0.005465		

Elasticity of substitution in the composite price taken to be -0.111.

$$\hat{\ln}\left(\frac{q_{ijt}}{\hat{Q}_{it}}\right) = -0.965 - 0.111\ln\left(\frac{p_{ij}}{\hat{P}_i}\right) + 0.955\ln\left(\frac{y_{ij}}{\hat{Y}_i}\right) + 0.228\ln\left(\frac{imp}{Y}\right)$$

(0.593) (0.119) (0.716) (0.122)

Appendix 4: ADF tests for unit roots in the price series for 3 ports under study

Null Hypothesis: PRBR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic based on SIC, MAXLAG=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.276550	0.8670
Test critical values:	1% level	-4.440739	
	5% level	-3.632896	
	10% level	-3.254671	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRBR)
Method: Least Squares
Date: 07/05/06 Time: 15:52
Sample (adjusted): 1994S2 2005S1
Included observations: 22 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PRBR(-1)	-0.424232	0.332327	-1.276550	0.2180
D(PRBR(-1))	-0.496962	0.245108	-2.027518	0.0577
C	51.75656	43.14511	1.199593	0.2459
@TREND(1993S2)	-0.376344	0.450361	-0.835650	0.4143

R-squared	0.493728	Mean dependent var	-0.613182
Adjusted R-squared	0.409350	S.D. dependent var	6.975868
S.E. of regression	5.361217	Akaike info criterion	6.359225
Sum squared resid	517.3677	Schwarz criterion	6.557596
Log likelihood	-65.95147	F-statistic	5.851347
Durbin-Watson stat	1.661199	Prob(F-statistic)	0.005676

Null Hypothesis: PRSYD has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.878051	0.6330
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRSYD)
Method: Least Squares
Date: 07/05/06 Time: 15:54
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PRSYD(-1)	-0.319703	0.170231	-1.878051	0.0750
C	28.12072	16.50429	1.703843	0.1039
@TREND(1993S2)	0.086350	0.155816	0.554179	0.5856

R-squared	0.218772	Mean dependent var	-0.196522
Adjusted R-squared	0.140649	S.D. dependent var	4.887197
S.E. of regression	4.530490	Akaike info criterion	5.980645
Sum squared resid	410.5068	Schwarz criterion	6.128753
Log likelihood	-65.77742	F-statistic	2.800356
Durbin-Watson stat	1.860442	Prob(F-statistic)	0.084680

Null Hypothesis: PRMEL has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.183230	0.8903
Test critical values:	1% level	-4.416345	
	5% level	-3.622033	
	10% level	-3.248592	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(PRMEL)
Method: Least Squares
Date: 07/05/06 Time: 15:55
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PRMEL(-1)	-0.170628	0.144206	-1.183230	0.2506
C	11.90175	14.56711	0.817029	0.4235
@TREND(1993S2)	-0.166515	0.391221	-0.425629	0.6749

R-squared	0.160916	Mean dependent var	-2.078696
Adjusted R-squared	0.077007	S.D. dependent var	5.396058
S.E. of regression	5.184128	Akaike info criterion	6.250188
Sum squared resid	537.5036	Schwarz criterion	6.398296
Log likelihood	-68.87716	F-statistic	1.917755
Durbin-Watson stat	2.360973	Prob(F-statistic)	0.173004

Appendix 5: Results of regressions for conjectural variations parameters

Dependent Variable: DPRBR
Method: Least Squares
Date: 07/05/06 Time: 16:16
Sample (adjusted): 1994S2 2005S1
Included observations: 22 after adjustments
Convergence achieved after 7 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.678309	0.662423	-1.023980	0.3187
DPRSYD	0.268196	0.202500	1.324422	0.2011
AR(1)	-0.723262	0.189709	-3.812484	0.0012

R-squared	0.477948	Mean dependent var	-0.613182
Adjusted R-squared	0.422996	S.D. dependent var	6.975868
S.E. of regression	5.298925	Akaike info criterion	6.299009
Sum squared resid	533.4935	Schwarz criterion	6.447787
Log likelihood	-66.28910	F-statistic	8.697436
Durbin-Watson stat	1.825395	Prob(F-statistic)	0.002081
Inverted AR Roots	-.72		

Dependent Variable: DPRMEL
Method: Least Squares
Date: 07/05/06 Time: 16:18
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.995835	1.065255	-1.873575	0.0750
DPRSYD	0.421637	0.222679	1.893475	0.0722

R-squared	0.145829	Mean dependent var	-2.078696
Adjusted R-squared	0.105154	S.D. dependent var	5.396058
S.E. of regression	5.104470	Akaike info criterion	6.181052
Sum squared resid	547.1679	Schwarz criterion	6.279790
Log likelihood	-69.08209	F-statistic	3.585246
Durbin-Watson stat	2.200333	Prob(F-statistic)	0.072156

Dependent Variable: DPRSYD
Method: Least Squares
Date: 07/05/06 Time: 16:20
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.102316	1.000956	-0.102218	0.9196
DPRBR	0.205767	0.148930	1.381641	0.1816

R-squared	0.083327	Mean dependent var	-0.196522
Adjusted R-squared	0.039676	S.D. dependent var	4.887197
S.E. of regression	4.789264	Akaike info criterion	6.053572
Sum squared resid	481.6781	Schwarz criterion	6.152310
Log likelihood	-67.61608	F-statistic	1.908931
Durbin-Watson stat	2.049757	Prob(F-statistic)	0.181606

Dependent Variable: DPRSYD
Method: Least Squares
Date: 07/05/06 Time: 16:21
Sample (adjusted): 1994S1 2005S1
Included observations: 23 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.522424	1.036067	0.504238	0.6193
DPRMEL	0.345864	0.182661	1.893475	0.0722

R-squared	0.145829	Mean dependent var	-0.196522
Adjusted R-squared	0.105154	S.D. dependent var	4.887197
S.E. of regression	4.623107	Akaike info criterion	5.982952
Sum squared resid	448.8354	Schwarz criterion	6.081691
Log likelihood	-66.80395	F-statistic	3.585246
Durbin-Watson stat	1.861613	Prob(F-statistic)	0.072156