Reserve Bank of Australia

RESEARCH DISCUSSION PAPER

Modelling Manufactured Exports: Evidence from Australian States

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RDP 2006-01

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Research Discussion Paper
2006-01

April 2006

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Reserve Bank of Australia

The views expressed in this paper are those of the author and should not be attributed to the Reserve Bank of Australia. The author would like to thank Mark Knezevic for assistance with the COMTRADE data, and Luci Ellis, James Hansen, Christopher Kent, Marion Kohler, Anthony Richards, Andrew Stone and participants at an RBA seminar for helpful comments.

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Abstract

This paper looks at the determinants of national manufactured exports through the use of a panel of Australian states. The panel approach is taken to assess whether the coefficient instability present in direct estimates of export elasticities can be alleviated by utilising the cross-state variation present in both manufactured exports and their determinants. Estimates of the price elasticity using this approach are found to be relatively robust to the use of the mean-group or fixed-effects panel estimation, and to a range of different export demand specifications. Income elasticity estimates are found to be stable across models, but sensitive to the inclusion of other variables. However, the degree of coefficient instability is not found to be significantly less in panel models than when using direct estimates, suggesting that direct estimation remains appropriate.

The analysis is then extended to consider the role that domestic factors play in determining manufactured exports. In line with theory, it is found that domestic final demand and capacity utilisation are inversely related to manufactured exports.

JEL Classification Numbers: F17, R12
Keywords: manufactured exports, real exchange rates, regional

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David Norman

1. Introduction

Exports form an important part of the Australian economy, accounting for around 20 per cent of total GDP and around 30 per cent of average annual GDP growth over the past decade. Despite this, there has been a surprising paucity of research that attempts to model the determinants of Australian exports. This is particularly evident when the focus is narrowed to particular broad categories of exports; most recent studies have modelled total exports in a single framework, despite the accepted wisdom that agricultural and resource exports are supply determined, while manufactured exports are largely demand determined.

This paucity of research may in part be due to difficulties finding robust results in export models. Australian estimates, like those of other countries, tend to be characterised by income and price elasticities which are quite sensitive to changes in model specification, even when similar data, methods and sample periods are used. One method that might allow for more robust estimation is to separately model exports from each of the Australian states and then combine these results into a single implied national estimate. This method has the potential to result in more robust estimates of national elasticities by taking advantage of cross-state variation in the regressand and regressors. This strategy has been used successfully in other contexts, such as to reduce the problem of collinearity in estimates of consumption functions (Case, Quigley and Shiller 2005 and Dvornak and Kohler 2003), and to mitigate the effects of technological innovation through time on estimates of the income elasticity of money demand (Fischer 2006).

Such cross-state variation is inherently present in state manufactured exports, but it is not immediately clear that there is variation in the determinants of manufactured exports. However, if allowance is made for differences in the trade orientation of each state's exports, it is possible to produce price and foreign income series that are more closely matched to the conditions facing the average exporter in each state, and which vary across states. This is the approach used in this paper. It is found that there is indeed quite marked cross-state variation in the share of exports going to each trading partner, and that this has a noticeable impact on the profile of state-specific real exchange rates and trading partner GDP. It is also found that there is some variation in the coefficients of each state's model, which further distinguishes this approach from conventional, national, estimates.

The remainder of this paper is structured as follows. Section 2 reviews the previous research on modelling exports. Section 3 discusses the construction of the state-specific data used in the estimation and examines the cross-state variation. Section 4 presents the econometric framework used to model exports, while Section 5 provides results. Section 6 then extends the analysis to include a possible role for domestic influences to affect export outcomes. Section 7 concludes.

2. Previous Research

Recent published attempts to model Australian exports have tended to form part of multi-country studies, and have generally focused on modelling either goods and services exports or merchandise exports as a whole, rather than its components. The results of these studies have been quite diverse. With regards to the price elasticity of Australian exports, Wu's (2005) model of merchandise exports finds the smallest (and only insignificant) elasticity of –0.3. In contrast, Caporale and Chui's (1999) estimate of the price elasticity of goods and services exports is around –0.8, and Senhadji and Montenegro (1999) find an implausibly large elasticity of –2.2. Similarly, income elasticities also vary; ranging from 0.8 (Senhadji and Montenegro) to 1.3 (Caporale and Chui). This variation comes despite these studies all being estimated over similar samples (starting in 1960 and ending around the mid 1990s), using similar price variables (export unit values) and similar estimation techniques. This variation in results highlights the difficulty in finding robust estimates of aggregate export equations.

These results using aggregate exports are also likely to hide significant variation in the elasticities of export components, and are therefore not directly comparable to this study of manufactured exports. In particular, it is possible that the price elasticity of aggregate exports is somewhat lower than that for manufactured products, given the apparent insensitivity of the supply of resource and rural exports to changes in prices. Despite this, the only known study that separately models manufactured exports is that by Dvornak, Kohler and Menzies (2005), who find a price elasticity for manufactured exports of –0.8.

Finally, the only study that looks at manufactured exports at a state level is Neri and Jayanthakumaran (2005). Using annual data over the period 1989/90 to 2000/01 and a descriptive approach, they find that there is considerable diversity in the performance of manufactured exports across states which cannot be explained by differences in industrial composition.

3. The Characteristics of State Exports and their Determinants

3.1 Manufactured Exports

Quarterly data on manufactured export volumes are not published, but it is possible to construct such series by deflating the value of each state's manufactured exports at a disaggregated level by the corresponding deflator at a national level.[1] This is done for the period from the March quarter 1990 to the June quarter 2005. Figure 1 shows the resulting series, and highlights the variation in the profile of each state's exports.[2] In particular, since the early 1990s South Australian export growth has outpaced that of other states, while growth in NSW has been slower than all states other than Tasmania. Table 1 provides some detail on the growth rate of each state's manufactured exports. All states (except Tasmania) recorded rapid and relatively similar growth during the 1990s, but there has been more marked divergence in growth rates since 2000, with exports from NSW and Western Australia slowing quite markedly.

The bottom half of Table 1 also presents some information about the importance of manufactured exports for each state. Victoria is the largest manufacturing state, measured by the absolute size of manufacturing exports, accounting for over one-third of national manufactured exports. Combined with NSW and South Australia,

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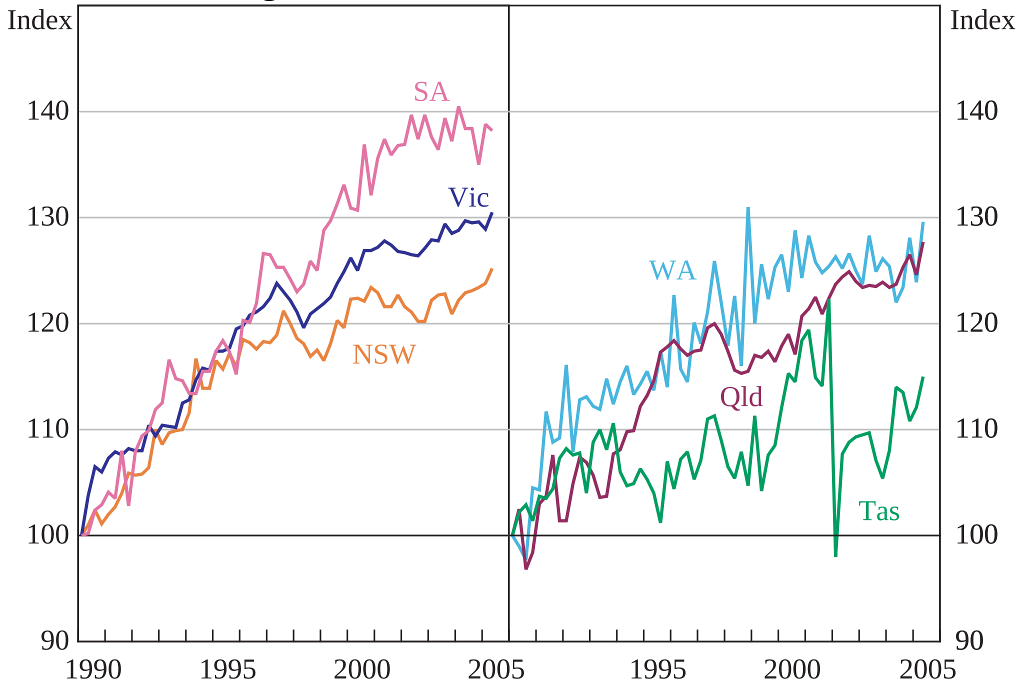
1 This deflation is done using 2-digit SITC data, to allow for variations in price movements for different manufactured goods. Further details of these calculations are given in Appendix A.

2 The sources for all data used in the paper are given in Appendix A.

the second and third largest manufacturing states, the three largest manufacturing states comprise over 80 per cent of national manufactured exports. Despite Victoria's large absolute size, the relative importance of manufacturing exports is greatest in South Australia, with manufacturing exports comprising 39 per cent of total exports in that state, followed by Victoria (27 per cent). In contrast, manufactured goods comprise a very small portion of total exports from Queensland, Western Australia and Tasmania.

Figure 1: State Manufactured Exports

Log scale, March 1990 = 100, volumes



Sources: ABS; author's calculations

There is also considerable diversity in the mix of manufactured goods exported by each state, which is highlighted in Table 2. The importance of transport equipment in Victoria, South Australia and Tasmania is immediately evident, reflecting the location of much of the automotive industry in these first two states and boat building in Tasmania. The share of beverages in South Australia is also substantially larger than in other states, underpinned by the wine industry. In contrast, Western Australia is heavily reliant on chemicals and metal & minerals manufacturing, consistent with the location of much of the mining industry in this state. Manufacturing in NSW is more evenly spread across sub-industries, compared with other states.

Table 1: State Manufactured Exports
Descriptive statistics

	Vic	NSW	SA	WA	Qld	Tas
Trend growth (per cent per annum)						
1990–2004	8.5	7.0	13.3	7.6	8.2	2.6
1990s	10.7	10.1	14.9	10.6	10.2	2.0
2000–2004	3.4	0.3	5.5	–1.0	6.6	–6.5
As a share of:						
National manufactured exports	36.5	28.2	16.1	9.6	8.9	0.7
State exports	27.2	15.6	38.9	5.9	7.0	5.9

Notes: Trend growth is calculated using a logarithmic regression of exports on a time trend, and is expressed in volume terms. All shares are calculated using the value of total exports, both service and merchandise.

Table 2: Manufactured Exports by Sub-industry
SITC classifications; per cent of manufactured exports

	Vic	NSW	SA	WA	Qld	Tas
Transport equipment	27.2	5.9	37.2	11.8	14.2	44.2
Machinery	30.5	32.4	12.1	22.3	40.5	13.0
Metals & minerals	3.5	6.8	3.1	12.7	8.5	1.0
Chemicals	16.3	26.1	3.8	45.4	20.4	20.8
Beverages	4.1	8.5	38.3	1.9	0.9	0.9
Other	18.4	20.3	5.4	6.0	15.6	20.1

Note: Shares calculated as the average shares of quarterly data from 2000 to 2004.

These differences in the composition of manufactured goods are also likely to induce variation in the importance of each country as an export destination. However, data on the destination of exports by state are only available for total merchandise trade, which may be unduly influenced by the destination shares of resource and rural exports, given their importance in Australia’s overall export basket. Hence, manufacturing-specific export destination shares by state are constructed by assuming that the export destinations of any given (2-digit SITC) manufactured product are invariant across states; automotive producers are assumed to export to the same set of countries, regardless of the state in which they are located. Consequently, the share of manufactured good *i* exported to country *j* is uniform across states and is derived from national data on the destination of manufactured goods. These shares can then be used to calculate the importance of that country for the state's manufactured exports according to the shares of the various manufactured goods in that state's exports, as follows:

$$\alpha_s^j = \sum_i \left(\frac{x_{i,s}}{x_s} \times \frac{x_{i,Aus}^j}{x_{i,Aus}} \right) \tag{1}$$

where: α_s^j is the share of manufactured exports from state *s* to country *j*; $x_{i,s}$ is exports of manufactured product *i* from state *s*; x_s is total manufactured exports for that state; $x_{i,Aus}^j$ is national exports of manufactured product *i* to country *j*; and $x_{i,Aus}$ is total national exports of manufactured good *i*.[3]

Table 3 shows the share of each state's manufactured exports to various destinations resulting from this calculation. The most obvious variation across states is in the share of manufactured exports going to other east Asia – around 25 per cent for NSW and Victoria, but 35 per cent for Western Australia and only 14 per cent for South Australia. Among the larger manufacturing states, the share of Victorian and South Australian exports to 'Other countries' is noticeably larger than in NSW, reflecting the importance of Saudi Arabia as a customer for the automotive industry. South Australia is also considerably more reliant on the UK as a destination, given that country's importance as a wine importer.

3 An alternative to constructing these manufacturing-specific weights is to use published data on the destination of merchandise exports by state. The method described by Equation (1) is preferred to this alternative for two reasons; merchandise export weights are heavily influenced by the destination of resource exports and differences in the resource-intensity of states, which could unduly alter the results; and merchandise weights limits the sample of destination countries to only 10 (compared with 23 used in this paper). Nonetheless, the results in the remainder of this paper are qualitatively robust to the use of export destination shares based on total merchandise exports.

Table 3: Manufactured Exports By Destination
Share of total manufactured exports in each state

	Vic	NSW	SA	WA	Qld	Tas
NZ	19.5	20.6	14.2	15.0	20.2	15.7
Japan	4.1	4.5	3.5	7.3	4.9	2.8
Other east Asia	25.6	26.3	14.1	34.5	28.2	22.3
US	20.3	20.3	24.6	17.8	19.0	25.0
UK	5.4	8.4	15.6	4.9	5.1	7.5
Euro area	8.1	10.9	6.3	11.7	10.3	18.1
Other countries	17.0	9.1	21.8	8.9	12.3	8.6

Note: Shares calculated as the average share of monthly data from 2000 to 2003.

3.2 Competitiveness

These differences in trading partner composition produce varying trends in the competitiveness of the manufacturing industry in each state as measured by effective exchange rates. This is particularly relevant when there are sizeable movements in bilateral exchange rates between Australia's trading partners, as has occurred over the past decade; the US dollar is around 25 per cent above its 1990s average against the yen and a basket of Asian currencies (in real terms), but remains around its 1990s average against the euro. It is likely that these divergences will have caused states that trade most heavily with Asian nations – Western Australia, NSW and Victoria – to have appreciated by more than states that trade mostly with Anglo and European nations – such as South Australia – against whom the Australian dollar has been relatively steady.

These differences in trading partner composition can be combined into a single effective exchange rate using the methodology recommended by Ellis (2001).[4] Of course, competitiveness of firms in one economy relative to those in other is not only affected by the nominal exchange rate between their currencies, but also by differences in the prices charged for their products. *Real* effective exchange rates

[4] These indices use the same 23 countries as are included in the trade-weighted index (TWI) published by the Reserve Bank of Australia, with the exception of Taiwan and Vietnam, for which there are data limitations. As with the TWI, the index is re-weighted annually, using prior-year data.

for each state are therefore calculated to measure competitiveness using the following formula:

$$E_t^s = \frac{\prod_{j=1}^{21}\left[ER_t^j \times P_t / P_t^j\right]^{\alpha_{s,t}^j}}{\prod_{j=1}^{21}\left[ER_{t-B}^j \times P_{t-B} / P_{t-B}^j\right]^{\alpha_{s,t}^j}} \times E_{t-B}^j \tag{2}$$

where: $\alpha_{s,t}^j$ represents the share of manufactured exports from state s to country j at time t; ER^j is the number of Australian dollars per unit of country j's currency; and P and P^j are the domestic and foreign price levels, respectively.

The choice of which price series to use in the real exchange rate calculations is not straightforward. Ideally, the price series will be specific to the manufacturing industry in each state, and will closely match actual export prices. Most recent studies (including Caporale and Chui 1999, Senhadji and Montenegro 1999 and Dvornak *et al* 2005) have used export unit values for this purpose. This ensures that they closely measure export prices, but, as noted by Kemp (1962), the use of export unit values as a deflator can bias the estimated price elasticities towards 1 if these same prices are also used to deflate the nominal value of exports.[5] Relative consumer price indices or unit labour costs are other commonly used price series, but these indices are more closely related to input costs than actual export prices (Chinn 2005 refers to such indices as measures of *cost* competitiveness). For these reasons, this paper uses aggregate manufacturing producer prices. These series are likely to be fairly close measures of actual export prices and are manufacturing-specific. However, they are not separately available for each Australian state, and it is necessary to assume that trends in producer prices are uniform across states.[6]

5 This depends on the method of calculating real series. Dvornak *et al* use directly calculated volume estimates, and their results are therefore unlikely to be affected by such bias. However, the volume estimates used in this paper are calculated by deflating nominal values by price deflators, and using unit values would therefore induce some bias.

6 Trends in wage prices across states provide some evidence in favour of this assumption – the range in trend annual growth in the wage price index is only 0.2 of a percentage point.

3.3 Trading Partner GDP

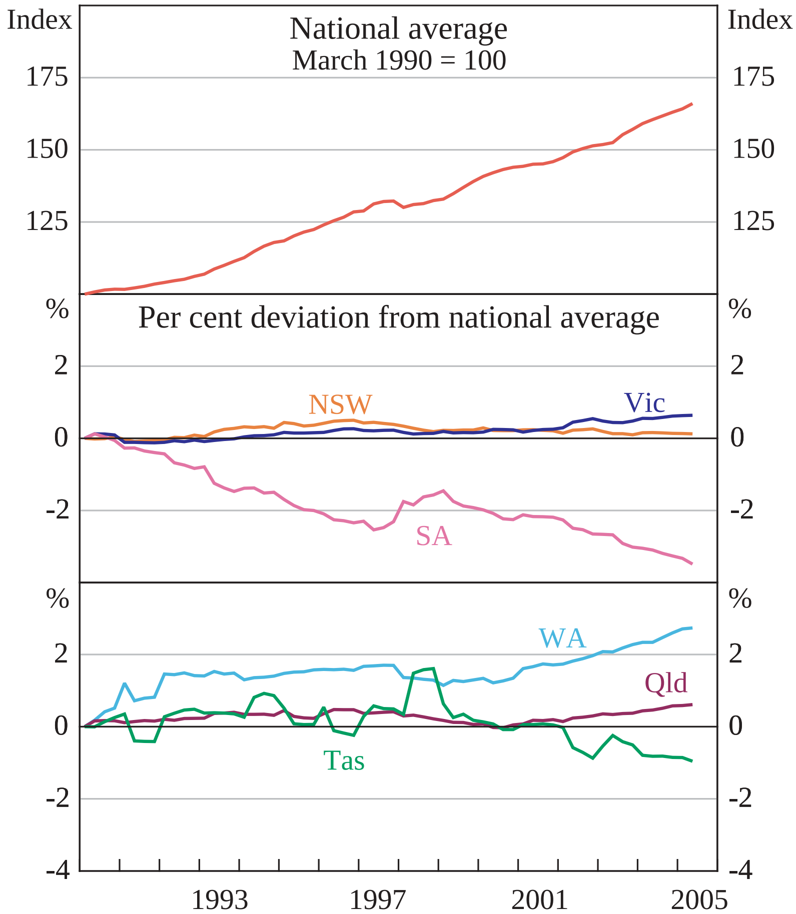
Differences in the composition of trading partners across states may also produce variation in the strength of foreign demand if growth of foreign income diverges across countries. Indeed, states which trade heavily with east Asian countries are likely to have seen more rapid growth in the GDP of their trading partners, which might provide some offset to their greater loss of competitiveness.

The index of foreign GDP for state *s*, $YF_s(t)$, is calculated by taking a weighted average of each trading partner's GDP, using the weights constructed in Section 3.1, and chain-weighting the resultant series:

$$YF_s(t) = \alpha_s^j(t) \times \frac{\sum_j Y^j(t)}{\sum_j Y^j(t-B)} \times YF_s(t-B) \tag{3}$$

where: $\alpha_s^j(t)$ is the share of manufactured exports to country *j* at time *t*; $Y^j(t)$ is GDP of country *j* at time *t*; and *B* is the number of quarters elapsed since the March quarter of the previous year (the base period). The constructed series are presented in Figure 2. As expected, Western Australia has seen the fastest growth in its trading partners' income, reflecting its large export share with east Asian nations, particularly China. In contrast, the growth of South Australia's trading partners has been considerably less, reflecting its greater exposure to more moderate growth countries such as the US and UK.

Figure 2: Trading Partner GDP



4. Methodology

4.1 Cointegration

Examining the profile of exports and trading partner GDP strongly suggests that these series are non-stationary, so that any regression of exports on trading partner GDP will produce spurious results if these series are not cointegrated. However, cointegration between these series is likely, given that exports are typically assumed to grow in line with trading partner GDP, adjusted for movements in competitiveness.

A range of unit root tests were conducted on the variables of interest to determine their appropriate order of integration. Exports for all states except Tasmania, and trading partner GDP for all states were found to be non-stationary using the

Kwiatkowski *et al* (1992) test (the KPSS test). However, it is unclear whether these series are I(1) or trend stationary; neither the KPSS test of stationarity nor the Perron and Ng (1996) test of non-stationarity can reject their respective hypotheses when a trend is included in the export or trading partner GDP series. With regard to each state's real exchange rate, KPSS tests cannot reject the hypothesis of stationarity for all states except Tasmania. In summary, it is clear that exports are either I(1) or trend-stationary for all states except Tasmania, trading partner GDP is either I(1) or trend-stationary for all states, and real exchange rates are stationary, in general.

Several methods are used to test for cointegration, with the results summarised in Table 4.[7] First, the Engle-Granger (1987) test finds that the residuals from a regression of exports on a constant, the level of the real exchange rate and trading partner GDP are stationary in all states, indicating cointegration. However, this test has been found to have low power, and an alternative test based on the significance of the coefficient on the error-correction term in an error-correction model has been proposed by Kremers, Ericsson and Dolado (1992). Using the modified version of this test suggested by Zivot (1994), cointegration is found for all states, although only at the 10 per cent level for NSW and Victoria. Finally, the Johansen (1991) systems cointegration test was also used; this test finds evidence of cointegration in all states.

In short, it is clear that both exports and trading partner GDP are non-stationary and, on the assumption that they are I(1), exports, trading partner GDP and the real exchange rate are cointegrated for all mainland states. In this case, it seems appropriate to estimate the long-run relationship between these variables, using cointegration techniques. Alternatively, if exports and trading partner GDP are trend-stationary, standard regression techniques are valid and these same cointegration techniques are appropriate. The following section discusses these techniques in further detail.

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7 Given that Tasmanian exports are stationary, cointegration tests do not apply. Furthermore, it is inappropriate to model (stationary) exports as a function of (non-stationary) trading partner GDP. Given the small size of Tasmania's manufactured exports, and the desire for a consistent modelling approach, its exports are not studied further in this paper.

Table 4: Cointegration Tests

Manufactured exports, trading partner GDP and the real exchange rate

	Cointegration test		
	Engle-Granger (ADF statistic)	Zivot alpha test (*t*-statistic)	Johansen (trace statistic)
Vic	–4.83**	–1.96*	45.2**
NSW	–3.48**	–1.78*	45.3**
SA	–5.35**	–2.32**	50.5**
WA	–3.39**	–3.21**	49.3**
Qld	–3.69**	–3.33**	42.5**

Notes: * and ** denote significance at the 10 and 5 per cent levels respectively. The Engle-Granger test is an Augmented Dickey-Fuller test on the residuals of a regression of exports on trading partner GDP and the real exchange rate, with a 5 per cent critical value of 3.29 (Engle and Yoo 1987). The Zivot alpha test is a *t*-test of the coefficient on the residuals from the above regression when included in an error-correction model of manufactured exports; this test is distributed normally, with 5 per cent critical value of –2.00. The Johansen test is a systems test of the rank of the matrix of cointegrating vectors, and is conducted with a constant included in the cointegrating vector; the 5 per cent critical value for this statistic is 35.2.

4.2 Specification

Two alternative specifications are used to estimate the cointegrated equations, the dynamic ordinary least squares (DOLS) and autoregressive distributed lag (ADL) models.[8] Following Stock and Watson (1993), the DOLS model take the following form:

$$x_{s,t} = \alpha_s + \boldsymbol{\theta}_s \mathbf{z}_{s,t} + \sum_{k=-2}^{+2} \boldsymbol{\pi}'_{s,k} \Delta \mathbf{z}_{s,t+k} + \varepsilon_{s,t} \tag{4}$$

where: $x_{s,t}$ is the volume of manufactured exports in state s; $\mathbf{z}_{s,t}$ is a (column) vector of the real exchange rate and trading partner GDP for each state; and $\boldsymbol{\theta}_s$ is a (row) vector of long-run elasticities with respect to the real exchange rate and trading partner GDP (all variables are in natural logs). The Newey-West (1987) covariance matrix is used to account for serial correlation, and leads and lags of the

8 Johansen's (1991) vector error-correction model is frequently used with cointegrated systems, but it is not used in this paper because its desirable properties in the face of endogeneity are not likely to be relevant for this study, and in small samples it can produce estimates with large variance and non-normal errors.

first-differenced regressors are included to remove correlation between the regressors and the error terms. Consistent with Pesaran and Shin (1998), the ADL model is estimated as follows:

$$x_{s,t} = \alpha_s + \varphi_s \mathbf{z}_{s,t} + \sum_{i=1}^{p} \delta_{s,i} x_{s,t-i} + \sum_{j=0}^{q-1} \boldsymbol{\pi}'_{s,j} \Delta \mathbf{z}_{s,t-j} + \varepsilon_{s,t} \tag{5}$$

where the long-run price and income elasticities are defined as $\theta_s = \varphi/(1 - \Sigma_p \delta_p)$. Appropriate lag lengths, p and q, are chosen by minimising the Schwarz information criteria for each state. Standard errors for the long-run elasticities can then be estimated using a Bewley (1979) transformation:

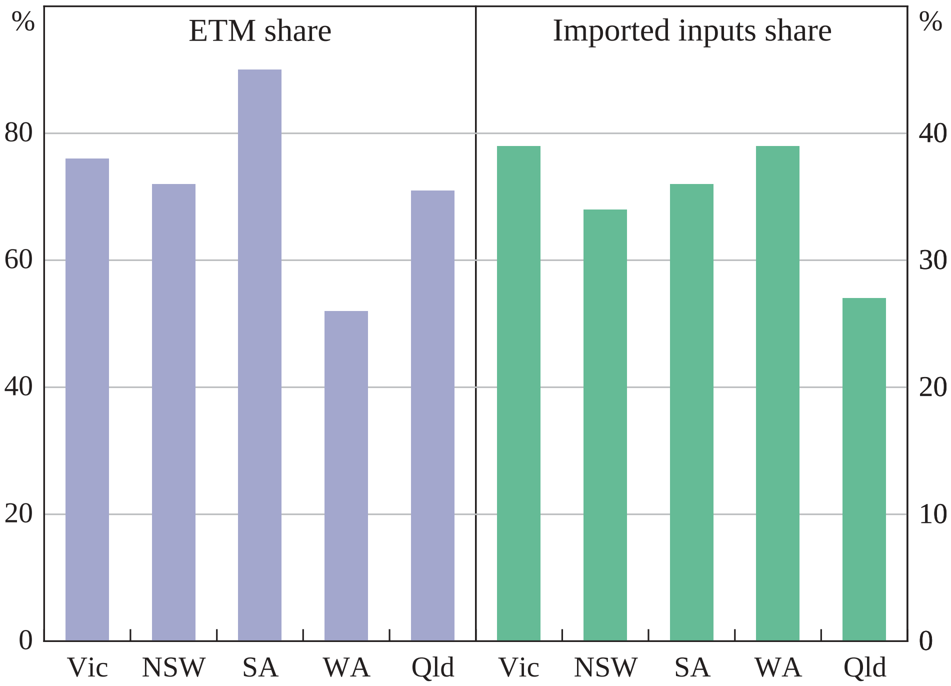
$$x_{s,t} = \alpha_s + \boldsymbol{\theta}_s \mathbf{z}_{s,t} + \sum_{i=0}^{p-1} \kappa_{s,i} \Delta x_{s,t-i} + \sum_{j=0}^{q-1} \boldsymbol{\omega}'_{s,j} \Delta \mathbf{z}_{s,t-j} + \eta_{s,t} \tag{6}$$

with x_{t-i-1} instrumenting Δx_{t-i}. Both DOLS and ADL specifications have been found to perform well in a Monte Carlo analysis of small-sample cointegrated equations (see, for example, Stock and Watson 1993 and Panopoulou and Pittis 2004).

4.3 Panel Estimation

For each of these models specifications, two panel methods are used to estimate national elasticities. The first is the mean-group panel, where each state equation is estimated allowing elasticities to vary across states, and a single national elasticity estimate is then calculated as the weighted average of each state's elasticity (where the weights are each state's share of national exports, excluding Tasmania and the territories). To improve the efficiency of the estimates, and allow for the likely correlation of residuals across states, all five state regressions are jointly estimated using the Generalised Methods of Moments estimator, allowing for both auto- and cross-correlation of the residuals. Pesaran and Smith (1995) suggest using this mean-group approach when elasticities are heterogeneous, which may occur here given that factors often thought to influence the elasticity of exports vary across states. Elasticities are likely to vary according to market power, which may depend, among other things, on the share of elaborately transformed goods in total manufactured exports; highly skilled products requiring elaborate transformation tend to have fewer direct competitors and hence less negative price elasticities (Figure 3). Products with a higher import share of production are also likely to have less negative elasticities, given that the price of imports will fall in domestic-currency terms following an appreciation, allowing exporters to maintain world-currency prices while still maintaining margins. On this basis, we would expect Victoria and South Australia to have smaller elasticities (in absolute terms) than other states, given their high share of elaborately transformed products and imported inputs in production, while Queensland and Western Australia are likely to have larger (absolute) elasticities.

Figure 3: Elaborately Transformed Manufacturing (ETM) and Imported Input Share of Manufactured Exports



Notes: ETM share is calculated as the share of manufactured exports, using 2-digit SITC data that are elaborately transformed, using 2000–2004 data. The imported inputs share is calculated from 1999/2000 data.

A second approach is to use a fixed-effects panel, which constrains all states' elasticities to be common but allows for differences in intercepts. This specification saves on degrees of freedom and is therefore potentially more efficient than the mean-group method. However, it will produce inconsistent estimates if elasticities are not equal across states (Pesaran and Smith 1995).[9] The DOLS and ADL specifications are used to estimate the fixed-effects model. Following Mark and Sul (2003), only coefficients on the elasticity terms are constrained in this panel, with coefficients on the lags and leads (where present) assumed to vary across states.

5. Results

5.1 Mean-group Panel

Estimates of the long-run elasticities from the mean-group panel are given in Table 5. In general, the estimates are relatively consistent using either the DOLS or ADL model (although the standard errors on the price elasticity are generally larger for the ADL model and are therefore typically insignificant). The exceptions are for NSW and Western Australia, with price and income elasticities varying considerably across models. Using the DOLS model, estimates of the price elasticity of manufactured exports range from –0.3 for Western Australia to –0.8 for NSW, but only the coefficients for NSW and Victoria are statistically different (using a Wald test). Estimated income elasticities are between 2.1 and 2.3, but the South Australian elasticity is significantly larger at 3.9.

The mean-group estimates of the national elasticities are shown in the final column of Table 5. The estimated national price elasticity is –0.5 using the DOLS model and –0.3 using the ADL model, with the latter insignificant due to the wider confidence intervals of the ADL estimates. These elasticities are smaller than those of Dvornak *et al* (2005), who find an elasticity of –0.8, and may reflect their use of export unit values as the deflator for their real exchange rate (which could bias the estimate towards 1). The estimated national income elasticity is 2.5 using the DOLS model and 2.2 using the ADL model, which are considerably larger than those in previous studies; Caporale and Chui's (1999) estimate (using total exports) is the largest known estimate of the income elasticity of Australian exports at 1.3.

9 This is due to two problems; first, a single vector will not cointegrate for all states with heterogenous long-run elasticities, leading to spurious results; and second, if the regressors are serially correlated, this will also cause the residuals to be serially correlated. However, Rebucci (2000) suggests that these concerns may not be important if the time series is sufficiently large.

It is likely that the considerably higher estimate in this paper stems from the shorter sample used here, with global trade in manufactured exports accelerating during the 1990s following the dismantling of barriers to trade in the 1980s.[10] This is consistent with the findings of Wu (2005), who estimates an income elasticity of 1.2 for Australian exports over a sample from 1960 to 1998, but an elasticity of 1.9 over the period from 1988 to 1998.

Table 5: Estimated Elasticity of Manufactured Exports

	Vic	NSW	SA	WA	Qld	Australia
			Price elasticity			
DOLS	–0.36**	–0.77**	–0.67**	–0.31*	–0.57**	–0.54**
	(0.12)	(0.21)	(0.28)	(0.17)	(0.16)	(0.16)
ADL	–0.27	–0.26	–0.73**	0.06	–0.51	–0.33
	(0.17)	(0.43)	(0.16)	(0.29)	(0.30)	(0.27)
			Income elasticity			
DOLS	2.37**	2.15**	3.89**	2.18**	2.31**	2.53**
	(0.07)	(0.14)	(0.11)	(0.10)	(0.11)	(0.10)
ADL	2.15**	1.60**	3.62**	1.68**	2.56**	2.22**
	(0.21)	(0.28)	(0.17)	(0.27)	(0.31)	(0.23)
			Diagnostics			
$\overline{R}^2$						
DOLS	0.97	0.91	0.97	0.80	0.92	
ADL	0.99	0.96	0.97	0.84	0.95	
LM (serial correlation, ADL)	3.75	6.02	3.41	0.50	3.88	
	[0.15]	[0.05]	[0.18]	[0.78]	[0.14]	

Notes: * and ** denote significance at the 10 and 5 per cent levels respectively. Figures in parentheses represent standard errors; those estimated using the DOLS specification use the Newey-West correction. Australian elasticities and standard errors are calculated using the mean-group method. LM (serial correlation) refers to the Breusch-Godfrey LM test (number of observations x R^2 statistic), with p-values in square brackets.

5.2 Robustness Checks

Section 2 highlighted the apparent sensitivity of previous direct Australian estimates of the export price and income elasticity to changes in the specification

[10] It may also be due, in part, to the increasing share of manufactured exports in global trade, underpinned by increasing product variety or quality (Krugman 1989 and Grossman and Helpman 1991).

or estimator used. Given this sensitivity, it is appropriate to check whether the fixed-effects estimation used in this paper provides more robust results.

Three robustness checks were performed on the DOLS model, and two of these are repeated on the ADL model. First, the DOLS model is estimated without including leads of the first differenced regressors. The inclusion of leads in the DOLS model is intended to account for the possible endogeneity of the regressors, which is not expected to be of much importance in this sample, given that manufactured exports in any particular state are likely to have little influence on Australian dollar exchange rates. Consequently, estimating the model without leads may provide a more parsimonious model, at little cost. The second check is to include a trend term in the specification of the DOLS and ADL models. This variable is intended to proxy the increasing integration of global manufacturing trade during the 1990s following the dismantling of trade barriers. Third, the DOLS and ADL models are augmented with a measure of the capital stock in the manufacturing sector. This appears to be a reasonable proxy for the extent of vertical and/or horizontal integration (Krugman 1989 and Grossman and Helpman 1991).[11]

The baseline DOLS estimates are robust to the exclusion of leads of the regressors in all states, with the mean-group estimates of the price and income elasticities falling only marginally from the baseline specification (Table 6). Similarly, the price elasticity estimates are also quite robust to the inclusion of a time trend; while the change in price elasticity estimates is quite large for some states (such as NSW), the new estimates are rarely outside their previous confidence intervals, and the mean-group estimate declines (in absolute value) by only 0.1 using the DOLS model (and increases marginally using the ADL model). Similar results are also found when the capital stock is included, although the (absolute) decline is somewhat more pronounced.

In contrast, estimates of the income elasticity are quite sensitive to the inclusion of a time trend or the capital stock. Under these alternative specifications, the income elasticities increase for all states except South Australia, and the mean-group

[11] Krugman and Gross and Helpman argue that vertical integration (increasing the variety of products) and/or horizontal integration (increasing the quality of products) can introduce an upwards bias to estimates of the income elasticity of exports. The use of the capital stock to proxy this effect is due to Muscatelli, Stevenson and Montagna (1995).

estimate of the income elasticity rises to implausibly large levels. Interestingly, the coefficients on the trend term and the capital stock is negative for all states except South Australia – in contrast to its expected sign – with the estimates implying a trend decline in exports of around 8 per cent per annum (absent trading partner growth).

Table 6: Alternative Estimates of the Elasticity of Manufactured Exports

	DOLS model		**ADL model**	
	Price elasticity	Income elasticity	Price elasticity	Income elasticity
Baseline	–0.54**	2.53**	–0.33	2.22**
Excluding leads	–0.49**	2.47**	na	na
Including trend	–0.39**	4.93**	–0.35**	4.58**
Including capital stock	–0.33**	3.75**	–0.31	3.32**

Notes: ** represents significance at the 5 per cent level, with standard errors on the DOLS model calculated using the Newey-West correction. Elasticities are the mean-group estimate of the national elasticity. The baseline model for the DOLS and ADL specification is the mean-group estimates from Equations (4) and (5) respectively.

5.3 Fixed-effects Panel

Given the similarity of the estimated elasticities across states, it is reasonable to estimate a fixed-effects panel that constrains these elasticities to be the same across states. To ensure stationary errors in the South Australian equation, the estimated panel DOLS model (but not the ADL) includes a trend term; otherwise the model is as represented in Equation (4), with long-run coefficients constrained to be identical across states.

Results from the fixed-effects model are generally consistent with the mean-group estimates. In the baseline DOLS specification, the price elasticity of –0.53 is very similar to the estimate from the DOLS mean-group estimate, although the income elasticity is slightly lower at 2.26 (Table 7). The price elasticity estimated from the ADL model is similar in magnitude to that using the DOLS specification and is larger than that found with the mean-group estimator, but not statistically so, while the income elasticity estimate is little changed. This similarity of elasticities according to the two models, and the stationary errors that arise from the fixed-effects estimation, suggest that there is little heterogeneity in the true long-run income and price elasticities (with the exception of the South Australian income elasticity, which is constrained in the DOLS specification by the use of a time trend).

Table 7: Fixed-effects Panel Models

	Price elasticity	Income elasticity
Panel DOLS	–0.53**	2.26**
	(0.09)	(0.07)
Panel ADL	–0.62**	2.51**
	(0.10)	(0.11)
DOLS excluding leads	–0.49**	2.24**
	(0.09)	(0.07)
DOLS including trend	–0.42**	4.57**
	(0.09)	(0.48)
DOLS including capital stock	–0.37**	3.56**
	(0.11)	(0.32)

Notes: ** represents significance at the 5 per cent level. Figures in parentheses are standard errors, estimated using a Newey-West correction. All models include a trend in the South Australian equation to ensure cointegration.

The fixed-effects estimates of the price elasticity are again relatively robust to changes in the specification. As with the mean-group estimates, there is little difference when leads of the regressors are excluded. The price elasticity is somewhat more affected by the inclusion of a trend or the capital stock in the equation, but these new estimates are not statistically different to those previously. In contrast, the income elasticity estimates continue to be significantly affected by the inclusion of a time trend or the capital stock, rising to 4.6 and 3.6 respectively.

5.4 Direct Australian Estimates

Given the focus of this paper has been to estimate the national price and income elasticity of manufactured exports, it is a useful comparison to consider direct estimates of these coefficients. To ensure comparability, the same DOLS and ADL models are estimated on Australian data. Trading partner weights used to construct the real effective exchange rate and foreign income are manufacturing-specific.

The results of the baseline DOLS and ADL models are shown in the top half of Table 8. The elasticity estimates from these models are consistent with those from the panel estimates. The price elasticity estimate according to the DOLS model is slightly lower in absolute value than in the panel estimation (shown in Table 5), while the ADL estimate is slightly higher in absolute value (and significant). The income elasticity estimates in each model are slightly higher than those of the panel specification. The bottom half of the table indicates that the direct estimates of the income elasticity continue to suffer from instability when a time trend or the capital stock are included, in line with the panel results.

Table 8: Direct Estimates of National Export Elasticities

	Price elasticity	Income elasticity	$\bar{R}^2$	LM
DOLS	–0.46**	2.75**	0.98	
	(0.08)	(0.05)		
ADL	–0.39**	2.58**	0.99	2.73
	(0.16)	(0.14)		[0.25]

	DOLS model		**ADL model**	
	Price elasticity	Income elasticity	Price elasticity	Income elasticity
Excluding leads	–0.44**	2.71**	na	na
Including trend	–0.38**	4.58**	–0.34**	3.50**
Including capital stock	–0.37**	3.43**	–0.38**	4.94**

Notes: ** represents significance at the 5 per cent level. Figures in parentheses represent standard errors; those estimated using the DOLS specification use the Newey-West correction. LM (serial correlation) refers to the Breusch-Godfrey LM test (number of observations x R^2 statistic), with the p-value in square brackets.

6. Domestic Influences on Export Outcomes

The implicit assumption in the modelling thus far has been that the estimated equations represent export demand curves, with the Australian export supply curve taken to be perfectly elastic (so that prices can be assumed to be exogenous). This is an approach taken in much of the previous literature, and accords with the notion that Australian firms satisfy all foreign demand for their goods at a given price. However, it is likely that domestic conditions (domestic demand and capacity utilisation) influence manufacturers' desire or ability to *supply* exports. For example, for a firm that is a price-taker on world markets, an increase in domestic demand will in theory cause exports to be reduced one for one to satisfy that demand.

Alternative models have also been developed to examine firms that have some degree of pricing power in world markets.[12] For example, Ball (1961) presented a model in which firms set marginal revenue from exports equal to marginal revenue from domestic sales and marginal costs, implying that changes in domestic conditions influence its desired export sales. Alternatively, if firms respond to changes in demand with a lag, perhaps reflecting delays in expanding production, then increases in domestic demand may also cause such firms to divert production from export to domestic sales, if domestic sales are more profitable (because of transport costs, for example). Similarly, Artus (1970) suggested that changes in domestic demand may cause firms to alter the effort (such as marketing) they exert to sell products overseas, thus influencing their non-price competitiveness and affecting export sales. These considerations have resulted in a large literature that allows for the possibility that exports also depend on *domestic* demand conditions, a possibility which is allowed for in the following section.

One way to capture these domestic influences is to estimate a simultaneous equation model, with both export volumes and prices modelled as functions of explanatory variables (including relative prices, world demand and domestic demand). While this is the most common approach in the literature, the results for Australian states suggest the price equation has little role to play in modelling exports,[13] consistent with Australian manufacturers being price-takers on world markets.

A more appropriate way to measure the influence of domestic demand pressure on Australian manufactured exports is to include some proxy for such pressures in our earlier DOLS model. The augmented model thus becomes:

$$x_{s,t} = \alpha_s + \boldsymbol{\theta}_s \mathbf{z}_{s,t} + \beta_s K_t + \sum_{k=-2}^{+2} \boldsymbol{\pi}'_{s,k} \Delta \mathbf{y}_{s,t+k} + \varepsilon_{s,t} \tag{7}$$

where K_t is a proxy for the strength of domestic demand (relative to supply) – so that β is expected to be negative – and $\mathbf{y} = \{z, K\}$.

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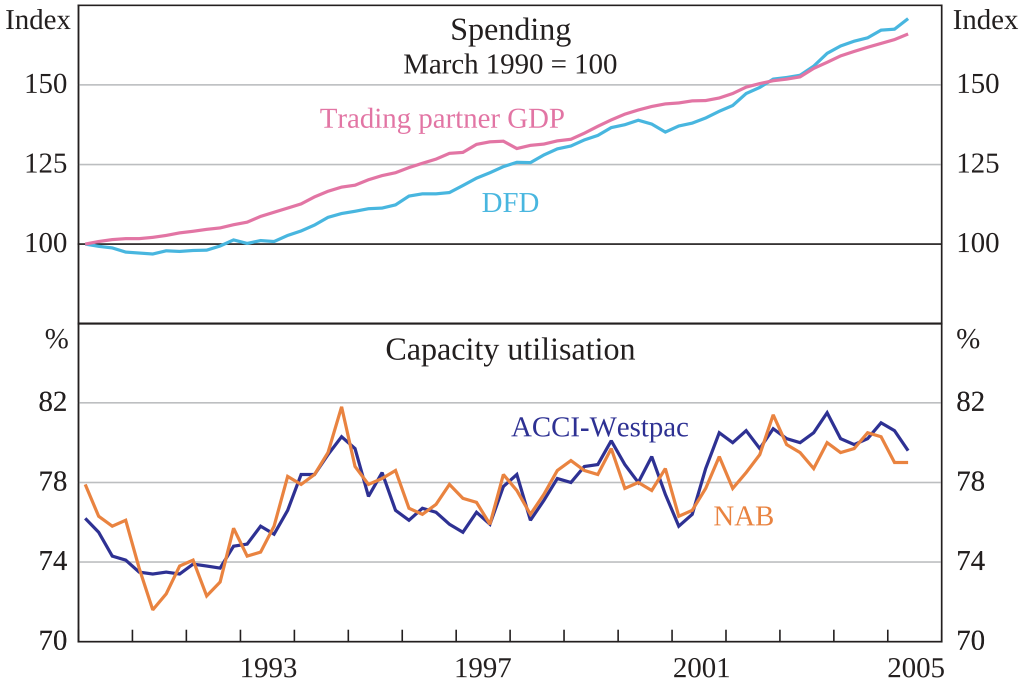
[12] Dwyer, Kent and Pease (1993) found that Australian manufacturers are price-takers on world markets. For contrary evidence, see Swift (1998).

[13] Specifically, the supply price elasticities are very large, and the volumes equation is relatively unchanged from results shown earlier in the paper.

A natural proxy for such pressure is domestic final demand (DFD). Alternatively, a measure of capacity utilisation in the manufacturing industry may be an effective proxy of the strength of domestic demand relative to supply. Two alternative measures of capacity utilisation are used; one calculated by the Australian Chamber of Commerce and Industry and Westpac (the ACCI-Westpac survey) and the second by the National Australia Bank (NAB).[14] The profiles of these series are shown in Figure 4.

Figure 4: Domestic Demand Proxies



The properties of these proxies are as follows. Domestic final demand is an I(1) process, according to unit root tests, and is cointegrated with exports, trading partner GDP and the real exchange rate. Both capacity utilisation series are also I(1), indicating that the spare manufacturing capacity created by the recession in the early 1990s has been gradually utilised. A cointegrating relationship is also found when these capacity utilisation series are included in place of domestic final demand.

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14 Domestic final demand and both measures of capacity utilisation are national, rather than state-specific, measures. This is done because national measures of demand pressure should better capture the incentive to divert production to domestic (local or interstate) sale.

The domestic demand elasticity of manufactured exports is shown in the left-hand column of Table 9. This elasticity is significant and of the expected (negative) sign for NSW, Victoria and Queensland, resulting in a significant negative mean-group estimate of the national elasticity. Similarly, the fixed-effects estimate of the domestic demand elasticity is also negative and significant. These results support the hypothesis that domestic demand pressure influences exports independently of competitiveness, consistent with the theory presented earlier. However, interpreting the magnitude of this result is made difficult by the instability of the income elasticity when domestic final demand is included; for those states in which domestic final demand is found to reduce manufactured exports, the income elasticity rises to implausibly large levels of between 5 and 6 (this also occurs in the fixed-effects estimate). This instability in the income elasticity estimate is likely to stem from the collinearity between trading partner GDP and domestic final demand.

Table 9: Elasticity of Manufactured Exports to Domestic Demand Pressure

	Domestic final demand	**Capacity utilisation**	
		ACCI-Westpac measure	NAB measure
Vic	–2.18**	–2.21**	–0.87
NSW	–3.45**	–1.57	0.97
SA	1.03	–3.92**	–4.10**
WA	0.20	–1.24	–0.97
Qld	–3.05**	–1.92	–0.46
Australia			
Mean-group estimate	–1.88**	–2.18**	–0.83
Fixed-effects estimate	–1.70**	–2.23**	–1.08*

Notes: * and ** represent significance at the 10 and 5 per cent levels respectively.

Using the ACCI-Westpac measure of manufacturing capacity utilisation as a proxy for domestic demand pressure provides more stable results that also suggest a role for domestic demand pressure in determining manufactured exports. Increased capacity utilisation is found to constrain manufactured exports in Victoria and South Australia, with both the mean-group and fixed-effects estimates of the elasticity negative and significant (middle column, Table 9). The price and income elasticities are also largely unchanged from the baseline model. Increases in the NAB measure of capacity utilisation are found to have an insignificant effect on national manufactured exports using the mean-group estimate, with only the South

Australian elasticity significant (right-hand column, Table 9). Nonetheless, the sign of these elasticities are as expected for most states, and the price and income elasticities are stable. Furthermore, the fixed-effects estimator finds a negative coefficient on the NAB measure of capacity utilisation that is significant at the 10 per cent level.[15] While these results are not completely satisfactory, they are highly suggestive that domestic demand pressure has some role to play in determining manufactured exports.

7. Conclusion

This paper examines the determinants of manufactured exports through the use of a panel of five Australian states, taking advantage of the cross-state variation in manufactured exports, real exchange rates and trading partner GDP. This approach can potentially provide more robust estimates of the determinants of manufactured exports than direct estimation of a national model.

The results indicate that this estimation approach provides reasonably robust estimates of the price elasticity of manufactured exports, using both a mean-group and a fixed-effects panel and various specifications of export demand. In contrast, income elasticity estimates are sensitive to the inclusion of other trending variables. These results are then compared with the robustness of direct estimates. It is found that direct estimates of the national price elasticity are similarly robust, and direct estimates of the income elasticity are similarly unstable. These results indicate that the direct approach to modelling manufactured exports is appropriate, despite the instability of parameter estimates. Section 6 of the paper extends the analysis to consider the role that domestic conditions play in determining exports. The results are consistent with the theoretical considerations discussed in the paper, which posit an inverse relationship between the strength of domestic demand and manufactured exports, controlling for trading partner GDP.

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[15] An alternative method would be to estimate a non-linear relationship between exports and capacity utilisation (such as squared capacity utilisation), or to estimate separate elasticities for periods of low and high capacity utilisation (using interactive dummies). The use of interactive dummies produces qualitatively similar results, although the high-capacity utilisation elasticities are significant for more states than when a single elasticity is used. Results using squared capacity utilisation are largely unchanged from those using its level.

Appendix A: Data

To construct an estimate of state manufactured exports in real terms, the value of manufactured exports for each state and 2-digit SITC manufactured product is deflated using the national deflator for the same product. This level of disaggregation is used to account for differences in the mix of products across states, and in price trends across various goods.

Data on 2-digit SITC manufactured export values for each state are sourced from the Australian Bureau of Statistics (ABS Cat No 5465.0). Manufactured exports consist of all categories within Sections 5–8 of the 2-digit SITC classification, plus beverages (Division 11). However, automatic data processing (ADP) exports and Divisions 67 (iron & steel) and 68 (non-ferrous metals) are excluded. ADP exports are excluded because of the bias inherent in this division's deflator (arising from its changing product mix over time). Adjustments are also made to the Victorian series, to remove the value of frigate exports in 1997:Q2 and 1999:Q4. The national implicit price deflators that are used to deflate these values estimates are sourced from the ABS (Cat No 6457.0). The resulting disaggregated estimates in real terms are then aggregated, and seasonally adjusted using the X-12 program.

Real exchange rates are calculated as per Equation (2), with daily nominal exchange rates (sourced from Reuters) averaged to form quarterly series. The 21 economies used in calculating exchange rates are: Canada; China; the euro area; Hong Kong; India; Indonesia; Japan; Malaysia; New Zealand; Papua New Guinea; the Philippines; Saudi Arabia; Singapore; South Africa; South Korea; Sweden; Switzerland; Thailand; the United Arab Emirates; the United Kingdom; and the United States. These countries are included based on their presence in the Reserve Bank of Australia's trade weighted index (Taiwan and Vietnam are excluded due to data limitations).

The domestic price used to calculate the real exchange rate is the national manufacturing output producer price index (ABS Cat No 6427.0). National prices are used due to the lack of a corresponding state-specific series; it would theoretically be possible to use constructed implicit price deflators for manufactured exports, as calculated above, but any errors in the construction of these series could bias the estimated price elasticity towards 1 (Kemp 1962).

Foreign prices are, in general, producer prices for manufactured goods, although the CPI is used for China, Papua New Guinea and the United Arab Emirates due to the lack of suitable producer price series. Where data for a country commences part-way through the sample (such as for India), that country is spliced onto the exchange rate index by using growth rates of the index with and without the inclusion of this country.

Weights used in the construction of real effective exchange rates and trading partner GDP are calculated from data on Australian exports by country for each (2-digit) SITC manufactured product. The share of exports from state *s* to country *j*, is calculated by summing over all manufactured products, *i*, as follows:

$$\alpha_s^j = \sum_i \left(\frac{x_{i,s}}{x_s} \times \frac{x_{i,Aus}^j}{x_{i,Aus}} \right) \tag{A1}$$

where: $x_{i,Aus}^j$ is Australian exports of product *i* to country *j*; $x_{i,Aus}$ is total Australian exports of product *i*; $x_{i,s}$ is state exports of product *i*; and x_s is total state exports. This method assumes that exports of product *i* are traded with the same countries (and in the same proportion) regardless of where they are produced, so that differences in state trading partner weights derive solely from differences in the share of each product in total state exports. Data on Australian trade by SITC good and destination country are taken from the IMF’s COMTRADE database. Weights are updated annually, using the prior year’s trade data.

Trading partner GDP is calculated as per Equation (3), with data on quarterly real GDP sourced from national statistics offices via Datastream. Quarterly Chinese GDP is calculated by fixing the level of GDP in the June quarter 2000 to 53.3 per cent that of the US economy, in line with PPP weights, and then using the profile of year-to-date average growth, published by the National Bureau of Statistics of China office, to extrapolate quarterly growth rates. The shares of exports from state *s* to each country are again used as weights.

A quarterly estimate of the (national) manufacturing capital stock is interpolated from annual data (ABS Cat No 5204.0, Table 71). Domestic final demand is sourced from the ABS (Cat No 5206.0), and is in chain volume, seasonally adjusted terms. The NAB measure of capacity utilisation is for only the manufacturing industry, and is taken from the quarterly survey published by the NAB. The ACCI-Westpac capacity utilisation measure is sourced from ACCI. This measure is presented in net balance terms. It is scaled to a level series using the ratio of the long-run averages of the NAB and ACCI-Westpac series, adjusted for differences in their variances.

The proportion of each state's exports that are elaborately transformed is calculated using 2-digit SITC export data by state for 2000–2004, and classifying each category as simply or elaborately transformed according to Productivity Commission (2003) classifications (Table 4.2). This implies that SITC Sections 5 and 6 are simply transformed, except Divisions 54 (medical & pharmaceuticals), 59 (chemical materials) and 69 (metal manufacturing). In addition to these three divisions, all products in Sections 7 and 8, except miscellaneous manufacturing (89), are classed as elaborately transformed. Beverages (Division 11) are also classified as elaborately transformed. The proportion of imported inputs in manufacturing production is calculated by weighting each state's share of manufacturing industry *i* (defined using ANZSIC classifications, with data on production by state and industry taken from ABS Cat No 8221.0) by the import content of that industry nationally (see Productivity Commission 2003, Table 6.2). Adjustments are made for the exclusion of food, much of printing & publishing and most of the metal products division from SITC manufactured export classifications.

The cost of inputs to manufacturing, used in the simultaneous equations model, is represented by the 'materials used in manufacturing' series from the Producer Price Indexes, Australia release (ABS Cat No 6427.0), and is common across all states.

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