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MODELLING AUSTRALIA'S EXPORTS OF NON-COMMODITY GOODS AND SERVICES

Michael Kouparitsas, Linden Luo and Jazmine Smith[1]

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1 Macroeconomic Modelling and Policy Division, Macroeconomic Group, The Treasury, Langton Crescent, Parkes ACT 2600, Australia. Correspondence: michael.kouparitsas@treasury.gov.au.
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2 The views expressed in this paper are those of the authors and do not necessarily reflect those of The Australian Treasury or the Australian Government.

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Manager
Communications
The Treasury
Langton Crescent Parkes ACT 2600
Email: medialiaison@treasury. gov. au

Modelling Australia's exports of non-commodity goods and services
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ABSTRACT

This paper models both the supply and demand of Australian non-commodity exports. We derive long-run export demand relationships from first principles. On the demand side, the paper finds a relatively low substitution elasticity between Australian exports and a broad basket of foreign produced goods and services. So, for instance, if Australian export prices increase, overseas buyers are less likely to respond by purchasing the same goods and services from foreign competitors, and are instead more likely to respond by reducing their demand for the product – whether Australian or foreign-made. In other words, income effects trump substitution effects. This result is consistent with other Australian studies. On the supply side, our modelling assumes that Australian manufacturing and services exporters are price setters – an assumption consistent with existing literature. This means that if global input costs increase, Australian exporters are able to pass some of that increase onto their customers. Based on this assumption, our modelling suggests that labour costs are a larger contributor to Australia's non commodity export prices than imported intermediate inputs costs.

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Michael Kouparitsas, Linden Luo and Jazmine Smith
Macroeconomic Modelling and Policy Division
Macroeconomic Group
The Treasury
Langton Crescent
Parkes ACT 2600

1. INTRODUCTION

International trade plays a critical role in fostering improvements in economic welfare, especially in small open economies. It allows economies to grow faster and achieve higher material living standards than they would in the absence of such trade. Theoretical and quantitative trade policy literature has shown that the gains from trade are determined by the price elasticities of export demand and supply. For example, Goldstein and Khan (1985) argue that welfare enhancing policy change in an open economy relies on robust estimates of the price elasticities of export demand and supply. Yet despite its importance, there is little empirical research devoted to estimating export demand and supply elasticities at either the country or global level. This paper adds to this literature by modelling Australia's exports of non-commodity goods (for example, manufactured goods) and services (for example, education, travel and business services).

This paper is not comparable with all empirical export demand studies. These studies fall into either country specific studies (see, for example: Jilek, Johnson and Taplin, 1993; Senhadji and Montenegro, 1999[3]; Dvornak, Kohler and Menzies, 2005; and Norman, 2006) or global studies (see, for example: Broda and Weinstein, 2008; and Broda, Lamão and Weinstein, 2008). Country-specific studies typically model aggregate time-series data, while global studies focus on the welfare effects of increasing product variety by modelling highly disaggregated panel data (that is, data with both a cross-sectional and time dimension). This paper focuses on the former. As such, its results are not directly comparable to modelling that uses more disaggregated panel data.

For completeness we revisit the theoretical export demand framework. Our framework is based on the reasoning that Australia's exports are the imports of our trade partners. Conditional import demand relationships are derived from representative household/firm-level utility-maximisation/cost-minimisation problems for each Australian trading partner. These country-specific import demand relationships are then summed to form an aggregate export demand equation. Following the broader international trade literature (see, for example, Dixit and Stiglitz, 1977), our approach assumes households/firms have both a taste for variety and rival sources of supply. Consistent with other country-specific studies, this long-run theoretical demand framework is augmented by cyclical explanatory variables to form empirical error correction models (that is, short-run demand models) which are estimated using standard econometric methods.

Over the past 30 years, the imports of Australia and its trading partners have grown at a much faster rate than their respective gross domestic product (GDP). This is generally characterised as rising import penetration. Recent studies that have explored Australian non-commodity export demand (Dvornak et al, 2005; and Norman, 2006) modelled this feature of the data by allowing the foreign income elasticity to be greater than one. But this approach encounters some problems. It is inconsistent with the underlying theoretical framework which implies an income elasticity of one. It is also problematic if the estimated export demand relationship is embedded in a broader macroeconomic model because it is incompatible with balanced growth. In light of this, we deviate from other Australian studies by adhering to the theoretical model by imposing a foreign income elasticity of one and allowing rising foreign import penetration to be captured via a deterministic time trend.

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3 No further reference is made to Senhadji and Montenegro (1999) because their analysis is unfortunately not directly comparable with the analysis reported in this paper. They focus on total exports, which include goods such as commodities, that are subject to fundamentally different market conditions to non-commodity goods and services.

On the demand side, our key finding is that there is relatively low substitutability between non-commodity goods and services that are exported by Australia and a broad basket of foreign produced goods. The main implication of this is that when there is a change in the relative prices of these exports, income effects will dominate substitution effects. So for example, other things being equal, a rise in export prices will reduce purchasing power among the buyers of those exports, leading to a fall in demand for both Australian and competing exports.

The theoretical underpinning of the supply of non-commodity exports is motivated by previous Australian research undertaken by Swift (1998). It suggests Australian exporters have some ability to set prices on the world market. Swift's (1998) results are consistent with subsequent research by Dvornak et al. (2005) which found that Australia's manufacturing and services exporters are price setters. Supply of non-commodity exports is modelled via a log-linear price mark-up equation, where the price of the export is a mark-up over nominal unit labour costs (labour cost per unit of output) and intermediate goods costs per unit of output. The final function form is similar to that used by de Brouwer and Ericsson (1998) in modelling aggregate inflation. Again, the long-run theoretical framework is augmented by cyclical explanatory variables to form empirical error correction models (that is, short-run supply models) which are estimated using standard econometric techniques.

The remainder of this paper is organised as follows: Section 2 derives the theoretical long-run export demand and supply relationships; Section 3 describes the data used in estimating export demand and supply; Section 4 provides details of the econometric method and reports parameter estimates; and Section 5 summarises the analysis and outlines plans for future work.

2. THEORY

Long-run demand for exports

For completeness consider a representative consumer living in foreign country i who solves a nested utility maximising problem. At the top of the nest is the choice between different types of consumption goods. Assuming the consumer's preferences are captured by Dixit and Stiglitz (1977) preferences (that is, a constant elasticity of substitution utility function), the problem can be summarised by the following:

$$\max_{c_{it}^k} c_{it} = \left[\sum_{k=1}^{q} \pi_i^k c_{it}^{k\,\frac{\upsilon-1}{\upsilon}} \right]^{\frac{\upsilon}{\upsilon-1}}, \sum_{k=1}^{q} \pi_i^k = 1 \qquad (1)$$

subject to:

$$pc_{it} c_{it} \geq \sum_{k=1}^{q} pc_{it}^k c_{it}^k \qquad (2)$$

where q is the number of varieties, υ is the elasticity of substitution between varieties, $\pi_i^{\,k}$ is a weighting parameter, c_{it} is the ideal/aggregate consumption level, pc_{it} is the ideal/aggregate consumption price, and $pc_{it}^{\,k}$ the price of consumption good k.

The Lagrangian for the consumer's maximisation problem is:

$$L = \left[\sum_{k=1}^{q} \pi_i^k c_{it}^{k\,\frac{\upsilon-1}{\upsilon}} \right]^{\frac{\upsilon}{\upsilon-1}} - \lambda_{it} \left[\sum_{k=1}^{q} pc_{it}^k c_{it}^k - pc_{it} c_{it} \right] \qquad (3)$$

where λ_{it} is the multiplier associated with aggregate consumption.

The first order conditions for maximisation are:

$$\frac{\partial L}{\partial c_{it}^{k}} = 0 \Rightarrow \left[\sum_{k=1}^{q} \pi_i^k c_{it}^{k\frac{\upsilon-1}{\upsilon}} \right]^{\frac{\upsilon}{\upsilon-1}-1} \pi_i^k c_{it}^{k\frac{\upsilon-1}{\upsilon}-1} = \lambda_{it} pc_{it}^{k} \tag{4}$$

$$\frac{\partial L}{\partial \lambda_{it}} = 0 \Rightarrow pc_{it} c_{it} = \sum_{k=1}^{q} pc_{it}^{k} c_{it}^{k} \tag{5}$$

Combining (4) and (5) implies:

$$\lambda_{it} = \frac{1}{pc_{it}} \tag{6}$$

which in turn implies:

$$\pi_i^k c_{it}^{k\frac{-1}{\upsilon}} c_{it}^{\frac{1}{\upsilon}} = \frac{pc_{it}^{k}}{pc_{it}} \tag{7}$$

Taking logarithms and rearranging implies the following demand relationship for good *k*:

$$\ln(c_{it}^{k}) = \upsilon \ln(\pi_{it}^{k}) + \ln(c_{it}) - \upsilon[\ln(pc_{it}^{k}) - \ln(pc_{it})] \tag{8}$$

The aggregate price index can be derived using (5) and (7). Specifically, (5) implies:

$$1 = \sum_{k=1}^{q} \frac{pc_{it}^{k} c_{it}^{k}}{pc_{it} c_{it}} \tag{9}$$

while equation (7) implies:

$$\frac{pc_{it}^{k} c_{it}^{k}}{pc_{it} c_{it}} = \left(\frac{1}{\pi_i^k} \right)^{-\upsilon} \left(\frac{pc_{it}^{k}}{pc_{it}} \right)^{1-\upsilon} \tag{10}$$

Substituting (9) into (10) implies the aggregate consumption price index is an aggregation of individual goods prices:

$$1 = \sum_{k=1}^{q} \left(\frac{1}{\pi_i^k} \right)^{-\upsilon} \left(\frac{pc_{it}^{k}}{pc_{it}} \right)^{1-\upsilon}$$

$$pc_{it}^{\;1-\upsilon} = \sum_{k=1}^{q} \left(\frac{1}{\pi_i^k} \right)^{-\upsilon} pc_{it}^{k1-\upsilon} \tag{11}$$

$$pc_{it} = \left[\sum_{k=1}^{q} \pi_i^{k\upsilon} pc_{it}^{k1-\upsilon} \right]^{\frac{1}{1-\upsilon}}$$

Once the consumer has made their decision at the top level, they move to the next level, which involves the choice between domestically produced and imported varieties of the goods subject to the value of aggregate expenditure decided at the previous level. Assuming that Dixit-Stiglitz preferences also apply at this level, the consumer has the following nested maximisation problem:

$$\max_{d_{it}, m_{it}} c_{it}^{k} = \left[\theta_i^k d_{it}^{k\,\frac{\sigma_k - 1}{\sigma_k}} + \left(1-\theta_i^k\right) m_{it}^{k\,\frac{\sigma_k - 1}{\sigma_k}} \right]^{\frac{\sigma_k}{\sigma_k - 1}} \tag{12}$$

subject to:

$$pc_{it}^k c_{it}^k \geq pd_{it}^k d_{it}^k + pm_{it}^k m_{it}^k \tag{13}$$

where σ_k is the elasticity of substitution between domestic and imported varieties of k, θ^k is a weighting parameter which implies home bias, d_{it}^{k} is the volume of domestically produced good k, pd_{it}^{k} is the price of domestically produced k, m_{it}^{k} is the volume of imported good k and pm_{it}^{k} is the price of imported k.

This implies the following demand relationships for domestically produced and imported k:

$$\begin{aligned} \ln(d_{it}^k) &= \sigma_k \ln(\theta_i^k) + \ln(c_{it}^k) - \sigma_k \left[\ln(pd_{it}^k) - \ln(pc_{it}^k) \right] \\ \ln(\mathrm{m}_{it}^k) &= \sigma_k \ln(1-\theta_i^k) + \ln(c_{it}^k) - \sigma_k \left[\ln(pm_{it}^k) - \ln(pc_{it}^k) \right] \end{aligned} \tag{14}$$

and price index for good k:

$$pc_{it}^k = \left[\theta_i^{k\,\sigma_k} pd_{it}^{k\,1-\sigma_k} + (1-\theta_i^k)^{\sigma_k} pm_{it}^{k\,1-\sigma_k} \right]^{\frac{1}{1-\sigma_k}} \tag{15}$$

Finally, consumers in country i must choose between imported varieties of good k sourced from different trading partners. Assuming Dixit-Stiglitz preferences also apply at this level yields the following nested maximisation problem:

$$\max_{m_{ijt}} m_{it}^k = \left[\sum_{j=1}^{n} \omega_{ij}^k m_{ijt}^{k\,\frac{\eta_k - 1}{\eta_k}} \right]^{\frac{\eta_k}{\eta_k - 1}}, \sum_{j=1}^{n} \omega_{ij}^k = 1 \tag{16}$$

subject to:

$$pm_{it}^k m_{it}^k = \sum_{j=1}^{n} pm_{ijt}^k m_{ijt}^k \tag{17}$$

where n is the number of varieties, η_k is the elasticity of substitution between imported varieties of k, ω^{k}_{ij} is a weighting parameter, m_{ijt}^{k} is the volume of good k imported from country j and pm_{ijt}^{k} is the price of good k imported from country j.

The first order conditions for this maximisation problem imply the following individual import demand equations for country i with respect to imports sourced from country j:

$$\ln(m_{ijt}^k) = \eta_k \ln(\omega_{ij}^k) + \ln(m_{it}^k) - \eta_k \left[\ln(pm_{ijt}^k) - \ln(pm_{it}^k) \right] \tag{18}$$

Recognising that one country's imports are another country's exports and assuming first stage pass-through[4] of prices implies:

$$\begin{aligned} m_{ijt}^k &= x_{ijt}^k \\ pm_{ijt}^k &= px_{jt}^k e_{ijt} \end{aligned} \tag{19}$$

where x^k_{ij} is the export of good k from j to i, px_j^k is the price of country j exports and e_{ij} is the country i-country j exchange rate in terms of country j currency.

This implies the following demand equation for country i with respect to country j exports:

$$\ln(x_{ijt}^k) = \eta_k \ln(\omega_{ijt}^k) + \ln(m_{it}^k) - \eta_k \left[\ln(px_{jt}^k) + \ln(e_{ijt}) - \ln(pm_{it}^k)\right] \tag{20}$$

Furthermore, aggregate export demand for country j can be approximated as the share weighted sum of the individual export equations:

$$x_{jt}^k = \sum_{i=1}^{n} x_{ijt}^k \tag{21}$$

$$\begin{aligned} \frac{x_{it}^k - x_{it-1}^k}{x_{it-1}^k} &= \sum_{j=1}^{n} \left(\frac{x_{ijt-1}^k}{x_{it-1}^k} \right) \frac{(x_{ijt}^k - x_{ijt-1}^k)}{x_{ijt-1}^k} \\ &= \sum_{j=1}^{n} s_{ijt}^k \frac{(x_{ijt}^k - x_{ijt-1}^k)}{x_{ijt-1}^k} \end{aligned} \tag{22}$$

where

$$s_{ijt}^k = \frac{x_{ijt-1}^k}{x_{it-1}^k} = \frac{px_{it-1}^k x_{ijt-1}^k}{px_{it-1}^k x_{it-1}^k} \tag{23}$$

where s^k_{ijt} is the time t export share for country j. Recognising $\ln(1+\varepsilon)$ is approximately equal to ε for small ε, implies the following approximate aggregate export demand equation for country j's good k:

$$\begin{aligned} \ln(x_{jt}^k) &\approx \sum_{i=1}^{n} s_{ij}^k \ln(x_{ijt}^k) \\ &\approx \sum_{i=1}^{n} s_{ij}^k \left\{ \eta_k \ln(\omega_{ij}^k) + \ln(m_{it}^k) - \eta_k \left[\ln(px_{jt}^k) + \ln(e_{ijt}) - \ln(pm_{it}^k) \right] \right\} \\ &\approx \sum_{i=1}^{n} s_{ij}^k \eta_k \ln(\omega_{ij}^k) + s_{ij}^k \ln(m_{it}^k) - \eta_k \left[s_{ij}^k \ln(px_{jt}^k) + s_{ij}^k \ln(e_{ijt}) - s_{ij}^k \ln(pm_{it}^k) \right] \end{aligned} \tag{24}$$

where $s_{ijt}^k = x_{ijt}^k / x_{jt}^k$

4 First stage pass through refers to passing on (to consumers) changes in import prices driven by the exchange rate.

This equation shows that aggregate demand is driven by a trade-weighted foreign demand index, a trade-weighted exchange rate and a trade-weighted foreign import price index for *k*.

Assuming the nested decisions have the same elasticity of substitution ($\sigma=\eta$) and substituting (15) into (25), the export demand for country *j*'s good *k* can be written in terms of aggregate foreign consumption volumes and prices:

$$\ln(x_{jt}^k) \approx \phi_j^k + \sum_{i=1}^{n} s_{ij}^k \ln(c_{it}^k) - \sigma_k \left[\ln(px_{jt}^k) + \sum_{i=1}^{n} s_{ij}^k \ln(e_{ijt}) - \sum_{i=1}^{n} s_{ij}^k \ln(pc_{it}^k) \right] \tag{25}$$

This expression can be simplified further by defining trade-weighted foreign consumption, nominal exchange rate and foreign expenditure prices respectively:

$$\begin{aligned} c_t^{*k} &= \sum_{i=1}^{n} s_{ij}^k \ln(c_{it}^k) \\ e_t^k &= \sum_{i=1}^{n} s_{ij}^k \ln(e_{ijt}) \\ pc_t^{*k} &= \sum_{i=1}^{n} s_{ij}^k \ln(pc_{it}^k) \end{aligned} \tag{26}$$

and substituting these expressions into (25), which implies:

$$\begin{aligned} \ln(x_{jt}^k) &\approx \phi_j^k + \ln(c_t^{*k}) - \sigma_k \left[\ln(px_{jt}^k) + \ln(e_t^k) - \ln(pc_t^{*k}) \right] \\ &\approx \phi_j^k + \ln(c_t^{*k}) - \sigma_k \ln(px_{jt}^k e_t^k / pc_t^{*k}) \end{aligned} \tag{27}$$

Long-run supply of exports

Swift (1998) and Dvornak et al. (2005) find that there is empirical support that Australia is not a price taker in global markets for non-commodity exports. Following this, we assume domestic firms have some market power, with export prices determined by the cost of inputs. Specifically, supply of non-commodity exports is modelled via a log linear price mark-up equation, where the price of good *k* is a mark-up over nominal unit labour costs (labour cost per unit of output) and intermediate goods costs per unit of output:

$$\ln(px_{jt}^k) = \alpha_j^k + \theta_j^k \ln(w_{jt}^k n_{jt}^k / y_{jt}^k) + (1-\theta_j^k)\ln(pi_{jt}^k i_{jt}^k / y_{jt}^k) \tag{28}$$

where *w* is the wage rate for good *k*, *n* is the level of labour input for good *k*, *y* is the level of output, *pi* is intermediate price, and *i* is intermediate volume, $0<\theta<1$. This framework is further simplified by assuming that there is no substitution in intermediate goods, so *i/y* is fixed which suggests[5]:

$$\ln(px_{jt}^k) = \beta_j^k + \theta_j^k \ln(w_{jt}^k n_{jt}^k / y_{jt}^k) + (1-\theta_j^k)\ln(pi_{jt}^k) \tag{29}$$

5 This is the form typically used in aggregate Australian studies, such as de Brouwer and Ericsson, 1998.

Assuming the prices of domestically produced intermediate inputs are governed by a similar cost mark-up equation it follows that the export price can be written in terms of nominal unit labour costs and imported intermediate input prices:

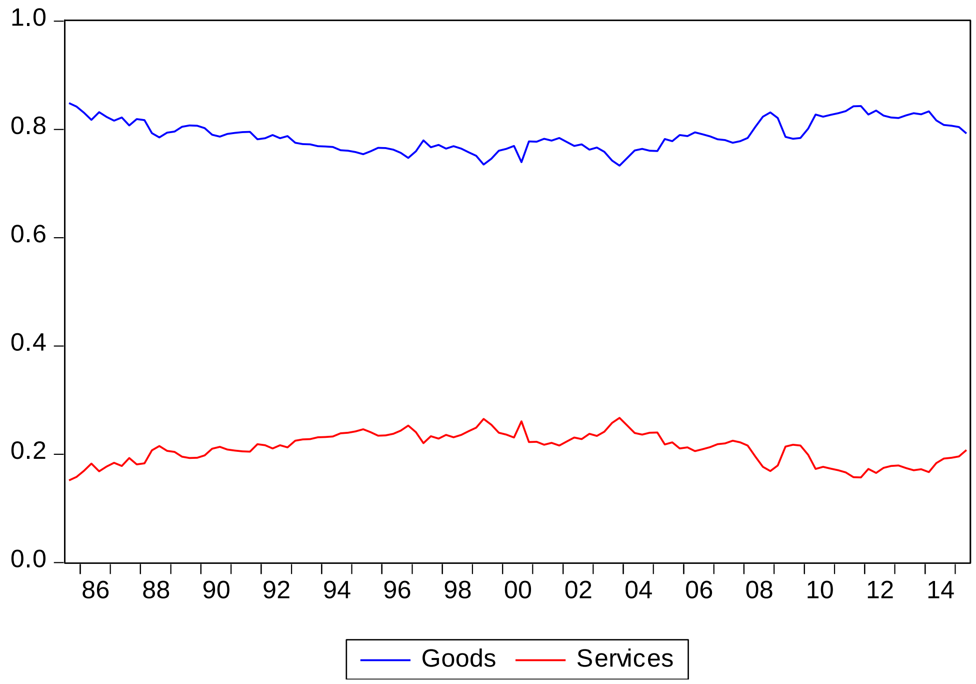
$$\ln(px_{jt}^{k}) = \beta_{j}^{k} + \psi_{j}^{k}\ln(w_{jt}^{k}n_{jt}^{k} / y_{jt}^{k}) + (1-\psi_{j}^{k})\ln(pm_{jt}^{k}) \tag{30}$$

3. Data

Exports of goods and services

Australian exports include both goods and services. According to the Australian Bureau of Statistics (ABS), exports of goods and services are defined as being domestically produced output acquired by non-residents (ABS, 2011). Exports are reported by the Australian Bureau of Statistics (ABS) in the Balance of Payments and International Investment Position (ABS Cat. no. 5302.0) at a quarterly frequency and on a seasonally adjusted basis (see ABS (2012) for further details). Goods exports include general merchandise, which consists of rural and non-rural goods, net exports of goods under merchanting and non-monetary gold.

Chart 1: Ratio of goods and service exports to total exports value



Source: Authors' calculations based on ABS Cat. no. 5302.0.

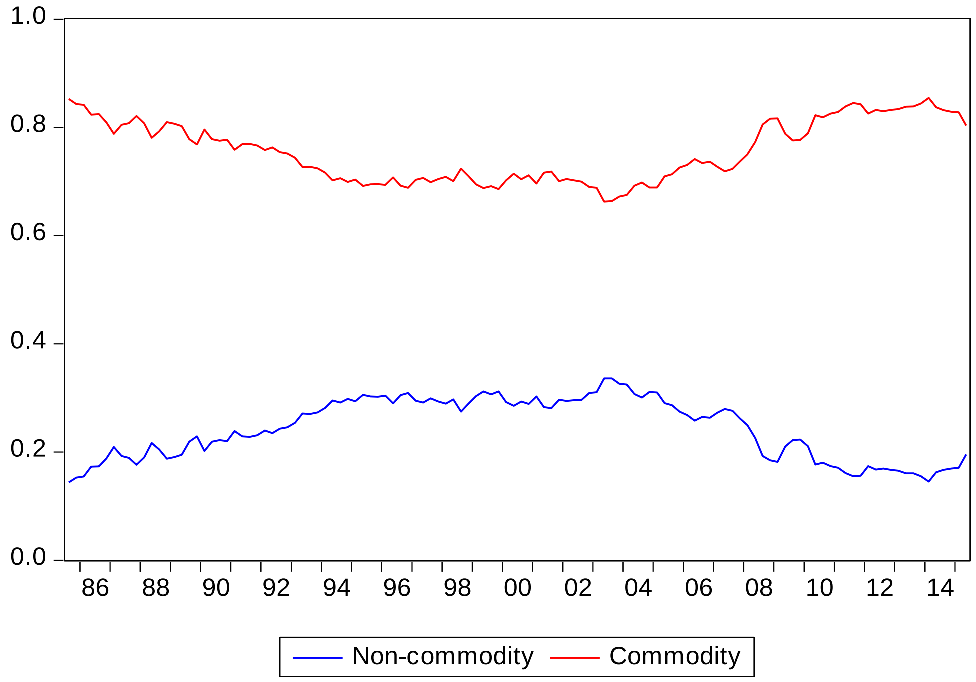
Chart 1 plots the shares that goods (including commodities) and services exports account for in total exports values. The shares of the two exports remain relatively stable over our sample, despite a slight upward (downward) trend for services (goods) exports from the mid 1980s to 2000, which became a slight downward (upward) trend after 2000. The shares seem to have stabilised more recently, with services exports accounting for around 20 per cent of Australia's total export value.

The changes in shares of export values reflect shifts in our export compositions over the sample period. The increasing share of services exports in the early years of our sample reflects the decline of the market shares of our rural exports, whereas the mining boom from the mid-2000s lifted the share of goods exports.

Exports of non-commodity goods

Since this paper focuses on non-commodity goods exports, this series needs to be defined and constructed. In this paper, non-commodity goods exports include the following export items: machinery; transport equipment; other manufactures; other non-rural (including sugar and beverages); and goods procured in ports by carriers.

Chart 2: Ratio of non-commodity goods to total goods value



Source: Authors' calculations based on ABS Cat. no. 5302.0.

Chart 2 plots the share of the total value of goods exports that non-commodity goods account for over the sample period. For comparison purposes, we also plot shares of commodity exports over the same period. Unsurprisingly, due to the mining boom, the share of non-commodity goods exports has almost halved in recent years from its peak. The share decreased from around 35 per cent in early 2003 to around 20 per cent in 2015.

Exports of services

Service exports cover a wide range of activities, such as manufacturing services, maintenance and repair services, travel and financial services. The analysis presented here is limited to aggregate services, which implicitly assumes all activities are homogenous. We leave it to future research to explore the appropriateness of this assumption.

Services exports are largely non-tradable in the sense that the bulk of our services exports never physically cross Australia's borders and are consumed by international visitors while in Australia. For example, education-related services exports, Australia's largest services exports sub-category, consists of spending by international students who come to Australia for study.

The non-tradable nature of most services exports sets this category apart from goods exports, which are generally highly tradable. For this reason, among others, we would expect changes in explanatory variables to have different impacts on goods exports and services exports.

Foreign market penetration versus relative export prices

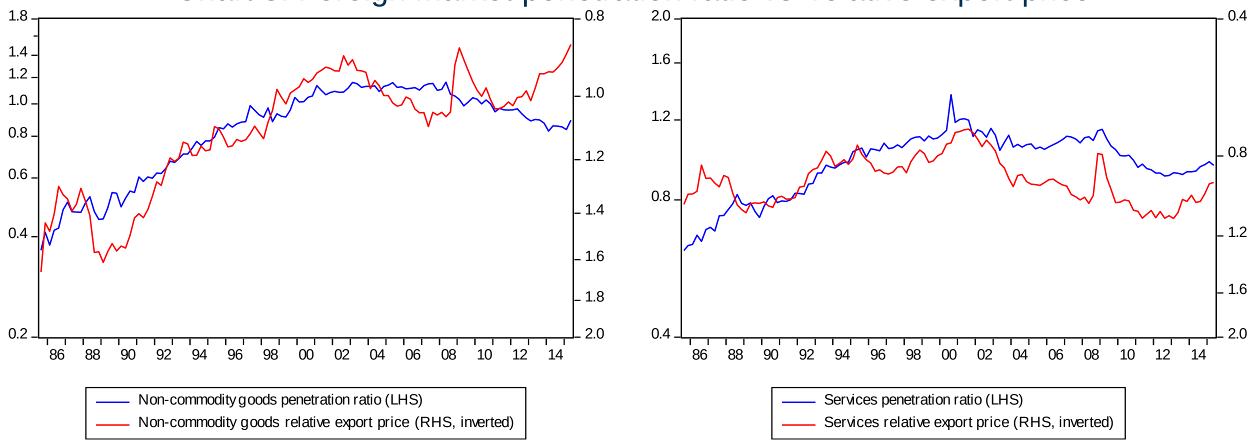
The theory outlined above predicts that if there is substitution between Australian exports of goods/services and goods/services from competing countries (that is, $\sigma>0$), then the foreign market penetration ratio of these goods/services (that is, the ratio of the volume of Australian exports to the volume of total expenditure) should have the same trend as the respective relative export price (that is, the ratio of the export price to the price of total export expenditure). To explore this relationship, in Chart 3 we plot the penetration ratios in the foreign market against relative prices. The volume of total expenditure is calculated as a weighted average of total export expenditures by Australia's major trading partners. The price of total export expenditure is calculated as a weighted average of the Consumer Price Index (CPI) of our major trading partners.

Chart 3 plots the foreign market penetration ratio on the left hand axis and the relative export price on the right hand axis using an inverted scale. Consistent with the theory derived above, the graphs display that the relationship between the penetration ratios and the relative price holds well in general over the sample period, although there seems to be a deviation of the relationship for non-commodity goods exports towards the end of the sample.

The penetration ratio for goods exports seems to be hump-shaped, increasing until around 1999, remaining relatively stable until 2008, and then declining afterwards. The chart suggests that while price movements can explain some portion of the movement in exports, other factors may also be needed to account for full movements in demand. In this paper, we use deterministic time trends and shift terms to account for these factors. We leave it to future research to explore these factors in more detail.

The penetration ratio for services exports is also hump-shaped, though the inflection points may be slightly different from those in goods exports. Other factors may also be needed to fully explain long run fluctuations in the demand of services exports. Again, deterministic time trends and shift terms are used to account for these factors in this paper, with future research left to explore them in further detail.

Chart 3: Foreign market penetration ratio vs. relative export price



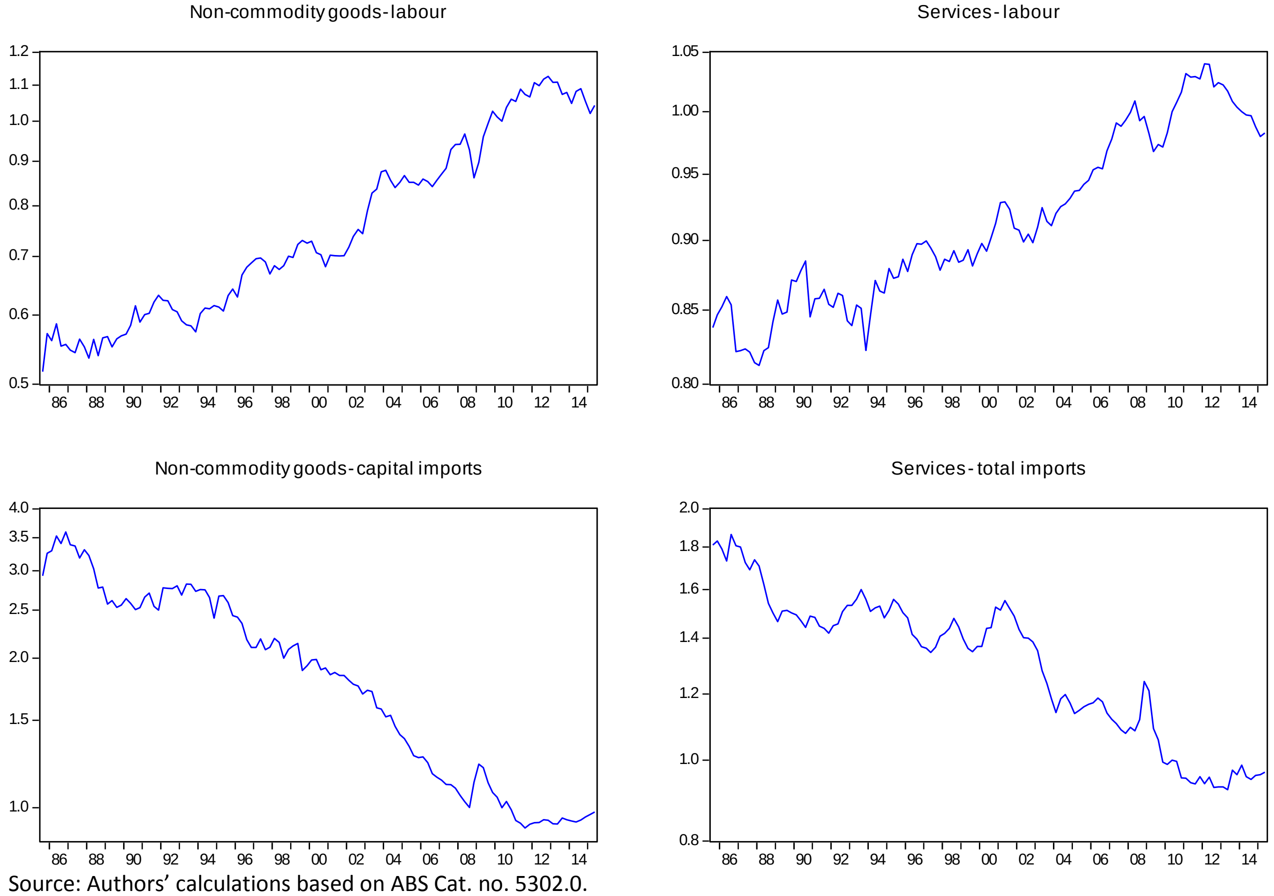
Source: Authors' calculations based on ABS Cat. no. 5302.0.

Export price mark-up

To explore the supply relationship derived in equation (30), in Chart 4 we plot unit labour costs and intermediate input costs for goods and services exports respectively. We use the capital goods import price deflator as the measure of intermediate input costs for non-commodity exports, and the total imports price deflator as the intermediate input costs for services. The use of the price of imported capital goods captures the main intermediate input cost to produce non-commodity exports, such as industrial machinery and equipment. The total imports deflator captures the varied nature of the inputs into services exports. All cost terms are expressed relative to their corresponding export prices, after conversion into their price in Australian currency. That is, the labour and intermediate input costs for non-commodity goods are expressed relative to the price of non-commodity goods exports, and the costs of services exports are expressed relative to the price of services exports, all in a common currency.

As displayed in Chart 4, the price mark-up has trended upwards over most of the sample for exports of both non-commodity goods and services. Note that in this paper, unit labour costs are an average across all sectors in the economy, due to the lack of available industry-specific labour cost data. Hence, our measure may not capture the true cost of labour in each of the two sectors. We leave it to future research to explore this issue in further detail.

Chart 4: Export price mark-up



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As chart 4 shows, the price of imports of capital goods relative to non-commodity exports has declined over most of our sample. Similarly, the price of total imports relative to services exports has also fallen, though in a more volatile manner. This could be a consequence of the cheaper goods produced as output expanded in Asia during our sample period or the more general trend decline in global manufactured goods prices.

These cost movements will have an impact on our estimation of the price mark-up equations. Ignoring the constant term in equation (30) and dividing the RHS by the log price on both sides, the mark-up equation requires the sum of unit labour and intermediate input costs relative to the export price to be zero. This requirement is likely to be met for non-commodity goods exports as the rise of unit labour costs may be offset by the decline of the import price of capital goods. On the other hand, we may need another term in the price equation for services exports to offset the rise in both the unit labour costs and oil prices in our sample period. Again, we use a deterministic trend as this term.

4. RESULTS

Econometric method: demand

We estimate the demand for exports of non-commodity goods and services using an error correction model where the short- and long-run are jointly estimated. Short-run dynamics are estimated via a general error correction model, which includes contemporaneous and lagged first differences of logged foreign consumption and logged relative prices of exports, and lagged first differences of non-commodity exports and trend shift terms.

Using the long-run export demand function derived in (27), the error correction model of non-commodity export demand is:

$$\begin{aligned}\Delta\ln(x_t^k) = \delta^k \{&\ln(x_{t-1}^k) - \ln(c_{t-1}^{*k}) - \sigma_k \ln(px_{t-1}^k e_{t-1}^k / pc_{t-1}^{*k}) \\ &-\alpha - \sum_i [\alpha_{1i} D_{i,t-1} + \alpha_{2i} D_{i,t-1}(t-1-t_{i,-1})] - \xi(t-1)\} \\ &+\sum_{s=0} \beta_{1s}^k \Delta\ln(c_{t-s}^{*k}) + \sum_{s=0} \beta_{2s}^k \Delta\ln(px_{t-s}^k e_{t-s}^k / pc_{t-s}^{*k}) + \sum_{s=1} \beta_{3s}^k \Delta\ln(x_{t-s}^k) + \mu_t^k\end{aligned} \tag{31}$$

where: the speed at which actual exports adjusts to its desired level is determined by $-1<\delta^k<0$; α is a constant; ξ is the coefficient on a linear time trend; α_1 captures permanent level shifts; α_2 captures permanent slope shifts; D_i denotes a dummy variable that is 0 for time periods less than i and one otherwise; t is a linear time trend; and t_i is the value of the linear time trend at time i; $\beta_{1s}{}^k$ is the short-run coefficient for trade-weighted foreign consumption; $\beta_{2s}{}^k$ is the short-run coefficient for relative export price; and $\beta_{3s}{}^k$ is the short-run coefficient for lagged exports.

As discussed earlier, the inclusion of deterministic trends and shift terms is necessary to account for factors other than price terms that may affect demand. For non-commodity goods exports, we choose 1999:Q3 and 2008:Q3 to be the dates for possible inflection points. The former coincides with the timing of the start of the modern rise of Asia, which raises competition for our non-commodity exports, while the latter captures possible trend shifts after the Global Financial Crisis (GFC). For services exports, the two inflection dates are assumed to be 2000:Q3 and 2008:Q3, coinciding with the Sydney Olympic Games and introduction of the GST, and the GFC.

Estimation results: demand

Table 1 reports estimation results for the demand equations. The elasticity of substitution is 0.36 and 0.75 for non-commodity goods exports and services exports respectively. This implies that both categories of Australian exports are gross complements to locally produced goods and services in foreign markets. Hence, gross expenditures on our non-commodity goods and services exports will increase when the price of these exports increases (including price changes driven by changes in the exchange rate). However, the elasticity of substitution for services exports is twice as large as that of non-commodity goods, indicating that services exports are more substitutable with services provided in foreign markets.

Our estimate of the long-run elasticity of substitution for non-commodity exports is consistent with recent Australian studies in relatively low substitutability between Australian exports and a broad basket of foreign produced goods and services. Specifically, our point estimate is somewhat lower than estimates for manufactured goods exports reported by Dvornak et al. (2005) and Norman (2006) of around 0.8 and 0.5, respectively. Our sensitivity analysis suggests these differences are likely due to the fact that these earlier studies do not constrain the foreign income elasticity to one. In particular, we find that the elasticity of substitution increases with the foreign income elasticity.

Turning to services exports, Dvornak et al. (2005) also report a somewhat lower elasticity of substitution of 0.5. Again, this outcome is consistent with our sensitivity analysis, with Dvornak et al. reporting an income elasticity estimate of around 0.8.

Jilek, Johnson and Taplin (1993) estimate an aggregate of non-commodity goods and services. They report an aggregate non-commodity elasticity of substitution of 1.7, which is higher than more recent Australian estimates for non-commodity goods or services. This significantly higher estimate could stem from the period of model data (1975 to 1995). It could also be the result of imposing an income elasticity of one but not including a time trend to capture rising foreign import penetration.

The time trends, which are included to capture rising export/import penetration, are significantly different from zero in both of the demand equations. The coefficient of the linear time trend in the non-commodity goods equation implies that demand for these exports experienced an increase of 1.4 per cent per quarter above that explained by the independent variables (as shown in the initial period of Chart 3). However, the trend rate of growth slowed to around 0.4 per cent in the September quarter of 1999, and became negative after the September quarter of 2008. The estimation results confirm the decline of the penetration ratio of non-commodity exports in recent times, shown in Chart 3.

Exports of services are estimated to be around 0.4 per cent a quarter above that explained by the independent variables before the June quarter of 2009, and around 0.3 per cent lower from this point onwards, a slowing of around 0.6 per cent a quarter. The Sydney Olympics and the GFC appear to have had significant one-off impacts in the September quarter of 2000 and the June quarter of 2009 respectively.

The trend terms may capture the effects of the rise of Asia's share of non-commodity goods in the world market and a change in general demand preferences for our exports of non-commodity goods and services exports. These are topics for future research.

The error correction adjustment parameter in the non-commodity goods equation is -0.53, indicating that more than half of the short-run deviation is corrected in the first quarter. On the other hand, the adjustment speed in the services equation is much slower, correcting only -0.15 in the first quarter.

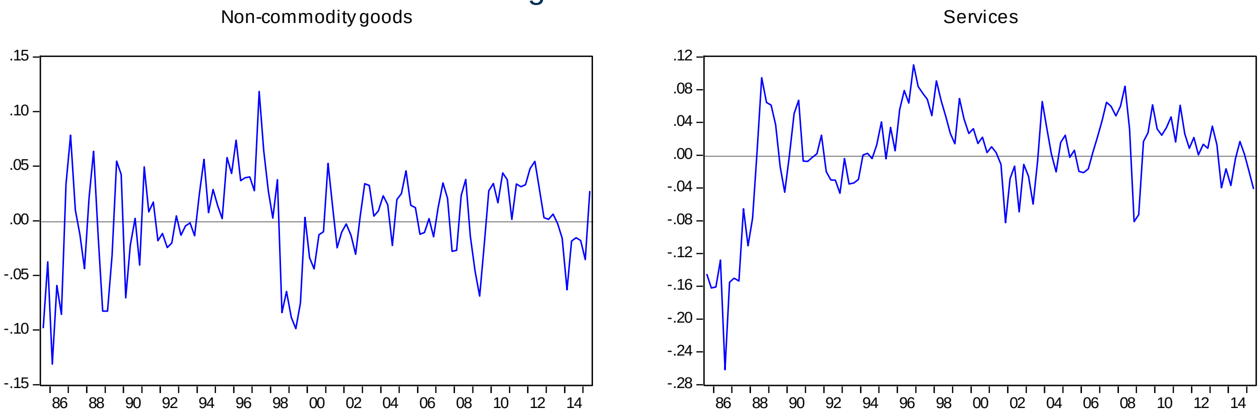
Table 1: Estimation results – Demand

	Non-commodity	Services
Long-run		
σ_k	-0.3553	-0.7450
	(0.1046)	(0.1727)
α	7.0839	9.9969
	(0.4827)	(0.5887)
ξ	0.0136	0.0038
	(0.0010)	(0.0008)
$\alpha_{1,1999:3}$	-0.0103	
	(0.0015)	
$\alpha_{1,2008:3}$	-0.1059	
	(0.0283)	
$\alpha_{2,2008:3}$	-0.0122	
	(0.0017)	
$\alpha_{1,2000:3}$		0.1635
		(0.0204)
$\alpha_{1,2009:2}$		-0.0549
		(0.0286)
$\alpha_{2,2009:2}$		-0.0062
		(0.0036)
Short-run		
δ	-0.5271	-0.1456
	(0.0847)	(0.0463)
β_{10}		0.8256
		(0.4466)
β_{20}	-0.1692	-0.1181
	(0.1097)	(0.0666)
Summary statistics		
R-squared	0.3862	0.4749
Adjusted R-squared	0.3475	0.4371
Durbin Watson	1.8862	2.2564
ADF statistic (long run residuals)	-6.33	-4.00
Sample	1985:3-2015:2	1985:3-2015:2

Note: Standard errors in parentheses.

The long-run residuals of the two models are plotted in Chart 5. Residuals for non-commodity goods have displayed rapid fluctuations around the mean, whereas residuals for services have displayed large cyclical fluctuations over the full sample. Applying co-integration tests to the long-run residuals leads us to reject the null of a unit root (that is, reject the null of no cointegration) at conventional levels of significance.

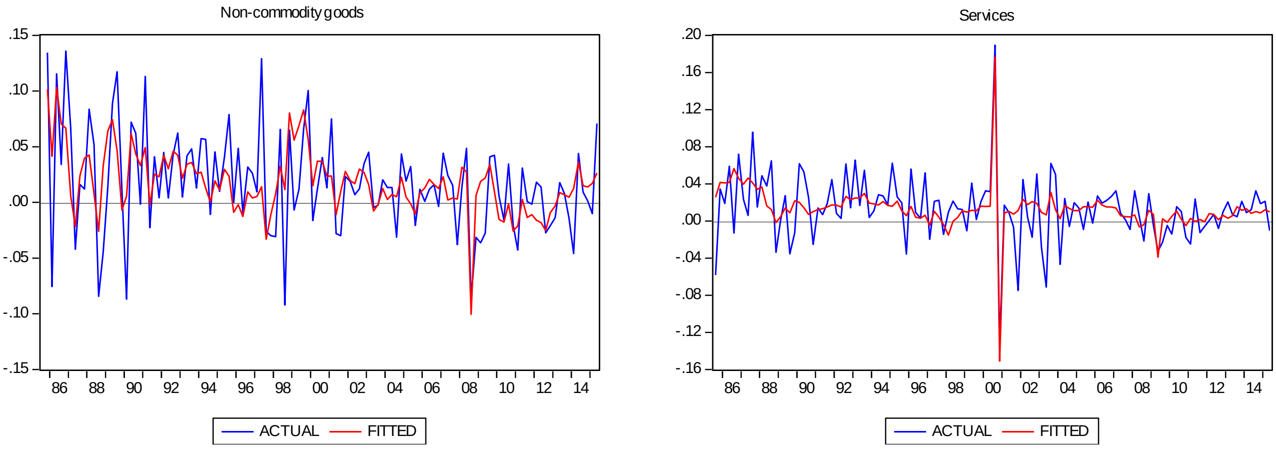
Chart 5: Long-run residuals – Demand



Source: Authors' calculations based on ABS Cat. no. 5302.0.

Finally, Chart 6 highlights the volatility of the quarterly growth rates of the two categories of exports, the overall fit of the model and the extent to which the exogenous shift terms capture the one-off impact of the Olympic Games and the GFC.

Chart 6: Short-run residuals – Demand



Source: Authors' calculations based on ABS Cat. no. 5302.0.

Econometric method: supply

Following the approach used to model demand, the supply of exports is estimated using an error correction model which allows for the short-run and long-run to be jointly estimated. Short-run dynamics are estimated via a general error correcting model, which includes contemporaneous and lagged first differences of log unit labour costs, intermediate input prices and the error correcting term consistent with the long-run export supply relationship described by equation (30). The resulting general error correction model is:

$$\begin{aligned}\Delta \ln(px_t^k) = {} & \delta^k \left\{ \ln(px_{t-1}^k) - \psi^k \ln(w_{t-1}^k n_{t-1}^k / y_{t-1}^k) - (1-\psi^k)\ln(pm_{t-1}^k) - \alpha \; - \xi(t-1) \right\} \\ & + \alpha_{1i} D_{i,t} + \sum_{s=0} \beta_{1s}^k \Delta \ln(w_{t-s}^k n_{t-s}^k / y_{t-s}^k) + \sum_{s=0} \beta_{2s}^k \Delta \ln(pm_{t-s}^k) + \mu_t^k \end{aligned} \qquad (32)$$

where: the speed at which the actual price approaches its desired level is determined by $-1<\delta^k<0$; ψ^k is the long-run mark-up coefficient of unit labour costs; α is a constant; ξ is the coefficient on a linear time trend; $\beta_{1s}{}^k$ is the short-run coefficient for unit labour cost; and $\beta_{2s}{}^k$ is the short-run coefficient for intermediate input prices (that is, import prices).

The services export price equation contains a dummy to account for the negative impacts of the September 11 terrorist attacks.

Estimation results: supply

Table 2 reports the estimation results of the equations for export prices of non-commodity goods and services. The long-run coefficients of unit labour costs in the two equations are 0.65 and 0.86, respectively, indicating labour costs are the main contributor in both of these prices, particularly in the case of services exports. As discussed in Chart 4, which shows price mark-ups, the significance of the deterministic trend in the services export supply equation indicates that services export prices grew slightly below the growth rate implied by labour costs and the price of imports.

Table 2: Estimation results – Supply

	Non-commodity	Services
Long-run		
ψ^k	0.6525	0.8644
	(0.0108)	(0.0411)
α	0.4719	0.8603
	(0.0198)	(0.0997)
ξ		-0.0011
		(0.0003)
Short-run		
δ	-0.2758	-0.2152
	(0.0667)	(0.0383)
$\alpha_{1,2001:3}$		-0.0185
		(0.0073)
β_{10}	0.4936	0.1366
	(0.2055)	(0.0675)
β_{20}	0.3187	0.0762
	(0.0410)	(0.0225)
Summary statistics		
R-squared	0.3897	0.3822
Adjusted R-squared	0.3682	0.3494
Durbin Watson	1.9420	1.9103
ADF statistic (long run residuals)	-4.72	-3.15
Sample	1985:3-2015:2	1985:3-2015:2

Note: Standard errors in parentheses.

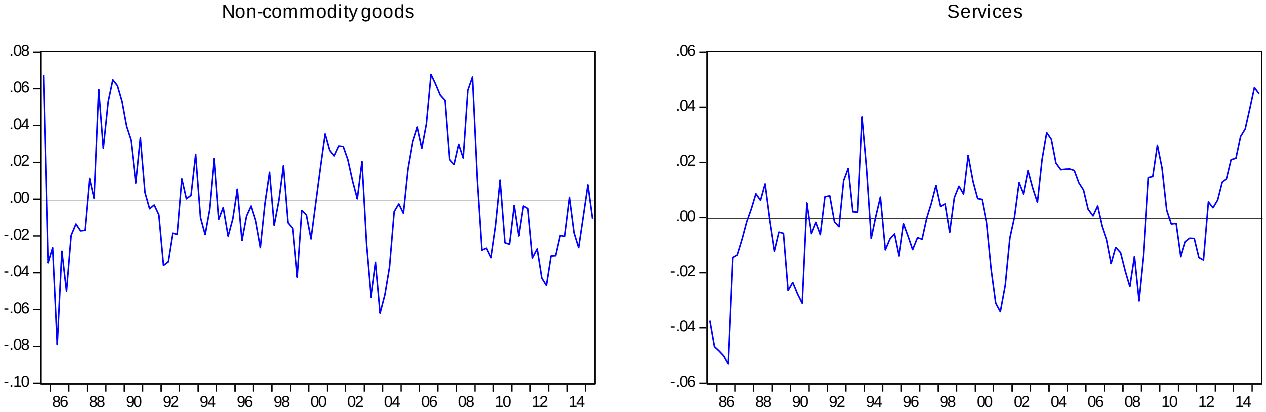
The short run dummy variable in the services equation indicates that the September 11 terrorist attacks had a noticeable impact on our services exports. This is not a particularly surprising result given the large share of services exports that are tourism related.

Estimates of the speed of adjustment coefficients indicate that the price of non-commodity exports adjusts around 28 per cent of the way toward the long-run equilibrium in the first quarter, while the price of services exports is estimated to adjust around 22 per cent of the way toward the long run equilibrium.

Chart 7 plots the long-run residuals for the two export price categories. Again, the residuals for non-commodity goods exports display quicker reversion to the long-run relationship than the price of services exports.

Applying co-integration tests to the long-run residuals leads us to reject the null of a unit root (that is, reject the null of no cointegration) at conventional levels of significance.

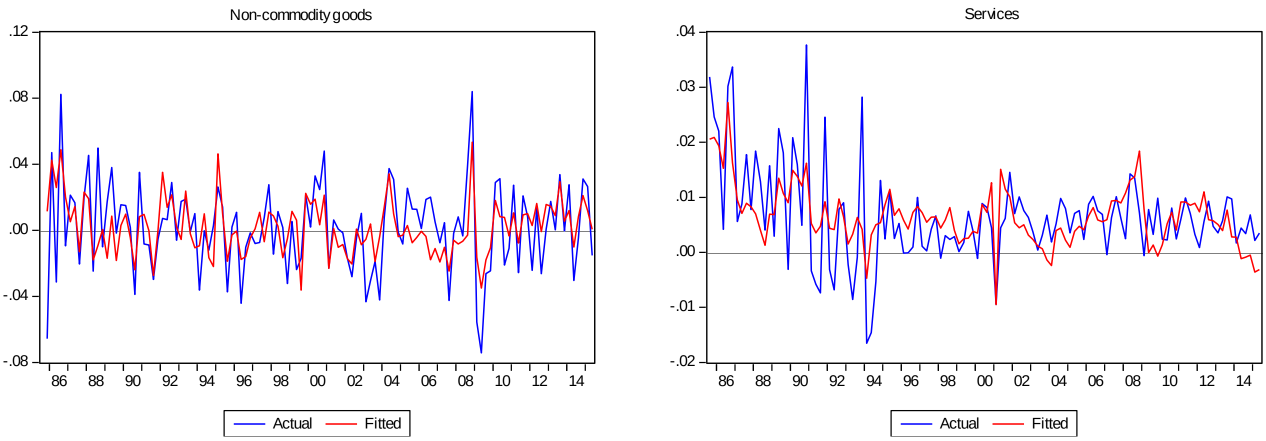
Chart 7: Long-run residuals – Supply



Source: Authors' calculations based on ABS Cat. no. 5302.0.

Chart 8 displays the volatility of the quarterly growth rates of the two prices and the overall fit of the model. The fit for the short-run dynamics of the price for the non-commodity goods is reasonably good, whereas the short-run model for the price of services exports does not capture the dynamics to a large degree. This again is left for our future research.

Chart 8: short-run residuals – Supply



Source: Authors' calculations based on ABS Cat. no. 5302.0.

5. Conclusion

This paper models both the supply and demand of Australian non-commodity exports.

It builds on earlier demand modelling by Jilek, Johnson and Taplin (1993); Senhadji and Montenegro (1999); Dvornak et al. (2005) and Norman (2006) by deriving long-run export demand relationships from first principles. These long-run relationships are augmented by cyclical explanatory variables to form error correction models, which are estimated using quarterly data for non-commodity goods and services from 1985 to 2015.

On the demand side, the paper finds a relatively low substitution elasticity between Australian exports and a broad basket of foreign produced goods and services. So, for instance, if Australian export prices increase, overseas buyers are less likely to respond by purchasing the same goods and services from foreign competitors, and are instead more likely to respond by reducing their demand for the product – whether Australian or foreign-made. In other words, income effects trump substitution effects. This result is consistent with other Australian studies.

On the supply side, our modelling assumes that Australian manufacturing and services exporters are price setters – an assumption consistent with existing literature. This means that if global input costs increase, Australian exporters are able to pass some of that increase onto their customers. Based on this assumption, our modelling suggests that labour costs are a larger contributor to Australia's non-commodity export prices than imported intermediate inputs costs.

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APPENDIX A: DATA SOURCES

Australian Bureau of Statistics (2012a) *Balance of Payments and International Investment Position, Australia*, ABS Cat. no. 5302.0, December 2012: imports volumes and prices; and trade-weighted non-exchange rate index.

Australian Bureau of Statistics (2012b) *Australian National Accounts: National Income and Product*, *Australia*, ABS. Cat. No. 5206. 0., December 2012: gross national expenditure volumes and prices; aggregate household non-commodity volumes and prices; rental services volumes and prices; and gross fixed capital expenditure: machinery and equipment volumes and prices.