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Productivity and the New Zealand Dollar: Balassa-Samuelson tests on sectoral data

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NON-TECHNICAL SUMMARY

The Balassa-Samuelson hypothesis suggests there should be a relationship between the real exchange rate and a country's relative productivity performance. Specifically, countries with a weak relative productivity performance should see a low or falling real exchange rate. While there does seem to have been a connection between exchange rates and productivity over time internationally; at least superficially, this does not seem to have been the case in New Zealand. On standard measures, New Zealand's real effective exchange rate has been roughly flat, on average, over 50 years, in spite of an apparent substantial deterioration in the economy's relative productivity.

This note digs down into some sectoral data to see whether it can shed any light on this real exchange rate puzzle. Simple sectoral productivity and price measures are constructed from industry level data for New Zealand, Australia, Japan, the United Kingdom and the United States for the period 1978 to 2006. The sectoral measures attempt to approximate the concepts of tradable and non-tradable sectors that underlie the Balassa-Samuelson theory, but are necessarily imperfect so should more properly be referred to as 'more tradable' and 'more non-tradable' sectors. These measures suggest that the more tradable sectors have exhibited faster productivity growth than the more non-tradable sectors in all five countries. Non-tradable sectors have to compete for labour with tradable sectors, but without matching productivity growth, an acceleration in tradable sector productivity growth will be associated with higher non-tradable inflation. Prices of tradable goods, by contrast, are typically assumed to be set, over time, in world markets.

The note tests for both *domestic* and *international* Balassa-Samuelson effects. The domestic test involves testing whether an increase in the differential between New Zealand tradable to non-tradable productivity growth has tended to be associated with an increase in the differential between non-tradable and tradable inflation. The international test involves testing whether an increase in the productivity growth differential between the tradable and non-tradable sectors in New Zealand compared to the same differential in each other country tended to be associated with a stronger bilateral real exchange rate. On the measures used here, there appears to be little evidence of either domestic or international Balassa-Samuelson effects having held in New Zealand.

1. Introduction

This note examines the longer-run relationship between New Zealand's productivity performance and the real exchange rate. Over recent decades, a substantial aggregate productivity gap has opened up between New Zealand and other advanced economies (Figure 1). All other things equal, the BS hypothesis suggests that such a divergence in relative productivity should drive down the real exchange rate over the long-term (i.e. once cyclical factors like house price fluctuations or slow price adjustment can be abstracted from).[1] But Figure 2 suggests that there has been no positive relationship between various measures of relative productivity and the Reserve Bank's real trade-weighted index (TWI) measure of the real exchange rate over this horizon. Empirical tests tend to struggle to find a statistically significant and positive relationship between aggregate productivity and the real exchange rate in New Zealand.[2] It is puzzling that the real exchange rate has, over the long-term, resisted the apparent deterioration in the economy's underlying competitiveness.

The BS hypothesis is often used to explain deviations from what the theory of Purchasing Power Parity (PPP) would otherwise suggest for the evolution of the real exchange rate.[3] The BS hypothesis suggests that relative productivity differences between countries, and changes in relative productivity over time, will affect the real exchange rate. This is because measures of the real exchange rate reflect relative national price levels – which comprise prices in the traded and non-traded sectors – across countries. If productivity growth accelerates in a country's tradables sector – whose product prices are determined internationally – activity in that sector will expand and, in competition with non-tradables sector firms, real wages will be bid up across the economy. All else equal, that will tend to raise prices in the non-tradable sector relative to those in the tradable sector, raising that country's real exchange rate. If, on the other hand, productivity growth in a country's tradable sector lags, there will be less competition for resources in the non-tradable sector, and the real exchange rate will tend to weaken. Section 2 and Box 1 explain the mechanics in more detail.

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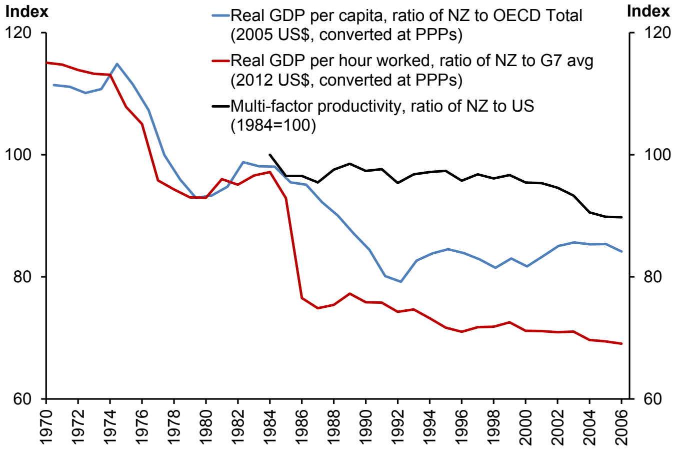
[1] See seminal papers by Balassa (1964) and Samuelson (1964).

[2] Updating the Dynamic OLS results from Brook and Hargreaves (2001) provides some evidence of a positive relationship between various productivity proxies and the real bilateral exchanges rate between New Zealand and Australia, Japan and the UK, provided terms of trade are controlled for. No productivity proxies are significant for the comparison with the US. Most of the specifications tested however still had serial correlation in their residuals, so the autoregressive distributed lag approach of Pesaran and Shin (1999) and Pesaran *et al* (2001) was also considered. This approach can be used irrespective of the order of integration of the variables in the model and can improve efficiency in small samples relative to VAR approaches. Based on this approach, there is evidence of cointegration between the real exchange rate, relative productivity and relative terms of trade for the bilaterals with the US, Japan and the UK, but not Australia. Relative productivity is only significant in the regressions for Japan and the UK. In a dynamic panel setting using a sample running from 1973 to 2008, Chong, Jordà and Taylor (2012) find that there is support for the BS effect globally, although for New Zealand the effect is small and statistically insignificant (negative when the US is used as numeraire and positive when the sample average is used as reference).

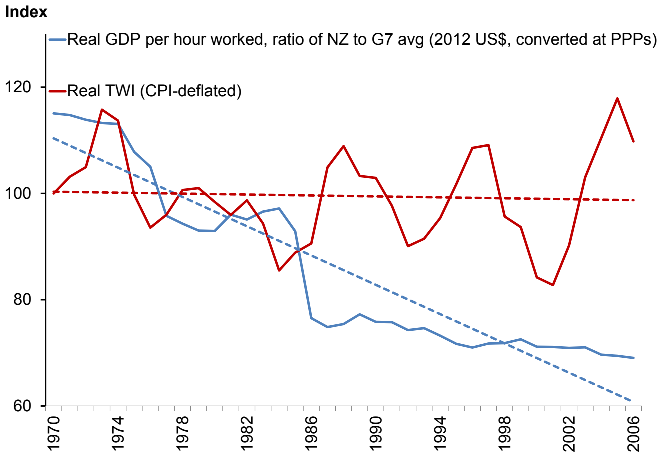
[3] Over the long-term, PPP suggests that aggregate price levels, expressed in a common currency, should be roughly equal across countries (known as absolute PPP). Likewise, PPP implies that the exchange rate should adjust to cross-country inflation differentials over time (known as relative PPP).

Figure 1: Measures of relative aggregate productivity



Source: OECD, Conference Board, author calculations

Figure 2: Relative aggregate productivity and the real exchange rate



Source: OECD, Conference Board, RBNZ, author calculations. Trends are linear time trends.

This note considers the link between productivity and the real exchange rate using sectoral data for the period 1978 to 2006. Sectoral productivity and price measures are constructed for New Zealand and four of our major trading partners using industry level production data. The constructed sectoral series are then used to test for key relationships using a simple BS framework.

2. THE LINK BETWEEN PRODUCTIVITY AND THE REAL EXCHANGE RATE

2.1 UNDERLYING MECHANICS OF THE BALASSA-SAMUELSON THEORY

Differences in productivity growth between the traded and non-traded sectors can give rise to BS effects. Pricing behaviour tends to differ in the two sectors, since the tradable sector is more exposed to foreign competition (keeping common currency prices more or less aligned across countries - i.e. ensuring that the law of one price (LOOP) will hold for tradables over time), while the non-tradable sector competes with the tradable sector for resources and is largely exposed to domestic competition only (so that prices, expressed in a common currency, may persistently differ between countries). In general, tradable sectors also tend to exhibit faster productivity growth because of economies of scale and technological spill overs.

The mechanics of the BS effect are as follows (see Box 1 for more technical elaboration). An improvement in domestic tradable sector productivity growth, all else equal, leads to faster wage increases in the traded sectors since productivity gains imply increasing sales and higher demand for labour, bidding up the price of labour in the tradables sector. Higher wages in tradable sectors tend to spill over to non-traded sectors because these sectors have to match tradable sector wages to retain employees. In the absence of a matching improvement in non-tradable productivity growth, inflation in non-tradable sectors will increase relative to that for tradable goods. That occurs because international arbitrage ensures that common currency traded good prices are aligned globally for a given nominal exchange rate. By contrast, the increase wage inflation boosts inflation in the non-traded sector, causing the economy's relative inflation rate to rise. This implies a more appreciated real exchange rate, relative to what PPP would otherwise imply. This means that over time, non-tradable services like haircuts (with limited scope for productivity gain) will become more expensive and the price level will rise in countries that are becoming relatively wealthier. These relationships can therefore be expressed in levels terms or in growth rates as they are in equations (4) to (9) in Box 1.

Box 1: A simple Balassa-Samuelson framework

The real exchange rate ($rer_{NZ,t}$) can be decomposed as follows (all variables expressed in log terms):

$$rer_{NZ,t} = ner_{NZ,t} + [pr^{T}_{NZ,t} - pr^{T}_{i,t}] + \left(1-\alpha^{NZ}\right)\left[pr^{NT}_{NZ,t} - pr^{T}_{NZ,t}\right] - \left(1-\alpha^{i}\right)\left[pr^{NT}_{i,t} - pr^{T}_{i,t}\right] \quad (1)$$

where the equation is derived using the following:

- The real exchange rate is the relative price of domestic and foreign goods, measured in domestic currency terms: $rer_t = ner_{NZ:i,t} + pr_{NZ,t} - pr_{i,t}$ (2)

  using aggregate prices in each country (pr) and with the nominal rate defined ($ner_{NZ,t}$) as the foreign currency price of one New Zealand dollar relative to country *i* (an increase in the real exchange rate therefore represents appreciation).
- In each economy, aggregate prices are a weighted average of the prices of traded and non-traded goods, such that $pr_t = \alpha pr^{T}_{t} + (1-\alpha)pr^{NT}_{t}$ (3)

  where α represents the share of tradables in domestic output. In this note, price series are constructed using sectoral value-added deflators.

The real exchange rate therefore comprises two parts: the first two terms on the right hand side of equation (1) describe the relative price of tradable goods between New Zealand and a trading partner, while the second term captures the difference between tradable and non-tradable prices between New Zealand and a given trading partner.

The basic version of the BS model makes four main assumptions:

1. Labour and capital shares are equal across sectors and across countries.[4]

[4] If factor intensities differ across sectors, changes to sectoral productivity can have impacts on relative sectoral prices that are not one-for-one. See Mihaljek and Klau 2003 or Égert 2002b for more discussion. Cross-country differences in factor shares will also matter. For example, in economies with higher relative capital intensity in tradables relative to non-tradables, labour productivity measures may overstate the importance of BS effects compared to total factor productivity (TFP) that measures combined productivity of all inputs. In this note, the shares

2. There is perfect competition so that labour is paid its marginal product.
3. Perfect labour mobility domestically so that wages are equalised across sectors and perfect capital mobility so that interest rates are exogenous.
4. Terms of trade, and other demand side factors, are ignored.

These assumptions can be relaxed in order to apply the model to more realistic cases (described in later sections). Under these assumptions, domestic tradable to non-tradable inflation will reflect domestic tradable to non-tradable productivity growth differentials:

$$\Delta pr^{NT}_{NZ,t} - \Delta pr^{T}_{NZ,t} = \Delta prod^{T}_{NZ,t} - \Delta prod^{NT}_{NZ,t} \quad (4)$$

with all variables are expressed in rates of change (Δ) and *prod* representing total factor productivity growth, which is typically proxied using labour productivity.[5]
Likewise, it can be shown that the New Zealand to trading partner non-tradable to tradable inflation differential will depend on the tradable to non-tradable productivity growth differential between the countries:

$$\left(\Delta pr^{NT}_{NZ,t} - \Delta pr^{T}_{NZ,t}\right) - \left(\Delta pr^{NT}_{i,t} - \Delta pr^{T}_{i,t}\right) = (\Delta prod^{T}_{NZ,t} - \Delta prod^{NT}_{NZ,t}) - (\Delta prod^{T}_{i,t} - \Delta prod^{NT}_{i,t}) \quad (5)$$

Substituting equation (3) into equation (1) yields the following:

$$\Delta rer_{NZ,t} = \Delta ner_{NZ,t} + [\Delta pr^{T}_{NZ,t} - \Delta pr^{T}_{i,t}] + (1-\alpha^{NZ})\left[\Delta prod^{T}_{NZ,t} - \Delta prod^{NT}_{NZ,t}\right] - (1-\alpha^{i})\left[\Delta prod^{T}_{i,t} - \Delta prod^{NT}_{i,t}\right] \quad (6)$$

Rewriting equation (5) in terms of non-tradable prices and using the definition of aggregate prices, aggregate inflation differentials between New Zealand and a trading partner *i* will be given by:

$$\Delta pr_{NZ,t} - \Delta pr_{i,t} = \Delta pr^{T}_{NZ,t} - \Delta pr^{T}_{i,t} + (1-\alpha^{NZ})\left[\Delta prod^{T}_{NZ,t} - \Delta prod^{NT}_{NZ,t}\right] - (1-\alpha^{i})\left[\Delta prod^{T}_{i,t} - \Delta prod^{NT}_{i,t}\right] \quad (7)$$

If LOOP holds for tradables, that is $pr^{T}_{i,t} = ner_{NZ:i,t} + pr^{T}_{NZ,t}$, then (7) can be simplified to:

$$\Delta pr_{NZ,t} - \Delta pr_{i,t} = -\Delta ner_{NZ,t} + (1-\alpha^{NZ})\left[\Delta prod^{T}_{NZ,t} - \Delta prod^{NT}_{NZ,t}\right] - (1-\alpha^{i})\left[\Delta prod^{T}_{i,t} - \Delta prod^{NT}_{i,t}\right] \quad (8)$$

while the first term in (6) will be mean-reverting and will drop away, such that:[6]

$$\Delta rer_{NZ,t} = (1-\alpha^{NZ})\left[\Delta prod^{T}_{NZ,t} - \Delta prod^{NT}_{NZ,t}\right] - (1-\alpha^{i})\left[\Delta prod^{T}_{i,t} - \Delta prod^{NT}_{i,t}\right] \quad (9)$$

2.2 TESTS FOR BALASSA-SAMUELSON EFFECTS

There are five tests that are typically used to test for BS effects using a basic version of the BS model as the benchmark (summarized in Figure 3). At an aggregate level, the basic BS model predicts that weak productivity growth relative to country *i* (i.e. a lower cross-country productivity differential) should be associated with depreciation of

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of labour and capital in each sector are assumed to be equal given the difficulty of obtaining a long series of internationally comparable data. If labour intensities are not equal then $pr^{NT}_{NZ,t} - pr^{T}_{NZ,t} = \left(\frac{\delta^{NT}}{\delta^{T}}\right) prod^{T}_{NZ,t} - prod^{NT}_{NZ,t}$ with δ representing the labour share of the sectors.

[5] This representation assumes Cobb-Douglas production functions, constant returns to scale and no mark-ups over unit labour costs. Average labour productivity can therefore be used as proxy for marginal labour productivity. However, different definitions of productivity are likely to behave differently through time. For example, productivity per hour may capture some of the effects of capital deepening and changes in TFP. TFP, on the other hand, may be impacted differently by the cycle from other measures and may contain measurement error from imprecise estimates of the capital stock.

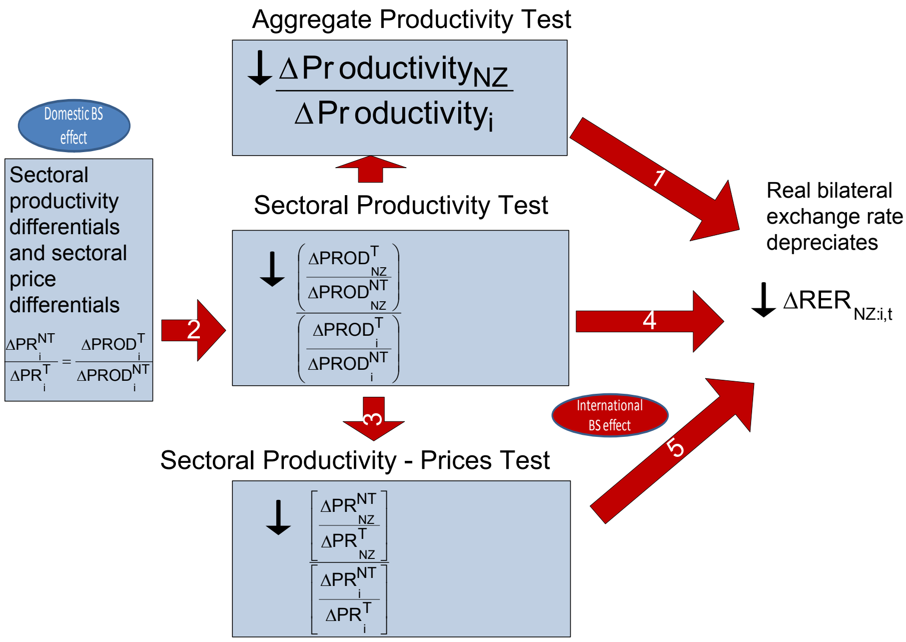
[6] Likewise, changes in the bilateral real exchange rate may then be written as the changes in the relative price of traded to non-traded goods between New Zealand and a trading partner *i*: $\Delta rer_{NZ,t} = (1-\alpha^{NZ})\left[\Delta pr^{NT}_{NZ,t} - \Delta pr^{T}_{NZ,t}\right] - (1-\alpha^{i})\left[\Delta pr^{NT}_{i,t} - \Delta pr^{T}_{i,t}\right]$

the real bilateral exchange rate (Test 1).[7] Figure 2 suggests that this has not held in New Zealand's case.

The predicted aggregate relationship depends on implied relationships between sectoral inflation and productivity differentials and the real exchange rate. The basic model assumes that the domestic differential between non-tradable to tradable inflation ($\Delta PR^{T}_{NZ,t}$ less $\Delta PR^{NT}_{NZ,t}$) reflects the differential between relative productivity growth between the two sectors ($\Delta PROD^{T}_{NZ,t}$ over $\Delta PROD^{NT}_{NZ,t}$) (Test 2 using equation 4 in Box 1). This is sometimes called the *domestic test of the BS effect*.[8]

The external transmission mechanism of the BS effect relies on the assumption that a country's tradable to non-tradable productivity growth differential with different trading partners are responsible for observed bilateral non-tradable to tradable inflation differentials (Test 3 and equation 5).[9] Said differently, this supposes that the domestic BS relationship holds across trading partners – if the gap between New Zealand's tradable and non-tradable productivity increase relative to that in another country we would also expect to see the gap between New Zealand's tradable and non-tradable inflation relative to that other country increase.[10]

Figure 3: Simple tests for BS effects



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[7] See, for example, Balassa (1964) or De Broeck and Slok (2001) in a cross-sectional setting, Alquist and Chinn (2002) in a time series cointegration setting, Drine and Rault (2005) in a panel context or Chowdhury (2011) for an ARDL application.
[8] This is also sometimes referred to as the Baumol and Bowen (1966) effect. Productivity is expected to rise more slowly in service sectors, which tend to have higher labour intensity than the manufacturing sector. See Mihaljek and Klau (2003, 2008) for more detail.
[9] See Égert (2002a) or (2002b) for examples.
[10] Some studies proceed directly to testing whether bilateral inflation differentials can be explained by relative sectoral productivity differentials (i.e. using equation 7 or 8). See OLS studies by Lojschova 2003 or Mihaljek and Klau (2003, 2008). The latter also include a lagged dependent variable to deal with autocorrelation. Drine and Rault (2005) use only relative sectoral productivities and apply Johansen's cointegration approach in a panel setting.

The expected direction of the BS effect will depend on how tradable and non-tradable productivity growth rates stack up across countries (Test 4 and equation 6). The BS effect would serve to put downward pressure on the real bilateral exchange rate ($RER_{NZ:i,t}$) relative to country *i*, for example, if New Zealand's traded productivity growth declined relative to country *i*'s (for given relative levels of productivity growth in each country's non-traded sector), or if productivity growth in country *i*'s non-traded sector declined relative to New Zealand's (for given relative levels of productivity growth in each country's traded sector).

A decline in the non-tradable to tradable inflation differential between New Zealand and a trading partner would therefore be expected to be associated with depreciation of the long-run real exchange rate (Test 5), if LOOP is assumed to hold for tradables over the long-run.[11]

To summarize, this note will test for the following relationships using a simple BS framework:

1. A *domestic* BS effect – whether an increase in the differential between domestic tradable sector productivity growth and that in the non-tradable sector tends to have been associated with an increase in the differential in domestic non-tradable to tradable inflation.
2. An *international* BS effect – whether an increase in the productivity growth differential between the tradable to non-tradable sectors in New Zealand compared to the same differential in a given trading partner tends to have been associated with a stronger bilateral real exchange rate.
3. An external transmission mechanism associated with BS effects:
    a. that an increase in the non-tradables to tradables inflation differential in New Zealand relative to a given trading partner tends to have been associated with a higher tradables to non-tradables productivity growth differential between New Zealand and that trading partner, and
    b. that a higher non-tradable to tradable inflation differential between New Zealand and a given trading partner tends to have been associated with a stronger real bilateral exchange rate.

Even with good data, empirical tests for these long-run relationships have to confront two problems. The first is the difficulty of identifying long-term phenomena in volatile time series data. Short-run frictions, shocks and cyclical changes in economic variables mean that adjustment back to long-run exchange rate relationships tend to be very slow. The other problem is that tests for stationarity can be biased over the short history over which time series are available and this problem can be made worse if there are unidentified structural breaks in the data.

[11] Even if LOOP does not hold, BS effects might still be present (the third term in equation 1, see also footnote 5). For OLS testing of tradables LOOP see Lojschova (2003) or Egert (2002a).

To address these problems, studies tend to opt for methodologies that use low frequency time series or panel data to help improve the power of econometric tests. Over recent years, cointegration techniques using higher frequency data have also become popular in identifying long-run relationships between real exchange rates, BS effects and other determinants of exchange rates. Given the short sample for which data are available, the analysis here relies on the simple decomposition of the real exchange rate outlined in Box 1 and some simple regressions.

3. DATA

Getting good quality data to test for BS relationships is itself a challenge. Comparable tradable and non-tradable measures for New Zealand and Australia, Japan, the United Kingdom and the United States are constructed using sectoral output and labour-input measures. In the absence of long series of internationally comparable total factor productivity measures or data on hours worked, productivity is proxied using output per worker. This is calculated as real value-added divided by total number engaged using data from the OECD's STAN database, which has data available for New Zealand from 1977 to 2006. To obtain long series of New Zealand industry level employment data, unofficial backdated series were obtained from Statistics New Zealand. These series only go back to 1978 and are used for the full sample – which is from 1978 to 2006.[12] All series used are annual and are re-indexed to a 1978 base year (1989 when comparing New Zealand and Australia since Australian sectoral employment data is not available prior to that in the STAN database).

It is also difficult to accurately separate tradable and non-tradable sectors.[13] In the main text, manufacturing plus agriculture and mining are together taken to represent the tradable sector and total services plus construction and electricity are used to represent the non-tradables sector. The labelling of services as non-tradables can be quite problematic. For example, a substantial portion of New Zealand's tourism and education exports are captured as services and in the UK financial services make up a substantial share of total exports.[14] Because these categorisations are necessarily imperfect, sectors should more properly be referred to as 'more tradable' and 'more non-tradable'.

In the Appendix, results are also presented using a narrower classification scheme (Classification 2), in which the traded sector is represented as as manufacturing only, while services are taken to represent non-tradables.

[12] There are several caveats around the unofficial sector employment series used, which mean that these figures have not been completely quality assured by Statistics New Zealand.
[13] Both tradable and non-tradable products and services will include intermediate inputs from the other sector and the share of tradable components in the aggregate output might have varied over time.
[14] In the STAN database, services comprise wholesale and retail trade, restaurants and hotels; transport, storage and communications; finance, insurance, real estate and business services; community, social and personal services.

It is quite common to see discussion of tradables and non-tradables inflation drawing on components of the Consumer Price Index (CPI) because of their international comparability. Unfortunately, CPI-based measures of tradables and non-tradables are not available for all the countries of interest for a sufficiently long sample. Sectoral value-added deflators, on the other hand, are useful as they capture all production in different sectors of the economy, though they will not capture import prices. In this note, value-added deflators are used to calculate all price series to ensure consistency in the measurement of productivity growth and sectoral inflation.[15] Likewise, all real exchange rates used for formal empirical work are computed on the basis of value-added deflators.

Aggregate price series are created by using sectoral deflators and by weighting tradables and non-tradables by their volume value-added shares in total output, as in equation (3) in Box 1. The share of tradables in total output for each country, α in equation (1), is calculated using the average values of α during the period 1978 to 2006, except Australia (where 1989 to 2006 is used). This yields an average tradable share of 23 percent in the first classification and 21 percent in the second.[16]

Figure 4 shows that, for New Zealand and Australia, using a value-added definition of sectoral prices produces very different inflation measures than those based on consumer prices, especially for tradable prices. This distinction is particularly important in the Australian case, where the high rate of tradables sector inflation reflects the strong increase in the country's commodity export prices over the period (which has little direct bearing on general Australian consumer prices).

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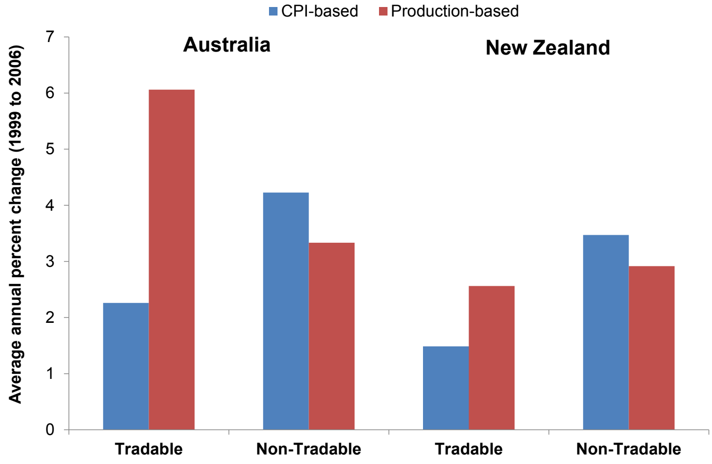
[15] Producer prices could instead be used to capture tradables prices and consumer prices instead used to proxy non-tradables prices. Under the narrow sector classification 2, for example, over recent history tradable real bilateral exchange rates ($ner_{NZ,t} + pr^{T}_{NZ,t} - pr^{T}_{i,t}$) would be more appreciated against all four currencies. Relative non-tradable prices $(1-\alpha^{NZ})[pr^{NT}_{NZ,t} - pr^{T}_{NZ,t}] - (1-\alpha^{i})[pr^{NT}_{i,t} - pr^{T}_{i,t}]$, on the other hand, would be higher compared to the US and UK and lower for Japan and AU over recent history. Note also that using different measures of sector prices would give different weight to non-tradables in domestic prices. In Engel (1999), for example, the contribution to the price index of non-tradables is higher when using output series than when using CPI-based measures.

[16] The use of sample averages to weight the sectors does not fully capture the decline in the share of manufacturing in production in Australia, the UK and New Zealand over the sample. Alternative weighting schemes were also considered: the first uses each country's average tradable sector share over the sample (which yields US=0.17, JP=0.24,UK=0.24, NZ=0.27, AU=0.22 for classification 1, US=0.16, JP=0.25,UK=0.22, NZ=0.22, AU=0.16 for classification 2), while the second uses each country's period by period shares of manufacturing to total value added. When changes in these shares through time are taken into account, the international BS effects are slightly larger, but this does not affect judgements about the relevance of BS effects. Note that the STAN data do not provide the unallocated components of production GDP or FISM for all countries considered so combined sectoral output does not equal total GDP. This makes is difficult to calculate the coverage of each classification scheme. The first scheme accounts for close to, but probably a little less than, full coverage, while the narrower classification covers roughly 80 percent of total output in all countries under consideration.

Figure 4: CPI- versus value-added deflator-based inflation (1999 – 2006)*



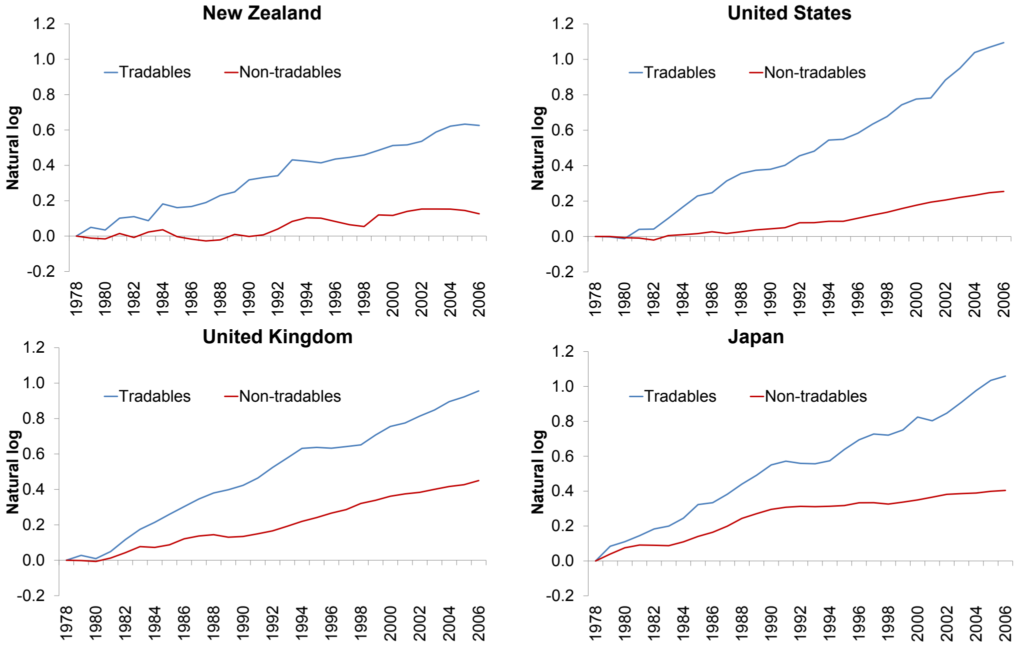
* The period selected reflects data availability.

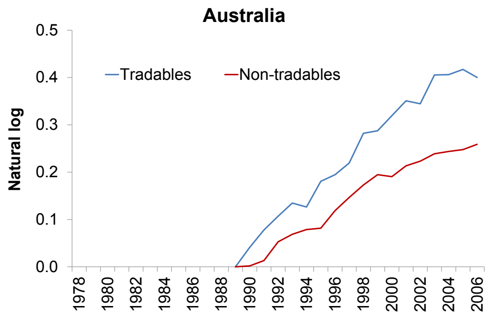
4. Sectoral Productivity and Price Measures: Some Results

This section compares how the *levels* of sectoral prices and productivity in New Zealand and four of our major trading partners have changed over time. In section 5, some of the tests from Figure 3 using prices and productivity data expressed in *growth rates* are conducted.

Figure 5 compares developments in tradable and non-tradable sector productivity for each country. In all five countries, tradable sector productivity growth has exceeded non-tradable productivity growth. But New Zealand's productivity growth, in both tradable and non-tradable sectors, has been low relative to the other economies.

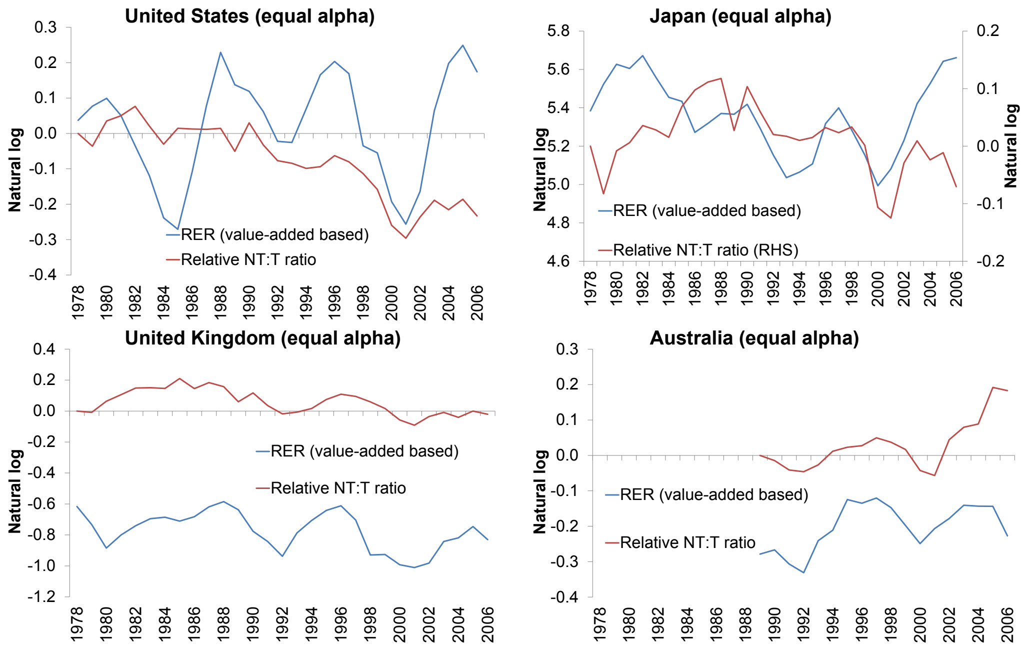
Figure 5: Tradable and non-tradable productivity





The BS hypothesis asserts that, over time, there is a positive relationship between non-tradable to tradable price differentials and tradable to non-tradable productivity growth differentials domestically, as well as across trading partners. Non-tradable to tradable price differentials between New Zealand and the four countries considered $(1-\alpha^{NZ})[pr^{NT}_{NZ,t} - pr^{T}_{NZ,t}] - (1-\alpha^{i})[pr^{NT}_{i,t} - pr^{T}_{i,t}]$ are plotted along with real bilateral exchange rates (calculated using equation 1 in Box 1) in Figure 6. Here, the share of tradables in total output for each country, *alpha*, is assumed to be equal for all countries.

Figure 6: Relative non-tradable to tradable price ratios (value-added measures) and real bilateral exchange rates (each with New Zealand)



The data do not permit direct comparison of level differences in common currency, so our focus is on comparing how these measures have changed over time. To read these, consider the US chart. The trend decline in the red line means that the gap between tradable and non-tradable prices in the US has increased at a faster rate over time than in New Zealand. The correlations between each country's non-tradable to tradable price differential with New Zealand and the bilateral real exchange rate are positive but small in the US and Japanese cases (both 0.09), but larger in the case of the UK (0.65) and Australia (0.53).[17]

[17] For a large sample of OECD economies, Drozd and Nosal (2010) find that the median correlation between real exchange rates and relative non-tradable prices is 0.09 (-0.38 for the 10th percentile and 0.47 for the 90th

Figure 7 plots domestic non-tradable to tradable price ratios ($pr^{NT}_{i,t} - pr^{T}_{i,t}$) against domestic tradable to non- tradable productivity differentials ($prod^{T}_{i,t} - prod^{NT}_{i,t}$) for each of the countries considered. This suggests that there may be evidence of a domestic BS effect in the US, Japan, the UK and New Zealand. That is, in each country, prices of non-tradables to tradables have tended to rise as the relative productivity of the traded to the non-traded sector has risen. The correlations between the two series are high for the US (over 0.9), Japan (over 0.9), UK (over 0.9) and New Zealand (0.89), but negative for Australia. In Australia's case the fall in the non-tradable to tradable price ratio reflects its terms of trade boom starting from the mid-2000s.

Figure 7: Domestic non-tradable to tradable price ratios (value-added based) and domestic tradable to non-tradable productivity differentials

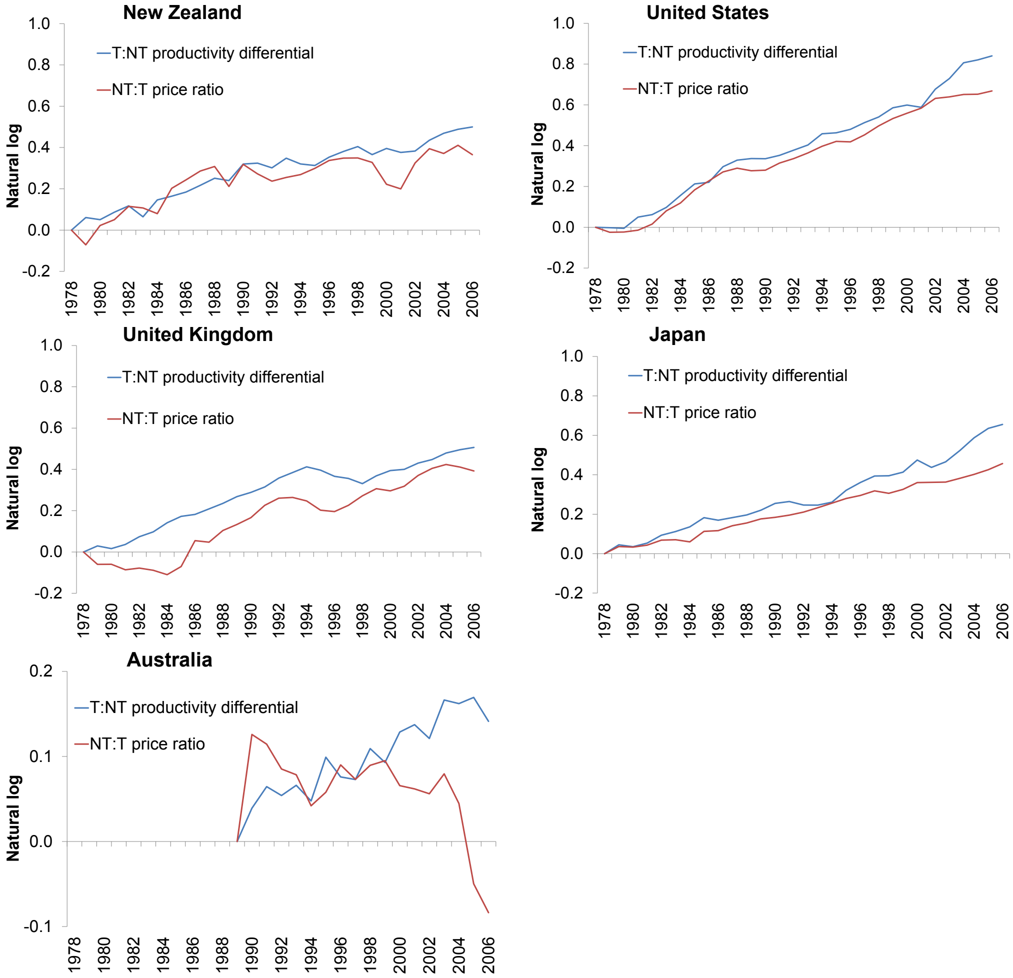
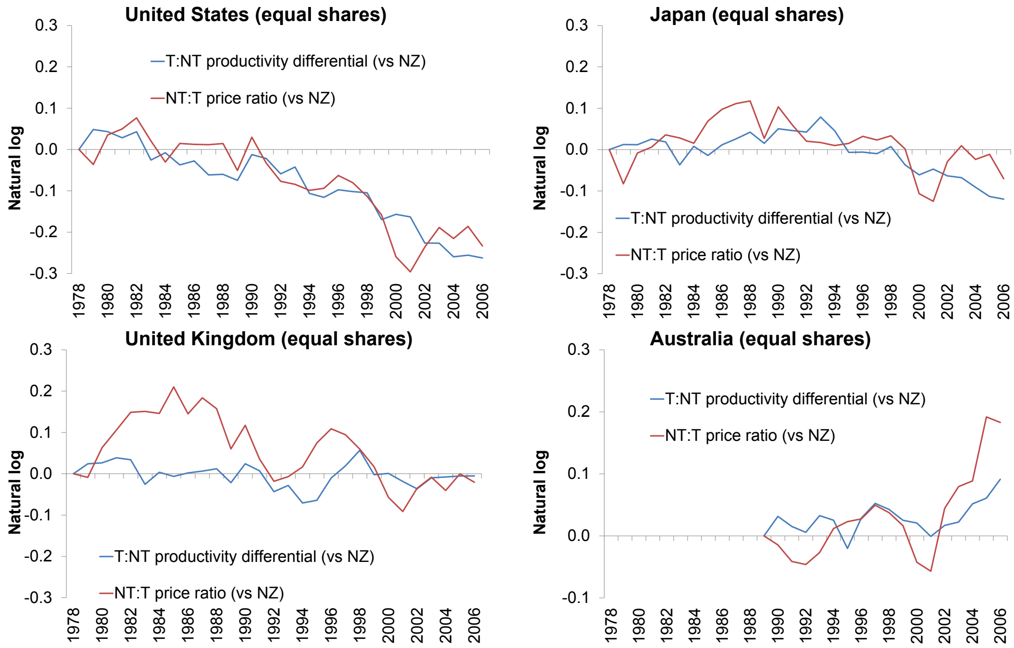


Figure 8 plots relative non-tradable to tradable price ratios between New Zealand and each country ($(1-\alpha^{NZ})[pr^{NT}_{NZ,t} - pr^{T}_{NZ,t}] - (1-\alpha^{i})[pr^{NT}_{i,t} - pr^{T}_{i,t}]$) as well as relative productivity differentials ($(1-\alpha^{NZ})[prod^{T}_{NZ,t} - prod^{NT}_{NZ,t}] - (1-\alpha^{i})[prod^{T}_{i,t} - prod^{NT}_{i,t}]$). Relative to the US, in particular, the behaviour of the differential between tradables and non-tradables prices does appear to have been consistent with differences between the relative

percentile). The authors use a sample of 21 countries (210 country pairs) using annual hp-filtered (lambda = 100) data between 1970 and 2005 (deflators are also obtained from the STAN database) and a common tradable sector weight of 0.22 for all countries.

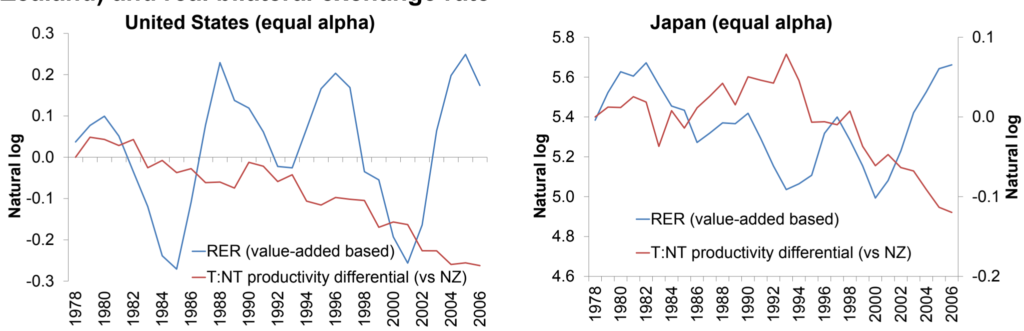
productivity performance of the tradable and non-tradable sectors in the two countries. The charts show that New Zealand's tradables to non-tradables productivity differential has grown by less than those in Japan, the UK and the US, while New Zealand's non-tradables and tradables price ratio has risen by less than in Australia (for the shorter period).

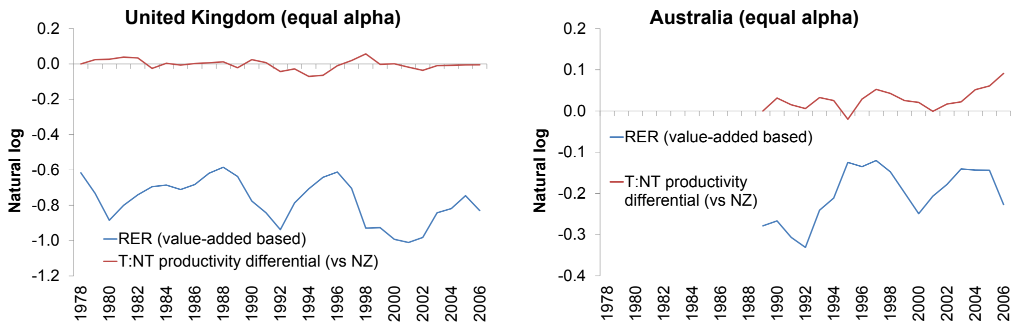
Figure 8: Relative non-tradable to tradable price ratios (value-added) and tradable to non-tradable productivity differentials (each with New Zealand)



Under the BS hypothesis, the real exchange rate is expected to depreciate if New Zealand's tradable sector productivity decreases relative to that in the non-tradable sector, or if traded sector productivity decreases relative to trading partners (for given relative levels of productivity in each country's non-traded sector). Figure 9 plots bilateral real exchange rates against tradable to non-tradable productivity between New Zealand and each country $(1-\alpha^{NZ})[prod^{T}_{NZ,t} - prod^{NT}_{NZ,t}] - (1-\alpha^{i})[prod^{T}_{i,t} - prod^{NT}_{i,t}]$. In contrast to what the BS theory would predict, relative tradable to non-tradable productivity differentials have not shown positive co-movement with the real bilateral exchange rate with the US and Japan. The overall correlation between the two series is, however, positive in the Australian case, although the correlation between the series is only 0.17 over the period since data is first available.

Figure 9: Tradable to non-tradable productivity differentials (each with New Zealand) and real bilateral exchange rate





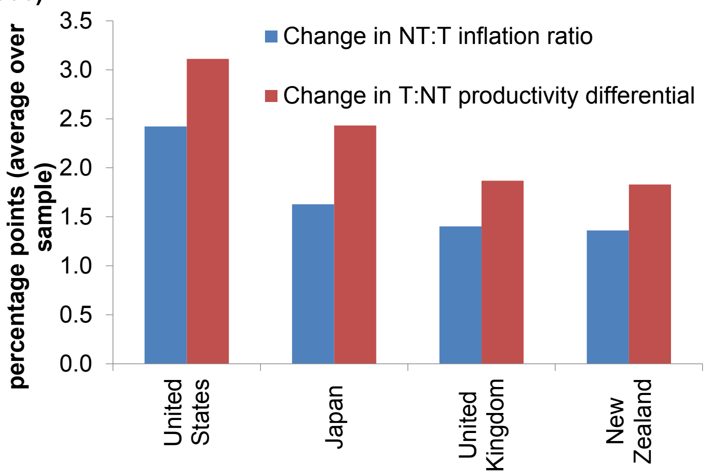
5. TESTING THE DOMESTIC AND INTERNATIONAL TRANSMISSION CHANNELS OF BS EFFECTS

Table 1 compares the growth rates of each country's sectoral productivity and prices. As predicted by the BS hypothesis, productivity has grown faster in the more tradable sectors in all economies and (value-added) prices have risen faster in the more non-tradable sectors, with the exception of Australia (especially since the early 2000s). Both New Zealand's domestic tradable to non-tradable productivity growth differential and non-tradable to tradable inflation differential have been less than those in the US, UK and Japan (Figure 10).

Table 1: Comparison of sectoral productivity growth and inflation (value-added based) (average annual percent changes)

Period	Country							
		Inflation (value-added)				Productivity		
		Inflation	Tradable inflation (value-added) (1)	Non-tradable inflation (value-added) (2)	NT:T inflation differential (3)=(2)-(1) (% pts)	Tradable productivity (4)	Non-tradable productivity (5)	T:NT productivity differential (6)=(4)-(5) (% pts)
1990 to 2006	Australia	2.5	3.0	2.4	-0.6	2.4	1.5	0.9
	New Zealand	**2.0**	**1.4**	**2.3**	**0.8**	**2.3**	**0.7**	**1.6**
1979 to 2006	United States	3.4	1.6	4.0	2.4	4.0	0.9	3.1
	Japan	0.7	-0.5	1.2	1.6	3.9	1.5	2.4
	United Kingdom	0.7	3.9	5.3	1.4	3.5	1.6	1.9
	New Zealand	**5.7**	**4.8**	**6.2**	**1.4**	**2.3**	**0.5**	**1.8**

Figure 10: Domestic non-tradable to tradable inflation (value-added based) and domestic tradable to non-tradable productivity growth differentials (1979 to 2006)



The BS hypothesis predicts a positive relationship between tradable to non-tradable productivity differentials between trading partners and relative non-tradable to tradable inflation differentials. Table 2 is based on equation 8 in Box 1 and demonstrates that New Zealand's average (value-added) inflation rate has, on average since 1979, been higher than in the US, Japan and UK, and lower than inflation in Australia since 1990. Relative tradable to non-tradable productivity growth has been higher in New Zealand than in Australia, but lower than in the US, Japan and the UK. The contribution of BS effects to bilateral (value-added) inflation differentials is negative with the US and Japan and positive with Australia. This is because the domestic BS effect was larger in Japan, the UK and US than in New Zealand.

Table 2: Contribution of BS effects to (value-added based) inflation differentials compared to New Zealand (average annual percent changes)[18]

Period	Country	Inflation differential (value-added) (1)	Change in nominal ER (inverted) (2)	T:NT productivity growth differential with NZ (3)	BS effect (4)
1990 to 2006	Australia	-0.5	-0.9	0.7	0.5
1979 to 2006	United States	2.3	1.1	-1.3	-1.0
	Japan	5.0	3.1	-0.6	-0.5
	United Kingdom	0.8	1.2	0.0	0.0

1 is pnz - p*, 2 is an appreciation when the sign is negative, 3 is (prodTnz-prodNTnz)-(prodTi-prodNTi), 4 is (1-αNZ)(prodTnz-prodNTnz)-(1-αi)(prodTi-prodNTi).

Table 3 summarises tests assessing whether BS effects have had a statistically significant impact on domestic non-tradable to tradable inflation differentials for New Zealand, the US, the UK and Japan between 1979 and 2006. Given short samples (only 28 observations), the results from regressions should be interpreted with caution. Tradable to non-tradable productivity growth differentials only have a statistically significant relationship with non-tradable to tradable inflation differentials in Japan and the United States. A one percentage point increase in the domestic sectoral productivity differential is associated with a 0.36 percentage point increase in domestic sectoral inflation differentials in the US, and 0.3 percentage points in Japan. In both countries, the domestic BS effect accounts for almost half of the observed change in the non-tradable to tradable inflation differential (though its contribution falls when corrected for the share of the non-tradable sector).[19]

Finally, Table 4 shows that there has been no statistically significant relationship between tradable to non-tradable productivity growth differentials between New Zealand and the countries considered and changes in real bilateral exchange rates (equations 6 and 9 in Box 1). The signs on the BS coefficients are also sensitive to whether LOOP is assumed to hold for tradables.[20]

[18] The assumption that LOOP holds for tradables can be relaxed (see equation 7 in Box 1), but this would not affect the value of the contribution of the BS effect in Table 2.
[19] Tests of the contribution of the sectoral productivity differential to New Zealand-trading partner inflation differentials (Test 3 from Figure 2) were also carried out, but the results are not presented because they were sensitive to the approach used to deal with structural breaks in the relative inflation rate series.
[20] Unit root tests do not reject null of non-stationarity for tradable prices with the US and Japan, implying that LOOP does not appear to hold across tradables for New Zealand and these two countries. Unit root tests provide some evidence, however, that tradable prices are equalised between New Zealand and the UK, over the sample.

Table 3: Estimates of the domestic BS effect

Dependent variable: ΔpNTi,t-ΔpTi,t				
Explanatory variables: ΔprodTi,t-ΔprodNTi,t				
	BS term		**Contribution of T:NT productivity growth differential to NT:T inflation differential (percentage points) (1)**	**Domestic BS effect (percentage points) (2)**
Country	**β**	**R^2**		
New Zealand	0.30	0.03	0.54	0.39
United States	0.36**	0.20	1.09	0.90
United Kingdom	0.07	0.00	0.12	0.09
Japan	0.30***	0.28	0.70	0.53

1 is calculated as beta times average productivity growth differential over the estimation period. 2 is calculated as the contribution variable times each country's share of non-tradables to domestic prices (here proxied using output shares). A constant is included in all regressions. Variables are in logged differences to ensure stationarity. Estimated using least squares. *, **, *** are 10, 5, 1 percent

Table 4: Estimates of the BS effect on real exchange rates

Dependent variable: Δrert				
Explanatory variables:	Δnert	ΔpTnz,t-ΔpTi,t	(1-αnz)ΔprodNTi,t-(1-αi)ΔprodTi,t	
			BS term	
		No tradables LOOP assumption		
Country	**β_1**	**β_2**	**β_3**	**R^2**
United States	1.02***	1.24	0.14	0.87
United Kingdom	1.01***	1.04	0.18	0.84
Japan	0.99***	1.35*	0.31	0.86
		Assuming LOOP holds for tradables		
United States			-0.29	0.01
United Kingdom			-0.34	0.01
Japan			-0.11	0.00

with rer calculated using the aggregate price indices weighting tradable and non-tradable prices together. A constant is included in all regressions. Variables are in logged differences to ensure stationarity. Estimated using least squares. *, **, *** are 10, 5, 1 percent significance.

To test whether the results are sensitive to the classification of sectors as tradable and non-tradable, a second sectoral classification scheme is considered, using a narrower definition of tradables and non-tradables as manufacturing and total services respectively. This alternative approach raises New Zealand's measure of tradable inflation, lowering New Zealand's overall non-tradable to tradable inflation differential (see Tables A1 and A2 in the Appendix). The change also lowers the measure of tradable sector productivity in New Zealand, causing the tradable to non-tradable productivity differential to fall over the full sample.

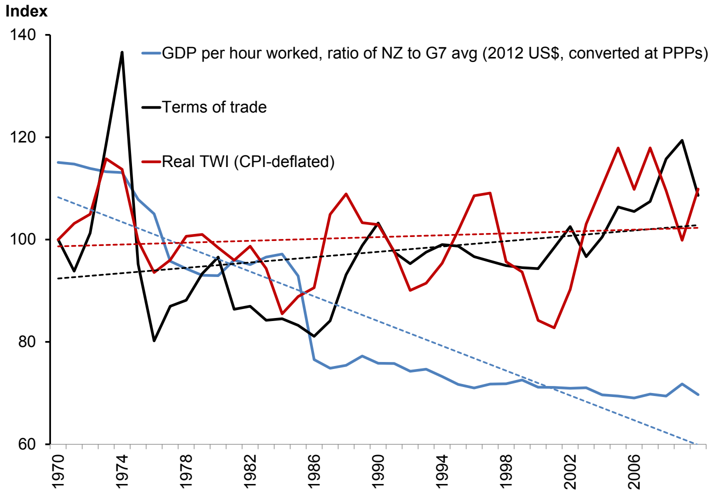
The narrower classification lowers Japan's tradable to non-tradable productivity growth and non-tradable to tradable inflation differentials, but raises them with the UK and the US, resulting in a larger negative value for the BS effect for these comparisons.

Under the narrower classification, there is stronger empirical support for domestic BS effects in the US and Japan and the BS term for the UK is significant at 10 percent (Table A3). But tradable to non-tradable productivity growth differentials still do not have a statistically significant relationship with non-tradable to tradable inflation in New Zealand. And in contrast to the predicted relationship between the real exchange rate and bilateral tradable to non-tradable productivity growth, the coefficients on beta 3 in Table A4 remain insignificant, as well as being negative against in the regressions for the US and the UK.

5. IMPLICATIONS

Overall, this analysis suggests that changes in tradable to non-tradable productivity have not had a material impact on changes in the ratio of non-traded to traded prices in New Zealand or the real exchange rate over the period between 1977 and 2006. If the data are adequately capturing the concepts used to test for BS effects, then other factors must explain the long run behaviour of the real exchange rate. One potential answer is that other relative prices (such as terms of trade – the ratio of export over import prices) might have had an important influence over this horizon.[21] Figure 11 plots a multilateral CPI-deflated measure of the real exchange rate and shows that there has been a much stronger correlation between New Zealand's terms of trade and the real exchange rate than with economy-wide relative productivity. Future research should relax the assumption in the basic BS model that trading partners produce the same basket of tradable goods, and investigate the relationship between changes in relative terms of trade and the real exchange rate.

Figure 11: Relative productivity, terms of trade and the real exchange rate



Source: OECD, Conference Board, RBNZ, authors calculations. Trends are linear time trends.

6. CONCLUSION

Productivity growth gaps between countries are expected to influence how sectoral (non-tradable to tradable) inflation ratios move in different countries over time and therefore how the real exchange rate behaves. The long-term deterioration in New Zealand's relative productivity against its major developed country peers over the last several decades would suggest that the real exchange rate should have, all other things equal, shown some material depreciation over this horizon.

This paper tested this notion using constructed sectoral data for New Zealand and four of its major advanced economy trading partners. The sectoral composition attempts to approximate the concepts of tradable and non-tradable sectors that

[21] See Reddell (2013) for another possible explanation.

underlie the Balassa-Samuelson theory, but are necessarily imperfect so should more properly be are referred to as ‘more tradable’ and ‘more non-tradable’.

Constructed sectoral price and productivity measures show that the more tradable sectors have exhibited faster productivity growth than the more non-tradable sectors in all countries considered. But there appears to have been little correlation between tradable to non-tradable productivity growth differentials between New Zealand and our trading partners and changes in real bilateral exchange rates.

REFERENCES

Alquist, R. and Chinn, M. D. (2002), 'Productivity and the euro-dollar exchange rate puzzle', NBER Working Paper 8824.

Balassa, B. (1964), 'The purchasing power parity doctrine: a reappraisal', *Journal of Political Economy*, Vol.72.

Baumol, W., and Bowen, W. (1996), 'Performing arts: The economic dilemma', Twentieth Century Fund, New York.

Brook, A. and Hargreaves, D. (2001). 'PPP-based analysis of New Zealand's equilibrium exchange rate,' Reserve Bank of New Zealand Discussion Paper Series DP2001/01, Reserve Bank of New Zealand.

Chong, Y., Jordà, O. and Taylor, A.M (2012), 'The Harrod–Balassa–Samuelson Hypothesis: Real Exchange Rates And Their Long-Run Equilibrium', *International Economic Review*, Department of Economics, University of Pennsylvania and Osaka University Institute of Social and Economic Research Association, Vol. 53(2).

Chowdhury, K. (2011). 'Modelling the Balassa-Samuelson Effect in Australia', A*ustralasian Accounting Business and Finance Journal*, Vol.5(1).

De Broeck, M. and Slok, T. (2001), 'Interpreting Real Exchange Rate Movements in Transition Countries', IMF working paper 56.

Drine, I. and Rault, C. (2005), 'Can the Balassa-Samuelson theory explain long-run real exchange rate movements in OECD countries?', *Applied Financial Economics*, Vol.15(8).

Drozd, L.A and Nosal, J.B. (2010). 'The Nontradable Goods' Real Exchange Rate Puzzle,' NBER Chapters, in: NBER International Seminar on Macroeconomics 2009, pp. 227-249, NBER Inc.

Égert, B. (2002a), 'Estimating the impact of the Balassa-Samuelson effect on inflation and the real exchange rate during transition', *Economic Systems*, Vol.26.

Égert, B. (2002b), 'Investigating the Balassa-Samuelson Hypothesis in the Transition: Do We Understand what We See?', Bank of Finland BOFIT Working Paper No. 2002-6.

Engel, C. (1999), 'Accounting for U.S. Real Exchange Rate Changes', *Journal of Political Economy,* University of Chicago Press, Vol.107(3), pp.507-538.

Lojschova, A. (2003), 'Estimating the impact of the Balassa-Samuelson effect in transition economies', Institute for Advanced Studies', Working Paper no 140.

Mihaljek, D. and Klau, M. (2003), 'The Balassa-Samuelson Effect in Central Europe: A Disaggregated Analysis'. BIS Working Paper No. 143.

Mihaljek, D. and Klau, M. (2008). 'Catching-up and inflation in the transition economies: The Blassa-Samuelson effect revisited'. BIS Working Paper No. 270.

Pesaran, M.H. and Shin, Y., (1999). 'An autoregressive distributed lag modeling approach to cointegration analysis'. In: Strom, S. (Ed.), Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, chapter 11. Cambridge University Press, Cambridge.

Pesaran, M.H., Shin, Y., and Smith, R.J., (2001). 'Bounds testing approaches to the analysis of level relationships'. *Journal of Applied Econometrics, Vol.*16.

Reddell, M. (2013). 'The long-term level "misalignment" of the exchange rate: Some perspectives on causes and consequences'', Paper prepared for the Reserve Bank/Treasury Exchange Rate Forum, Wellington, March 2013.

Rogoff, K. (1992), 'Traded Goods Consumption Smoothing and the Random Walk Behavior of the Real Exchange Rate,' NBER Working Paper Number 4119.

Samuelson, P. (1964), 'Theoretical problems on trade problems', *Review of Economic and Statistic*, Vol.46.

APPENDIX

Classification 1 takes manufacturing plus agriculture and mining to represent the tradable sector and total services plus construction and electricity to represent the non-tradables sector. *Classification 2* defines the traded sector as manufacturing only, while services are taken to represent non-tradables.

Table A1: Comparison of sectoral productivity growth and inflation (value-added based) (Classification 2 less Classification 1, annual average percent changes)

Period	Country	Inflation (value-added)			Productivity		
		Tradable inflation (1)	Non-tradable inflation (2)	Internal inflation differential (3)=(2)-(1)	Tradable productivity (4)	Non-tradable productivity (5)	Internal productivity differential (6)=(4)-(5)
1990 to 2006	Australia	-0.6	0.1	0.7	-0.3	0.1	-0.4
	New Zealand	**0.4**	**-0.1**	**-0.5**	**-0.4**	**0.0**	**-0.5**
1979 to 2006	United States	-0.2	-0.1	0.1	0.2	0.2	0.1
	Japan	0.0	-0.2	-0.1	-0.4	0.2	-0.6
	United Kingdom	-0.2	0.1	0.2	0.0	0.0	0.1
	New Zealand	**0.7**	**0.0**	**-0.7**	**-0.4**	**-0.1**	**-0.3**

Table A2: Contribution of BS effects to (value-added based) inflation differentials compared to New Zealand (Classification 1 vs Classification 2, annual average percent changes)

Period	Country	Relative tradable inflation (1)		Relative T:NT productivity growth differential (2)		Domestic BS effect (3)	
		1	2	1	2	1	2
1990 to 2006	Australia	-1.5	-0.5	0.7	0.6	0.5	0.5
1979 to 2006	United States	3.2	4.1	-1.3	-1.6	-1.0	-1.3
	Japan	5.3	6.0	-0.6	-0.3	-0.5	-0.2
	United Kingdom	0.9	1.8	0.0	-0.4	0.0	-0.3

Relaxing the assumption that LOOP holds (equation 7 in Box 1). 1 prTnz-prTi, 2 is (prodTnz-prodNTnz)-(prodTi-prodNTi), 3 is (1-αNZ)(prodTnz-prodNTnz)-(1-αi)(prodTi-prodNTi).

Table A3: Estimates of the domestic BS effect (Classification 2)

Dependent variable: ΔpNTi,t-ΔpTi,t
Explanatory variables: ΔprodTi,t-ΔprodNTi,t

Country	BS term β	R^2	Contribution of T:NT productivity growth differential to NT:T inflation differential (percentage points) (1)	Domestic BS effect (percentage points) (2)
New Zealand	-0.14	0.02	-0.21	-0.15
United States	0.38***	0.49	1.16	0.96
United Kingdom	0.35*	0.12	0.65	0.50
Japan	0.36***	0.39	0.63	0.48

1 is calculated as beta times average productivity growth differential over the estimation period. 2 is calculated as the contribution variable times each country's share of non-tradables to domestic prices (here proxied using output shares). A constant is included in all regressions.Variables are in logged differences to ensure stationarity. *, **, *** are 10, 5, 1 percent significance.

Table A4: Estimates of the BS effect on real exchange rates (Classification 2)

Dependent variable: Δrert

Explanatory variables:	Δnert	ΔpTnz,t-ΔpTi,t	(1-αnz)ΔprodNTi,t-(1-αi)ΔprodTi,t BS term	
No tradables LOOP assumption				
Country	β_1	β_2	β_3	R^2
United States	1.06***	4.21***	-0.12	0.95
United Kingdom	1.05***	3.03***	-0.08	0.90
Japan	1.00***	3.485***	0.04	0.93
Assuming LOOP holds for tradables				
United States			-1.16*	0.12
United Kingdom			-0.49	0.03
Japan			-1.08*	0.13

with rer calculated using the aggregate price indices weighting tradable and non-tradable prices together. A constant is included in all regressions.Variables are in logged differences to ensure stationarity. Estimated using least squares. *, **, *** are 10, 5, 1 percent significance.