Empirical Evidence on Growth Spillovers from China to New Zealand

Denise R Osborn and Tugrul Vehbi

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Abstract

This paper provides a quantitative analysis of the impact on New Zealand of economic growth in China through the framework of an econometric model. The analysis compares the roles of China and the US both for growth in New Zealand and also for world commodity prices, the latter being important for New Zealand as an exporter of primary products. Finally, in the light of the increasing role of China in the world economy over the last two to three decades, the paper also investigates whether spillover effects from China to New Zealand have changed over this period. Using models estimated from the mid-1980s to 2011, we find that growth spillovers from China are important for New Zealand, with estimates of the accumulated increase in domestic GDP from a one percent increase in output growth in China being in the range of around 0.2 to 0.4 percent. It is striking that growth spillovers are substantially greater from the US than from China, despite the latter's increasing importance in the world economy. Both domestic and foreign shocks have been important drivers of real exchange rate fluctuations, while the contribution of the latter has been relatively more important. The time-varying estimates provide some evidence of time-variation, with the greatest impact from China applying for about a decade from the mid-1990s, but also being relatively large in the latter part of our sample period.

JEL CLASSIFICATION C32, E32, F43, F44

KEYWORDS Structural VAR, growth spillovers, commodity prices

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Executive Summary

This paper provides a quantitative analysis of the impact on New Zealand of economic growth in China through the framework of an econometric model. It is the third of three working papers looking at the impact of China on the New Zealand economy.

The analysis compares the roles of China and the US both for growth in New Zealand and also for world commodity prices.

Using models estimated from the mid-1980s to 2011, growth spillovers from China are important for New Zealand, with estimates of the accumulated increase in domestic GDP from a one percent increase in output in China being in the range of 0.2 to 0.4 percent.

It is striking that growth spillovers are substantially greater from the US than from China, despite the latter's increasing importance in the world economy.

The impact of China on global commodity prices has been steadily increasing over time, with growth in China having strongest effects on dairy and aluminium price inflation. US demand, on the other hand, is generally more important than China in driving global commodity prices.

Both domestic and foreign shocks are important drivers of real exchange rate fluctuations, the contribution of the latter (particularly commodity prices) is relatively more important.

Alongside the broader descriptive analysis by Bowman and Conway (2013a, 2013b), these results highlight the growing importance of China for the contemporary New Zealand economy.

Empirical Evidence on Growth Spillovers from China to New Zealand

1 Introduction

China is now the second largest economy in the world at current exchange rates and, according to the International Monetary Fund, is forecast to overtake the United States later in the next decade in purchasing power parity (PPP) terms. Indeed China's economic performance over the last two decades has been remarkable, accounting for 3.9% of world gross domestic product (GDP) in 1990 but 15.0% in 2012.[1] These figures would be striking at any time, but in the context of faltering global growth since the onset of the 2008 financial crisis, they underline the importance of continued growth in China for the world economic outlook.

China is now the second largest market for New Zealand's product exports, behind only Australia. In discussing this, Bowman and Conway (2013a, 2013b) point particularly to the increased industrialisation and urbanisation of China. This, alongside increased per capita income and a changing diet, has led to rising demand for primary products from New Zealand, especially dairy, meat and forestry products. These effects are reinforced because Australia has also received substantial benefits from China's growth, with these most evident in its mining sector.[2] It is to be anticipated, therefore, that over recent years New Zealand has received positive spillovers from growth in China not only by increasing exports to that country, but also through effects on its long-term major trading partner, namely Australia.

This paper provides a quantitative analysis of the impact on New Zealand of economic growth in China through the framework of an econometric model. This complements the more descriptive analysis of Bowman and Conway (2013a, 2013b) by providing estimates of, for example, the effect on New Zealand of a one percent increase (or decrease) in China's output growth, comparing this with estimated effects from growth in the US. The analysis also compares the roles of China and the US for world commodity prices, which are important for New Zealand as an exporter of primary products. Finally, in the light of the increasing role of China in the world economy over the last two to three decades, the

[1] The projections in the database accompanying International Monetary Fund (2013) show China accounting for 18.3% of world GDP (based on a purchasing power parity valuation) in 2017, compared with 17.9% for the US. The 1990 and 2012 figures for China are also from this source, which shows the US share of world GDP share declining from 24.7% to 18.9% over the same period.

[2] Plumb, Kent and Bishop (2012) discuss the implications for Australia of strong growth in Asia. Specifically, they use recent data to illustrate the current position in relation to the three phases of adjustment predicted by macroeconomic theory for a small resource-rich open economy that is subject to a commodity price boom.

paper also investigates whether spillover effects from China to New Zealand have changed over this period.

A large literature exists on the role of the US in the international economy, with that country widely assumed to drive world economic growth. However, despite it now being the world's second largest economy, surprisingly few studies are currently available focusing on the role of China and, further, their results are somewhat ambiguous. In particular, Arora and Vamvakidis (2011) find large growth spillovers from China to both the rest of Asia and the world (38 and 172 countries, respectively) over the last two decades. On the other hand, although Sato, Zhang and McAleer (2011) detect evidence that the impact of China on other East Asian economies has increased since 1978, they conclude that growth in China plays a small role for that region relative to the US. Sun (2011) focuses on effects in New Zealand and Australia, studying the role of growth in 'emerging Asia' (including China) versus that in the US. Although Sun (2011) finds that 'emerging Asia' plays a stronger role than the US for Australia in the decade from 2000, she detects no impact from that region on New Zealand over the same period. This leads her to conclude that growth in 'emerging Asia' affects New Zealand only indirectly through its impact on Australia. Nevertheless, this is a surprising finding in the context of the different products exported by these two antipodean countries to China and that country's role as the second largest market for New Zealand exports.

The small group of papers mentioned in the preceding paragraph use broadly similar modelling methodologies based on vector autoregressive (VAR) models. Nevertheless, there are important differences across their approaches, as discussed in the next section. The present paper also employs a VAR modelling framework, but imposes restrictions in order to capture adequately the effect of a dominant world economy (China and/or the US, as appropriate) on New Zealand. Since Australia is New Zealand's largest trading partner, and in the light of the results of Sun (2011), our analysis also examines the role played by that country. Although previous VAR analyses for New Zealand, such as Buckle, Kim, Kirkham, McLellan and Sharma (2007) or Dungey and Fry (2009), employ a larger range of domestic variables than in the current study, more parsimonious specifications of the domestic sector are employed here to facilitate more detailed examination of international spillovers. In particular, those studies employ a single 'international' or 'foreign' economy, whereas we investigate separate effects for China, the US and Australia on New Zealand.

The paper is organised as follows. Section 2 discusses methodological issues in relation to previous studies and also the nature of the VAR analysis of this paper. This is followed by a discussion of the data employed, including some preliminary analysis, in Section 3. Our principal results are contained in Section 4, which examines spillovers to New Zealand from China and the US through a range of VAR models, focusing particularly on a specification that includes commodity prices. The following section then focuses on changes over time, with conclusions drawn in Section 6.

2 Methodology

In line with other empirical studies of cross-country growth spillovers, this paper employs a VAR methodology, which explicitly allows for dynamic interactions between variables. The main tool employed is the so-called structural vector autoregressive (SVAR) model, which in our context is used to specify that a small country (specifically New Zealand) can be affected by, but does not influence, growth in a large country (China or the US, say).

Representing output growth for the foreign country and New Zealand in a particular period t (typically a quarter) by $y_{F,t}$ and $y_{NZ,t}$, respectively, the form of the SVAR[3] often used in this context can be written as

$$y_{F,t} = b_{11}y_{F,t-1} + b_{12}y_{NZ,t-1} + u_{F,t}$$

$$y_{NZ,t} = a_{21}y_{F,t} + b_{21}y_{F,t-1} + b_{22}y_{NZ,t-1} + u_{NZ,t} \quad (1)$$

in which $y_{NZ,t}$ depends on contemporaneous $y_{F,t}$ (through the term $a_{21}y_{F,t}$ in the second equation), but not *vice versa*, while the lagged variables capture cross-country and internal growth dynamics. Additional lags, beyond one period, can easily be accommodated in this system and are also discussed below. Each equation is a dynamic regression model and, provided that the SVAR captures all the dynamics of growth, the disturbances $u_{F,t}$ and $u_{NZ,t}$ are uncorrelated over time. Further, through the imposition of the assumption that contemporaneous causality runs from $y_{F,t}$ to $y_{NZ,t}$, these disturbances are also mutually uncorrelated. Since they cannot be predicted by the system, $u_{F,t}$ and $u_{NZ,t}$ are often referred to as 'shocks'. The VAR then permits estimation of the effects over time of a shock (such as a 1% increase) in output growth in the large foreign country on growth in the small country.

The form of the SVAR given in (1) embeds economic information through the causality assumption that the small open economy will not have contemporaneous feedback to the large economy[4]. An assumption of this type is made by virtually all papers concerned with international growth spillovers to small countries, including Sun (2011). However, we prefer to impose a stronger assumption.

Although the contemporaneous causality is assumed to apply only from the large to the small economy, the SVAR model of (1) treats the two countries in a symmetric way in terms of potential feedbacks or spillovers over time. However, it is *a priori* implausible that a small country like New Zealand will affect growth in China or the US in any way. This implies that the restriction $b_{12} = 0$ (with corresponding zero restrictions also on any further lags) should be imposed in (1), so that the system becomes

$$y_{F,t} = b_{11}y_{F,t-1} + u_{F,t}$$

$$y_{NZ,t} = a_{21}y_{F,t} + b_{21}y_{NZ,t-1} + b_{22}y_{NZ,t-1} + u_{NZ,t} \quad (2)$$

and output growth in the large economy is influenced by its own past, but not $y_{NZ,t-1}$. Restrictions of this form, often referred to as exogeneity restrictions, were popularised by Cushman and Zha (1997) in the context of modelling Canada and the US. Such exogeneity restrictions are imposed in the New Zealand studies of Buckle *et al*. (2007) and Dungey and Fry (2009), while Sato *et al*. (2011) use the form of (2) when analysing

[3] The model also includes an intercept in each equation, which are omitted from (1) for notational convenience.

[4] The SVAR form of (1) is often obtained as a Cholesky decomposition of the covariance matrix of the disturbances in a conventional VAR that includes only lagged variables.

the role of shocks in China or the US on individual East Asian economies. Although Sun (2011) leaves the lags unrestricted as in (1), she notes that the estimated spillover effects from Australia and New Zealand to large economies are small[5]. Nevertheless, using the Cushman and Zha (1997) model for Canada and the US, Zha (1999) illustrates the undesirable implications that the SVAR can yield when these restrictions are not imposed on the role of the small economy.

Additional countries can easily be incorporated in the analysis. Indeed, Sun (2011) employs five GDP growth series, namely for the US, 'emerging Asia' (including China), the rest of the world, Australia and New Zealand. In the framework of (1), and hence imposing no restrictions on the coefficients of lagged values, she assumes that the first three series represent large economies that contemporaneously cause growth in Australia and New Zealand, with Australia in turn contemporaneously causing New Zealand output growth. As noted above, however, this analysis imposes only the direction of contemporaneous causality, allowing feedbacks across all series. Following the arguments of Bayoumi and Swiston (2009), no specific stance is taken on the causal ordering between the first three growth rate series. Rather, the main analysis is based on averaging across the SVARs that result from considering each of the six possible causality orderings between the US, emerging Asia and the rest of the world.

Recognising the small size of the New Zealand economy, the analysis of the present paper is based on the more restricted form of (2). Therefore, exogeneity restrictions are employed to avoid the anomalous implications of the estimated SVAR model for the effect of the small economy on the dominant large one over time, as documented by Zha (1999). However, in the light of the role of Australia as New Zealand's largest trading partner, a generalisation of (2) is employed, which for three countries is given by

$$y_{F_1,t} = b_{11}y_{F_1,t-1} + u_{F_1,t}$$

$$y_{F_2,t} = a_{21}y_{F_1,t} + b_{21}y_{F_1,t-1} + b_{22}y_{F_2,t-1} + u_{F_2,t}$$

$$y_{NZ,t} = a_{31}y_{F_1,t} + a_{32}y_{F_2,t} + b_{31}y_{F_1,t-1} + b_{32}y_{F_2,t-1} + b_{33}y_{NZ,t-1} + u_{NZ,t} \quad (3)$$

where the countries are ordered as China (or the US), Australia and New Zealand. In other words, and in line with the relative sizes of these economies, output growth in China/US (country F_1) is exogenous to both Australia (country F_2) and New Zealand, while Australia is similarly exogenous to New Zealand.

The models outlined so far in (1) to (3) consider only output growth. However, it is also important for macroeconomic policy that the impacts of output growth in China (or, indeed, the US or Australia) influence other key variables for New Zealand, namely inflation, interest rates and the exchange rate. This block of domestic variables then replaces $y_{NZ,t}$ in (3). In an analogous way to that for the variables in (1), a contemporaneous causal ordering is imposed within the domestic variable block in the extended model. This follows the conventional contemporaneous causal order widely used in empirical SVAR modelling, namely output growth, inflation, interest rate and the nominal exchange rate. Therefore, domestic output growth responds to foreign output growth in the current quarter but not to current values of any domestic variables, inflation can respond to contemporaneous values of both foreign and domestic output growth, interest rates respond to current foreign and domestic output growth and (domestic) inflation, while the exchange rate is affected by all variables. The lagged coefficients are unrestricted within

[5] See, specifically, footnote 7 of Sun (2011).

the domestic block, so that the lags of all (foreign and domestic) variables are included in the equation for each variable in this block.

The above discussion assumes the presence of only one large economy, China or the US. When both are included, $y_{F_1,t}$ in (3) becomes a two variable vector. Although our models then permits dynamic feedback in both directions, US economic growth is assumed to contemporaneously cause that in China. The extension to include world commodity prices takes a similar form, with this being added as a third variable in the $y_{F_1,t}$ block, with the order of contemporaneous causality being US growth, China growth, world commodity price inflation.

In summary, the SVAR model we employ in matrix form is

$$Ay_t = B_1 y_{t-1} + u_t \tag{4}$$

in which y_t is a vector containing all the variables of the model, while A and B_1 are matrices. The specific form used imposes A to be lower triangular (with diagonal elements of unity), while zero restrictions are placed on appropriate lagged coefficients in B_1 in order to impose the restrictions of (2) or (3) that growth spillovers do not occur from a small country to a large one. Although intercepts are not included in (4) for notational ease, in practice all estimated equations include an intercept. With the contemporaneous relationships captured through A, the disturbances u_t are assumed to be mutually uncorrelated and (following the usual convention in the literature) are referred to as shocks.

3 Data and Preliminary Analysis

All data are quarterly and the sample period used in our SVAR analysis is 1982Q2 to 2011Q4, or a slightly shorter period when commodity price data are employed. As usual, economic growth is measured in terms of real GDP (seasonally adjusted) for each country. The GDP series, together with New Zealand's short-term (90 day) interest rate and the consumer price index (seasonally adjusted), are mainly downloaded from the Haver Database[6]; New Zealand's trade weighted real exchange rate series is obtained from the database of the New Zealand Treasury. Commodity prices relevant to New Zealand are captured through the nominal ANZ world commodity price series, which are also downloaded from Haver Analytics. These represent weighted average world prices for New Zealand's major commodity exports, with both the overall index and the dairy, forestry, meat and wool, and aluminium sub-indices employed. The commodity price data are available from 1986. The nominal commodity price indices (expressed in US dollars) are seasonally adjusted using the X-11 method in EViews and deflated by the US consumer price index to obtain real commodity prices. For model estimation, all variables are expressed as quarterly growth rates (100 times the quarterly differences of log values) with the exception of interest rates which are in levels.

Appendix Table 1 provides information on the dataset employed in the analysis, including some descriptive statistics. The rapid expansion of China's economy is evident, as is the volatility of quarterly growth in China relative to the US, from the sample means and standard deviations, while the volatility of the various real commodity price inflation series is also notable.

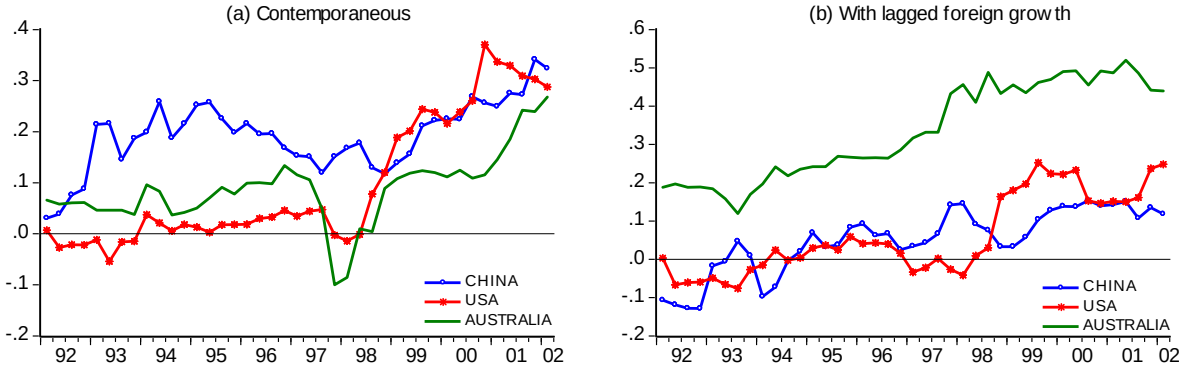
3.1 Growth rate correlations

To provide initial insights into the international spillovers to New Zealand GDP and how these change over time, Figure 1 examines simple correlations of growth rates in a time-varying framework. More specifically, each correlation is calculated using ten years of data, starting at the indicated date; panel (a) shows the contemporaneous correlations for New Zealand's GDP growth with that in each of the other three countries, while panel (b) shows the corresponding correlations but now calculated in relation to foreign growth one quarter earlier.

Over the period 1992-1998, panel (a) indicates that growth in New Zealand is more strongly contemporaneously correlated with that of China and Australia than with the US and the relationships are rather stable. From around 1998, all correlations are relatively higher, which may reflect the effects of the global financial crisis internationally on GDP growth.

[6] Historic quarterly data for real GDP in China are unavailable from Haver and the data employed are from the Econometric Studies Unit, National University of Singapore (www.fas.nus.edu.sg/ecs/esu/data.html). These quarterly data for China are interpolated from annual values using the methodology described in Abeysinghe and Rajaguru (2004).

Figure 1: Correlations of New Zealand GDP growth with China, USA and Australia



Note: All correlations are computed using ten years of quarterly data, starting at the date indicated on the horizontal axis. Source: Statistics Haver, authors' calculations.

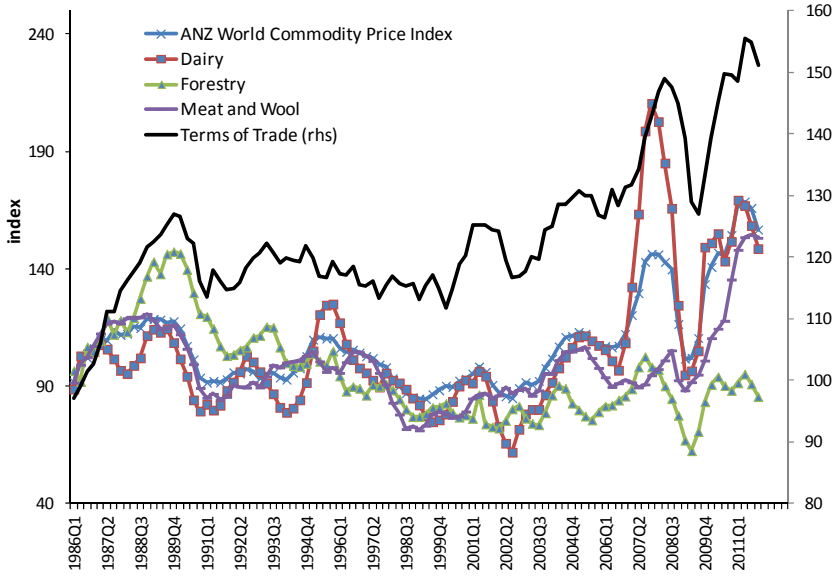
Interestingly, the correlations with lagged growth in panel (b) generally imply a less strong role for China on New Zealand than the contemporaneous ones of panel (a), indicating that the spillover effects from China growth to New Zealand appear quickly. On the other hand, spillovers from the US and Australia may take time to feed through to New Zealand, particularly later in the period. Nevertheless, lagged correlations with the US and China are relatively low before the global financial crisis.

In terms of our later modelling, the contemporaneous correlations, in particular, indicate that China's importance for GDP growth in New Zealand is not purely a recent phenomenon. The different temporal patterns of spillover effects from China and the US to New Zealand are also informative. Although these correlation patterns provide a useful first look at the data, they tell only part of the story, because they are not conditional on any other variables, either foreign or key domestic variables (namely inflation, interest rates and the exchange rate).

3.2 Commodity prices

As a small open economy and a commodity exporter, it can be anticipated that New Zealand will be influenced by changes in world commodity prices. This is supported by Figure 2, which shows the evolution of the weighted average world price for New Zealand's major commodity exports, expressed in US dollars and deflated by the US consumer price index, alongside New Zealand's terms of trade during the period 1986Q1 to 2011Q4. Four real commodity price series are shown: the aggregate ANZ world price index and the indices for dairy, forestry and meat and wool products. It is evident that real commodity prices have risen dramatically over the past decade (except for forestry products), with a relatively brief interruption due to the global financial crisis. Largely in line with these commodity prices, New Zealand's terms of trade have also risen since 2000.

Figure 2: Real commodity prices and New Zealand terms of trade



Note: Data are seasonally adjusted and expressed as indices with 1986=100. Nominal commodity price indices are deflated by the US consumer price index to form real commodity prices. Source: Statistics Haver, authors' calculations.

Commodity price increases since 2000 are driven by growing demand from developing countries, including China and India, and also reflect the impact of constrained supply conditions in various parts of the world due to factors such as adverse weather conditions. The marked peak in the dairy price index for about a year from the middle of 2007 pre-dates the melamine scandal in China, but nevertheless may reflect growth in demand from China for dairy products; see Bowman and Conway (2013a, 2013b) for further discussion.

4 SVAR Results

This section reports our results from the structural VAR (SVAR) analysis to examine the size, direction and effects of international growth spillovers to New Zealand economy. The baseline SVAR model of subsection 4.1 includes the four key New Zealand macroeconomic variables (GDP growth, inflation, interest rates and the real exchange rate), together with quarterly GDP growth for China or the USA. Australia is also included in these models, due to its important role for the New Zealand economy, and to allow spillovers from shocks to GDP growth originating in Australia (and not due to China/USA) to be examined. Subsection 4.2 then employs extended models to investigate the role of commodity prices for the New Zealand economy, in a specification that also includes both China and US growth. Further analysis of this extended model investigates the relative importance of different shocks for New Zealand's historical growth and real exchange rate movements (subsection 4.3) and the impacts of China and US growth on world commodity price inflation (subsection 4.4).

As explained in Section 2, our SVARs impose block exogeneity restrictions, so that China and/or the USA (as appropriate) is exogenous to both Australia and New Zealand, with no feedback from these smaller economies to growth in China/USA. Australian output is similarly treated as exogenous with respect to New Zealand, based on the assumption that New Zealand is a small economy in relation to its neighbour. Finally, within the domestic (New Zealand) block, the conventional contemporaneous causal ordering is adopted of output growth, inflation, interest rates and the exchange rate. Dynamics are captured through a single lag in the SVAR context, which is sufficient to capture the dynamics adequately[7].

Matlab software is used for SVAR estimation and analysis. As usual for SVAR models, the results are presented mainly through impulse response functions and historical decompositions. Those presented reflect the focus of the paper, namely the role of foreign output growth for the New Zealand economy.

4.1 Baseline model

Figure 3 shows the estimated responses of the six variables in the baseline model employing China as the large international economy influencing growth in New Zealand and Australia. More specifically, estimated mean responses are shown to a one unit (percentage point) shock to China's output growth, when estimation is over the entire sample period from 1982, with these shown as solid lines. The shaded bands around these impulse responses show 90 percent confidence bands estimated by 2000 Monte Carlo simulations.

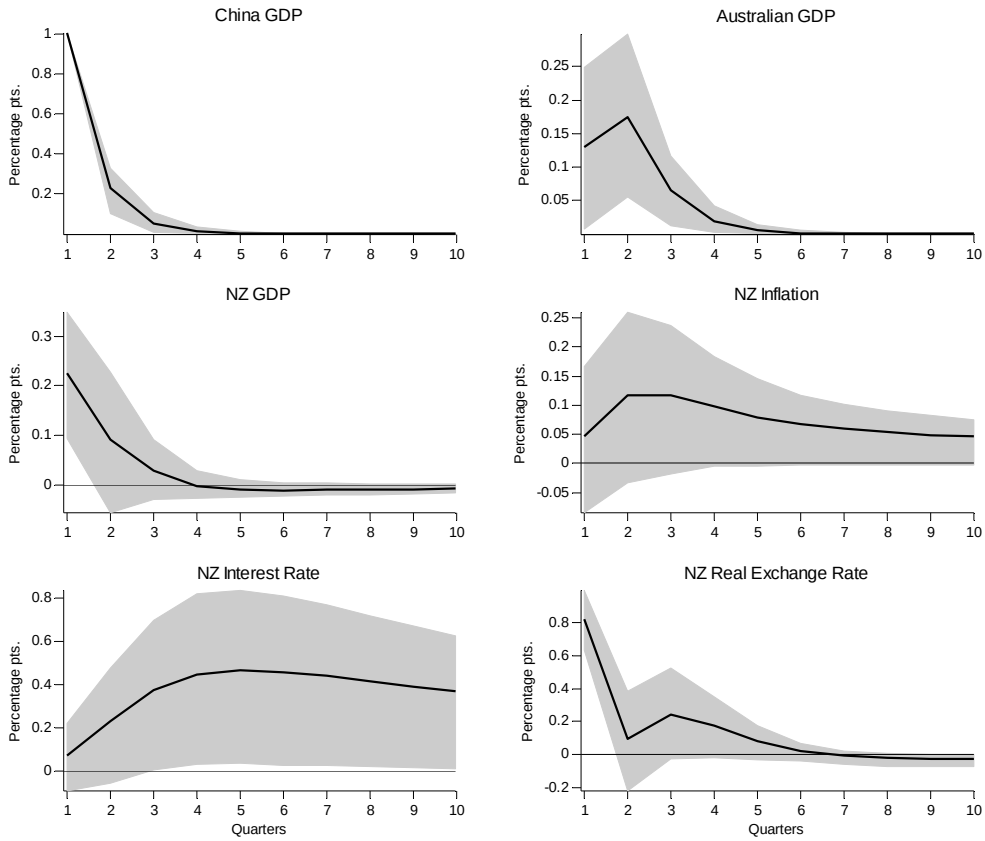
This baseline model implies that New Zealand's output increases by 0.23 percent on impact (quarter 1 on the horizontal axis). The effect is largely completed within four quarters of the China growth shock, with subsequent domestic output responses being virtually zero. Although the confidence bands indicate that the point estimate of the impact is not very reliable after the first quarter, nevertheless it is both statistically significant and important economically, and contrasts with the lack of spillovers detected in the analysis of Sun (2011) over a shorter sample period. It is notable that the initial response of Australia's GDP to the growth shock from China is lower than that of New Zealand but is

[7] A lag length of one is indicated as appropriate by the Akaike Information Criteria in an unrestricted VAR specification. Detailed results are not reported to conserve space.

more persistent. The peak impact occurs in this case in the quarter after the shock and the effect is statistically significant for five quarters. The persistence and the pattern of effects can be partially explained by the possible lagged effect of the mining industry on growth in Australia. In other words, the nature of Australia's commodities means there needs to be investment to supply them and therefore longer lag times for production. This contrasts with New Zealand's 'soft' commodities where supply can be ramped up relatively quickly up to a point constrained by biological processes. The implication is that much of the growth spillovers from China to New Zealand are direct effects, rather than operating indirectly through Australia, as suggested by Sun (2011) for spillovers from 'Emerging Asia'. Such a direct role is also implied by the current importance of China as a destination for New Zealand exports.

With the increase in domestic output, Figure 3 shows mild but insignificant increases in domestic inflation, although with a stronger response in New Zealand interest rates and a highly significant appreciation in the exchange rate. The appreciation in the exchange rate is important, as it acts as a buffer against the inflationary impact that would otherwise apply due to the additional stimulus.

Figure 3: SVAR Responses to a China GDP shock

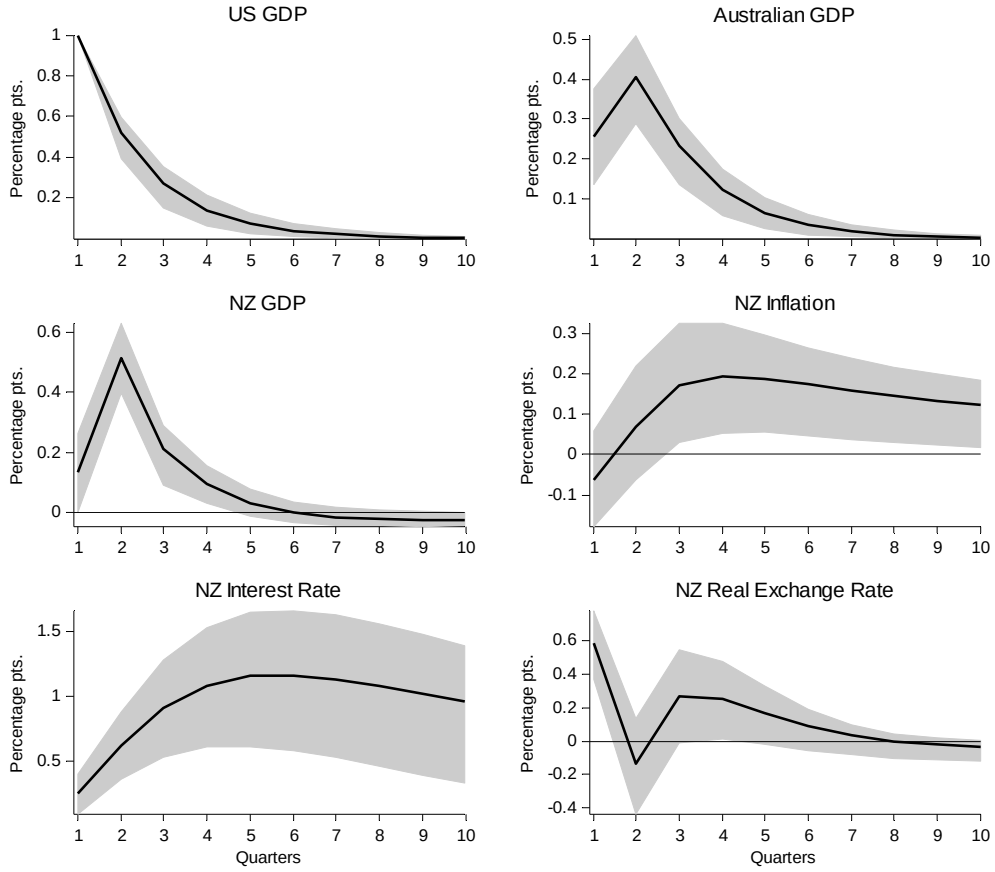


Notes: The figure depicts the impulse responses to a one-percentage point orthogonalised shock to China's GDP. The baseline SVAR model is estimated using data for 1982Q1-2011Q4. The solid line shows the estimated mean responses, with the shaded bands indicating the 90 percent confidence interval, obtained using 2000 Monte Carlo replications. Responses are shown for the quarter of the shock (quarter 1) and 9 subsequent quarters. Source: Authors' calculations.

Using the same SVAR specification, but replacing China with the US as the international driving force, Figure 4 shows the estimated responses to a one percentage point shock to US output, and these responses differ substantially from those seen in Figure 3. The impact of the US shock (Figure 4) on both domestic New Zealand variables and also Australian GDP is relatively longer-lived and statistically more significant; however, the impact on New Zealand within the quarter is lower. In particular, after an initial estimated

increase of 0.13 percentage points that applies in the quarter of the shock, the peak output response is at a lag of one quarter (labelled 2 in the graph) and domestic New Zealand GDP continues to increase due to positive impulse responses for a total of around 5 quarters; the cumulative response of domestic output to the shock originating in the US is estimated to be approximately 0.66. This, combined with the positive and significant response of inflation to the output increase after three or four quarters, leads to an increase in interest rates of around one percentage point. The exchange rate appreciates on impact, helping to keep inflation low, with further responses not being significant.

Figure 4: Responses to a US GDP shock



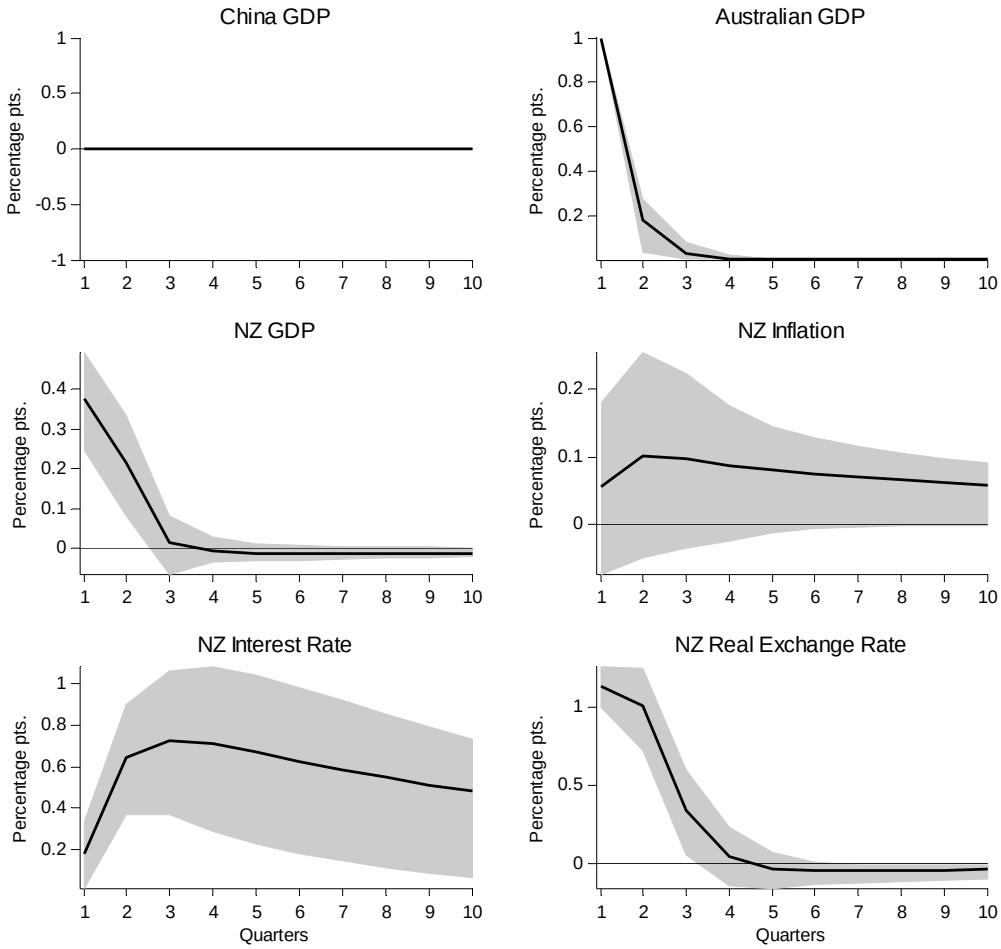
Notes: The figure depicts the impulse responses to a one-percentage point orthogonalised shock to US GDP. The SVAR model is estimated using data for 1982Q1-2011Q4. The solid line shows the estimated mean responses, with the shaded bands indicating the 90 percent confidence interval, obtained using 2000 Monte Carlo replications. Responses are shown for the quarter of the shock (quarter 1) and 9 subsequent quarters. Source: Authors' calculations.

Notwithstanding the importance of China in relation to New Zealand trade over the recent past, a comparison of Figure 3 with Figure 4 emphasises the key role played by the US economy for GDP growth in both New Zealand and Australia over the three decades of the sample period. Indeed, while the growth spillovers from China to New Zealand are found to have an important role for domestic variables beyond output, those from the US are more pervasive, with both inflation and monetary policy responding due to the strength of the growth spillovers. Interestingly, New Zealand's exchange rate responds in a similar way, irrespective of whether the growth shock originates in China or the US, hinting at the role of a common channel.

Finally, Figure 5 shows the responses to a one percentage point shock to Australian GDP, estimated from the model including the US as the major international economy. These responses follow broadly similar patterns to those seen in Figure 3 and Figure 4, with

positive growth spillovers. Although the response of New Zealand to an Australian output shock (Figure 5) is stronger than to one from China (Figure 3), the patterns of a relatively quick response of domestic output alongside insignificant effects on inflation are shared by both these figures. However, domestic interest rates respond more strongly and the exchange rate appreciation is substantially more marked and significant when the output shock originates from Australia compared with China.

Figure 5: Responses to Australia GDP shock



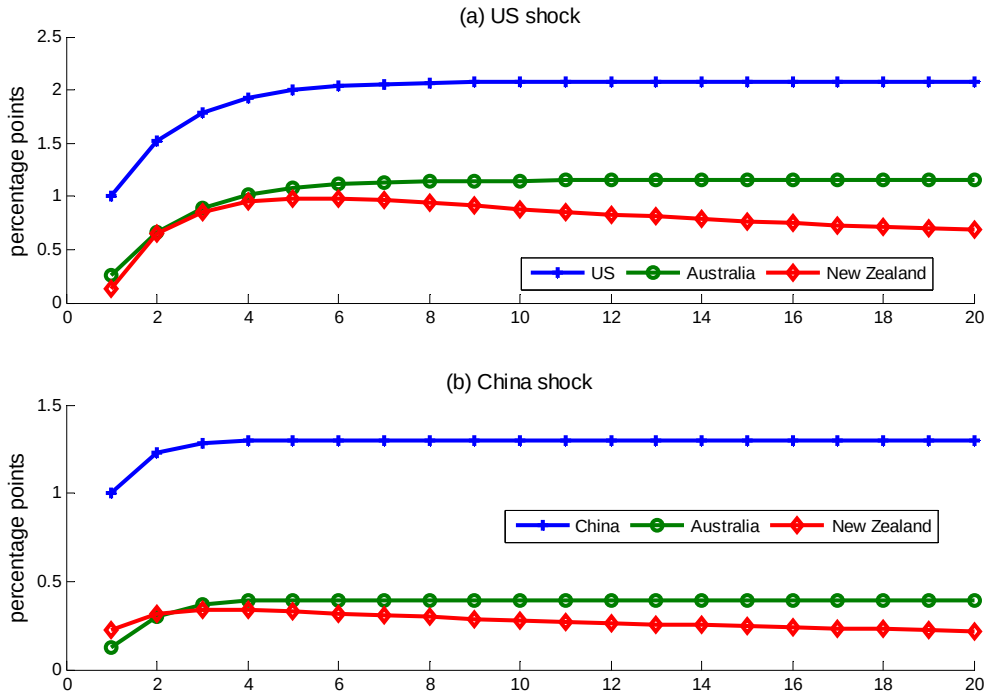
Notes: The figure depicts the impulse responses to a one-percentage point orthogonalised shock to Australia's GDP. The SVAR model is estimated using data for 1982Q1-2011Q4. The solid line shows the estimated mean responses, with the shaded bands indicating the 90 percent confidence interval, obtained using 2000 Monte Carlo replications. Responses are shown for the quarter of the shock (quarter 1) and 9 subsequent quarters. Source: Authors' calculations.

Across the three sets of impulse responses, the important role of the US in the world economy over this period is reflected in the stronger overall domestic output response to this shock than others, and also in the greater responses of domestic New Zealand inflation seen in Figure 4 compared with Figures 3 and 5. In other words, the source of the foreign growth shock matters. Also, and perhaps surprisingly, shocks originating in Australia have less impact overall on the New Zealand economy (except for the exchange rate) than those originating in the US.

A further comparison of the growth spillovers from the two major foreign sources of shocks are shown in Figure 6, where the corresponding impulse responses seen in Figures 3 and 4 are aggregated over lags. In addition to those for New Zealand, the figure includes the own China or US responses and also the responses of Australia obtained from each model. While the own responses of the US or China, respectively, are greater than the spillovers, the effects on Australia are (except for the initial effect of a China

shock) larger than on New Zealand. Further, according to these models, the response of output in both New Zealand and Australia to a China output shock is about half that of a US output shock. This may reflect the role of the US in the world economy over this period, with effects originating there having spillovers to many countries, which in turn influence growth in New Zealand and Australia. Furthermore, the more persistent nature of US shocks relative to China shocks may also be a contributing factor to the greater New Zealand response. The faster pattern of response of domestic New Zealand output when the shock originates in China may reflect increased demand from China for New Zealand products (such as dairy products), whereas that from the US may operate more indirectly through other countries.

Figure 6: Accumulated GDP responses to growth shocks in the US and China



Notes: Impulse responses are accumulated from those shown in Figure 4 and Figure 3 for US and China shocks, respectively.
Source: Authors' calculations.

The overall conclusion from the baseline SVAR model, using data over the three decades from 1982 to 2011, is that growth spillovers from China to New Zealand are non-trivial, with a one percentage point shock to China's growth estimated to increase New Zealand's GDP by around 0.3 percentage points within a one year period. Further, this effect on New Zealand applies relatively quickly, and with little significant impact on other domestic variables beyond an immediate appreciation of the real exchange rate. On the other hand, shocks originating in the US or Australia have greater spillovers to New Zealand's growth, with consequent effects also on domestic interest rates in addition to the exchange rate. The implication of Figure 6 is also that growth in New Zealand has an overall slightly lower response to shocks from the major economies of the US and China than does Australia particularly in the medium term. It is important to note that the analysis so far has concentrated on the spillover impacts on the volume of domestic output. This, on the other hand, is only part of the story as the transmission channel via commodity prices has an important impact on domestic nominal GDP as well as second-round impacts on volumes via an income effect. The next subsection extends the investigation to include a commodity price channel, in order to further explain these response patterns.

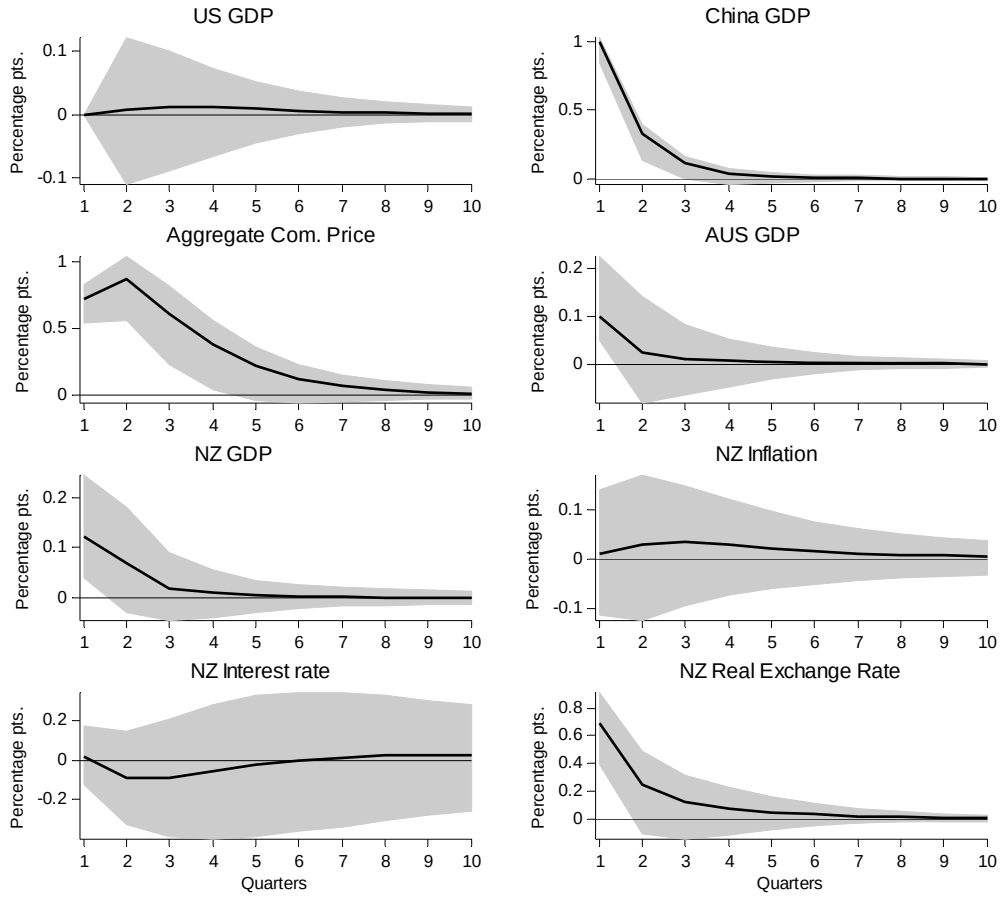
4.2 Transmission via commodity prices

As noted in subsection 3.2, the evolution of commodity prices is important for the New Zealand economy. Indeed, as discussed by Bowman and Conway (2013a, 2013b), growth in China over the last decade may be particularly important as an explanation of the rise in commodity prices, which affects New Zealand as an exporter of primary products. Related to this, Roache (2012) investigates the impact of shocks to aggregate activity in China on real prices of oil and base metals (relative to the US consumer price index) for the period 2000-2011; while shocks to aggregate activity in China have a significant and persistent short-run impact on the prices of oil and copper, they are generally insignificant for other metals. However, Roache (2012) also finds that effects are larger for a demand shock originating in the United States than in China. In the Australian context, the results of Sun (2011) indicate that commodity prices are the most important channel for the transmission of shocks from emerging Asia to Australia over her sample from 2000, with some results (Sun, 2011, Figure 9) suggesting that these are important also for the transmission of shocks from that region to New Zealand. Nevertheless, this latter analysis is not entirely satisfactory in that commodity prices are treated as exogenous to even the world's largest economies.

Against this background, and also the results of our baseline SVAR presented in subsection 4.1, it is useful to investigate empirically the role of commodity prices in the transmission of growth spillovers to the New Zealand economy. Since Roache (2012) finds that the US is more important for the evolution of commodity prices than China, our SVAR model includes GDP growth for both of these large economies in a single specification and, reflecting their importance for world demand, the model allows growth in both China and the US to contemporaneously influence commodity prices. In recognition of the historical role of the US for the world business cycle, contemporaneous causality between these countries runs from the US to China. However, unrestricted lags apply across these two countries and commodity prices. This block is exogenous for Australia and New Zealand, so that growth in China and the US affects these countries, but not vice versa. Due to the availability of commodity price data, the estimation period for the extended SVAR starts in 1986. A schematic representation of the model description is provided in Appendix Figure 1.

Figure 7 shows the estimated responses of all eight variables to a one percentage point shock to China's growth rate in this extended model that employs the real aggregate ANZ commodity price index. Although there is virtually no effect on the US from the China growth shock, the commodity price index responds positively, increasing by about 0.7 percent within the quarter, and the effect is rather persistent and statistically significant. The pattern of response of domestic output is similar to the output response to a China shock shown in Figure 3, albeit with the estimated mean response being a little lower than in the baseline case. The real exchange rate immediately appreciates in response to the increase in China's output and the associated boost in commodity prices, while interest rates and inflation responses are small and insignificant.

Figure 7: Responses to China GDP shock with commodity price channel

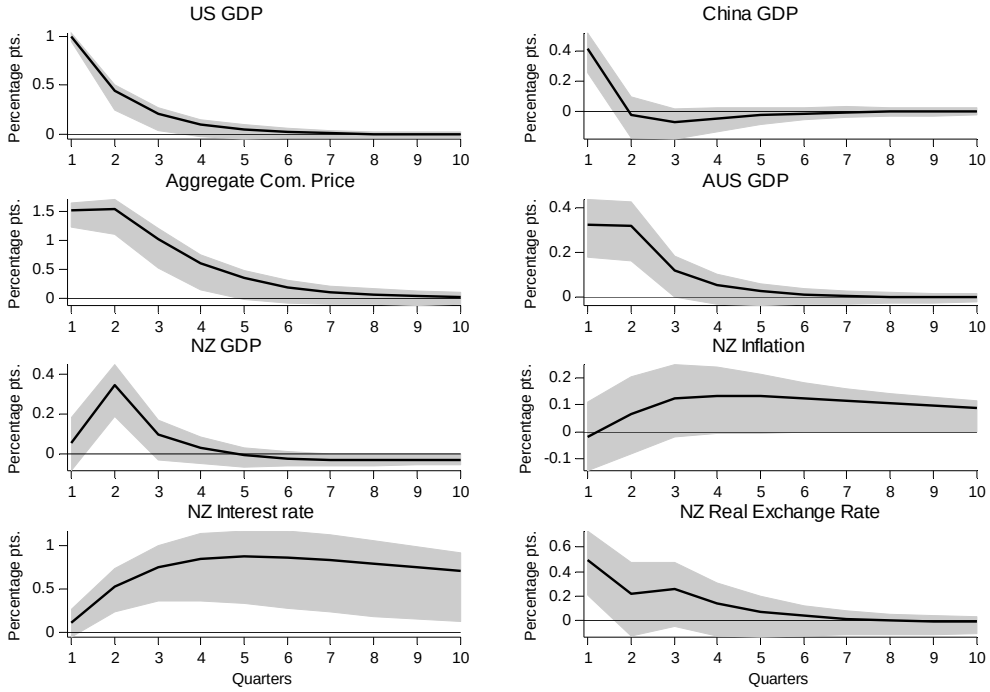


Notes: The figure depicts the impulse responses to a one-percentage point orthogonalised shock to China's GDP. The SVAR model includes the aggregate commodity price index and is estimated using data over 1986Q1 to 2011Q4. The solid line shows the estimated mean response, with the shaded bands indicating the 90 percent confidence interval, obtained using 2000 Monte Carlo replications. Responses are shown for the quarter of the shock (quarter 1) and 9 subsequent quarters. Source: Authors' calculations.

A comparison of the responses to a US shock in Figure 8 with those just discussed for a China shock reveals a number of interesting differences. Firstly, in line with the results of Roache (2012) for oil and base metals, the response of commodity prices to a US growth shock in Figure 8 is around double that seen when growth originates in China (Figure 7). Although this stronger effect is partly due to the contemporaneous causal ordering we adopt between these large economies, it also reflects the wider impact of the US on the world economy over most of the 1986-2011 period[8]. Secondly, the peak GDP responses of New Zealand occur in the quarter after the shock, in line with the estimates from the baseline model of subsection 4.1, but in contrast to the responses to a China shock.

[8] The contemporaneous response of about 0.4 percent China to the US growth shock in **Error! Reference source not found.** is not sufficient to account for the different responses of commodity prices in the two figures.

Figure 8: Responses to US GDP shock with commodity price channel



Notes: The figure depicts the impulse responses to a one-percentage point orthogonalised shock to US GDP. The SVAR model includes the aggregate commodity price index and is estimated using data over 1986Q1 to 2011Q4. The solid line shows the estimated mean response, with the shaded bands indicating the 90 percent confidence interval, obtained using 2000 Monte Carlo replications. Responses are shown for the quarter of the shock (quarter 1) and 9 subsequent quarters. Source: Authors' calculations.

Further, using the extended model Figure 8 reveals some differences in responses to US shocks compared with the baseline case (Figure 4. In particular, in omitting both China and commodity prices when analysing the responses to US shocks, the baseline model conflates the appreciation of New Zealand's real exchange rate that operates through those sources with an anticipated negative direct effect from a US shock, with these shocks more adequately isolated in the extended model.

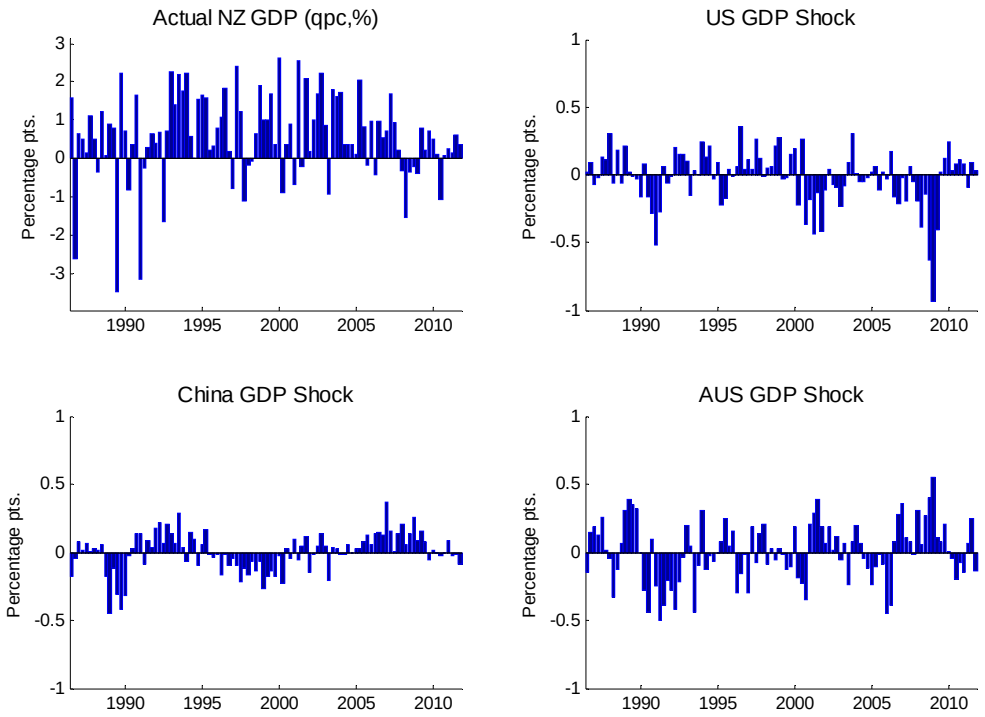
These results suggest that commodity prices play an important role in the transmission of shocks from both China and the US to New Zealand. These effects operate partly through Australia, which itself strongly influences Australia's domestic growth (Figure 5). The positive and significant response of the real exchange rate in Figure 7 is another manifestation of the importance of commodity prices. Although results are not shown, a one percent shock to the real commodity price index increases this variable by around 0.4 percent, which is significant and implies that this channel makes an important contribution to the impact response of the real exchange rate seen in Figure 7. These results on the role of commodity prices are in line with findings of Karagedikli and Price (2012) and Jääskelä and Smith (2011), who study the sources of terms of trade shocks for New Zealand and Australia, respectively.

4.3 Historical decomposition

Historical decompositions measure the contributions of different structural shocks to realisations of endogenous variables. In order to shed further light on the importance of the different shocks, Figures 9 and 10 show the estimated historical decompositions of New Zealand's GDP and real exchange rate growth in terms of the contributions of each foreign shock, as identified using the extended SVAR model of the preceding subsection.

In each case, growth rates of quarterly actual GDP and the real exchange rate from 1986 to 2011 are shown as the first panels of the figures, with these growth rates then decomposed into the effects as sourced by the three of the eight separate shocks of the model.

Figure 9: Contributions of foreign shocks to New Zealand's economic growth

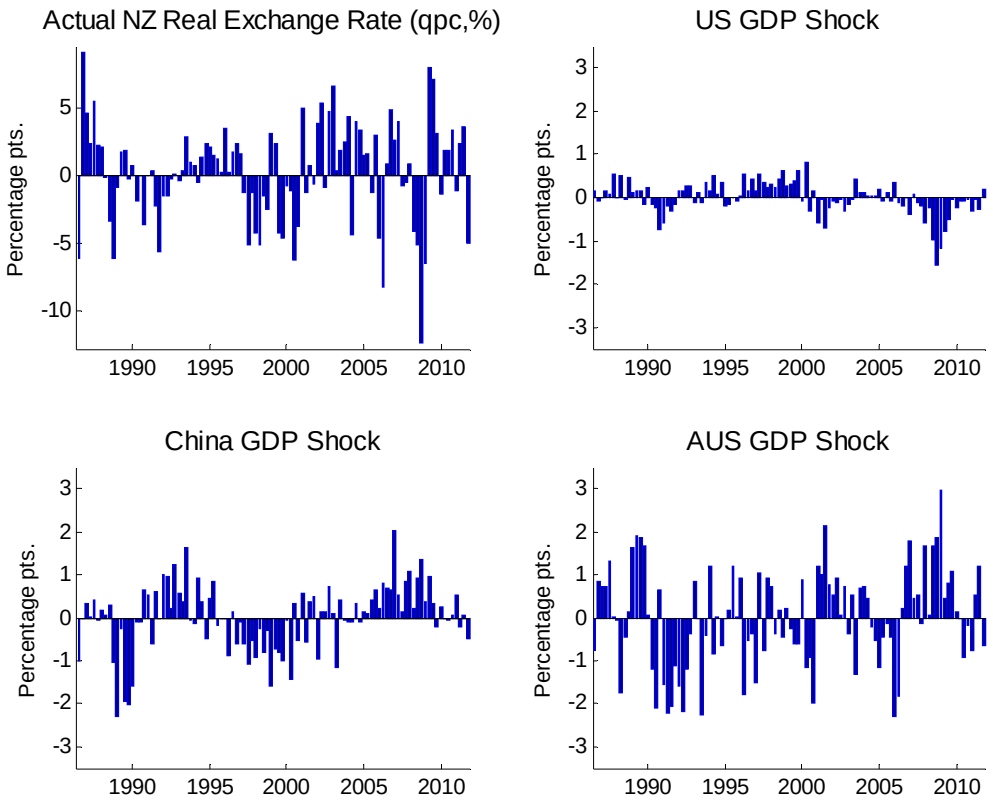


Notes: The historical decomposition relates to the sources of shocks as identified in the SVAR model of subsection 4.2. Source: Authors' calculations.

In line with the impulse responses seen in Figure 7 and Figure 8, shocks originating in US have been relatively more important overall for New Zealand GDP than those from the China. The positive contribution of shocks from China's growth after 2005 and the negative impact of US growth shocks during the global financial crisis are evident. Shocks to Australia's GDP have had a sizeable contribution throughout the sample period.

Turning now to the real exchange rate, Figure 10 shows that foreign shocks play a major role in the dynamics of New Zealand's real exchange rate while domestic shocks are relatively less important (not shown but are available upon request).

Figure 10: Contributions of foreign shocks to New Zealand's real exchange rate



Notes: See Figure 9. Source: Authors' calculations.

4.4 Further commodity price analysis

The analysis of subsections 4.2 and 4.3 illustrates the importance of world commodity prices for the New Zealand economy, particularly for movements in the real exchange rate. However, it is plausible that different sub-categories of commodity prices may affect the New Zealand economy in different ways. In particular, Bowman and Conway (2013a, 2013b) highlight changes associated with China's demand for dairy and forestry products from New Zealand. Commodity prices, particularly those relating to mineral products, are important also for the Australian economy, which in turn affects New Zealand. The present subsection therefore analyses sub-groups of the ANZ commodity price index, specifically dairy, forestry, meat and wool, and aluminium.

Table 1 shows the accumulated impact of shocks to the growth rates of both China and US on these commodity prices; those shown for the aggregate index in Table 1 are accumulated from the responses shown in Figures 7 and 8, with those for commodity categories obtained in the same way, but using the respective sub-group world price index in the SVAR model of subsection 4.2. The effects of demand shocks originating in both countries have statistically significant impacts on all commodity price series. On the other hand, the impact varies across sectors, with the biggest responses being for aluminium and dairy products. A one percentage point shock to growth rates in the US and China leads to accumulated increases in the real price of aluminium within four quarters of 12.6 and 5.5 percentage points respectively. The corresponding increases in dairy products are 6.7 and 5.6 percentage points respectively. The relatively high elasticity for aluminium products may be due to the rapid growth of China's manufacturing sector during the period studied here. While the response of forestry product prices is also sizeable in both cases, the impacts on the meat and wool category are relatively muted. As discussed in

Bowman and Conway (2013a), wool would have been influenced by China in late 1980s but more stable since then even though they are the dominant market. China, on the other hand, is becoming more important for meat exports but the effect might not have shown up yet.

Overall, the results in Table 1 show that US demand is generally more important than China in driving global commodity prices, whether these prices are examined through the aggregate ANZ index or through sub-indices relevant to New Zealand. This partly reflects the larger international spillovers generated by US growth to other major economies, indicated in Figure 8 for China, and is in line with the findings of Roache (2012). It is important to note here that our analysis is silent about the supply side responses that may have an impact on the movements in commodity prices.

Nevertheless, the effects on commodity prices of growth from these major economies are only part of the story, since the focus of interest of this study is the effects on the New Zealand economy itself. Therefore, Table 2 provides the comparable accumulated responses of domestic GDP growth to US and China shocks in the SVAR model with commodity prices, both when the aggregate commodity price series is used (as in subsection 4.2) and when sub-group indices are employed in place of the aggregate. However, the overall pattern is unaffected by which index is used. To be specific, the US shocks are found to have a substantially greater impact on New Zealand GDP than those originating from China. Although the confidence intervals are relatively wide, the response to China peaks one quarter after the shock while the response to the US is longer-lived, with a one percentage point rise in US and China's GDP estimated to result in accumulated increases of approximately 0.5 and 0.2 percentage points, respectively, in that of New Zealand within four quarters.

Table 1: Estimated cumulative responses of real commodity prices to US and China GDP shocks

	Aggregate Index		Dairy Index		Forestry Index		Meat and Wool Index		Aluminium Index	
	US Shock	**China Shock**	**US Shock**	**China Shock**	**US Shock**	**China Shock**	**US Shock**	**China Shock**	**US Shock**	**China Shock**
Q1	1.52	0.72	2.15	1.40	2.35	-0.32	1.09	0.67	4.83	2.87
	(1.24,1.67)	(0.53,0.82)	(1.75,2.33)	(1.15,1.51)	(1.99,2.48)	(-0.43,-0.17)	(0.85,1.22)	(0.49,0.77)	(4.00,5.20)	(2.44,3.01)
Q2	3.07	1.59	4.42	3.33	4.15	1.08	1.86	1.01	9.07	4.42
	(2.36,3.40)	(1.08,1.88)	(3.35,4.86)	(2.54,3.65)	(3.22,4.50)	(0.57,1.50)	(1.33,2.14)	(0.59,1.27)	(7.04,9.94)	(3.10,5.06)
Q3	4.09	2.19	5.87	4.75	4.84	1.89	2.34	1.19	11.41	5.13
	(2.91,4.60)	(1.31,2.73)	(4.06,6.60)	(3.26,5.37)	(3.38,5.43)	(0.89,2.60)	(1.52,2.73)	(0.58,1.59)	(8.10,12.76)	(2.95,6.39)
Q4	4.69	2.57	6.68	5.64	5.01	2.20	2.60	1.27	12.59	5.45
	(3.08,5.37)	(1.36,3.30)	(4.16,7.70)	(3.47,6.55)	(3.18,5.80)	(0.81,3.16)	(1.57,3.09)	(0.54,1.78)	(8.15,14.41)	(2.68,7.18)

Notes: Estimated responses are shown in percentage points, for a GDP shock of one percent, for the quarter of the shock (Q1) and three subsequent quarters (Q2, Q3, Q4). The 90 percent confidence intervals shown in parentheses are based on 2000 Monte Carlo replications. The model used is the SVAR of subsection 4.2, with the aggregate ANZ commodity price index replaced by the dairy, forestry, meat and wool, or aluminium sub-group index, as appropriate. Source: Authors' calculations.

Table 2: Estimated cumulative domestic GDP responses to China and US shocks in models with aggregate and sub-group commodity price indices

	Aggregate Index		Dairy Index		Forestry Index		Meat and Wool Index		Aluminium Index	
	US Shock	**China Shock**	**US Shock**	**China Shock**	**US Shock**	**China Shock**	**US Shock**	**China Shock**	**US Shock**	**China Shock**
Q1	0.06	0.12	0.07	0.12	0.07	0.12	0.07	0.12	0.05	0.12
	(-0.08,0.19)	(-0.02,0.25)	(-0.06,0.20)	(-0.02,0.24)	(-0.07,0.20)	(-0.03,0.25)	(-0.06,0.21)	(-0.02,0.24)	(-0.08,0.19)	(-0.03,0.24)
Q2	0.40	0.19	0.44	0.19	0.41	0.19	0.41	0.18	0.38	0.19
	(0.12,0.65)	(-0.08,0.44)	(0.15,0.68)	(-0.08,0.44)	(0.12,0.66)	(-0.09,0.44)	(0.12,0.65)	(-0.09,0.43)	(0.10,0.64)	(-0.09,0.43)
Q3	0.50	0.21	0.53	0.20	0.51	0.20	0.52	0.20	0.51	0.21
	(0.10,0.82)	(-0.14,0.54)	(0.11,0.84)	(-0.17,0.53)	(0.10,0.83)	(-0.19,0.55)	(0.12,0.83)	(-0.14,0.51)	(0.08,0.85)	(-0.14,0.52)
Q4	0.53	0.22	0.55	0.20	0.55	0.20	0.56	0.22	0.55	0.23
	(0.05,0.91)	(-0.19,0.60)	(0.06,0.91)	(-0.24,0.59)	(0.07,0.91)	(-0.25,0.62)	(0.10,0.92)	(-0.16,0.56)	(0.03,0.95)	(-0.17,0.57)

Notes: See Table 1. Source: Authors' calculations.

5 Time-Varying Estimation

For all the models examined, plausible results have been obtained in terms of the direction of the domestic impacts of shocks to China and US growth. That is, the foreign output shock increases domestic New Zealand output and inflation, with monetary policy responding by increasing interest rates. The results of section 4 also imply that commodity prices are important for the transmission of these effects. Nevertheless, these results are obtained using a relatively long sample of data (25 to 30 years), whereas the correlation analysis in subsection 3.1 points to changing impacts of output growth on New Zealand over time.

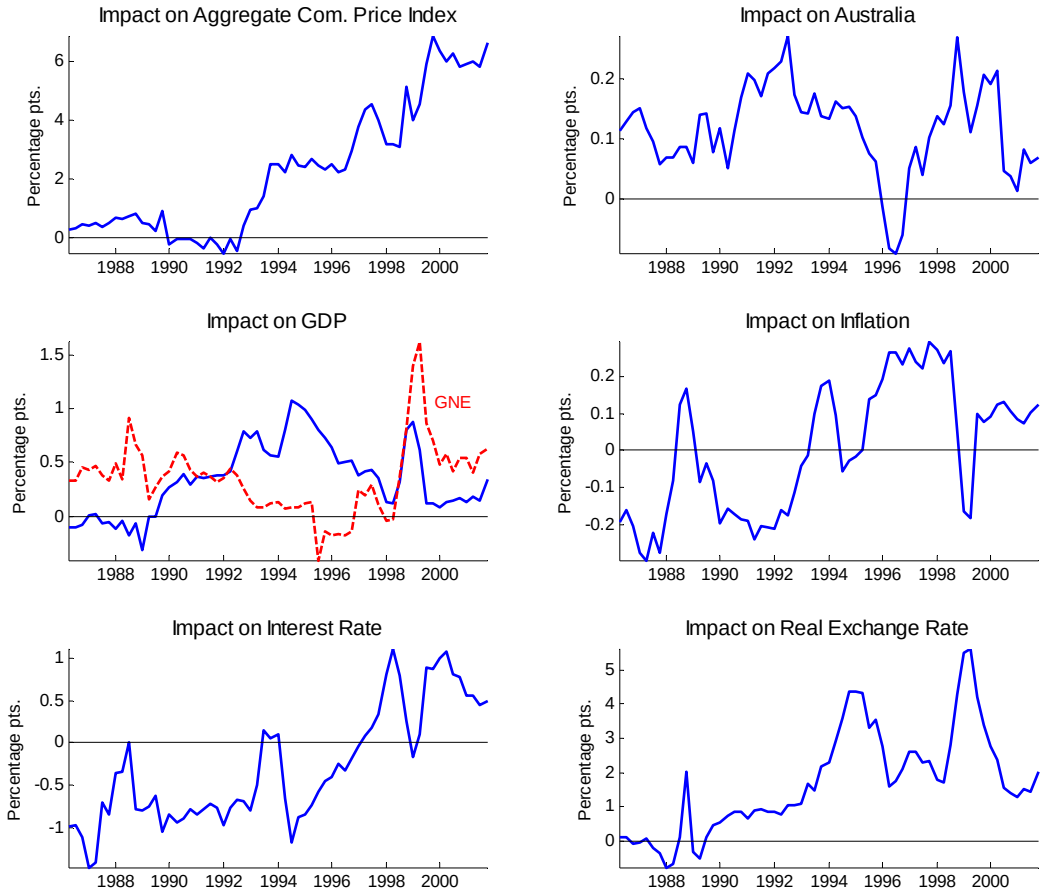
To examine the possibility of time variation in the impacts of foreign shocks on New Zealand, we estimate the SVAR model with aggregate commodity prices, as used in subsection 4.2, but now estimating the coefficients over a moving sample of ten years of data. The focus of interest is China, and Figure 11 plots the estimated four-quarter (accumulated) impacts over time of a shock to China GDP on the other variables of the model. Note that, in common with the correlations in Figure 1, the values are plotted against the first quarter of the ten years over which the model is estimated.

These results strongly suggest that spillovers from China's growth to New Zealand GDP vary over time. In terms of GDP volumes, the estimated impact rises to around 1.1 for the decade from the mid-1990s. Although dropping to be close to 0.2 from the late 1990s, this rises again to about 0.3 at the end of the sample. This last result is in keeping with the discussion of Bowman and Conway (2013a, 2013b) about the importance of the Chinese market for New Zealand's agricultural exports in recent years. It is also striking in Figure 11 that China has an increasing impact on commodity prices from the early 1990s, with these factors also implying an increased impact on New Zealand's domestic interest rates and real exchange rate.

It is important to note that the focus of analysis is on the volume of GDP that does not reflect the income gains or losses from the terms of trade changes. To reflect these changes, we repeat the exercise by replacing GDP volumes with Gross National Expenditure (GNE). GNE measures New Zealanders' expenditure and therefore better reflects income changes owing to terms of trade movements. The results (red dotted line in Figure 11) show that the impact on GNE exhibits an upward trend during 1997-1999 reflecting the significant terms of trade gains in recent years.

Rather than using moving data windows, SVAR modelling sometimes takes account of time-variation in responses through applying a time-varying parameters VAR approach, as for example in Stock and Watson (2005). Although this approach is quite promising, the computational burden of estimating an eight-variable SVAR of this type would be substantial (Del Negro, 2003). Therefore, we do not pursue this here and leave it as an avenue for further research.

Figure 11: Time-varying four-quarter cumulative impact of China GDP shock



Notes: Values shown are the four-quarter accumulated impacts computed from the SVAR of subsection 4.2, estimated over a ten year moving window starting at the indicated date. Source: Authors' calculations.

6 Conclusion

The effects of China's economic growth on the New Zealand economy is a topical issue, due both to the continued rapid growth of China and also its importance as an export market for New Zealand primary produce. However, to our knowledge, none of the available econometric models for New Zealand specifically explore the extent of growth spillovers from China to the domestic New Zealand economy. Indeed, surprisingly few studies exist that examine the wider issue of growth spillovers from China to other countries.

The substantive conclusion of the present paper is that, using models estimated from the mid-1980s to 2011, growth spillovers from China are important for New Zealand, with estimates of the accumulated increase in domestic GDP from a one percent increase in output in China being in the range of 0.2 to 0.4 percent. Nevertheless, it is also striking that estimated growth spillovers are substantially greater from the US than from China, despite the latter's increasing importance in the world economy. Although both domestic and foreign shocks are important drivers of real exchange rate fluctuations, the contribution of the latter (particularly commodity prices) is relatively more important.

The possibility of time-varying impacts is also investigated through estimation using a ten year window of data. This provides some evidence of time-variation, with the greatest impact from China applying for about a decade from the mid-1990s, but also being relatively large in the latter part of our sample period. The impact of China on global commodity prices has been steadily increasing over time, with growth in China having strongest effects on dairy and aluminium price inflation.

Alongside the broader descriptive analysis by Bowman and Conway (2013a, 2013b), these results highlight the growing importance of China for the contemporary New Zealand economy. Although data availability means that our estimations extend only to the end of 2011, more recent indicators, including China's demand for New Zealand dairy products, point to the role of China being maintained or increased in the near future.

A further extension of this work would be to include a broader set of countries and variables in the model to allow for more realistic cross-country dynamics such as the inclusion of Euro Area and additional financial variables.

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Appendix

Appendix Table 1 – Data description

Series	Mean	Std. Deviation	Skewness	Source
US GDP (SAAR, Bil.Chn.2005$)	0.71	0.66	-1.02	Haver Analytics
China GDP, (SA, 1997 price rmb mn)	2.43	1.04	-0.27	Haver Analytics & National University of Singapore*
Australia GDP (SA, Mil.Chn.Q3:09-Q2:10.A$)	0.83	0.72	0.08	Haver Analytics
New Zealand GDP (SA, Mil.Chn.Q3/1995-Q2/1996.NZ$)	0.60	1.15	-0.61	Haver Analytics (1987Q2-2011Q4). Prior to 1987Q2 the series is backdated as was used in Dungey and Fry (2009).
New Zealand Consumer Price Index (SA, Q2-06=1000)	0.99	1.10	2.09	Haver Analytics
New Zealand 90-Day Bank Bill Yield (Average, %)**	9.37	5.36	1.20	Haver Analytics
New Zealand Real Exchange Rate	0.10	4.20	-1.07	Haver Analytics
ANZ World Commodity Price Index, 1986=100	0.52	4.51	-0.17	Haver Analytics***
ANZ Dairy Products Index, 1986=100	0.50	8.69	0.30	Haver Analytics***
ANZ Forestry Products Index, 1986=100	-0.12	5.73	0.22	Haver Analytics***
ANZ Meat, Skins and Wool Index, 1986=100	0.50	4.30	-0.22	Haver Analytics***
ANZ Aluminium Prices Index, 1986=100	0.08	9.70	-0.67	Haver Analytics***

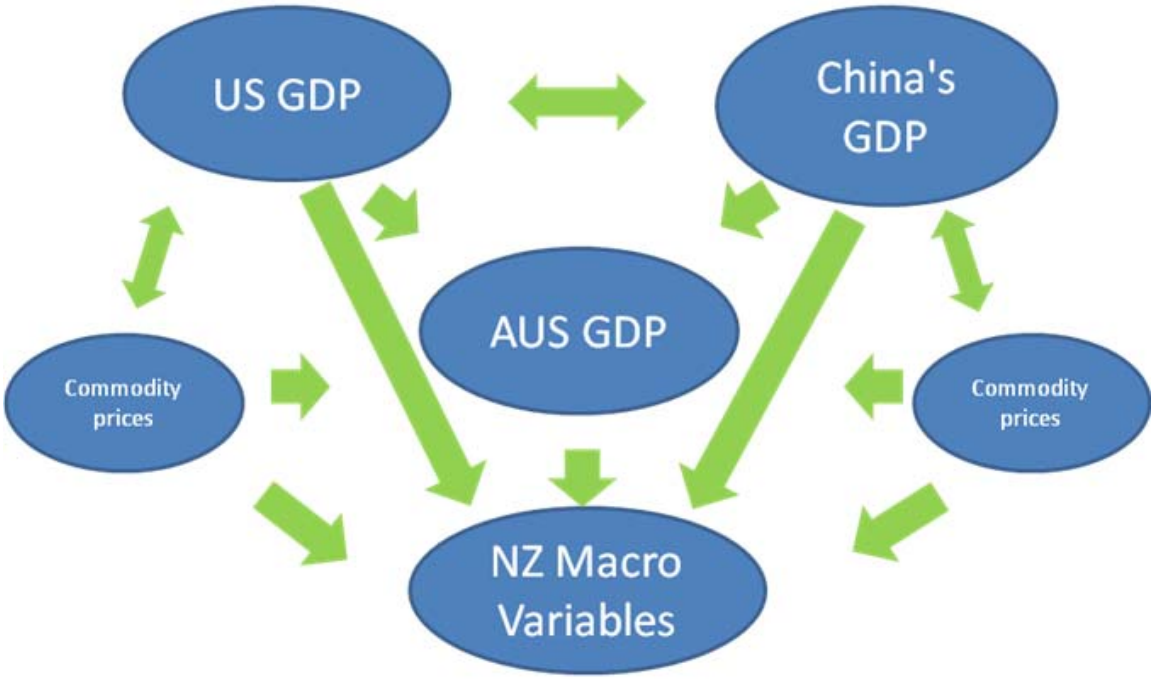
Notes: Unless indicated otherwise, the sample period is 1982Q4 to 2011Q4. Data are expressed as growth rates by multiplying the difference of the log series by 100 with the exception of 90-day rates that are in levels.

* Link: http://www.fas.nus.edu.sg/ecs/esu/data.html

** Percentage points

*** The sample period is 1986Q1 to 2011Q4. the available values are seasonally adjusted using X-11 and deflated by US CPI

Appendix Figure 1 – Schematic description of the extended model



Notes: The arrows indicate the direction of feedback across the three countries. New Zealand's macroeconomic variables comprise real GDP, inflation, interest rate and the real exchange rate.