

International spill-overs of uncertainty shocks: Evidence from a FAVAR*

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Abstract

This paper analyses the international spill-overs of uncertainty shocks originating in the US. We estimate an open economy, structural factor-augmented vector autoregression (FAVAR) model that identifies the uncertainty shocks and estimates the impact of these uncertainty shocks to the US economy, major world economies and a small open economy, namely New Zealand. As is common practice in the literature we use the VIX as our uncertainty measure but we also propose a measure of a uncertainty based on taking a principal component of the VIX and three other commonly used measures of uncertainty. Such an approach removes the idiosyncratic component that any individual uncertainty measure may have. We find that an unexpected increase in uncertainty is isomorphic to negative demand shocks in the US. Further that the US specific uncertainty shock is associated with synchronized downturns in the other advanced economies. Finally the data-rich nature of our model allows us to investigate different transmission channels from the US to the rest of the world. We find the confidence channels, measured by the expectations surveys, are a particularly important transmission of the uncertainty shock to our small open economy.

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1 Introduction

The effects of the Global Financial Crisis, although it originated in the US, have been felt around the world. Despite large amounts of monetary and fiscal stimulus in the US and other countries, most advanced economies have experienced prolonged and synchronised downturns. Recently economists are recognising the role uncertainty plays in the business cycle, particularly in the US.¹ The possibility therefore arises that the effects of an uncertainty shock originating in the US could have an effect on global business cycles. In this paper, we provide empirical evidence about the international transmission of US uncertainty shocks to other advanced economies – Australia, Canada, China, the Euro area, Japan, the UK – and a small open economy, namely New Zealand. New Zealand is an ideal small open economy test case, as it is a developed country with good institutions, a long tradition of independent monetary policy and a floating exchange rate. Further there is a considerable amount of available reliable data. Data is an important consideration for our empirical strategy as we estimate an international Factor-Augmented VAR (FAVAR), which relies on panels of world and country specific data. We identify uncertainty shocks following a two-step procedure similar to [Bernanke et al. \(2005\)](#). First, we estimate factors as principal components to summarise the information contained in our large dataset. Second, we estimate a VAR with these factors and a measure of uncertainty. We use a recursive identification scheme to identify uncertainty shocks. Our main findings are as follow. A US uncertainty shock causes a domestic recession with activity measures and inflation falling; in response the Fed funds rate is cut. On the financial side, credit growth and asset prices fall, while interest rate spreads increase. The same shock has statistically significant effects on the other major economies in our dataset, with output, inflation and stock prices falling in each country. In addition, commodity prices, including oil prices, fall in response to the uncertainty shock. In our small open economy, New Zealand, output, inflation and interest rates all fall and the exchange rate depreciates against the US. We find that financial variables and expectations are the main channels of transmission from the world to New Zealand. In our baseline specification, we use VIX as our measure of uncertainty and a model with 3 New Zealand factors and 5 international factors. We use the VIX as our baseline as it is the most common mea-

¹[Stock and Watson \(2012\)](#), for example, argue that financial disruptions and heightened uncertainty shocks are the primary cause of the 2007-2009 recession in the US. [Leduc and Liu \(2012\)](#), [Alexopoulos and Cohen \(2009\)](#), [Bloom \(2009\)](#), [Bachmann et al. \(2010\)](#), [Baker et al. \(2012\)](#) all look at how uncertainty interacts with the US business cycle

sure of uncertainty in the literature. Recognising that all measures of uncertainty are not completely perfect (that is they may have their own idiosyncratic component) we take three other common measures of uncertainty along with the VIX and create an factor. We use this factor as an alternative uncertainty measure. Our alternative specification yields similar, but not identical, transmission channels of uncertainty shocks. The FAVAR framework has a number of advantages in contrast to a standard structural VAR. FAVAR allows the use of a very large amount of information that is available to the economic agents therefore potentially minimising the omitted variable bias in a small VAR. Further the FAVAR overcomes the issue of, sometimes arbitrary, choice of variables to represent certain macroeconomic concepts. The identification of international transmission channels is challenging because involves estimating a model with many countries and many variables. The FAVAR allows us to analyse the effects of the identified shock on a large number of variables for many countries. There are alternative approaches to dealing with the dimensionality issue, namely GVAR. In the GVAR the country dimension is large, but the number of variables which can be examined in each country is limited. For example [Chudik and Fratzscher \(2011\)](#) use a GVAR approach to examine the transmission of US liquidity and risk shocks during the Global Financial Crisis to a number of countries, but can only look at four variables. [Alexopoulos and Cohen \(2009\)](#) take another approach to looking at the impacts of uncertainty on a large number of variables – specifically the dynamics of the components of GDP. Their approach is essentially based on the small VARs approach as they estimate multiple VARs but change the variables by adding and subtracting variables sequentially. Their focus is solely on the US however. The remainder of the paper is structured as follows: Section 2 introduces the empirical framework, and discusses estimation and identification, section 3 presents and discusses the results. Section 4 concludes.

2 Empirical Framework

In this section we first describe our dataset. We then present the FAVAR model and discuss out identification strategy.

2.1 Data

We use data from various sources including national statistics agencies. Most of the data is retrieved using HAVER. Table 1 in the appendix lists all the data used in the estimation as well as the transformation applied to each raw data. Prior to the estimation, all variables are demeaned and standardised. We use quarterly data covering the period 1994Q3 to 2011Q2. The sample is mainly imposed by data availability outside the US. Our variables are divided in two blocks: International and domestic. The international block is composed of data from the US and major world economies. For the US, we use an updated version of [Bernanke et al. \(2005\)](#) dataset. This dataset includes 116 individual data series covering a broad range of macroeconomic and financial variables. For the remaining part of the world block, we collect data for Australia, Canada, China, Japan, the UK and aggregated measures for the seventeen countries of the Euro area. These countries represent around 50 percent of world GDP and trade. Our data is less comprehensive for these non-US countries but nevertheless encompasses extensive macroeconomic information – GDP, industrial production, unemployment, capacity utilisation, interest rates, inflation, stock prices, exchange rates, measures of business and consumer confidence and terms of trade. Finally, measures of commodity prices are added in the world block. Overall our international dataset comprises 232 individual data series. The US specific data amounts, therefore, to half of the international block. The domestic block refers to New Zealand specific variables. Setting up a separate domestic block allows us to set up our model so that New Zealand variables are not influencing world aggregates – consistent with its small open economy status. We are interested in exploring alternative transmission channels to New Zealand economy. Consequently, we use a detailed dataset including disaggregated GDP components, prices and survey data, as well as a range of financial variables. We have 146 individual data series for New Zealand.

There is no agreement about an ideal measure of uncertainty. Therefore we consider two alternative measures. Because our objective is to investigate the transmission of an uncertainty shock originating in the US, we rely on US based measures of uncertainty. The first measure is the implied volatility index of SP 500 (VIX). VIX is our first choice as it has been popular in studies investigating the impact of uncertainty shocks and enables us to compare our results directly to these studies. The second measure is constructed by taking a factor of the VIX and three other commonly used uncertainty measures. The first of

these measures is the Michigan Survey of Consumers – specifically the share of households who report uncertainty about the future as a reason for delaying their large household goods purchases (see [Leduc and Liu \(2012\)](#)). The second measure is the Economic Policy Uncertainty Index recently suggested by [Bloom \(2009\)](#). The third measure uses data from the Survey of Professional Forecasters and constructs a measure of uncertainty as the percent difference between the 75th percentile and the 25th percentile of the 1 quarter ahead projections for the quarterly level of the US GDP. In order to make the uncertainty measures as compatible as possible with our identification restriction (namely uncertainty is not contemporaneously affected by the other shocks), our measures of uncertainty are taken from the first month of the quarter.

[Figure 1 about here.]

To illustrate why we take a factor of the uncertainty measures consider [Figure 1](#), which plots all the measures of uncertainty. They all show a general countercyclical pattern and rise during major economic disruptions such as the Asian crisis and the recent global financial crisis. There is nonetheless some heterogeneity in these four measures. Intuitively as two of the measures are survey measures (Michigan and Survey of Professional Forecasters) they may be subject to volatility not reflecting uncertainty but sample error. Further [Bekaert et al. \(2010\)](#) for example argue that the VIX can be decomposed into an uncertainty and risk aversion component. Extracting a factor from these four individual data series to help eliminate the idiosyncratic movements and get closer to a "truer" measure of uncertainty. The model is sequentially estimated using both the VIX and the factor uncertainty measures. We find that our results are qualitatively and quantitatively similar across alternative measures.

2.2 Estimation and identification

We estimate our model using a FAVAR approach as proposed by [Bernanke et al. \(2005\)](#). The FAVAR approach combines the standard VAR approach with estimated unobserved factors extracted from our large data set. We extract two sets of factors, domestic (F_t) and foreign (F_t^*), using principal components analysis. We model the joint dynamics of the extracted factors and the uncertainty index (U_t) by a reduced form VAR as follows:

$$\begin{bmatrix} U_t \\ F_t^* \\ F_t \end{bmatrix} = \beta(L) \begin{bmatrix} U_{t-1} \\ F_{t-1}^* \\ F_{t-1} \end{bmatrix} + u_t, \quad (1)$$

where U_t is a measure of uncertainty, F_t^* and F_t are sets of foreign and domestic factors respectively, $\beta(L)$ is a conformable lag polynomial of order p and u_t s are the reduced form residuals. The structural disturbances follow $u_t = \Omega^{1/2}\varepsilon_t$, with $\varepsilon \sim N(0, 1)$ and $\Omega = A_0(A_0)'$ where A_0 is the matrix of contemporaneous coefficients. The construction of our uncertainty data means we use a Cholesky identification scheme to identify the uncertainty shocks. In particular, we order the variables in the following order: uncertainty measure (U_t), international factors (F_t^*) and domestic factors (F_t), which assumes that uncertainty does not respond to the current quarter information contained in the domestic and foreign factors but not otherwise. Furthermore, we impose block exogeneity restrictions such that uncertainty and foreign factors don't respond to New Zealand factors. Therefore $\beta(L)$ is:

$$\begin{bmatrix} \beta_{11}(L) & \beta_{12}(L) & 0 \\ \beta_{21}(L) & \beta_{22}(L) & 0 \\ \beta_{31}(L) & \beta_{32}(L) & \beta_{33}(L) \end{bmatrix} \quad (2)$$

We assume that our large dataset can be represented as a linear combination of the latent factors as:

$$\begin{bmatrix} X_t^* \\ X_t \end{bmatrix} = \begin{bmatrix} \Lambda^{F^*} & 0 \\ \Lambda^F & \Lambda^D \end{bmatrix} \begin{bmatrix} F_t^* \\ F_t \end{bmatrix} + \begin{bmatrix} e_t^* \\ e_t \end{bmatrix}, \quad (3)$$

where X_t^* and X_t are vectors of observables for foreign and domestic blocks, respectively. Λ^{F^*} , Λ^F and Λ^D are matrices of factor loadings. Finally e_t^* and e_t are vectors of idiosyncratic, zero mean, disturbances. This structure, in particular the matrix Λ^F , ensures that we incorporate the effects of foreign factors in the domestic block. Once we estimate the impulse responses of the factors in response to an uncertainty shock, the factor loadings are used to calculate impulse responses for all variables in our dataset.

[Figure 2 about here.]

Statistical tests such as [Bai and Ng \(2002\)](#) provide criteria to determine the number of factors to be extracted from a large dataset. However, as [Bernanke et al. \(2005\)](#) argue, this criterion does not address the question of how many factors to include in the VAR specification. We determine the number of factors by examining the eigenvalues from the eigenvalue-eigenvector decomposition of the sample co-variance. [Figure 2](#) plots the change in the eigenvalues for domestic and foreign datasets. Visually inspecting [Figure 2](#) shows that 3 domestic and 5 foreign factors is where we begin to observe small changes in the scree plot; this represents the point where the remaining variance in the data explained by additional factors is small. Therefore given our relatively small sample size, we conduct our main estimations with 3 domestic and 5 foreign factors.

In order to control for the effect of foreign factors on the domestic block, we estimate domestic factors following an iterative approach as in [Boivin and Giannoni \(2007\)](#) and [Charnavoki and Dolado \(Charnavoki and Dolado\)](#). Starting from an initial principal component estimate of F , denoted by F^0 , we iterate through the following steps:

1. Regress X_t on F_t^0 and foreign factors F_t^* to obtain λ_F .
2. Compute $\widetilde{X}_t = X_t - \lambda_F * F_t^*$ to eliminate the contemporaneous effects foreign factors on X_t .
3. Estimate F_t^1 as the first K-5 principal components of \widetilde{X}_t .
4. Back to 1

We estimate the model using Bayesian method for the period 1994Q3-2011Q2. In setting the prior distributions, we use Minnesota priors that incorporate the belief that the more recent lags should provide more reliable information than the more distant ones and that own lags should explain more of the variation of a given variable than the lags of other variables in the equation. The hyperparameters are set as $\lambda = [\lambda_1, \lambda_2, \lambda_3, \lambda_4] = [0.1 \ 1 \ 0.05 \ 1]$ where λ_1 controls the standard deviation of the prior on own lags, λ_2 controls the standard deviation of the prior on lags of variables other than the dependent variable, λ_3 controls the degree to which coefficients on lags higher than 1 are likely to be zero and λ_4 controls the prior variance on the constant. We impose block exogeneity by imposing tight zero priors on the coefficients on domestic factors in uncertainty and foreign factor equations. We use four lags and employ 100,000 Gibbs replications while discarding the first 50,000 as burn-in sample.

3 Results

In this section we present the results from our estimation. Section [3.1](#) presents and discusses the estimated factors. Section [3.2](#) presents impulse responses of the US variables to a one standard deviation shock to both the level of VIX index and the uncertainty factor. Sections [3.3](#) and [3.4](#) present the impulse responses for the world and the New Zealand variables respectively. In subsection [3.5](#) we present the forecast error variance decompositions.

3.1 Factors

Figure 3 plots the estimated factors. Aside from splitting our factors into foreign and domestic factors to allow us to impose our block exogeneity structure on the VAR, we are agnostic about what the factors represent.

[Figure 3 about here.]

Factors are entirely statistical phenomena by construction, never-the-less it is useful to examine their correlations with observed variables to give them some economic meaning and help us understand our results. The first foreign factor is negatively correlated (greater than 0.5) with various foreign GDP and industrial production variables. The second factor displays a strong correlation with longer-dated interest rates. The third factor is highly correlated with prices - both producer price indices and export and import prices, while the fourth factor is correlated with export and import volumes. The fifth factor can be loosely described as a confidence factor – positively correlated with measures of consumer confidence (particularly in the US) and other variables that are driven by confidence, namely house and equity prices. Related to this confidence interpretation of the fifth factor, it is also strongly negatively correlated with the interest rate spreads - which we would expect to fall when confidence rises.

It is also informative to see how much of the variance in some key series are explained by the factors using the R-squared, which is shown in table 2.

[Table 1 about here.]

For quarterly growth in GDP the factors explain as little as 19% for Australia to around 75% for the Euro area; with the R-squared for Canada, U.K. and U.S. all being in the high-60s or 70s. A considerable proportion of world commodity prices is explained by the factors (85%), which is encouraging given this is a likely channel through which an uncertainty shock would be transmitted to New Zealand and therefore it is important that this channel can be captured by our model; further 65% of the variance in the oil price, a key variable in the global economy, is explained by the factors. The heterogeneity of R-squared numbers we observed across countries for GDP is also present for nominal exchange rates and inflation. Our factors generally explain between 55% and 78% of individual country exchange rates, with the exception of Japan where they only explain 33%. Japan (21%), along with Canada (45%), is also on the outlier for inflation, with the

R-squared in the other countries generally being between 62% and 85%. The R-squared for short term interest rates ranges between 68% for Japan and 91% for the US.

[Table 2 about here.]

Table 3 reports the R-Squared for some key New Zealand variables. The domestic factors explain more than half the variance in 90 day rates, GDP, unemployment rate and the exchange rate; the R-squared on inflation is also reasonably high at 52%. These reasonably high R-squared values give us a degree of comfort that the domestic factors are capturing the New Zealand economy well.

3.2 Impulse responses - US Economy

Figure 4 shows the impact of a one standard deviation shock to the level of VIX on key US variables.

[Figure 4 about here.]

Following the shock, activity declines with GDP immediately falling by around 0.1 percent and unemployment increasing by around 0.3 per cent at its peak after five quarters. The fall in GDP is significant for a year, while the rise in unemployment last for almost two years.

In terms of the sub-components of GDP, figure 4 shows that both consumption and investment persistently fall. durables consumption, which can potentially be deferred more easily, falls more than consumption of services, although the fall in consumption services is somewhat more persistent. The components of private investment fall significantly more than the components of consumption. Residential investment response is more front loaded and higher on impact. The largest impact on non-residential investment occurs several quarters after the shock. On the capital input side, capacity utilisation also falls with a hump shaped response where the response peaks just under one per cent in about 5 quarters. Reflecting the fall in output, inflation falls. As a result of falling inflation and reduced economic activity, the Fed funds rate is cut by approximately 40 basis points.

On the financial side, despite the fall in interest rates, asset prices in the US respond significantly to the uncertainty shock. The stock market for example falls by around 1.5 per cent on impact. As we will be discussing in section 3.3 this is consistent with the responses of the stock prices around the world. Possibly in accordance with falling

residential investment, house prices also respond negatively to the uncertainty shock. They fall by around 0.3 per cent within a few quarters. The BAA corporate bond spread over the Fed funds rate increases 30 basis points indicating that the increased uncertainty leads to agents facing a higher risk premium on their borrowing.

Figure 4 also shows that the US dollar exchange rate appreciates in response to this shock.² The appreciation of the US dollar exchange rate is consistent with a model of international risk sharing, where a shock to consumption in the US (brought about through more household saving owing to precaution owing to increased uncertainty) would see an appreciation in the exchange rate to make imported consumption goods cheaper. Alternatively it is consistent with the common perception in financial markets that the US dollar is a safe haven currency and thus in times of increased uncertainty capital flows out of currencies perceived to be more risky to the US dollar.

Leduc and Liu (2012) on the basis of their DSGE and VAR modeling concluded that uncertainty shocks in the US look like aggregate demand disturbances. Our FAVAR based results, at least regarding domestic variables, are in line with their results: Output, capacity utilisation, inflation and interest rates all fall and unemployment rises. However, the exchange rate appreciation and the increase in the corporate bond spreads are not fully consistent with an aggregate demand shock interpretation. A typical demand shock would have yielded a depreciation in the exchange rate.

Figure 5 shows the corresponding responses of US Macro variables to a one standard deviation shock to the principal component measure of uncertainty. It can be seen that the results are essentially identical with some quantitative differences. Headline variables such as GDP, capacity utilisation, inflation and interest rates all fall by approximately the same magnitude, but these variables, and indeed most others, exhibit a faster recovery using the uncertainty factor. Further variables such as GDP, durable consumption and the two investment aggregates overshoot zero during their recovery suggesting that some of the previous lost levels of the variable are recovered. Another interesting result is the stock prices fall less using the principal component of uncertainty than the VIX measure of uncertainty. Perhaps this is not surprising given the VIX is a financial market centric measure of uncertainty compared with the factor measure – which is based on more general measures of uncertainty. Alternatively if the VIX does indeed contain a risk aversion

²The appreciation of the US dollar is also consistent with the depreciation of the exchange rate of small open economies, such as New Zealand, which we will be discussing in the New Zealand section.

component as Berkaert et al. (2010) argue, this risk aversion component, together with the uncertainty component, may have led to a larger fall in stock markets. In contrast the principal component that isolates the uncertainty effect only may see less of a fall.

[Figure 5 about here.]

3.3 Impulse Responses - World Economy

In this section we present the transmission of uncertainty shock to the rest of the world. Figures 6 and 7 show the responses of key variables to a one standard error shock to the VIX index and the uncertainty factor respectively. Under both measures of uncertainty the shock has leads to a contraction in activity across countries. The magnitude of the contraction in GDP varies between 0.05 and 0.1. The impact is slightly larger on the Japanese GDP and the UK GDP, while the impact on other countries is similar in magnitude to that of the US GDP. Consistent with the fall in activity inflation falls in all countries and interest rates fall accordingly. There are some interesting cases. For example, Australian GDP is not affected much as a result their CPI falls the least. The resilience in the Australian economy is possibly due to the fact that our sample coincides with a prolonged expansion in Australia. Another interesting observation is the muted interest rate response in Japan. This is in line with Japan being close to the zero lower bound over most of our sample. The inability of interest rates to respond to the shock in Japan, makes its output contraction relatively larger.

The world economy also experience a synchronised fall in stock prices, which is consistent with the fall in economic activity across countries. The fall in stock prices is around 0.5-1 per cent in all five countries we report. The fall in stock prices in the world economy is comparable to those of the US stock prices. The falls in the various countries stock markets are remarkably synchronized, possibly reflecting the global nature of equity flows.

Prices decline for all commodities. Oil price shows the largest fall across commodities followed by the metal commodities. Agricultural raw commodities and food and beverage commodities do not fall by as much. The relative magnitudes of commodity price responses seem to reflect different income elasticities. For example agricultural and food products, which typically have a low income elasticity, are more affected than metals and oil.

[Figure 6 about here.]

[Figure 7 about here.]

As far as the confidence survey results are concerned, the confidence surveys fall in every country in our sample although they differ in magnitudes (8 and 9. In Australia both NAB and the Westpac-Melbourne Institute indices fall by around 0.5 standard deviation in response to the uncertainty shock. The euro area indices, Economic Sentiment Indicator and the Business Climate Indicator both fall and recover much slower compared to the others. A similar and persistent fall is also observed in Japan , the UK and China although the UK and the China indices recover quickly.

[Figure 8 about here.]

[Figure 9 about here.]

In terms of contrasting the results between the VIX and uncertainty factor the results are quite similar, although interestingly using the VIX measure both GDP and interest rates fall by less and then they both persistently overshoot zero after about 10 quarters. Using the factor uncertainty measure, however, the individual country GDP impulse responses converge back to zero and the interest rates do not recover to zero after 15 quarters. Perhaps an explanation is that a broad based uncertainty shock, as opposed to the financial market centric uncertainty shock represented by the VIX, is felt more severely in the world economy and for longer.

3.4 Impulse Responses - New Zealand Economy

In this section we discuss the transmission of the uncertainty shock originating in the US economy to New Zealand. Figure 11 shows the responses of selected variables for the New Zealand economy to a shock to the level of principal component measure of uncertainty.

On the activity side the effect of the shock on the New Zealand GDP is smaller than it is on the US economy but similar to the other advanced economies. The negative impact on the New Zealand GDP peaks after two to three quarters. This result is largely driven by the hump shaped dynamics of private consumption and investment. Similar to the US economy, investment in New Zealand falls more than consumption.

Interestingly, the traditional trade channel doesn't seem to contribute to the contraction in GDP following an uncertainty shock. There is not a significant fall in the exports of goods. There are a number of opposing effects in play determining the dynamics of

exports. New Zealand's exchange rate falls in response to the shock, consistent with the increase in the US dollar appreciation which we discussed above. Although this and the fall in the commodity prices stemming from the fall in world demand buffer the New Zealand exports to some degree, the fall in the world output acts as a drag on exports.

Following the lower economic activity and lower exchange rate, imports fall immediately and the magnitude of the fall is almost identical to the fall in private investment.

Unemployment rate increase by over 0.1 per cent and persistently stays high for over a year. The capacity utilisation also falls significantly in response to the shock and return to its pre-shock level after a year. The contraction in output and softer capacity pressures lead a fall in CPI inflation by around 0.05 per cent. As we will be discussing below, the depreciation of the exchange rate limits to fall in the headline CPI.

New Zealand dollar exchange rate falls against every major currency (in a trade weighted sense) except against the Australian dollar. The largest fall in the New Zealand dollar is against the US dollar, which is consistent with increase in risk aversion during highly uncertain times as investors substitute away from small country currencies such as the New Zealand dollar. At the height of the global financial crisis in 2008, and also around the 9/11 events, the New Zealand dollar, along with many other currencies, depreciated significantly against the US dollar. The fall in the New Zealand dollar is also related to the fall in the commodity prices. The commodity currency nature of the New Zealand and the Australian dollars probably explain the relative stability of the New Zealand dollar against the Australian dollar.³

[Figure 10 about here.]

[Figure 11 about here.]

Figure 12 shows the responses of macro-financial and expectations/confidence variables in the New Zealand economy. On the macro-financial side the fall in the credit growth is very persistent and peaks around six quarters. In line with falling prices and lower demand, interest rate falls. The magnitude of the interest rate fall is similar to the falls in other advanced economies. Despite falling interest rates, all asset prices and credit falls sharply. Figure 12 suggests that the dynamics of expectations can be important in

³ It should be noted that the New Zealand/Australia exchange rate is one of the most stable pair of freely floating currencies, whose relative peak to trough variance is around one third of that of the New Zealand/US dollar exchange rate for example.

understanding the macroeconomic dynamics in New Zealand. Both QSBO (Quarterly Survey of Business Opinions) and RBNZ based survey measures indicate that economic agents expectations about future activity sharply deteriorate. In particular, there is striking conformity between the dynamics of expected unemployment based RBNZ survey and actual unemployment dynamics following the uncertainty shock. Expected and actual GDP also follow somewhat similar patterns. The falls in survey measures without a corresponding fall in exports, suggest that confidence channels are particularly important in the transmission of uncertainty shocks.

[Figure 12 about here.]

3.5 Variance decomposition

[To be completed]

Table 4 presents the variance decomposition of the VIX owing to the VIX itself, and shows that the factors can explain around 11 percent of the error variance of VIX in one year, increasing to approximately 66 percent within 15-20 quarters horizon. This suggests that over the medium term most of the variation in the VIX can be explained by macroeconomic factors.

[Table 3 about here.]

4 Conclusions

This paper studies the international transmission of a US uncertainty shock to several major advanced economies and our small open economy, New Zealand. Using a FAVAR, which treats our small open economy as block exogenous, we quantify the impact of the uncertainty shock for a number of variables and for a number of countries. We show that in the US an uncertainty shock behaves like a demand shock, with interest rates, inflation and capacity utilisation all falling. The interconnected nature of world economies means that a US uncertainty centric shock propagates through through key world economies, financial variables, commodity prices and exchange rates in a relatively synchronized manner. However the synchronization across economies, commodity prices and exchange rates is far from perfect. Indeed the model displays remarkable consistency with our prior beliefs. One such example is that Japanese interest rates will not be able to be cut to respond

to a negative shock owing to their zero bound during the sample and therefore Japanese GDP will be the most adversely affected – the model illustrates this precisely. Another is the commodity currencies will fall if commodity prices fall – the currencies of Canada, Australia and New Zealand all fall, whilst the Yen and US dollar appreciate.

The implication of our analysis is that the non-US policy maker therefore needs to be aware of international events when setting domestic policy. Our paper does provide them with some hope however – namely that the foreign demand shock behaves like a foreign demand shock. Therefore the standard demand management tools of monetary and fiscal policy can be used in response. We also show that taking a factor of commonly used uncertainty measures can generate a measure of uncertainty that is driven less by idiosyncratic components and more by true movements in uncertainty. This may represent an avenue for further research.

References

- Alexopoulos, M. and J. Cohen (2009, February). Uncertain times, uncertain measures. Working Papers tecipa-352, University of Toronto, Department of Economics.
- Bachmann, R., S. Elstner, and E. R. Sims (2010, June). Uncertainty and economic activity: Evidence from business survey data. NBER Working Papers 16143, National Bureau of Economic Research, Inc.
- Bai, J. and S. Ng (2002, January). Determining the number of factors in approximate factor models. *Econometrica* 70(1), 191–221.
- Baker, S. R., N. Bloom, and S. J. Davis (2012, July-December). Has economic policy uncertainty hampered the recovery? In L. E. Ohanian, J. B. Taylor, and I. J. Wright (Eds.), *Government Policies and the Delayed Economic Recovery*, Book Chapters, Chapter 3. Hoover Institution, Stanford University.
- Bekaert, G., M. Hoerova, and M. L. Duca (2010). Risk, uncertainty and monetary policy. (16397).
- Bernanke, B., J. Boivin, and P. S. Elias (2005, January). Measuring the effects of monetary policy: A factor-augmented vector autoregressive (favar) approach. *The Quarterly Journal of Economics* 120(1), 387–422.

- Bloom, N. (2009, 05). The impact of uncertainty shocks. *Econometrica* 77(3), 623–685.
- Boivin, J. and M. P. Giannoni (2007). Global forces and monetary policy effectiveness. In *International Dimensions of Monetary Policy*, NBER Chapters, pp. 429–478. National Bureau of Economic Research, Inc.
- Charnavoki, V. and J. J. Dolado. The effects of global shocks on small commodity-exporting economies: New evidence from Canada.
- Chudik, A. and M. Fratzscher (2011). Identifying the global transmission of the 2007-2009 financial crisis in a GVAR model. *European Economic Review* 55(3), 325–339.
- Leduc, S. and Z. Liu (2012). Uncertainty shocks are aggregate demand shocks. Technical report.
- Stock, J. H. and M. W. Watson (2012, May). Disentangling the channels of the 2007-2009 recession. NBER Working Papers 18094, National Bureau of Economic Research, Inc.

Appendix

5 Data and Transformation

Table 1 below lists all the series used. All data obtained from Statistic New Zealand, RBNZ and Haver, unless otherwise specified. Output is measured using real value added using the production accounts. Column two shows the transformations used (1 for no transformation, 2 for natural logarithm and 3 for first difference of natural logarithm).

Table 1: Data

Variable number	Transform.	Description
1	3	Australia: Gross Domestic Product (SA, Mil.Chn.Q3:09-Q2:10.A\$)
2	3	EA 17: Gross Domestic Product (SA/WDA, Mil.Chn.2005.Euros)
3	3	Canada: Gross Domestic Product (SAAR, Mil.Chn.2002.C\$)
4	3	Japan: Gross Domestic Product (SAAR, Bil.Chn.2005.Yen)
5	3	U.K.: Gross Domestic Product (SA, Mil.Chained.2008.Pounds)
6	3	U.S.: Gross Domestic Product (SAAR, Bil.Chn.2005\$)
7	3	China: Gross Domestic Product (SA, Bil.2000.Yuan)
8	3	Canada: Consumer Price Index (SA, 2002=100)
9	3	Australia: Industrial Production excl Construction (SA, Q3.09-Q2.10=100)
10	3	Canada: Industrial Production Manufacturing, Mining & Utilities (SA, 2002=100)
11	3	EA 17: IP: Industry excluding Construction (SA/WDA, 2005=100)
12	3	U.K.: Industrial Production excluding Construction (SA, 2008=100)
13	1	Australia: Unemployment Rate (SA, %)
14	1	Canada: Unemployment Rate: 15 Years and Over (SA, %)
15	1	EA 17: Unemployment Rate (SA, %)
16	1	Japan: Unemployment Rate (SA, %)
17	1	U.K.: Unemployment Rate: Aged 16 and Over [3-Mo Moving Avg](SA, %)
18	1	Japan: Operating Rate: Manufacturing (NSA, 2005=100)
19	1	Australia: NAB Business Survey: Capacity Utilization (SA, %)
20	1	Canada: Capacity Utilization: Total Industrial (SA, %)
21	1	EA 17: Capacity Utilization: Manufacturing (SA, %)
22	1	Japan: Operating Rate: Manufacturing (SA, 2005=100)
23	3	World: Commodity Price Index: All Commodities (2005=100)
24	3	World: Non-fuel Primary Commodities Index (2005=100)
25	3	World: Commodity Price Index: Agricultural Raw Materials (2005=100)
26	3	World: Commodity Price Index: Food & Beverage (2005=100)
27	2	Australia: Nominal Effective Exchange Rate (2005=100)
28	2	Euro Area: Nominal Effective Exchange Rate (Avg, NSA,2005=100)
29	2	Euro Area: Real Effective Exchange Rate based on relative CPI (2005=100)
30	2	Japan: Nominal Effective Exchange Rate (Avg, NSA,2005=100)
31	2	Japan: Real Effective Exchange Rate: Consumer Price basis (2005=100)
32	2	United Kingdom: Nominal Effective Exchange Rate (Avg, NSA,2005=100)
33	2	U.K.: Real Effective Exch Rate: Consumer Price basis (2005=100)
34	2	United States: Nominal Effective Exchange Rate (Avg, NSA,2005=100)
35	2	China, PR: Nominal Effective Exchange Rate (2005=100)
36	2	China, PR: Real Effective Exch Rate: Consumer Price basis (2005=100)
37	2	Canada: Nominal Effective Exchange Rate (Avg, NSA,2005=100)
38	2	Canada: Real Effective Exchange Rate: Consumer Price Basis (2005=100)
39	1	Canada: Overnight Money Market Financing Rate [Target] (EOP, %)
40	1	Australia: 3-Month Bank Accepted Bills (AVG, %)
41	1	U.K.: 3-Month London Interbank Offered Rate: Based on British Pound (AVG, %)
42	1	Japan: Call Rate: Uncollateralized 3-Month (EOP, %)
43	1	Australia: 5-Year Treasury Bond Yield (EOP, %)
44	1	Australia: 10-Year Treasury Bond Yield (AVG, %)
45	1	Canada: 1-Year Treasury Bill Yield [Last Wednesday] (EOP, %)
46	1	Canada: 5-Year Benchmark Bond Yield [Last Wednesday] (EOP, %)
47	1	Canada: 10-Year Benchmark Bond Yield (AVG, %)
48	1	EA 11-17: 5-Year Benchmark Government Bond Yield (AVG, %)
49	1	EA 11-17: 10-Year Benchmark Government Bond Yield (AVG, %)
50	1	Japan: 1-Year Benchmark Government Bond Yield (AVG, % p.a.)
51	1	Japan: 5-Year Benchmark Government Bond Yield (AVG, % p.a.)

Table 1: Data

Variable number	Transform.	Description
52	1	Japan: 10-Year Benchmark Government Bond Yield (AVG, % p.a.)
53	1	U.K.: 1-Year London Interbank Offered Rate: Based on British Pound (%)
54	1	U.K.: Government Bonds, 5-Year Nominal Par Yield (AVG, %)
55	1	U.K.: Government Bonds, 10-Year Nominal Par Yield (AVG, %)
56	3	Canada: Consumer Price Index (SA, 2002=100)
57	3	EA 11-17: Monetary Union: Index of Consumer Prices(SA/H, 2005=100)
58	3	Japan: Consumer Price Index (SA/H, 2010=100)
59	3	U.K.: Harmonized Index of Consumer Prices [HICP] (SA, 2005=100)
60	3	China: Consumer Price Index (SA, 2005=100)
61	3	Canada: Industrial Price Index: All Commodities (SA, 2002=100)
62	3	EA 17: PPI: Industry excluding Construction (SA, 2005=100)
63	3	Japan: Output Price: Manufacturing (SA, 2005=100)
64	3	U.K.: PPI: Net Output Prices: Manufactured Products (SA, 2005=100)
65	3	Australia: Terms of Trade (SA, 2005=100)
66	3	Canada: Terms of Trade (SA, 2005=100)
67	3	EA 17: Terms of Trade (SA, 2005=100)
68	3	Japan: Terms of Trade (SA, 2005=100)
69	3	U.K.: Terms of Trade (SA, 2005=100)
70	3	Australia: Import Price Index (SA, Q3.89-Q2.90=100)
71	3	Canada: Import Price Index: Laspeyres Fixed Weighted (SA, 2002=100)
72	3	EA 17: Import Prices: Total (SA, 2000=100)
73	3	Japan: Import Price Index: All Commodities (SA, 2005=100)
74	3	U.K.: Import Price Index: Total Goods (SA, 2008=100)
75	3	Australia: Export Price Index (SA, Q3.89-Q2.90=100)
76	3	Canada: Export Price Index: Laspeyres Fixed Weighted (SA, 2002=100)
77	3	Japan: Export Price Index: All Commodities (SA, 2005=100)
78	3	U.K.: Export Price Index: Total Goods (SA, 2008=100)
79	3	ANZ Commodity Price Index - World Prices/ SDR
80	3	ANZ Commodity Price Index - SDR - Meat, Skin and Wool
81	3	ANZ Commodity Price Index - SDR - Dairy Products
82	3	ANZ Commodity Price Index - SDR - Horticultural Products
83	3	ANZ Commodity Price Index - SDR - Forestry
84	3	ANZ Commodity Price Index - SDR - Seafood
85	3	ANZ Commodity Price Index - SDR - Aluminium
86	3	Australia: Stock Price Index: All Ordinaries (AVG, Jan-01-80=500)
87	3	Canada: S&P TSX Composite Index, Close Price (AVG, 1975=1000)
88	3	Japan: Nikkei Stock Average: TSE 225 Issues (AVG, May-16-49=100)
89	3	U.K.: London Stock Exchange: FTSE 100 (AVG, Jan-2-84=1000)
90	3	Germany: Capital Market Indexes: DAX 100 (EOP, Dec-30-87=500)
91	3	FIBER INDUSTRIAL METALS PRICE INDEXES
92	3	Dubai Oil Price
93	3	Australia: Imports of Goods, cif (SA, Mil.A\$)
94	3	Australia: Exports of Goods, fob (SA, Mil.A\$)
95	3	Canada: Imports of Goods, BOP Basis (SA, Mil.C\$)
96	3	Canada: Exports of Goods, BOP Basis (SA, Mil.C\$)
97	3	Japan: Imports of Goods (SA, Bil.Yen)
98	3	Japan: Exports of Goods (SA, Bil.Yen)
99	3	U.K.: Imports of Goods (SA, Mil.Pounds)
100	3	U.K.: Exports of Goods (SA, Mil.Pounds)
101	3	Germany: GDP: Exports of Goods & Services (SA/WDA, Bil.Chn.2005.Euros)
102	3	Germany: GDP: Imports of Goods & Services (SA/WDA, Bil.Chn.2005.Euros)
103	3	EA 17: Imports of Goods (SA/WDA, Thous.Euros)
104	3	EA 17: Exports of Goods (SA/WDA, Thous.Euros)
105	3	China: Merchandise Imports, cif (SA, Bil.Yuan)
106	3	China: Merchandise Exports, fob (SA, Bil.Yuan)

Table 1: Data

Variable number	Transform.	Description
107	1	Australia: Westpac-Melbourne Institute Consumer Sentiment Index (SA)
108	1	Australia: NAB Business Confidence, Next 3 Months (SA, %)
109	1	Canada: Consumer Confidence OECD Indicator (Amp. Adj.) (SA, Norm=100)
110	1	EA 17: Economic Sentiment Indicator (SA, Long-term Average=100)
111	1	EA 17: Business Climate Indicator(SA, Standard Deviation Points)
112	1	Japan: Consumer Confidence: 2+ Person Households (SA, DI)
113	1	U.K.: Optimism About Business Situation Compared to 3 Months Ago (SA, % Bal)
114	1	U.K.: GfK Consumer Confidence Barometer (SA, % Bal)
115	1	China: Macroeconomic Climate Index: Leading Index (NSA, 1996=100)
US	DATA	
116	3	Industrial Production Index (SA, 2007=100)
117	3	Industrial Production: Mining (SA, 2007=100)
118	3	Industrial Production: Electric and Gas Utilities (SA, 2007=100)
119	3	Industrial Production: Nondurable Manufacturing (SA, 2007=100)
120	3	Industrial Production: Durable Manufacturing (SA, 2007=100)
121	3	Industrial Production: Manufacturing [NAICS] (SA, 2007=100)
122	3	Industrial Production: Final Products (SA, 2007=100)
123	3	Industrial Production: Consumer Goods (SA, 2007=100)
124	3	Industrial Production: Durable Consumer Goods (SA, 2007=100)
125	3	Industrial Production: Nondurable Consumer Goods (SA, 2007=100)
126	3	Industrial Production: Business Equipment (SA, 2007=100)
127	3	Industrial Production: Materials (SA, 2007=100)
128	3	Industrial Production: Durable Goods Materials (SA, 2007=100)
129	3	Industrial Production: Nondurable Goods Materials (SA, 2007=100)
130	3	Personal Income (SAAR, Bil.\$)
131	3	Personal Current Transfer Receipts (SAAR, Bil.\$)
132	3	U.S.: Industrial Production excluding Construction (SA, 2007=100)
133	3	U.S.: Industrial Production: Manufacturing (SA, 2007=100)
134	3	U.S.: IP: Intermediate Goods Nonindustrial Supplies (SA, 2007=100)
135	3	U.S.: Industrial Production: Capital Goods Business Equipment (SA, 2007=100)
136	1	U.S.: Capacity Utilization: Manufacturing (SA, %)
137	1	U.S.: Conference Board: Consumer Confidence (SA, 1985=100)
138	3	U.S.: Total Employees on Nonfarm Payrolls (SA, Thous)
139	3	U.S.: All Employees: Goods-Producing Industries (SA, Thous)
140	3	U.S.: All Employees: Mining (SA, Thous)
141	3	U.S.: All Employees: Construction (SA, Thous)
142	3	U.S.: All Employees: Manufacturing (SA, Thous)
143	3	U.S.: All Employees: Nondurable Goods Manufacturing (SA, Thous)
144	3	U.S.: All Employees: Service-Producing Industries incl Government (SA, Thous)
145	3	U.S.: All Employees: Trade, Transportation & Utilities (SA, Thous)
146	3	U.S.: All Employees: Wholesale Trade (SA, Thous)
147	3	U.S.: All Employees: Retail Trade (SA, Thous)
148	3	U.S.: All Employees: Financial Activities (SA, Thous)
149	3	U.S.: All Employees: Service-Producing Industries incl Government (SA, Thous)
150	3	U.S.: All Employees: Government (SA, Thous)
151	3	Civilians Unemployed for less than 5 Weeks (SA, Thous.)
152	3	Civilians Unemployed for 5-14 Weeks (SA, Thous.)
153	3	Civilians Unemployed for 15-26 Weeks (SA, Thous.)
154	3	Civilians Unemployed for 27 Weeks and Over (SA, Thous.)
155	3	Civilian Labor Force: 16 yr + (SA, Thous)

Table 1: Data

Variable number	Transform.	Description
156	3	Civilian Unemployed: 16 yr & Over (SA, Thous)
157	1	U.S.: Civilian Unemployment Rate (SA, %)
158	3	U.S.: S&PCase-Shiller Home Price Index: Composite 20 (SA, Jan-00=100)
159	3	Housing Starts (SAAR, Thous.Units)
160	3	Housing Starts: Northeast (SAAR, Thous.Units)
161	3	Housing Starts: Midwest (SAAR, Thous.Units)
162	3	Housing Starts: South (SAAR, Thous.Units)
163	3	Housing Starts: West (SAAR, Thous.Units)
164	3	Housing Authorized, Not Started: U.S. (NSA, Thous.Units)
165	3	Manufacturers' Shipments of Mobile Homes (SAAR, Thous.Units)
166	1	ISM Mfg: Inventories Index (SA, 50+ = Econ Expand)
167	1	ISM Mfg: New Orders Index (SA, 50+ = Econ Expand)
168	1	ISM Mfg: Supplier Deliveries Index (SA, 50+ = Slower)
169	3	Stock Price Index: NYSE Composite (Avg, Dec-31-02=5000)
170	3	Stock Price Index: Standard & Poor's 500 Composite (1941-43=10)
171	3	Stock Price Index: Standard & Poor's 500 Industrials (1941-43=10)
172	1	Shiller Cyclically Adjusted S&P Price to Earnings Ratio (Ratio)
173	1	S&P 500 Composite Price/Operating Earnings Ratio (Ratio)
174	1	Switzerland: Spot Exchange Middle Rate, NY Close (Francs/US\$)
175	1	Japan: Spot Exchange Middle Rate, NY Close (Yen/US\$)
176	1	United Kingdom: Spot Exchange Middle Rate, NY Close (Pounds/US\$)
177	1	Canada: Spot Exchange Middle Rate, NY Close (Canadian\$/US\$)
178	1	Federal Funds [effective] Rate (% p.a.)
179	1	3-Month Treasury Bill Market Bid Yield at Constant Maturity (%)
180	1	6-Month Treasury Bill Market Bid Yield at Constant Maturity (%)
181	1	1-Year Treasury Bill Yield at Constant Maturity (%)
182	1	3-Year Treasury Note Yield at Constant Maturity (%)
183	1	10-Year Treasury Bond Yield at Constant Maturity (%)
184	1	Moody's Seasoned Aaa Corporate Bond Yield (% p.a.)
185	1	Moody's Seasoned Baa Corporate Bond Yield (% p.a.)
186	1	Spread 3-Month Treasury Bill Yield (173) - Fed Funds Rates
187	1	Spread 6-Month Treasury Bill Yield (174) - Fed Funds Rates
188	1	Spread 1-Year Treasury Bill Yield (175) - Fed Funds Rates
189	1	Spread 5-Year Treasury Bill Yield (176) - Fed Funds Rates
190	1	Spread 10-Year Treasury Bill Yield (177) - Fed Funds Rates
191	1	Spread Moody's Seasoned Aaa Corporate Bond Yield (178) -Fed Funds Rates
192	1	Spread Moody's Seasoned Baa Corporate Bond Yield (179) -Fed Funds Rates
193	3	Money Stock: M1 (SA, Bil.\$)
194	3	Money Stock: M2 (SA, Bil.\$)
195	1	Velocity of Money: Ratio of Nominal GDP to Money Supply M2 (Ratio)
196	3	Adjusted Monetary Base (SA, Mil.\$)
197	3	Adjusted Reserves of Depository Institutions (SA, Mil.\$)
198	3	Adjusted Nonborrowed Reserves of Depository Institutions (SA, Mil.\$)
199	3	Commercial Paper Outstanding: Nonfinancial Issuers (SA, Bil.\$)
200	3	C & I Loans in Bank Credit: All Commercial Banks (SA, Bil.\$)
201	3	Consumer Revolving Credit Outstanding (EOP, SA, Bil.\$)
202	3	PPI: Finished Goods (SA, 1982=100)
203	3	PPI: Finished Consumer Goods (SA, 1982=100)
204	3	PPI: Intermediate Materials, Supplies and Components (SA, 1982=100)
205	3	PPI: Crude Materials for Further Processing (SA, 1982=100)
206	3	CPI-U: All Items (SA, 1982-84=100)
207	3	CPI-U: Apparel Less Footwear (SA, 1982-84=100)
208	3	CPI-U: Transportation (SA, 1982-84=100)
209	3	CPI-U: Medical Care (SA, 1982-84=100)
210	3	CPI-U: Commodities (SA, 1982-84=100)

Table 1: Data

Variable number	Transform.	Description
211	3	CPI-U: Durables (SA, 1982-84=100)
212	3	CPI-U: Services (SA, 1982-84=100)
213	3	CPI-U: All Items Less Food (SA, 1982-84=100)
214	3	CPI-U: All Items Less Shelter (SA, 1982-84=100)
215	3	CPI-U: All Items Less Medical Care (SA, 1982-84=100)
216	3	Avg Hourly Earnings: Prod & Nonsupervisory: Construction (SA, \$/Hr)
217	3	Avg Hourly Earnings: Prod & Nonsupervisory: Manufacturing (SA, \$/Hr)
218	1	University of Michigan: Consumer Expectations (NSA, Q1-66=100)
219	3	Gross Domestic Product (SAAR, Bil.\$)
220	3	Personal Consumption Expenditures: Durable Goods (SAAR, Bil.\$)
221	3	Personal Consumption Expenditures: Nondurable Goods (SAAR, Bil.\$)
222	3	Personal Consumption Expenditures: Services (SAAR, Bil.\$)
223	3	Private Nonresidential Fixed Investment (SAAR, Bil.\$)
224	3	Private Residential Investment (SAAR, Bil.\$)
225	3	Exports of Goods (SAAR, Bil.\$)
226	3	Exports of Services (SAAR, Bil.\$)
227	3	Imports of Goods (SAAR, Bil.\$)
228	3	Imports of Services (SAAR, Bil.\$)
229	3	National Defense Consumption & Gross Investment (SAAR, Bil.\$)
230	3	Federal Government Nondefense Consumption & Gross Investment (SAAR, Bil.\$)
DOMESTIC BLOCK		
1	3	Gross domestic product: Agriculture (SA, Chained vol.1995/6, ANZSIC06 sector classification).
2	3	Gross domestic product: Forestry and Logging (SA, Chained vol.1995/6, ANZSIC06 sector classification).
3	3	Gross domestic product: Fishing, Aquaculture and Agriculture, Forestry and Fishing Support Services (SA, Chained vol.1995/6, ANZSIC06 sector classification).
4	3	Gross domestic product: Mining (SA, Chained vol.1995/6, ANZSIC96 sector classification).
5	3	Gross domestic product: Food, Beverage and Tobacco Product Manufacturing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
6	3	Gross domestic product: Textile, Leather, Clothing and Footwear Manufacturing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
7	3	Gross domestic product: Wood and Paper Products Manufacturing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
8	3	Gross domestic product: Printing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
9	3	Gross domestic product: Petroleum, Chemical, Polymer and Rubber Product Manufacturing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
10	3	Gross domestic product: Non-Metallic Mineral Product Manufacturing (SA, Chained vol.1995/6, ANZSIC96 sector classification).
11	3	Gross domestic product: Metal Product Manufacturing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
12	3	Gross domestic product: Transport Equipment, Machinery and Equipment Manufacturing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
13	3	Gross domestic product: Furniture and Other Manufacturing (SA, Chained vol.1995/6, ANZSIC96 sector classification).
14	3	Gross domestic product: Electricity, Gas, Water and Waste Services (SA, Chained vol.1995/6, ANZSIC06 sector classification).
15	3	Gross domestic product: Construction (SA, Chained vol.1995/6, ANZSIC06 sector classification).

Table 1: Data

Variable number	Transform.	Description
16	3	Gross domestic product: Wholesale trade (SA, Chained vol.1995/6, ANZSIC06 sector classification).
17	3	Gross domestic product: Retail Trade and Accommodation (SA, Chained vol.1995/6, ANZSIC06 sector classification).
18	3	Gross domestic product: Accommodation and Food Services (SA, Chained vol.1995/6, ANZSIC06 sector classification).
19	3	Gross domestic product: Transport, Postal and Warehousing (SA, Chained vol.1995/6, ANZSIC06 sector classification).
20	3	Gross domestic product: Information Media and Telecommunications (SA, Chained vol.1995/6, ANZSIC06 sector classification).
21	3	Gross domestic product: Financial and Insurance Services (SA, Chained vol.1995/6, ANZSIC06 sector classification).
22	3	Gross domestic product: Rental, Hiring and Real Estate Services (SA, Chained vol.1995/6, ANZSIC06 sector classification).
23	3	Full-Time Equivalent Employees - Forestry and Mining
24	3	Full-Time Equivalent Employees - Manufacturing
25	3	Full-Time Equivalent Employees -Electricity, Gas, Water and Waste Services
26	3	Full-Time Equivalent Employees - Construction
27	3	Full-Time Equivalent Employees - Wholesale Trade
28	3	Full-Time Equivalent Employees - Retail Trade
29	3	Full-Time Equivalent Employees Accommodation and Food Services
30	3	Full-Time Equivalent Employees - Transport, Postal and Warehousing
31	3	Full-Time Equivalent Employees - Information Media and Telecommunications
32	3	Full-Time Equivalent Employees - Financial and Insurance Services
33	3	Full-Time Equivalent Employees - Rental, Hiring and Real Estate Services
34	3	Full-Time Equivalent Employees - Professional, Scientific, Technical, Administrative and Support Services
35	3	Full-Time Equivalent Employees - Total All Industries
36	3	QES - Salary and wages rates - Forestry and Mining
37	3	QES - Salary and wages rates - Manufacturing
38	3	QES - Salary and wages rates - Electricity, Gas, Water and Waste Services
39	3	QES - Salary and wages rates - Construction
40	3	QES - Salary and wages rates - Wholesale Trade
41	3	QES - Salary and wages rates - Retail Trade
42	3	QES - Salary and wages rates - Accommodation and Food Services
43	3	QES - Salary and wages rates - Transport, Postal and Warehousing
44	3	QES - Salary and wages rates - Information Media and Telecommunications
45	3	QES - Salary and wages rates - Financial and Insurance Services
46	3	QES - Salary and wages rates - Rental, Hiring and Real Estate Services
47	3	QES - Salary and wages rates - Professional, Scientific, Technical, Administrative and Support Services
48	3	QES - Salary and wages rates - Total All Industries
49	3	Real GDP: Imports of consumption goods (SA)
50	3	Real GDP: Total Household Consumption (SA)
51	3	Real GDP: Total Private Consumption (SA)
52	3	Real GDP: Total Govt Consumption (SA)
53	3	Real GDP: Private Investment Total (SA)
54	3	Real GDP: Govt Investment Total (SA)
55	3	Real GDP: Imports Goods Total (SA)
56	3	Real GDP: Imports Total (SA)
57	3	Real GDP: Exports of Goods (SA)
58	3	Real GDP: Exports Total (SA)
59	3	Real GDP: Gross National Expenditure (SA)
60	3	Real Production GDP: Manufacturing Total (SA)
61	3	Real GDP: Total Production GDP

Table 1: Data

Variable number	Transform.	Description
62	3	Real Retail Sales: All industries total (SA, Treasury backdate)
63	3	Real GDP: Private Investment: Dwellings (SA, RBNZ estimates)
64	3	Real GDP: Investment: computers
65	3	Real GDP: Investment: plant
66	3	Real GDP: Investment: transport equipment
67	3	Employment: Total (SA, HLFS)
68	3	Total number of actual hours worked each week (SA, HLFS)
69	3	Total labour force (SA, HLFS)
70	1	Unemployment rate: Total (SA, HLFS)
71	3	Total gross earnings (SA, QES)
72	3	Filled jobs (Full-time paid employment): Total (SA, QES)
73	3	Total paid hours (SA, QES)
74	3	Labour Cost Index: (Salary and Wages rates): All sectors combined
75	3	Permanent and long-term migration: arrivals (SA)
76	3	Permanent and long-term migration: departures (SA)
77	3	Debt to gross assets (RBNZ estimate)
78	3	Debt to disposable income (RBNZ estimate)
79	3	Housing value as percent of household disposable income
80	3	Household net wealth as percent of household disposable income
81	3	Currency (SA)
82	3	M3 (SA)
83	3	Private Sector Credit Resident (SA)
84	3	Quarterly House price Index (Quotable value, SA)
85	1	RBNZ survey of expectations: Business: Expected HLFS Unemployment Rate: 1 year ahead
86	1	RBNZ survey of expectations: Business: Expected HLFS Unemployment Rate: 2 years ahead
87	1	RBNZ survey of expectations: Business: Expected Quarterly (SA) GDP: Previous quarter
88	1	RBNZ survey of expectations: Business: Expected Quarterly (S.A.) GDP: Current quarter
89	1	RBNZ survey of expectations: Business: Expected Annual % change GDP: 1 year ahead
90	1	RBNZ survey of expectations: Business: Expected Annual % change GDP: 2 years ahead
91	1	QSBO survey: Economy wide: Number employed: next 3 months: Net (SA,NZIER)
92	1	QSBO survey: Economy wide: Profitability: next 3 months: Net (SA, NZIER)
93	1	QSBO survey: Economy wide: Domestic trading activity: next 3 months (SA, NZIER)
94	1	QSBO surveys: Economy wide: Capacity Utilization (NZIER)
95	1	QSBO survey: Economy wide: Exporters Capacity Utilization (NZIER)
96	1	National Bank survey: Business Confidence: Next 12 month: Total (3 month average)
97	1	National Bank survey: Activity Outlook: Next 12 month: Total (3 month average)
98	1	National Bank survey: Interest rate expectations: Next 12 months: Services (3 month average)
99	1	National Bank survey: Capacity Utilisation: Total (3 month average)
100	1	National Bank survey: Capacity Utilisation: Manufacturing (3 month average)
101	1	National Bank survey: Employment intentions: Next 12 months: Total (3 month average)
102	1	National Bank survey: Pricing intentions: Next 3 months: Total (3 month average)
103	1	Westpac-McDermot-Miller Consumer Confidence Index

Table 1: Data

Variable number	Transform.	Description
104	1	Marketscope/UMR survey of expectations: Current inflation
105	1	Marketscope/UMR survey of expectations: Net % Expect Higher Inflation: 12 Months
106	1	Marketscope/UMR survey of expectations: Expected Inflation: 12 Months: Median
107	3	Consents: Dwellings: Total new / altered value (SA)
108	3	Consents: Dwellings: Non-apartment dwelling units: Number (SA)
109	3	Total Dwellings: New: Value (quarterly total)
110	3	Total Dwellings: New: Floor area (quarterly total)
111	3	New residential buildings: Units: Total
112	3	New residential buildings: Value: Total
113	3	Real Building work put in place: Residential (SA)
114	3	Real Building work put in place: Non-residential (SA)
115	3	Value of Total Merchandise Exports (excludes re-exports) (SA)
116	3	OTI Value of Total Merchandise Imports (SA)
117	3	Import Price Index Capital Goods: Total
118	3	Export price index: Dairy Products (Agricultural)
119	3	Export price index: Meat (Food and Beverages)
120	3	Export price index of Total Manufactures
121	3	Export Price Index: All Merchandise
122	1	RBNZ survey of expectations: Business: Expected Annual CPI: 1 year from now
123	1	RBNZ survey of expectations: Business: Expected Annual CPI: 2 years from now
124	1	RBNZ survey of expectations: Business: Expected 90-day Bank Bill - End current quarter
125	1	RBNZ survey of expectations: Business: Expected 90-day Bank Bill - 3 quarters from now
126	1	RBNZ survey of expectations: Business: CPI - 1Q expectation (Professional forecaster)
127	1	RBNZ survey of expectations: Business: CPI - 2Q expectation (Professional forecaster)
128	1	RBNZ survey of expectations: Business: CPI - 1Y expectation (Professional forecaster)
129	1	RBNZ survey of expectations: Business: CPI - 2Y expectation (Professional forecaster)
130	1	New Zealand: 5-Year Government Bond Yield (%)
131	1	New Zealand: 10-Year Government Bond Yield (AVG, %)
132	3	New Zealand: Consumer Price Index (SA, Q2-06=1000)
133	3	New Zealand: Producer Price Index (SA, Q4-10=1000)
134	3	New Zealand: Import Price Index: Goods (SA, Q2-02=1000)
135	3	New Zealand: Capital Index: NZSX All Indexes (Jun-30-86=1000)
136	3	New Zealand: Gross Index: NZSX All Indexes (Jun-30-86=1000)
137	1	New Zealand: 90-Day Bank Bill Yield (AVG, %)
138	1	New Zealand: Trade Weighted Exchange Rate (AVG, %)
139	1	6 Months Deposit Rate
140	1	First Mortgage rate (floating rate for first home buyers)
141	1	New Zealand - Australia Nominal Exchange Rate
142	1	New Zealand - Euro Nominal Exchange Rate
143	1	New Zealand - Yen Nominal Exchange Rate
144	1	New Zealand - Pound Nominal Exchange Rate
145	1	New Zealand - US Nominal Exchange Rate
146	1	New Zealand - Yuan Nominal Exchange Rate

Figure 1: Measures of Uncertainty

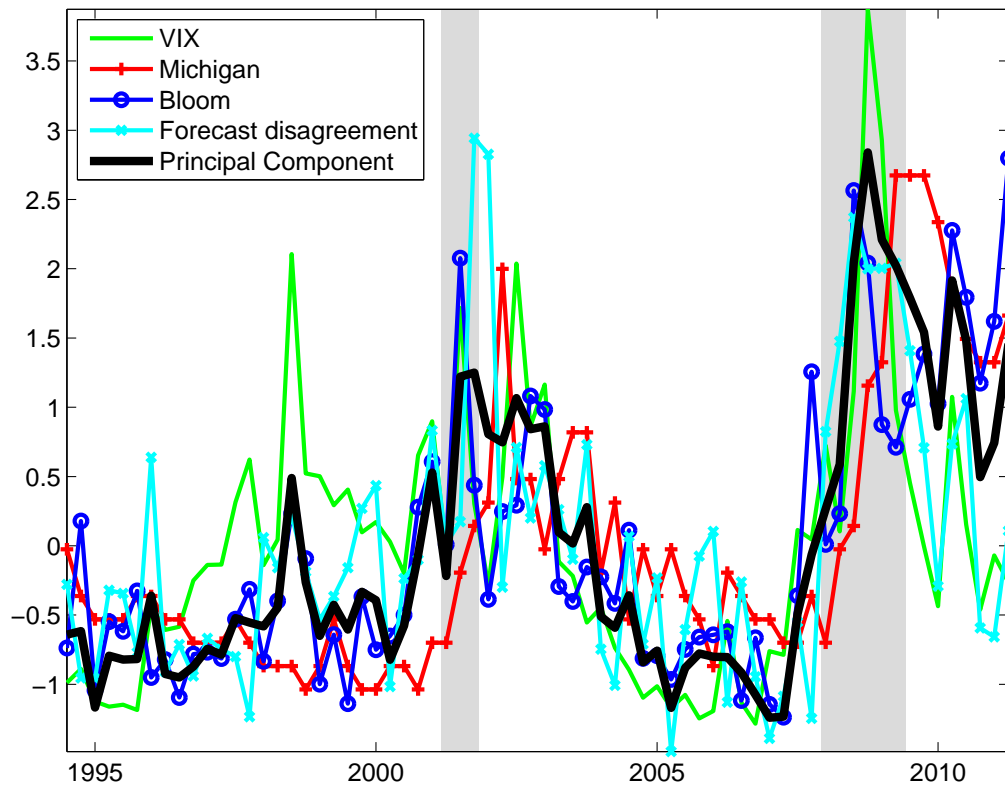


Figure 2: Scree Plot

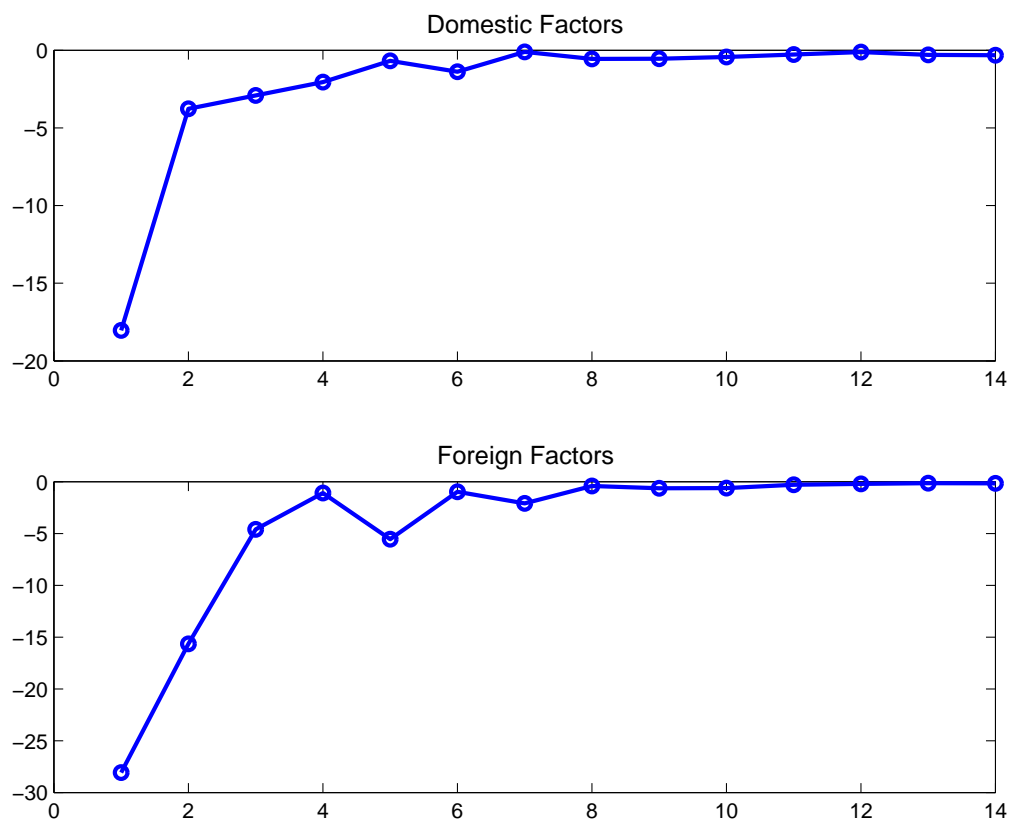


Figure 3: Estimated Principal Components

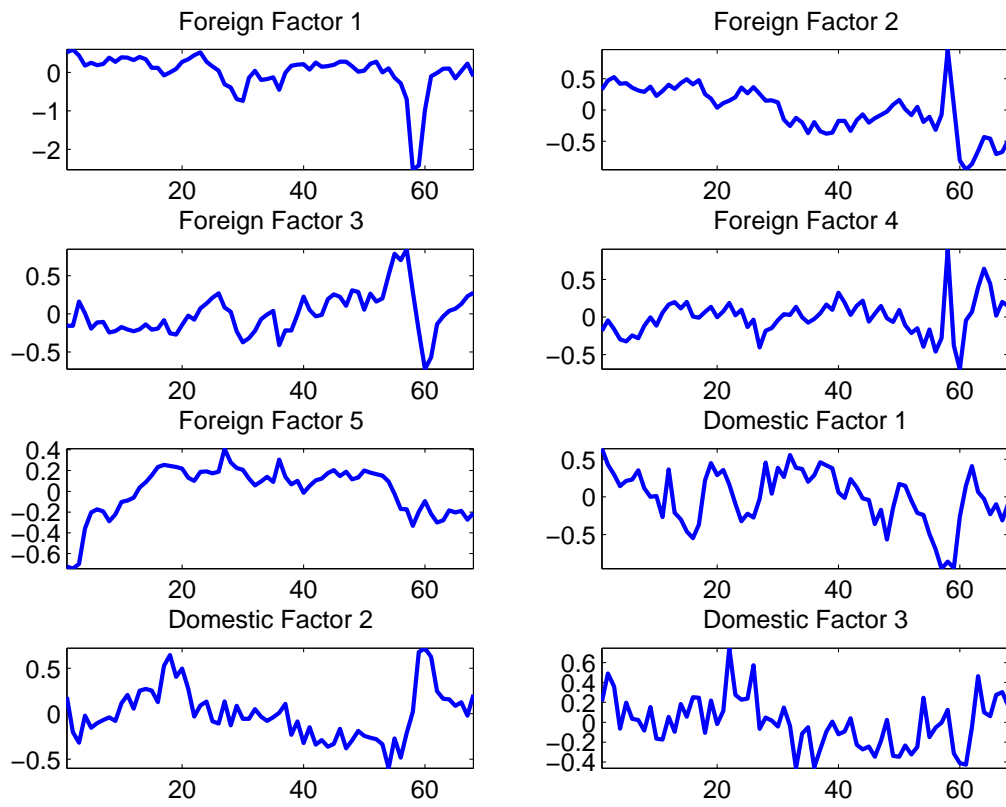


Figure 4: Responses of Key US Macro Variables to 1 s.d shock to VIX index

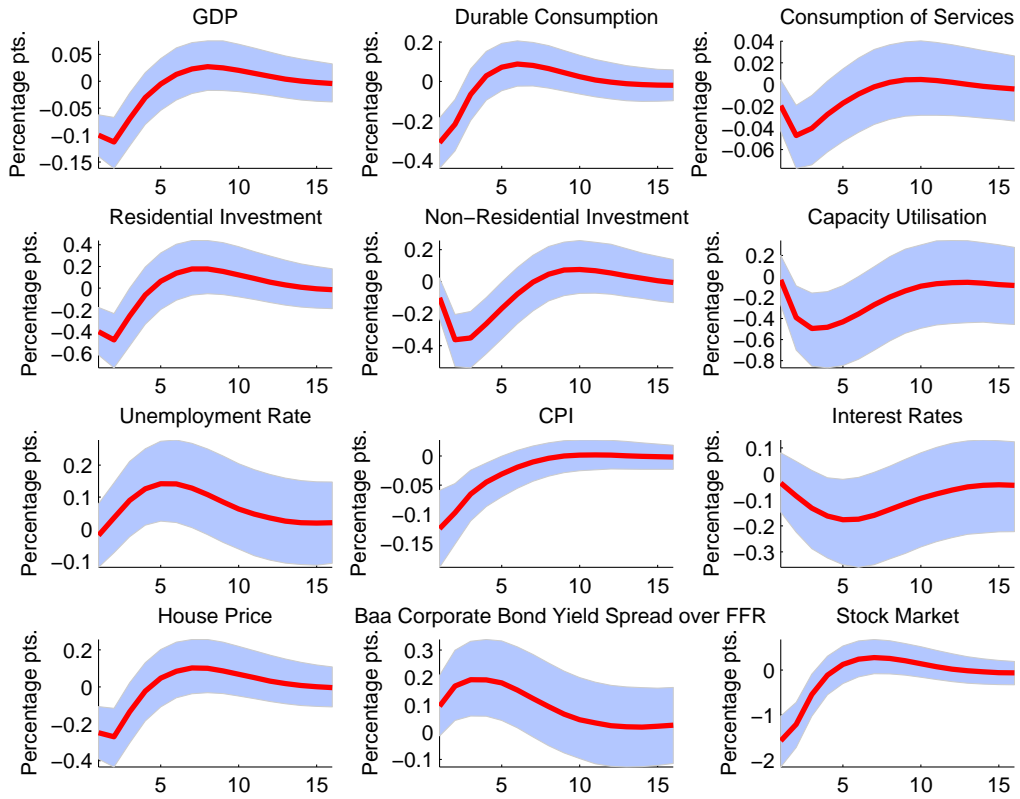


Figure 5: Responses of Key US Macro Variables to 1 s.d Shock to Principal Component Measure of Uncertainty

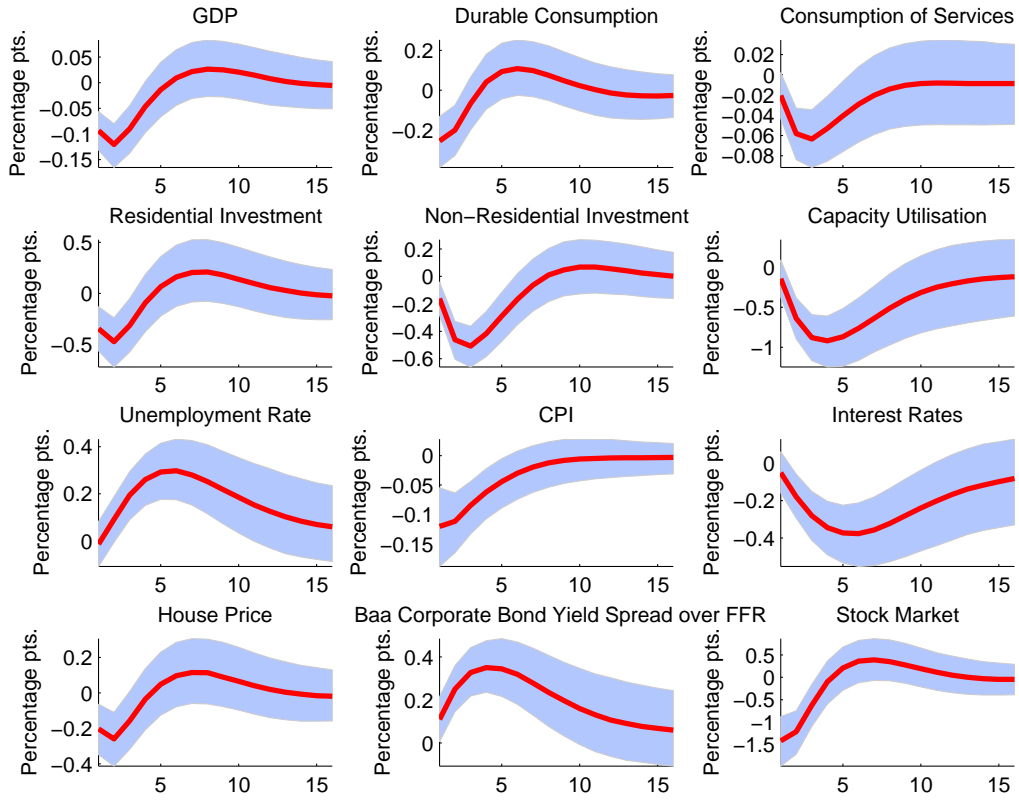


Figure 6: Responses Across the World (VIX)

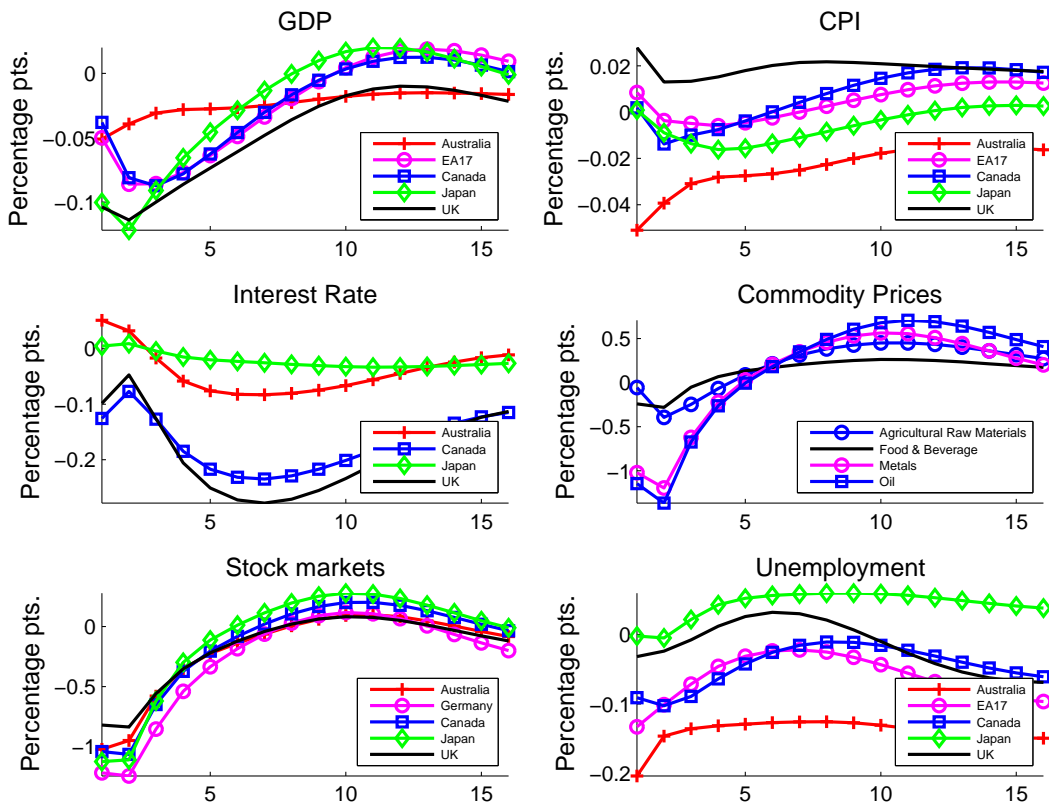


Figure 7: Responses Across the World (PC measure)

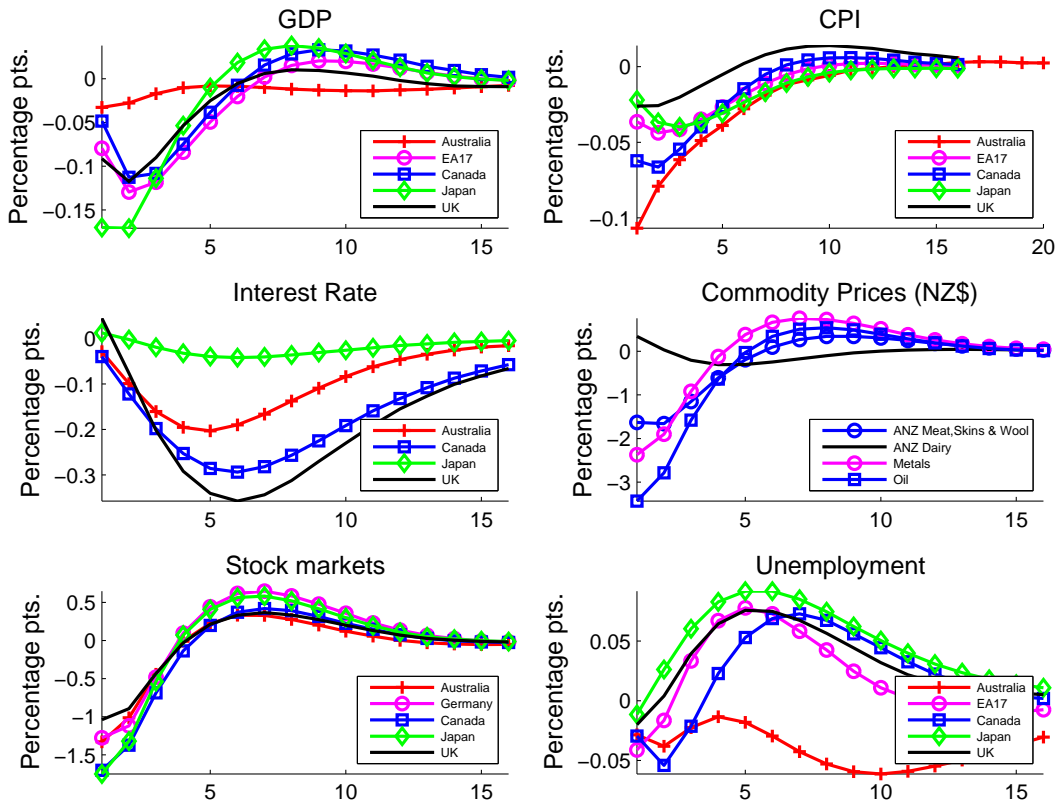


Figure 8: Responses Confidence/Expectations Across the World (VIX)

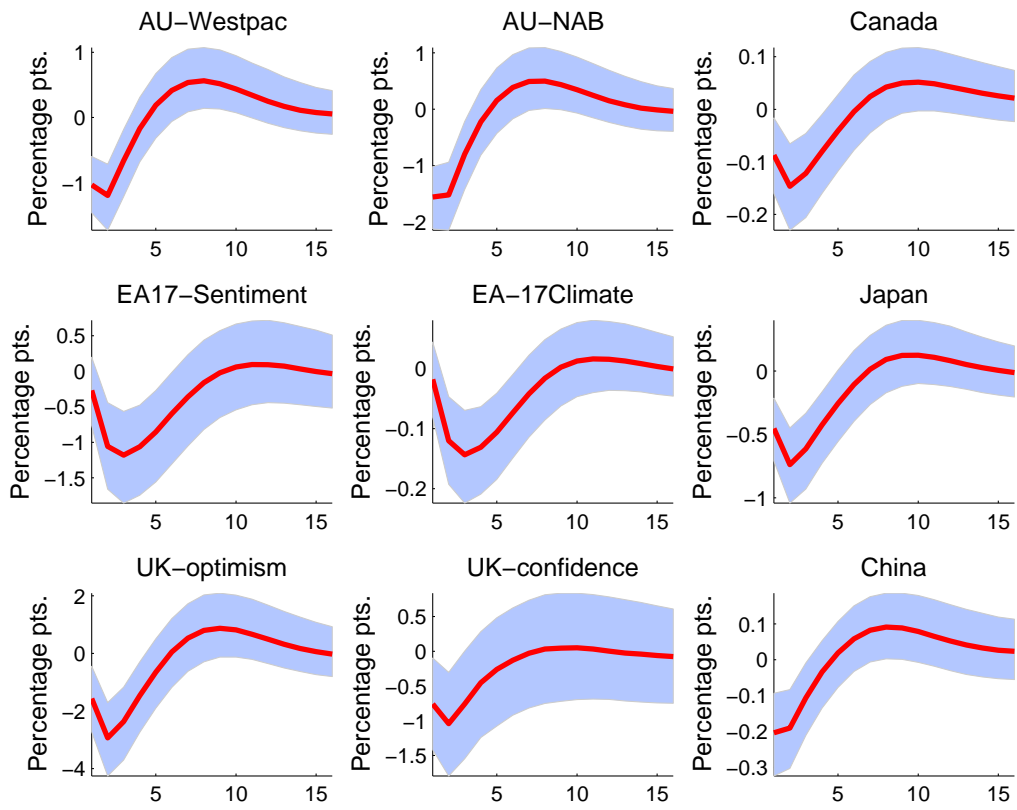


Figure 9: Responses Confidence/Expectations Across the World (PC measure)

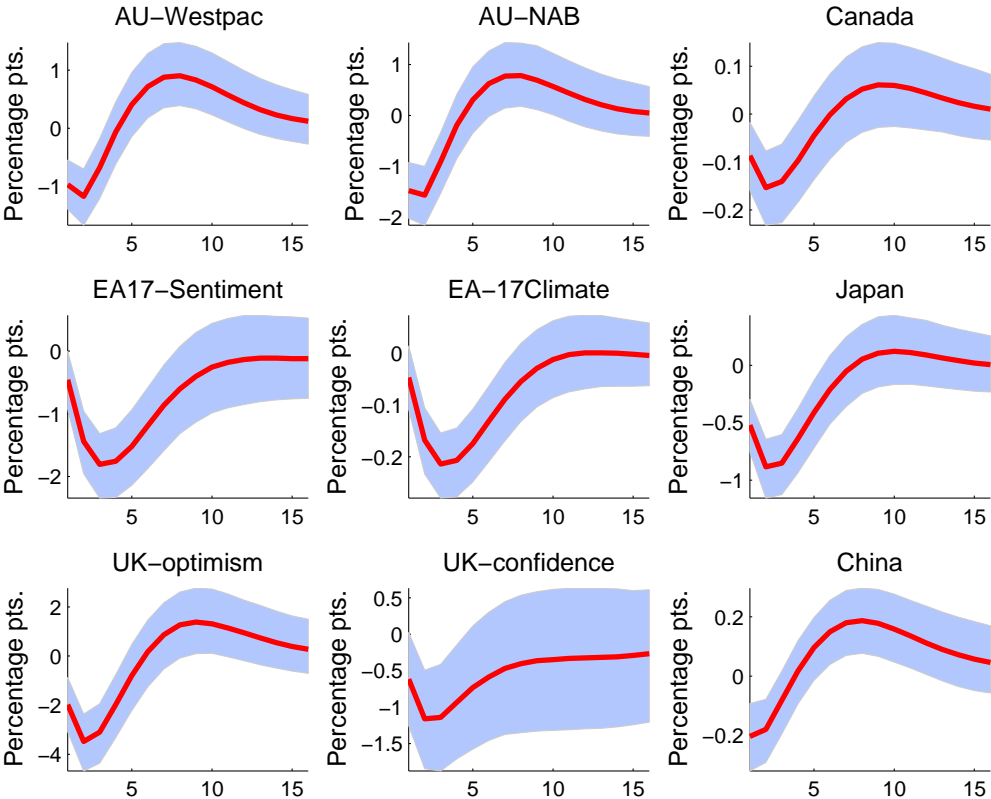


Figure 10: Exchange Rates

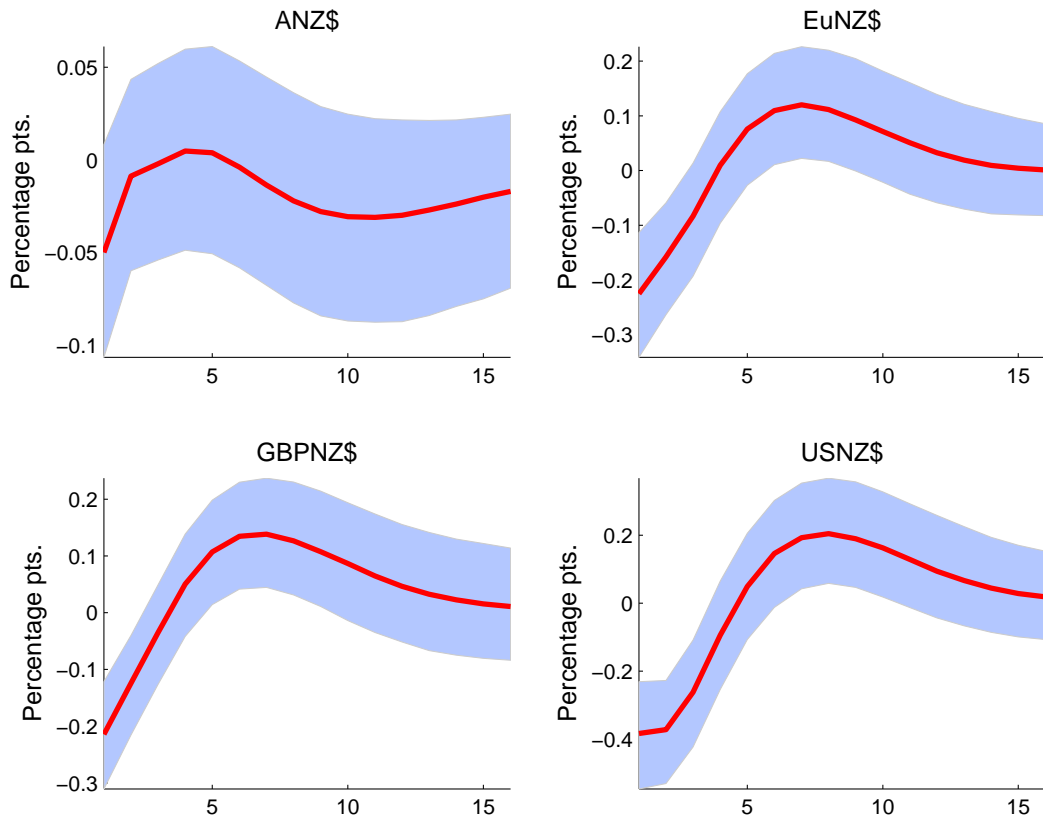


Figure 11: Responses of New Zealand Variables to 1 s.d shock to PC measure

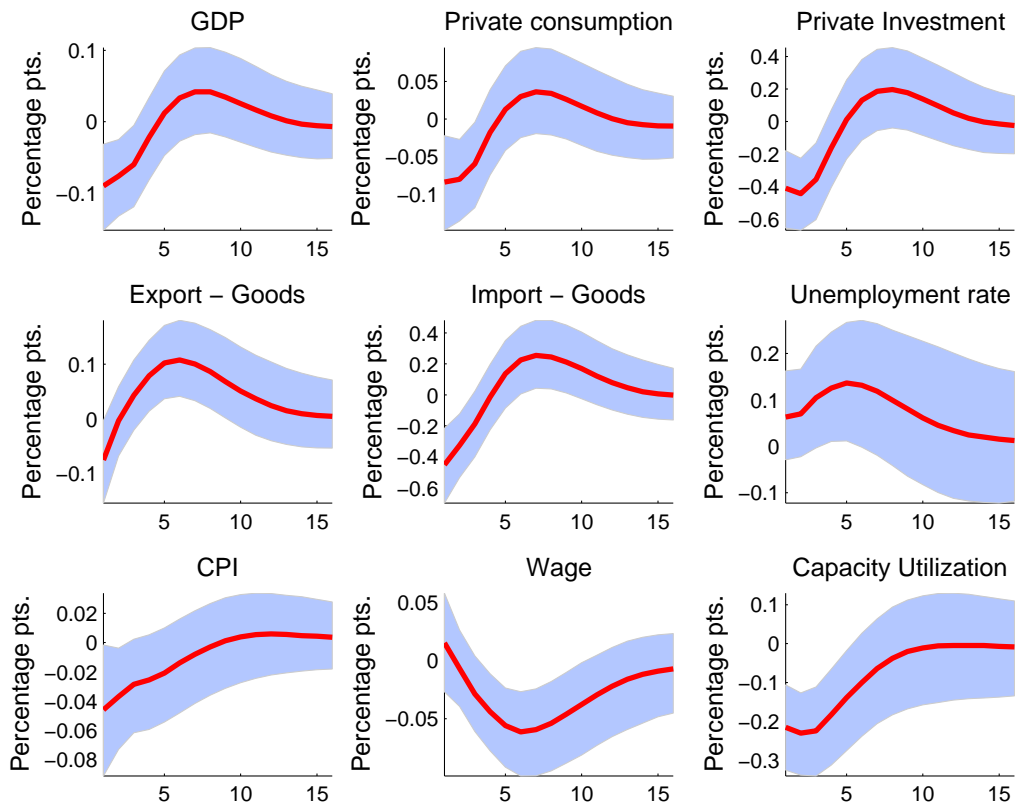


Figure 12: Selected NZ Macro Variables

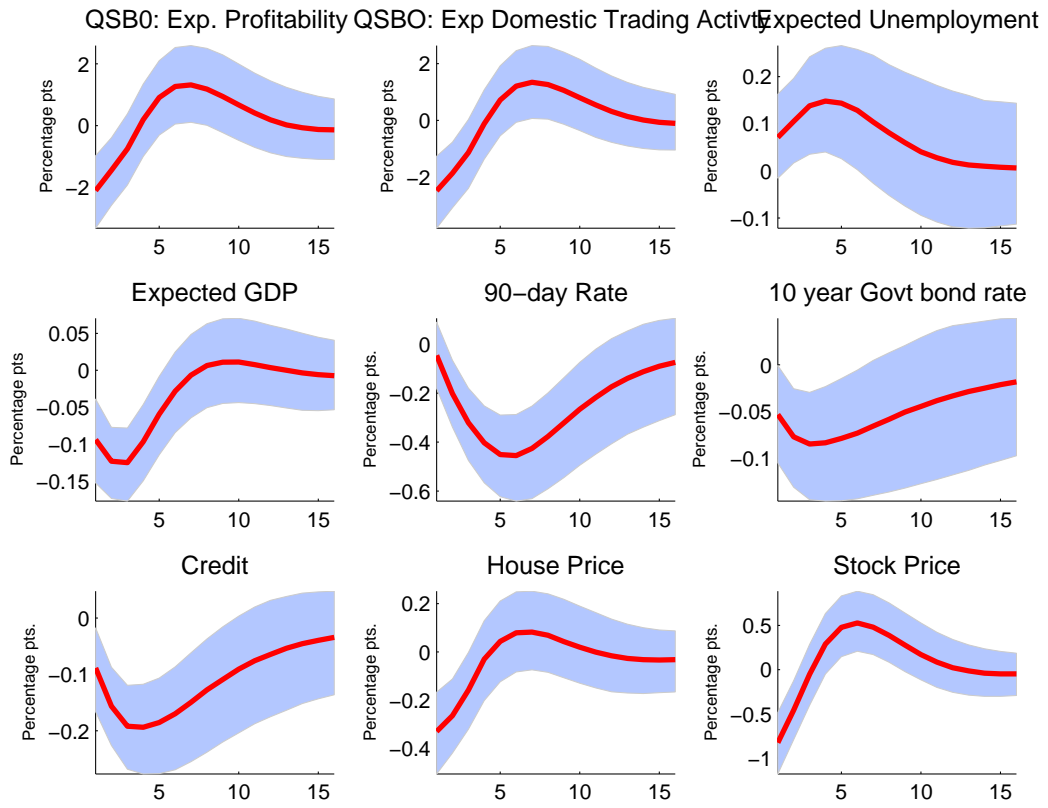


Table 2: Explanatory Power of Factors for Selected Variables

Variable	R squared
Australia: Gross Domestic Product (SA, Mil.Chn.Q3:09-Q2:10.A\$)	15%
EA 17: Gross Domestic Product (SA/WDA, Mil.Chn.2005.Euros)	79%
Canada: Gross Domestic Product (SAAR, Mil.Chn.2002.C\$)	66%
Japan: Gross Domestic Product (SAAR, Bil.Chn.2005.Yen)	40%
U.K.: Gross Domestic Product (SA, Mil.Chained.2008.Pounds)	71%
U.S.: Gross Domestic Product (SAAR, Bil.Chn.2005\$)	69%
China: Gross Domestic Product (SA, Bil.2000.Yuan)	29%
World: Commodity Price Index: All Commodities (2005=100)	85%
World: Non-fuel Primary Commodities Index (2005=100)	67%
World: Commodity Price Index: Agricultural Raw Materials (2005=100)	57%
Dubai Oil Price	65%
United States: Nominal Effective Exchange Rate (Avg, NSA,2005=100)	58%
Australia: Nominal Effective Exchange Rate (2005=100)	75%
Euro Area: Nominal Effective Exchange Rate (Avg, NSA,2005=100)	19%
Canada: Nominal Effective Exchange Rate (Avg, NSA,2005=100)	59%
Japan: Nominal Effective Exchange Rate (Avg, NSA,2005=100)	36%
United Kingdom: Nominal Effective Exchange Rate (Avg, NSA,2005=100)	45%
US Federal funds rate	84%
Australia: 3-Month Bank Accepted Bills (AVG, %)	92%
EA17 3 month rate	79%
Canada: 3-month Treasury Bill yield (Haver)	84%
Japan: Call Rate: Uncollateralized 3-Month (EOP, %)	68%
Canada: Consumer Price Index (SA, 2002=100)	45%
EA 11-17: Monetary Union: Index of Consumer Prices(SA/H, 2005=100)	64%
Japan: Consumer Price Index (SA/H, 2010=100)	21%
U.K.: Harmonized Index of Consumer Prices [HICP] (SA, 2005=100)	56%
U.S.: Consumer Price Index (SA, 1982-84=100)	72%
China: Consumer Price Index (SA, 2005=100)	72%

Table 3: Explained Variation - Domestic Variables

Variable	R squared
CPI	52%
Interest rate	88%
GDP	68%
Unemployment rate	89%
TWI	61%
NZ/USD	57%

Table 4: FEVD - Percent of variance decomposition of VIX owing to VIX

Horizon	FEVD
1	100%
4	89%
15	35%
20	34%