WORKING PAPER 7/2018

THE MACROECONOMIC RESPONSE TO REAL AND FINANCIAL FACTORS, COMMODITY PRICES, AND MONETARY POLICY: INTERNATIONAL EVIDENCE

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September 2018

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Part of the research for this paper was completed while I was a Visiting Scholar at the South East Asian Central Banks (SEACEN) Research and Training Centre. Some of the ideas in this paper were also presented in early form as part of a keynote address at the 2017 Ruhr International Energy Conference in Duisburg, Germany. Comments by Hans Genberg and Ole Rummel on earlier drafts are gratefully acknowledged. An earlier version of this paper was also presented at a SEACEN seminar where I received several helpful comments.

Abstract

This study estimates a variety of small dynamic factor macro models where the factors are time-varying. Different assumptions are made about the long-run impact of these shocks, including allowing commodity price shocks to alternatively be exogenous or endogenous. The sample consists of 20 economies around the world. It includes the most globally systemically important economies as well as 6 SEACEN member economies. Using quarterly data since the late 1990s I find that the focus of some policy makers on the spillovers of monetary shocks is exaggerated. Four separate types of shocks are identified, and these can easily offset each other with a neutral overall economic impact on the domestic economies investigated here. Nevertheless, it does appear resource rich economies including some of the SEACEN members in this category, tend to suffer a net economic loss from spillovers that originate in the US. Equally important, examining the interaction of real, financial, monetary and commodity shocks is improved when the various factors are time-varying.

Keywords: SEACEN, Commodity Prices, Dynamic Factor Models, Time-Varying Estimates

JEL Classification: E32, E44, E52, E65, F42

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THE MACROECONOMIC RESPONSE TO REAL AND FINANCIAL FACTORS, COMMODITY PRICES, AND MONETARY POLICY: INTERNATIONAL EVIDENCE

By

Pierre L. Siklos

1. Introduction

Even as the full effects of what some have referred to as the Great Financial Crisis (GFC) had yet to unfold, Fed Chair Ben Bernanke (2008) called attention to the role of commodity prices as a complicating factor in setting the course for monetary policy. He went on to ask: "…how should monetary policy deal with increases in commodity prices that are not only large but potentially persistent?" (Bernanke 2008). The European Central Bank would soon provide a test when the institution raised policy rates twice in 2011, in April and July, because of the fear that soaring commodity prices would unhinge expectations unless monetary policy was tightened and in spite of being in the throes of a sovereign debt crisis.[1] The central bank would soon reverse course but whether the price included a reputational loss is unclear. The Eurozone is not, however, a major exporter of commodities. Other central banks in commodity sensitive economies would also raise policy rates in spite of an ongoing financial crisis (e.g., Canada in 2010, Sweden in 2010 and 2011). Both countries, of course, are resource rich and major commodity exporters. Around the same time that there was increased interest in the macroeconomic impact of commodity markets, the fallout from the GFC also reminded economists that a financial cycle exists that also exerts an influence on business cycle movements even if both cycles need not operate concurrently.

There is a tendency for macroeconomic models to focus on the links between monetary policy and the business cycle, while a role for the financial cycle is often omitted. In the case of commodity prices there is an equally common habit of including an exogenous indicator of oil prices. The omission of financial factors, as well as the narrow treatment of commodity prices as a factor that can influence monetary policy and the business cycle, is becoming less defensible because of the GFC of 2008-2009 as well as the Eurozone's sovereign debt crisis of 2010 and beyond. For economies that are resource rich the treatment of commodity prices as an exogenous factor that can impact economic activity is also questionable. Unfortunately, we still have too little empirical evidence to gauge the impact of the financial cycle and the role of commodity prices on macroeconomic outcomes.

[1] The decisions of the ECB at the time remain controversial. Holm-Hadulla and Hubrich (2017) is one study that exonerates the ECB from criticisms that are cited and surveyed in their study.

The present study estimates models that incorporate financial factors and it also asks whether our understanding of macroeconomic activity is significantly influenced according to whether we consider the impact of a larger number of commodities as well as when their effect is considered endogenous in estimated models. We examine the evidence for 20 economies. Six of the economies in the sample belong to SEACEN (China, Hong Kong, Indonesia, Korea, Malaysia, and Thailand) and we devote some extra attention to the results obtained for these economies. Six of the twenty economies are considered advanced economies (AE), while the remaining are generally labelled emerging market economies (EME).

Dynamic factor models are estimated for each economy individually and the possibility of spillover effects from the US are also accounted for. Our sample consists of quarterly data from the late 1990s to the present. In addition, I separately examine whether two institutional developments over the past two decades, namely the spread of inflation targeting (IT) and the implementation of unconventional monetary policies (UMP) as well as quantitative easing (QE), may have influenced key economic shocks over time.

Briefly, I find that the focus of some policy makers on the spillovers of monetary shocks is exaggerated. Four separate types of shocks are identified below, and these can easily offset each other with a neutral overall economic impact on the domestic economies investigated here. Nevertheless, it does appear that resource rich economies, including some of the SEACEN members in this category, tend to suffer a net economic loss from spillovers that originate in the US. Equally important, examining the interaction of real, financial, monetary and commodity shocks is improved when the various estimated factors are time-varying.

The rest of the paper is organized as follows. A brief literature survey links the various strands of research relating to the role of financial factors and commodity prices, as well as UMP and QE, in improving our understanding of monetary policy and real economic outcomes over time. The econometric methodology is outlined in Section 3. Section 4 describes the data, discusses some stylized facts before providing a summary of the principal econometric estimates. The paper concludes in Section 5 with a summary and a few policy implications are also drawn.

2. Commodities, Monetary Policy, and Macroeconomic Performance: A Brief Literature Review

The study of commodity markets stands apart from the rest of the empirical macroeconomic literature insofar as a large literature exists that examines the behavior and impact of both individual and groups of commodities.[2] Over the past decade or more the so-called financialization of commodity markets (e.g., see Cheng and Xiong 2014, Chari and Christiano 2017) has further raised the profile of commodity market prices and their potential impact on financial as well as macroeconomic outcomes.

In empirical macroeconomics it has usually been the case that oil prices, first and foremost, play a role in determining inflation and business cycle movements. However, the usual approach has been to assume that oil price movements exogenously influence macroeconomic activity. Hence, some oil price indicator generally enters a model lagged to underscore its exogenous influence. One of the difficulties with this approach is that there is no attempt to identify whether changes in oil prices are demand or supply driven. Recent history at least suggests that supply interruptions are temporary (e.g., oil price shocks of the 1970s) while aggregate demand is thought to be the usual driver of oil prices. Nevertheless, there continues to be disagreement about which of the two forces became dominant and when (e.g., Hamilton 2009, Bernanke 2008, Baumeister and Peersman 2013, Baumeister and Kilian 2016, Kilian 2009).[3]

Financialization, as well as recent technological developments (e.g., fracking, improvements in energy efficiency), may well have altered both the relative importance of aggregate demand versus supply influences as well as the usual narrative of incorporating exogenously the effect of oil prices in standard macroeconomic models. Indeed, assumptions about the pass-through effects of oil price movements may also have changed in recent years (e.g., Blanchard and Galí 2009).

Since oil represents an important input into the exploitation of other commodities there is increasing interest in determining whether there are common features in commodity price changes. Financialization as well as the growth of China have also spurred research in this area. Not surprisingly, a number of studies have sought to empirically exploit the possibility of co-movements in commodity prices (e.g., Gospodinov and Ng 2013, Delle Chiale et. al. 2017).

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[2] Commodity markets are also distinctive to a degree because of the existence of several futures markets. The latter, of course, contain a forward-looking element that has proved useful in macroeconomic policy making. However, Chari and Christiano (2017) contend that commodity futures market do not operate along traditional lines where those with or without a direct interest interact in a manner such that latter groups insure the former.

[3] Indeed, the debate about the impact of the two oil price shocks of the 1970s has still not ended. See, for example, Blinder and Rudd (2013), and references therein.

Beyond these issues it has also long been apparent that the macroeconomic impact of commodities and commodity prices must confront potential differences between resource rich and other economies.[4] The potential for financial and commodity cycle driven business cycle movements, in addition to a role for monetary (and fiscal) policies, complicates the macroeconomic management challenges faced by large commodity exporters.

Moreover, it is feasible that macroeconomic and financial variables may help forecast commodity prices (Gargano and Timmermann 2014). This provides further impetus for treating oil prices in particular, but commodity prices more generally, as endogenous in most macromodels as noted above. The problem is exacerbated in emerging market economies (e.g., Alberola and Sousa 2017). All of these ingredients create the potential for raising the likelihood of financial crises (e.g., see Reinhart et. al. 2016).

In the realm of monetary policy commodity prices, but especially oil prices, also have the potential to impact inflation expectations. Indeed, as noted earlier, several central bankers in recent years have emphasized the role of commodity prices in determining inflation and the risks this poses for central banks that aim to maintain stable inflation rates. Nevertheless, empirical evidence has more often than not failed to shed a clear light on the size, strength, and nature of the links (e.g., see Chen et. al. 2014) although there is evidence that global oil supply shocks significantly impact inflation expectations (Feldkircher and Siklos 2018).

The era of low to ultra-low nominal (and real) interest rates, partially maintained via the application of quantitative easing and other unconventional monetary policies,[5] in parallel with the financialization of commodity markets, is also thought to have at times significantly inflated commodity prices (e.g., Frankel 2006). The bottom line is that commodity prices and monetary conditions, domestic and global, are intertwined (e.g., Ratti and Vespigani 2016, Barsky and Kilian 2002).

Interventions intended to supplement central bank policy rate changes usually referred to as quantitative easing or more generally as unconventional monetary policies, have led to charges that the systemically important economies at the center of the GFC created negative spillovers especially for EME. It is important, however, to distinguish between the immediate impact of these policies that are more likely to be felt at high sampling frequencies versus ones that may have longer lasting or medium-term economic consequences (e.g., see Lombardi et. al. 2018, Haldane

[4] This issue is related to the so-called ‘natural resource curse’, also often referred to as the Dutch disease, wherein a resource rich country may experience a temporary boom but with a long-run decrease in economic welfare. Van der Ploeg (2011) is a recent survey.
[5] Partly in the sense that low global inflation rates (see section 4 below) have also contributed to lowering nominal interest rates globally.

et. al. 2016). Since the data used below are quarterly I will not discuss further the former and concentrate on the relatively fewer studies that address the latter question.

Eschewing the use of dummy variables to identify QE episodes, a popular alternative in some studies including studies of the financial market effects of UMP, Haldane et. al. (2016) resort to using the size of a central bank's balance sheet, as a percent of GDP, and add the usual other macroeconomic and financial variables such as inflation, real GDP growth, interest rates (or spreads), and equity returns to describe the macroeconomy. Since it is unclear how one should identify the structural shocks of interest the authors consider a number of alternatives, including imposing sign restrictions (e.g., also see Weale and Wieladek 2016) and find, perhaps unsurprisingly, that QE effects are state dependent but that spillovers across AE are relatively strong.[6]

While most vector autoregressive (VAR) models are estimated for individual economies other VARs are of the global variety.[7] Chen et. al. (2017) combine data from AE and EME to investigate the impact of QE. However, since UMP in one form or another have been introduced in a few systemically important economies (viz., US, UK, Eurozone and Japan) as well as smaller AE (Canada, Denmark, Sweden, and Switzerland), the relative importance of each, not to mention spillover effects, are readily estimated from such models. The authors conclude that US style QE had the largest impact while the adverse spillover effects on EME claimed by some policymakers are exaggerated. This paper reports a similar finding (also see Chen et. al. 2014). The bottom line is that there continues to be considerable uncertainty surrounding the real economic effects of UMP (also see Lombardi et. al. 2018).

The brief overview of relevant research linking commodity markets and business cycles suggests not only that several commodities have the potential to impact the ability of central banks to control inflation but that their movements deserve to be considered alongside financial and monetary factors as potentially important drivers of macroeconomic outcomes. Moreover, it is worth examining separately the historical record of commodity exporters versus other economies less reliant on movements in these markets. Considering the potential impact of UMP and cross-border spillovers is another important task for empirical research in this area to which I now turn.

[6] Both Haldane et. al. (2016), and Weale and Wieladek (2016) contain references to several other studies of this kind. Also, see Ball et. al. (2016).

[7] Pesaran and Chudik (2016) is a recent survey of the GVAR technique. This modeling approach consists in attempting to estimate a model for N economies in the VAR framework for the express purpose of accounting for macroeconomic linkages that exist between the countries in a dataset. It is ideally suited to explore questions of financial integration and cross-country spillover effects. Nevertheless, since the technique does require a large number of restrictions, GVARs can be difficult to estimate and the identification of some shocks may not always have a readily available economic interpretation.

3. Econometric Methodology

As noted earlier the diversity of the various commodity sensitive and other economies considered in this study argues for a flexible econometric technique to investigate, for example, the impact of commodity price movements on the conduct of monetary policy as well as real economic performance. Additionally, since we are also interested in spillovers from the systematically important economies, which may originate from various sources, this has the effect of increasing the number of parameters that need to be estimated.[8] Given the economic and policy regime changes as well as data related challenges (more details are provided in the following section) a parsimonious estimation approach is desirable.

Many techniques purport to economize on the loss of degrees of freedom, which can be substantial, when selecting a particular time series techniques. Because we are also interested in country-specific responses to a variety of shocks I have opted to estimate dynamic factor models (DFM). Stock and Watson (2010, 2016), and others, have written extensively about the benefits and challenges in dealing with this kind of estimation technique. Hence, the reader is referred to their work for additional technical details beyond the essentials outlined below.

Let

$$\mathbf{X}_t = \boldsymbol{\lambda}_\mathbf{t}(\mathbf{L})\mathbf{f}_t + \mathbf{e}_\mathbf{t} \quad (1)$$

$$\mathbf{f}_\mathbf{t} = \boldsymbol{\Omega}_\mathbf{t}(\mathbf{L})\mathbf{f}_\mathbf{t-1} + \boldsymbol{\eta}_\mathbf{t} \quad (2)$$

where $\mathbf{X}$ is a vector of observable variables that are explained by a vector of latent dynamic factors $\mathbf{f}_t$ with $\boldsymbol{\lambda}_t(\mathbf{L})$ representing the time-varying dynamic factor loadings. The following section will provide some empirical substantiation for this strategy. Suffice it to say, however, that the extant literature also gives us good reason to permit the loadings to change over time, even if most of the existing empirical studies of the kind conduced here do not adopt this variant (e.g., see Stock and Watson 2010). Equation (2) is then a conventional vector autoregression (VAR) where the

[8] Although much of the emphasis in recent policy discussions is on the spillovers from advanced to emerging market economies more attention has recently been paid to spillbacks. After all, EMEs (and some AEs) are typically the recipients of spillovers but, with the growth of some EMEs, notably Brazil and China, there is the possibility that the spillovers generate a response that is felt later on in AE. This is one definition of spillbacks. See, for example, Agénor and da Silva (2018), and references therein. If the size of spillovers is difficult to determine this is even truer for spillbacks. Powell (2018), who took over as Chair of the US Federal Reserve in 2018, argues that some have exaggerated the size and impact of spillovers from the US while downplaying the possibility of spillbacks (a term he does not use). The evidence presented below provides a glimpse about spillbacks from China although the estimates are not conditioned on the portion due to spillovers from, say, the US. This is an important topic for future research.

factors themselves are considered to be endogenously related to each other and is effectively time-varying given the construction of the factor scores from equation (1).[9]

Since one of the objectives of the empirical study is to capture the potential for spillovers from large and systemically important economies, equation (2) is then augmented with a vector of spillovers from US estimated factors. Letting $\boldsymbol{\Sigma}$ denote the vector of spillovers from the US we can rewrite equation (2) as follows:

$$\mathbf{f_t = \Omega_t(L)f_{t-1} + \beta\Sigma^{US}_{t-1}} + \boldsymbol{\eta}'_{\mathbf{t}} \quad (3)$$

Spillovers are lagged one quarter and, hence, are exogenous in the DFM of all the economies in the data set save the US. In the case of the US we do augment the DFM with spillovers from the Eurozone and China, drawing upon the most recent literature suggesting that these two large economies have some impact on the US macroeconomy.[10]

Once the VAR in equation (2) is specified we can impose restrictions to identify the structural shocks of interest. The simplest one is to adopt a Cholesky decomposition which can serve as a benchmark of sorts. Next, we estimate a structural version of the DFM, that is, a dynamic structural factor model (DSFM), by imposing economically sensible long-run restrictions. Since four factors are assumed adequate in describing the economies in the data set a 4×4 matrix is required to define the appropriate number of restrictions. Accordingly, the long-run restrictions matrix used is written

$$\begin{bmatrix} NA & 0 & 0 & NA \\ NA & NA & 0 & NA \\ NA & 0 & NA & 0 \\ NA & 0 & NA & NA \end{bmatrix} \quad (4)$$

where six zero restrictions are imposed so that the DSFM is just identified. The elements labelled NA are not restricted in the long-run. Most of the hypothesized restrictions are of the conventional

[9] Hence, the form of equation (2) is not exactly the same one as the time varying VAR introduced by Primiceri (2005). Bates, Plagborg-Møller, Stock, and Watson (2013) demonstrate that structural instabilities impact factor loadings but may have a larger effect on the number of factors estimated. The time variation implemented below does not take a firm stand on when there is a structural break, if any, and maintains the same number of estimated factors over the entire sample. This is partly based on evidence to be discussed below as well as to permit a focus on the implications of whether commodity price movements are endogenous.

[10] Some would interpret spillovers from the Eurozone and China as spillbacks but this is not entirely accurate without additional restrictions on estimated models as suggested earlier. Hence, for ease of interpretation, we retain the spillovers expression.

variety. For example, given that the DFM consists of four factors, namely Real, Financial, Monetary, and Commodities, in that order, the zero restrictions imply that long-run monetary policy neutrality is imposed ([1,3] element). Other standard long-run restrictions include the neutrality of monetary policy to commodity price shocks ([3,4] element) and the long-run neutrality of financial conditions to commodity price shocks ([4,2] element).

The remaining three long-run restrictions shown in equation (4) might be considered less standard although they are consistent with some findings reported in the extant literature. For example, it is assumed that financial conditions have a neutral impact on real outcomes in the long-run; similarly, financial conditions are neutral to monetary policy in the long-run; and, finally, monetary policy reacts neutrally to financial conditions in the long-run. These additional restrictions are partly motivated by a desire to recognize that, while monetary policy and financial conditions can influence each other in the short-run, monetary policy in the long-run must stick to its knitting as it were and aim for some form of price stability.

In any case, since we aim to compare various estimates of DSFM against less restrictive DFM robustness can be investigated. In particular, we consider DFM and DSFM models where commodity prices are treated as exogenous which remains the case in much of the relevant empirical literature. Notice also that if equation (4) is modified to exclude the last column, such as when commodity prices are no longer treated as endogenous, we are left with a DSFM that is over-identified. We can either test the validity of these restrictions or modify equation (4) such that elements [2,3] and [3,2] are no longer subject to the zero long-run restriction. In that case the matrix of long-run restrictions becomes

$$\begin{bmatrix} NA & 0 & 0 \\ NA & NA & 0 \\ NA & NA & NA \end{bmatrix} \quad (5)$$

which is just identified. Both versions were estimated.[11] Accordingly, the strategy is to estimate an ensemble of models as this seems like a sensible way not only to examine the implications of treating commodity prices as endogenous but as a means of establishing the robustness of the findings reported in the following section.

[11] Based on a test for overidentification it seems that, on balance, equation (5) may be the preferred specification. See, however, below.

4. Data, Stylized Facts, and Empirical Results

4.1 Preliminaries

Data from 20 economies were collected at the monthly and quarterly sampling frequencies. Most of the time series were obtained from the International Monetary Fund's International Financial Statistics (between September 2017 and January 2018) and the Bank for International Settlements (BIS). Time series for one year ahead inflation and real GDP growth forecasts are from Consensus Economics and the International Monetary Fund's World Economic Outlook (WEO). Where possible, data were collected for all the series beginning in the early 1990s. However, owing to data limitations or particular events that would distort the results in some cases,[12] the results described in the following section generally cover the 1995Q1-2016Q4 sample before any transformations are applied to the raw data (see below).

As shown in Table 1, the economies are classified into three groups that can overlap. They are: China, Hong Kong, Indonesia, Korea, Malaysia, and Thailand. These same countries are also SEACEN members.[13] Half of the economies are AE while the remaining countries are EME.[14] Four of the twenty economies are large and systemically important. They are: the US, the Eurozone, Japan, and the UK. Based on the extant literature twelve of the twenty economies in the sample are generally treated as being commodity sensitive because exports, imports, or both, of commodities are considered to be a large proportion of their GDP or are known to be major producers of certain commodities (e.g., see Chen et. al. 2014). Most, but not all, are small open economies. Three notable exceptions are Brazil, China, and Russia, which are large but commodity sensitive economies.

Fourteen of the twenty economies are defined as inflation targeting economies because there is a numerical inflation target (IT), or target range, that the central bank is expected to meet. Japan, the US, and the Eurozone are also believed to aim for numerical medium-term inflation targets but would not normally be considered to be members of the group of IT economies. Finally, it is worth stressing that there is an ongoing debate about whether central banks in emerging markets that target inflation can be readily compared to the same group in advanced economies (e.g., see Fraga, Goldfajn, and Minella 2004, Siklos 2008, and Roger 2009). The potential heterogeneity of this group will become more apparent when the empirical evidence is discussed.

[12] For example, the hyperinflations in Brazil and Russia are omitted. The appendix to the paper provides more details about data availability.
[13] The South-East Asian Central Banks Research and Training Centre: https://www.seacen.org/.
[14] The classification of economies into the advanced and emerging markets varieties is the one adopted by the International Monetary Fund for its World Economic Outlook database. See http://www.imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx.

Table 2 lists the variables that are included in each of the four categories considered when estimating the factor models described in the previous section. A few series (see the appendix) are unavailable. For example, data on housing prices are either unavailable or samples were too short (less than 10 years) for China, Malaysia, and Thailand. Similarly, long-term bond yields are also not available or samples are too brief in a few cases (e.g., Brazil, Chile, Peru).

Many existing studies classify the variables as in Table 2 (e.g., see Siklos (2018), and references therein). Note, however, that in the real factor category the addition of a monetary policy uncertainty proxy is a novel one. An alternative would be to use the economic policy uncertainty (EPU) indicator of Baker, Bloom, and Davis (2016) and others. However, this proxy is not available for all the economies in our sample. Alternatively, several studies would use the VIX as a proxy for volatility if not, occasionally, uncertainty (e.g., Rey 2018). However, rates of change in some of the series listed in Table 2, notably certain asset prices and credit, may well also capture the effect of the VIX. Also, the VIX is a US based indicator and comparable ones are available for only a very small number of economies included in the present study. Moreover, since one of the aims of the paper is to explore the nexus between monetary policy, commodity prices, and real economic outcomes it seems preferable to construct a narrower indicator that seeks to proxy the amount of uncertainty around monetary policy described next.[15]

A core element of the strategy of any central bank is the publication of an inflation and real economic outlook. Consequently, to the extent that forecasters generate different forecasts this may, in part, reflect uncertainty about the future stance of monetary policy. Unfortunately, as we are unable to observe either a forecaster's objective function, the degree to which judgment is applied when publishing a forecast, or even the precise form of any model used to generate forecasts, any observed differences in forecasts only partly reflects uncertainty about the future conduct of monetary policy.[16] Nevertheless, it is posited that, as the sum of differences in inflation and real GDP growth forecasts rises, so does uncertainty about the future conduct of monetary policy. Data limitations, however, limit the analysis to differences in pairs of forecasts, namely the private sector forecasts from Consensus Economics and the forecasts generated by the IMF and published in the WEO.[17]

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[15] EPU data are available from http://www.policyuncertainty.com/ for a dozen countries so far. Partial correlations between existing EPU and the VIX vary considerably and reveal no consistent relationship between the various proxies. Results not shown.

[16] There are also differences in the timing of forecasts, the frequency with which they are published, as well as whether the forecasts are of the fixed horizon or fixed event varieties.

[17] The former forecasts are monthly or bi-monthly, depending on the economy in question, while IMF forecasts are published twice a year. Both forecasts are of the fixed horizon and converted to the fixed event (i.e., one year ahead) variety via a common transformation used in the literature. See, for example, Siklos (2013). A version of MPU that squares the differences between the two forecasts, thereby penalizing larger forecast discrepancies vis-à-vis smaller ones, was also generated but yielded similar results.

Models of the kind estimated here require the underlying time series to be stationary. This is usually accomplished via taking differences or first log differences of the raw data. One complication is that if the periodicity of business cycle and the financial cycle differ from each other it is unclear whether the same transformation is appropriate for the financial series listed in Table 2 as the one that might be applied to the series that belong in the remaining three factors.[18] Growth rates might render a time series stationary but, unless, it is assumed that all the series of interest can be treated as a random walk, it is unlikely that the resulting series will convey departures from equilibrium that are the source of economic shocks one is typically interested in investigating. Generally, the extant empirical literature has applied a version of the Hodrick-Prescott (HP) filter which has the advantage of allowing the researcher to specify the degree of data smoothing used to estimate the trend. This would, of course, influence the time series properties of the deviations from trend although the objective is always to generate a series that eventually returns to trend. There is, of course, an extensive literature on the selection of the smoothing parameter as well as other drawbacks and challenges inherent in relying on the HP filter (e.g., see Ravn and Uhlig (2002) and references therein). This led Hamilton (2017) to recommend never using the HP filter because of the distortions inherent in the constructions of deviations from some hypothesized equilibrium relationship. However, Hamilton's critique does not deal with potential differences in real, monetary, financial and commodity cycles. Needless to say the choice of transformations is fraught with challenges and there is no single answer that will meet all required conditions. Accordingly, in what follows, Hamilton's filter is used as an input for series used to eventually generate real, monetary and commodity factors. For the financial series, an HP filter is used. Some sensitivity analysis was used (e.g., using a Hamilton filter for the financial factor series or the HP filter for the real factor series) with the broad conclusions not greatly affected.[19]

All factor models were estimated via principal factors with the number of factors estimated via the Kaiser-Guttman method. Factor scores were then obtained via the Varimax method after rotation even though only the first factor is retained for all four factors in the model. When time-varying factors are estimated I use a rolling sample of five years in length for the real, monetary, and commodity factors, and an eight year cycle for the financial factor. As noted previously, there is evidence that the financial cycle is longer than the business cycle. However, it remains unclear whether this result extends globally. For example, in some Asian economies there is evidence of a closer coincidence in the length of financial and business cycles (e.g., see Pontines 2017a, 2017b; Rummel 2017).

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[18] Another potential complication is that the financial cycle often encompasses what is sometimes referred to as credit and housing price cycles.

[19] The appendix contains some additional details including an illustration of the impact on the time series from applying different filters. Generally, the swings in the time series display longer duration when using the HP filter. This seems to match the findings of Schüler (2018a, 2018b) concerning the cyclical properties of time series subject to HP and Hamilton style filters.

It seems sensible then to adopt a slightly longer sample in estimating time-varying financial cycle scores. Borio (2012) reports that financial cycles range from 8 to 20 years in length (also, see Claessens, Kose and Terrones 2011). Therefore, for simplicity, I adopt the eight year sample as a reasonable length to obtain rolling factor scores.

Other than for commodities, where there is always only one factor that explains all of the variation in almost all of the commodity price groups, estimates find usually two factors explain all of the variation in the data. Table 3 provides a few additional details about how commodity markets interact with each other. The contents of the table summarize how a shock in one commodity market impacts others. To generate the impulse responses a VAR was estimated consisting of inflation rates in each of six commodity price groups.[20] The first column indicates the commodity market where the shock originates and the market that is impacted by the shock. The second column indicates the sign of the accumulated responses while the last column indicates whether, after 10 quarters, the estimated impulse response dies out or not. The results strongly point towards a positive link between all of the commodity market groups considered. With the exception of the case when the shock originates in the food, seeds, or industrials group, all shocks, notably energy shocks, have a temporary impact on the remaining commodity market groups. The sign of the responses alone indicates that a model where a single factor drives commodity price inflation is reasonable.

Turning to the real factor there were several instances where three factors were estimated. Nevertheless, with very few exceptions, the second and, where relevant, the third factor explain an insignificant portion of the variation. Put differently, if we choose the usual metric of omitting factors with eigenvalues below one we end up in almost every case with a single factor. Also, since the present study is concerned with the links between the four factors and not the extent to which demand and supply conditions dictate these links, it seems reasonable to proceed with the assumption that a single factor adequately describes real, financial, monetary, and commodity price conditions in the twenty economies covered by the study.

Finally, it is worth mentioning that the factor scores mean that a rise in a real factor score signals an improvement in economic conditions. In contrast, a rise in the financial score signals an easing of financial conditions, an increase in the monetary score translates into a tightening of monetary conditions, while a rise in the commodity factor is equivalent to more inflation in commodity prices.

[20] They are: energy, food, seeds, industrials, livestock, and metals.

4.2 Factors

As noted above the objective of factor analysis is to find a few linear combinations of the variables deemed to capture real, financial, monetary, and commodity price and quantity influences on the economies investigated here. Another aim, of course, is to reduce the dimensionality problem associated with the inability of conventional VARs to deal with the large number of variables (see Table 2) without exhausting degrees of freedom. Consequently, the over 60 available time series are reduced to 4. The factor scores are then the estimates of the otherwise unobservable factors and are used as substitutes for the large number of potential determinants that could be included in the model.[21]

Figures 1a to 1d plot the factor scores under two different scenarios. The solid line shows the time-varying factor scores while the dashed lines indicate what these scores are when they are estimated for the full sample. For reasons already explained time-varying scores are preferred. Nevertheless, since assumptions must be made to obtain these readers are able to visually determine the impact of the two approaches to generating the factor scores. While there are periods when the two sets of estimates are comparable there are clearly other periods when the two sets of factor scores send a different message.

Figure 1a considers the six commodity price groups. The time-varying and full sample estimates generally look similar post-GFC while the differences are quite noticeable for the pre-crisis era. Interestingly, with the exception of livestock prices, commodity factor scores peak around 2008-2009 for the energy and seeds groups while the peak in factor scores for the food, industrials and metals groups takes place between 2010 and 2012, arguably after the worst of the GFC has passed. This interpretation holds whether or not the factors are estimated in a time-varying manner. Moreover, we also observe that factor scores are more volatile pre-GFC relative to full sample estimates. Further underscoring the results of Table 3, overall movements in both time-varying and full sample estimates are similar across all six commodity price groups. Possibly only livestock prices again behave somewhat differently from the other commodity price groups.
Figure 1b considers the factor scores for financial conditions. Consider first the SEACEN members in the data set. Overall, financial conditions look similar when both the full sample and time-varying estimates are considered, although there are two notable exceptions. They are: China and Korea. In China's case, the full sample estimates do not indicate a large loosening of financial conditions around 2012 that is apparent in the time-varying estimates. The same interpretation applies to the case of Korea. Elsewhere, time-varying estimates tend to differ from full sample factor score estimates post-GFC. In a few cases, whether the observer believes financial conditions are tighter or looser is quite sensitive to how the factor scores are estimated.

[21] Estimated from the loadings (i.e., the coefficients of the i^{th} variable on the j^{th} factor). As a result, the scores are used as the 'variables' in equation (1) and are obtained from equation (2).

An important example is Japan. Conditions are noticeably tighter in the early 2000s for the full sample estimates, while there is comparatively little variation in the time-varying estimates. Alternatively, any tightening of financial conditions in Japan peaks around the GFC based on the time-varying estimates, while the peak occurs around 2007 in the full sample estimates. Norway, Great Britain and the Eurozone offer other examples of the sensitivity of the interpretation of financial conditions according to the full sample versus time-varying distinction.

Figure 1c shows the factor scores for monetary policy conditions. Beginning with the SEACEN members in the sample there is a clear difference in the volatility of time-varying versus full sample estimates. Differences between the two sets of estimates are, on the whole, less apparent than was true for financial conditions, although there are occasionally contrasting signals sent by the results for a few countries. For example, around 2008, full sample factor scores for China indicate a loosening while the time-varying estimates indicate a tightening. China did loosen shortly after the GFC began in the US. Hence, time-varying estimates may tell a more accurate tale about the changing monetary policy stance of the PBOC. Similarly, in Hong Kong, the time-varying estimates show a much larger loosening of monetary policy conditions around 2010 than is apparent from the full sample estimates.[22] In the remaining 14 economies, examined factor scores are broadly comparable whether or not we allow the scores to vary over time. Nevertheless, there are important exceptions. For example, in Canada's case, time-varying estimates show a substantial loosening of conditions around the GFC that generally mirrors, with a small delay, the same large loosening seen in the US. Finally, and as in the other cases examined so far, differences in the factor score estimates are more likely pre than post-GFC.

Finally, Figure 1d shows the factor scores for the real variables in the twenty economies examined. Among the SEACEN members considered it is found that, post-GFC, overall economic conditions rebounded more strongly in three of the countries (China, Indonesia, and Thailand) when the factor scores are time-varying, while in the remaining three economies (Hong Kong, Korea, and Malaysia) economic conditions look better only when full sample estimates are considered. The differences between estimates are small in Korea's case. With the exception of Brazil, the downturn during the GFC is visually apparent everywhere and is most noticeable when time-varying factor scores are considered. Indeed, in SEACEN member economies, the downturn around 2008 is relatively stronger in the time-varying estimates although differences with full sample factor scores are arguably modest for Malaysia and Thailand.
Given the ongoing discussion about both the existence and the importance of the global component of various key economic variables (e.g., inflation, real GDP growth), it may be of

[22] Since the monetary factor consists of a linear combination of several variables (see Table 2) a loosening of policy can take place from a combination of changes in foreign exchange reserves or permitting changes in the US-HK interest rate differential, to give two examples. In other words, the presence of a fixed exchange rate between the USD and HKD need not prevent changes in the stance of monetary policy.

interest to consider how the various estimated factors are correlated across countries. Although care must be taken when interpreting such correlations because they are unconditional and, to conserve space, based on the full sample estimates of factor scores, there are indications that real factors are positively correlated between the US real factor scores and almost all the countries in the data set. However, the same is not true of the financial and monetary factors.[23] Almost half of the correlations are negative for the last two factors. This provides a general indication that a tightening of financial and monetary conditions in the US is associated with a loosening of these same conditions elsewhere. Whether this result reflects the impact of exchange rate adjustments or other frictions that limit such correlations is unclear. Nevertheless, these results suggest some interesting extensions beyond the results emphasized here.

4.3 Historical Decompositions and Spillovers

While it is common to examine the impulse responses in what follows. the focus is on attempting to understand the relative importance with which each potential shock in the model contributes to explaining movements in the observed factors. Accordingly, the method of the historical decomposition of the factors is used. Burbidge and Harrison (1985) were the first to decompose the structural residuals in order to estimate the contribution of the (accumulated) structural shocks in a model.[24] To conserve space only the historical decompositions for real and monetary factors are shown in Figures 2 and 3, respectively. Nevertheless, there are potentially four sources of shocks possible depending on the estimated model. They are: real, financial, monetary and commodity prices. In addition, to give an idea of the sensitivity of the results to the kind of estimated model, and where relevant, maximum, minimum and median historical decompositions are provided. Bars indicate median estimates for the historical decompositions. To ensure that the results are displayed in a meaningful manner Figure 2 shows only median estimates in 11 cases, both median as well as maximum and minimum estimates for 7 economies, and only maximum and minimum estimates for 2 countries. Only the decompositions due to the financial factor are not shown.

As before we begin the discussion of the results for the SEACEN members. Perhaps unsurprisingly, own shocks play the largest role. This indicates that a sizeable portion of variation in the real factor is due to persistence. Own shocks explain the bulk of the negative shock the GFC represents for most countries. The commodity factor, which is assumed endogenous, plays a small role in all SEACEN member economies with two notable exceptions, namely Indonesia and Malaysia and, to a lesser extent, Thailand. The first two are commodity sensitive economies

[23] Some of the correlations are reported in the appendix. Another drawback of unconditional correlations is that they fail to capture any lead-lag relationships between the various factors.

[24] They show that model variables at each point in time can be represented as a function of initial values plus the accumulate sum of all the structural shocks of the model.

(see Table 1). Negative contributions to the real factor in Malaysia during 2008-2009, and again in 2011-2012, are largely explained by commodity price movements. Monetary factors play a modest role at best except for Hong Kong and Korea. Arguably, these economies, either due to the exchange rate regime or trade links, are likely to have been relatively more strongly influenced by the GFC which originated especially in the US.

The relative importance of own shocks in also apparent for the non-SEACEN members in the study. Nevertheless, there can be large variations in the historical decompositions depending on the estimated model. For example, in Japan, the monetary policy factor is a relatively important driver of real economic activity and the same is true for the US. Commodity prices also play a relatively small role in economic activity outside some of the SEACEN members, but there are important exceptions: Brazil, Canada, Norway, Mexico, Peru, and Russia. All of these countries are among the commodity sensitive economies in this study.

Next, Figure 3 examines the decomposition of the monetary factor. Among the SEACEN members, commodity price shocks play an important role for China, Indonesia and, to a more modest extent, Malaysia. In the remaining member economies, monetary shocks are seen as the predominant drivers of the monetary factor, that is, the stance of monetary policy over time. Commodity shocks play an important role in driving the stance of monetary policy is several commodity sensitive economies such as Australia, Canada, Mexico, Norway, Russia and South Africa. Among the commodity sensitive economies only Brazil and New Zealand stand out as being relatively unaffected by commodity price shocks.

In addition to the relative contributions of each potential source of shocks in the model, the events of the past decade have also revived interest in cross-country spillovers. Table 4 provides the findings based on variants of equation (3). Although the spillovers that potentially concern policy makers need not originate only in the US, they are the ones that have attracted the most interest amongst academics. In the case of the US, we added spillovers from the Eurozone. The table indicates the sign of the estimated impact of a one quarter lagged change in the US real, financial or monetary factor on the four factors estimated for each country. This represents the $\boldsymbol{\beta}$ vector in equation (3). The sign alone, however, does not indicate whether the impact is beneficial or not for the economy in question. A beneficial effect would mean a combined improvement in the real factor, a loosening of financial and monetary conditions or an increase in commodity prices for a commodity sensitive economy and a decrease in any of the economies not included in the same group (see Table 1). Put differently, if we aggregate the spillover effects we find that four out of the six SEACEN members end up with a positive effect from the US. China, Hong Kong, Indonesia and Korea are net beneficiaries from spillovers. Only Thailand is a net negative recipient of US spillovers. Also interesting is the finding that net spillovers from China to the US are negative, while there are no statistically significant spillovers in aggregate from the Eurozone to the US. Other economies that suffer net negative effects are Australia, Brazil, and the UK. The summary at the bottom of Table 4 provides some of the details.

Table 4 indicates that exogenous real shocks from the US generate few real spillovers. However, when they do, the impact is positive. The SEACEN member economies do not stand out but both Indonesia and Korea are recipients of positive spillovers. Real shocks from the US also tend to produce positive effects on financial conditions, but in only seven countries, only two of whom are SEACEN members (i.e., Hong Kong and Korea). External real shocks from the US have even fewer effects on domestic monetary conditions. However, in every case, the impact is negative, implying a tightening of the domestic monetary policy stance. Only Hong Kong and Thailand are among the implicated SEACEN members. Finally, an improvement in last quarter's real economic conditions in the US has a modest impact on the commodity factor, with only Indonesia, Thailand, Mexico, Norway, and Peru experiencing any effects. The results are mixed, with Indonesia and Thailand, two SEACEN members, experiencing a negative impact, while the remaining economies, other than Mexico, are beneficiaries of this kind of shock.

Turning to a change in US financial conditions, these appear to change real economic conditions in two SEACEN member economies, namely Korea and Malaysia, where the domestic real factor has seen improvement. Only three other economies in the study are impacted. They are: Australia (negative), Mexico (positive), and Peru (positive). Financial spillovers from the US lead to very few changes in domestic financial conditions. Only Australia, Mexico, and New Zealand are affected and in the direction of a loosening of domestic financial conditions when US financial conditions were looser in the previous quarter. A change in US financial conditions only affects monetary and commodity price factors in four economies. Two of these are SEACEN economies (Indonesia and Malaysia for the monetary factor; Hong Kong and Malaysia for the commodity factor). In the case of commodity prices, a past loosening of US financial conditions negatively impacts the commodity factor in all four economies affected. The impact on the monetary factor is mixed, but both SEACEN members are beneficiaries. Perhaps the smallest spillovers from the US come via the stance of monetary policy. When the Fed tightens there is a negative effect on the commodity price factor (i.e., rising commodity prices) found in five economies, three of which are SEACEN members (Hong Kong, Indonesia, and Korea).

The bottom portion of the table provides a general summary of the net beneficiaries from US spillovers according to whether the economy in question is commodity sensitive or not. Overall, economies that are not commodity sensitive tend to be net beneficiaries, whereas the commodity sensitive economies more often experience negative (i.e., economically harmful) spillover effects.

It was noted in the introduction that the post-GFC era could well have also played a role in producing some of the results presented above. After all, the full sample is roughly evenly split between the period before and after 2008-2009. None of the results discussed so far provide any indications about whether the behavior of the errors from the four types of models estimated are linked to major policy developments over the sample period. Two notable developments deserve some additional attention. First, 14 of the 20 economies in the sample adopted inflation targets, most in the early years of the sample. Half of the SEACEN member economies have also adopted inflation targeting (Indonesia, Korea, Thailand).[25] Second, since 2008, four systemically important economies in the dataset (US, Japan, Eurozone, UK) have also pursued policies in response to the GFC identified as unconventional monetary policies, quantitative easing, or both. Therefore, as shown in Table 5, I estimate a panel regression for the four model types investigated in this study and ask whether there is cross-country evidence that real and monetary shocks were partly driven by the monetary policy strategy in place or the set of policies implemented over time in the four large advanced economies. The panel regressions are of the form:

$$\eta_{it}^{j} = \alpha_t + \delta_i + \phi_1 \mathrm{IT}_{it} + \phi_2 \mathrm{QE}_{it} + \omega_{it} \qquad (6)$$

where η^j, *j* = real, monetary, are the shocks obtained from the estimation of equation (3) for the models where commodity prices are treated as endogenous (models A and B) or exogenous (models C and D), and where either the Cholesky decomposition is applied (models A and C) or the structural restrictions given in equations (4) and (5) are applied (models B and D). Countries are identified by *i* so that both cross-section and period fixed effects are considered in equation (6). IT is a variable that takes on the value of the mid-point of the numerical inflation target. QE is a dummy variable (also see the appendix) that takes on the value of 1 or higher depending on the number of policy interventions in each quarter undertaken by central banks other than via changes in the policy rate. Clearly, this is not the only way to construct such a dummy variable. First, because the construction of the dummy treats all interventions as being of equal magnitude when this is not always the case. Second, some of these interventions may have longer lasting effects than others and the constructed dummy does not make the necessary allowances for temporary versus more permanent effects of QE, even if most observers agree that the impact of QE does wear off over time.

The results of Table 5 indicate that while real shocks were modestly higher among the IT economies, a breakdown of the dataset into advanced and emerging market economies suggests that real shocks were lower in the former group, whereas the positive coefficient obtained for all economies is only repeated in one of the four models. There is evidence that real shocks are lower as a result of QE, but only when the AE and EME distinction is applied. Hence, if QE lowered

[25] See the appendix for the details.

real shocks on average in both the economies directly and indirectly impacted by the GFC, then the efforts undertaken by the four central banks in question led to globally improved real outcomes.

Turning to the monetary shocks there is evidence that IT countries experienced, on average, less of these than the remaining economies in the sample, although the benefits appear to have accrued largely to the EME in the sample. In contrast, while QE on average also helped reduce the size of monetary shocks, the benefits seem to have gone to the AE. Overall, the results seem not terribly sensitive to the estimated model in question. Hence, there is some evidence of robustness in the results.

5. Conclusions

This paper estimates varieties of macroeconomic models for 20 economies, the majority of which are considered commodity sensitive. Six economies in the sample are SEACEN members. A ‘control’ group of large and small economies makes up the rest of the sample. Dynamic factor models are estimated to exploit as much of the available time series and to deal with the curse of dimensionality. Given that the past two decades have been relatively eventful in the macroeconomic sphere the factors are estimated in a time-varying manner. Four potential factors are identified. They are: real, financial, monetary and commodity. In the case of commodity prices we consider a model where, following the traditional strategy, commodity price fluctuations are treated as exogenous. This approach is then contrasted with one where commodity prices are allowed to move endogenously.

I conclude that time-varying estimates are essential to highlight the impact of the great financial crisis as well as differences in macroeconomic conditions before and after the crisis of 2008-2009. All four identified shocks are persistent over time in spite of the crisis. SEACEN members are fairly heterogeneous and the treatment and impact of commodity price movements, in particular, is one important source of differences in macroeconomic responses to various hypothesized shocks. Resource-rich SEACEN member economies such as Malaysia are considerably more sensitive to commodity price shocks than other members such as China. Non-resource rich SEACEN member economies are no less heterogeneous based on the relative importance of commodity price and monetary shocks in explaining economic activity and the stance of monetary policy. Results for the non-SEACEN members in the sample largely mirror the kinds of differences found for SEACEN member economies.

Turning to spillovers from the US, the results of this study suggest that a focus on the monetary policy response to shocks that originate from the US ignores that other shocks, namely real, financial, and commodity price shocks, also play a role. Indeed, the accumulated impact of these various shocks may have a neutral impact on the individual economies considered. Finally, an analysis of the institutional determinants of structural shocks suggests that unconventional monetary policies pursued by the four systemically large economies in the study have been largely beneficial for the global economy. There is no apparent distinction according to whether the central bank in question targets inflation or not. Nevertheless, inflation targeting economies experience more subdued monetary policy shocks than the rest. Moreover, the impact of inflation targeting and of unconventional monetary policies appears to differ between the advanced and emerging market economies in the sample.

The principal policy implication is that too much has been made concerning the economic impact of spillovers. In particular, economies that are not commodity sensitive are, on balance, net beneficiaries of US spillovers. In contrast, the reverse is true for the resource rich economies, including some SEACEN members. If the results of this study hold up over time then these economies need to implement policies that build the kind of resilience to external shocks that economies not considered to be commodity sensitive appear to have built-up over time.

There are also a number of extensions possible to the empirical work presented in the paper. I did not directly estimate the size of spillbacks that some policy makers have raised concerns about. Unconventional monetary policies have been treated as if they are homogeneous when this is not the case. Many of the interventions were targeted to deal with a variety of weaknesses in the financial sector. A sensitivity analysis according to the type of intervention would be useful. Moreover, I have not explicitly examined whether the results differ according to the exchange rate regime in place. An extension in this direction may provide additional clues about what policies could be pursued to achieve the resilience mentioned above. Finally, a more traditional set of models would have permitted a decomposition into the role of inflation and GDP growth shocks, to give two examples, as opposed to the decomposition by factor. A comparison between these different types of models would be an interesting check of model adequacy. All of these extensions are left for future research.

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Table 1: List of Economies in the Data Set

Commodity Sensitive Economies		Other	
Advanced	**Emerging Markets**	**Advanced**	**Emerging Markets**
AUSTRALIA(AU)*	BRAZIL(BR)*	HONG KONG(HK)	INDONESIA(ID)*
CANADA(CA)*	CHINA(CN)	UNITED KINGDOM (GB)*	THAILAND(TH)*
NORWAY(NO)*	CHILE(CL)*	JAPAN(JP)	
NEW ZEALAND(NZ)*	MEXICO(MX)*	KOREA*	
	MALAYSIA(MY)	USA(US)	
	PERU(PE)*	EUROZONE(EZ)	
	RUSSIA(RU)*		
	SOUTH AFRICA(ZA)*		

Note: * means that the economies in question formally target inflation. Shaded areas indicate SEACEN members.

Table 2: Variable Sets in Factor Estimation

Real	Financial	Monetary	Commodities
Real GDP growth	Central Government debt to GDP	Central bank policy rate[5]	Energy (7)[4]
Consumer price inflation	Private non-financial assets to GDP	Foreign exchange reserves	Food (11)
One year ahead inflation forecast	Equity prices	Real exchange rate	Seeds (5)
One year ahead real GDP growth forecast	Housing prices	Domestic-US short-term interest rate differential[3]	Livestock (3)
Current account to GDP	Slope of yield curve[2]		Industrials (10)
Monetary Policy Uncertainty[1]			Metals (12)

Notes: (1) The difference between Consensus and WEO inflation forecasts plus the difference between Consensus and WEO real GDP forecasts(squared version also tried with no change in the conclusions); (2) the spread between long-term government yields and short-term government yields; (3) where possible the difference between domestic and U.S. three month Treasury bill yields; (4) The numbers in parenthesis indicate the number of separate price indices that were collected for each commodity group; (5) for the US (2007Q2-2016Q1), EZ (2008Q3-2016Q4), JP (1998Q1-2016Q4), and GB 2008Q3-2016Q4), mean estimates, where available, of shadow policy rates by Wu and Xia (2016; https://sites.google.com/site/jingcynthiawu/home/wu-xia-shadow-rates), and Krippner (RBNZ, https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy) were used (samples given in parenthesis).

Table 3: Commodity Group Wise Accumulated Impulse Response: Summary

Direction of IRF estimate	Sign	Notes
ENERGY→ ENERGY	+	Dies out after 10 qtrs
ENERGY → FOOD	+	Temporary: 2 qtrs
ENERGY → SEEDS	+	Temporary: 4 qtrs
ENERGY → INDUSTRIALS	+	Temporary: 4 qtrs
ENERGY → LIVESTOCK	+	Temporary: 7 qtrs
ENERGY → METALS	+	Temporary: 3 qtrs
FOOD → FOOD	+	Permanent
SEEDS → SEEDS	+	Permanent
INDUSTRIALS → INDUSTRIALS	+	Permanent
LIVESTOCK → LIVESTOCK	+	Temporary: 8 qtrs
METALS → METALS	+	Temporary: 8 qtrs
INDUSTRIALS → METALS	+	Temporary: 9 qtrs
SEEDS → FOOD	+	Temporary: 3 qtrs

Note: The source of the impulse response is followed by the response to the variable listed to the right of the arrow. For example, **ENERGY → FOOD** is the accumulated impact of a shock to energy prices to food prices. The sign represents the sign of the impulse response. Temporary versus permanent indicates whether the accumulated responses are, respectively, not or are statistically different from zero after 10 quarters. Bootstrapped confidence intervals replicated 10000 were generated. The accumulated impulse responses are shown in the appendix.

Table 4: Spillovers: Sign of Estimated Coefficients from VAR Estimates

		Factor Impacted		
Country/Economy		Real	Financial	Monetary
AU	Real		-N	
	Financial		+P	
	Monetary			
	Commodity			-N
BR	Real			
	Financial			
	Monetary	-N	-N	
	Commodity			
CA	Real			
	Financial	+P		
	Monetary	-N		
	Commodity			
CL	Real			-N
	Financial			-N
	Monetary			+N
	Commodity	-N	+N	
CN	Real		-N	
	Financial			-P
	Monetary			+N
	Commodity			+N
EZ	Real			
	Financial	+P		
	Monetary			
	Commodity	-N		
GB	Real			
	Financial	-N		+N
	Monetary			
	Commodity			
HK	Real			-N
	Financial	+P		
	Monetary	-N		
	Commodity		-N	+P
ID	Real	+P		
	Financial			
	Monetary		+P	
	Commodity	-N	+P	-N
JP	Real			+P
	Financial			-P
	Monetary			
	Commodity			
KR	Real	+P	-P	
	Financial	+P		
	Monetary			
	Commodity			-N
MX	Real		-P	
	Financial		+P	
	Monetary			
	Commodity	-N	+N	

MY	Real		-P	
	Financial	+P		
	Monetary	+P		
	Commodity		+N	
NO	Real			
	Financial			
	Monetary			
	Commodity	+P	-N	
NZ	Real	+P	+N	
	Financial	+P	+P	
	Monetary		+P	
	Commodity	-N		-N
PE	Real		-P	
	Financial	+P		-P
	Monetary	-N	+P	-N
	Commodity	+P	+N	
RU	Real	+P		
	Financial			
	Monetary			
	Commodity	-N		
TH	Real			
	Financial			
	Monetary	-N		
	Commodity	-N		
US	Real			
	Financial	+P/0	+P/0	+N
	Monetary	+P/+P		
	Commodity	-N/-N		-N/-N
ZA	Real			
	Financial			
	Monetary			
	Commodity			

Summary

Net Beneficiary Non-Commodity	**Net Negative Impact**	**Mixed**	**No Spillovers**
EZ, NZ, US, HK, ID, JP, KR, MX, MY, NZ, RU	BR, CN, GB, TH	PE, RU, TH	NO, ZA
Net Beneficiary Commodity	**Net Negative Impact**	**Mixed**	**No Spillovers**
CN	AU, CL, EZ, KR, MX, MY, NZ, RU, TH, US	HK, ID, NO, PE	ZA, BR, CA, GB, JP

NOTE: Signs refer to the sign of the estimated spillover coefficients (i.e., US real, financial, and monetary factors, lagged one quarter) in SVAR described in the main body of the paper. P means positive spillover from the US; N means negative US spillover.

Table 5: Determinants of Real and Monetary Shocks: Panel Estimates

Model	Variable coeff. (s.e.)	Real Shocks	Monetary Shocks
	ALL economies		
A	IT	0.09 (.03)*	-0.07 (.03)+
	QE	-0.18 (.21)	-0.39 (.19)+
		T=1108, F=8.55*	T=1108, F=5.38*
B	IT	0.03 (.04)	-0.10 (.03)*
	QE	-0.52 (.24)	-0.57 (.19)*
		T=1097, F=11.52*	T=1097, F=3.83*
C	IT	0.04 (.01)*	-0.11 (.03)*
	QE	-0.13 (.21)	-0.41 (.19)+
		T=1097, F=1.62+	T=1097, F=3.83
D	IT	0.02 (.09)	-0.10 (.03)*
	QE	-0.52 (.24)	-0.57 (.19)*
		T=1097, F=11.68*	T=1097, F=21.92
	Advanced Economies		
A	IT	0.20 (.25)	0.12(.22)
	QE	-0.001 (.226)	-0.02 (.20)
		T=552, F=13.62*	T=552, F=5.97*
B	IT	-0.51 (.24)+	0.03 (.02)
	QE	-0.66 (.22)*	-0.38 (.17)*
		T=541, F=2.87*	T=541, F=1.33
C	IT	-0.04 (.03)	0.03 (.02)
	QE	-0.65 (.22)*	-0.21 (.18)
		T=541, F=1.33	T=541, F=1.38
D	IT	-0.51 (.24)+	0.02 (.19)
	QE	-0.66 (.22)*	-0.35 (.17)+
		T=541, F=2.73*	T=541, F=1.17
	Emerging Market Economies		
A	IT	0.01 (.02)	-0.09 (.03)+
	QE	-0.31 (.13)*	0.34 (.10)*
		T=544, F=0.40	T=544, F=5.13*
B	IT	-0.04 (.04)	-0.14 (.03)*
	QE	-0.52 (.14)*	0.03 (.10)
		T=544, F=13.61	T=544, F=33.42*
C	IT	0.04 (.02)*	-0.12 (.03)*
	QE	-0.64 (.12)*	-0.02 (.10)
		T=544, F=1.45	T=544, F=6.57
D	IT	-0.04 (.04)	-0.14 (.03)*
	QE	-0.52 (.14)*	0.03 (.10)
		T=544, F=13.61*	T=544, F=33.42

NOTES: Models **A**: 4 variables, Cholesky decomposition; **B**: 4 variables, SVAR (see (4)); **C**: 3 variables, Choesky decomposition; **D**: 3 variables, SVAR (see (5)). Commodity factor is excluded from the 4 variable model to obtain the 3 variable model. *, + signify that the null hypothesis is rejected at the 1%, and 5%, respectively. For coefficient estimates the null is that the estimated coefficient is zero. For the F-test the null is that the cross-sections are redundant. For all countries and the advanced economies panels both cross-section and period fixed effects are included. When the null cannot be rejected the coefficient estimates shown omit the fixed effects. For the emerging market economies panel only cross-section fixed effects are included. IT is a dummy equal to the mid-point of the inflation target since the introduction of the regime. See the Appendix for the dates. The dummy is zero for the economies that do not target inflation. QE are the dates when one or more announcements of unconventional monetary policies by the US Federal Reserve were made. A plot of the dummy type variable is relegated to the appendix. Precise dates can be found in Lombardi, Siklos, and St. Amand (2018).

Figure 1a: Time-Varying Versus Full Sample Factor Scores: Commodity Prices

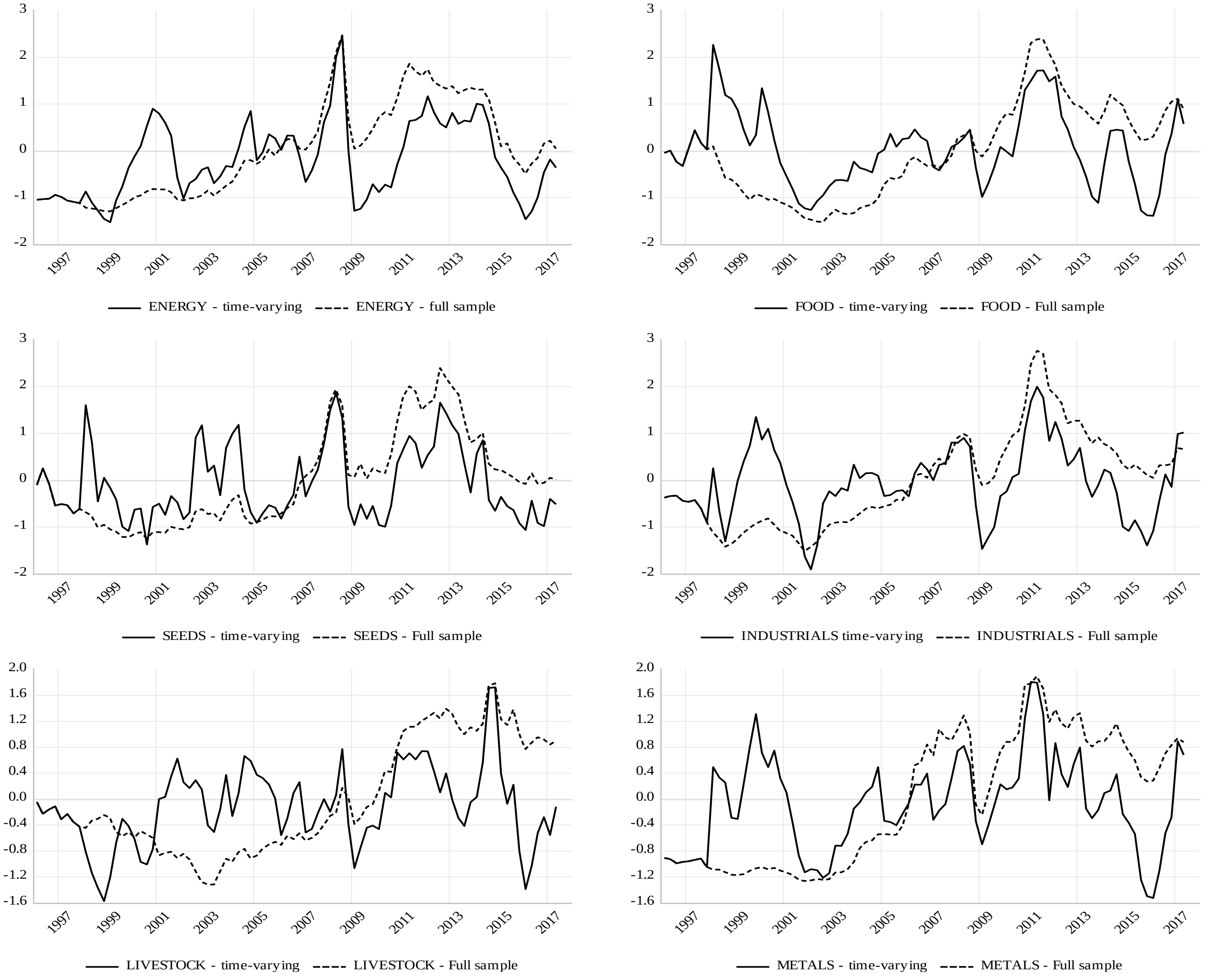


Figure 1b: Time-Varying Versus Full Sample Factor Scores: Financial Conditions

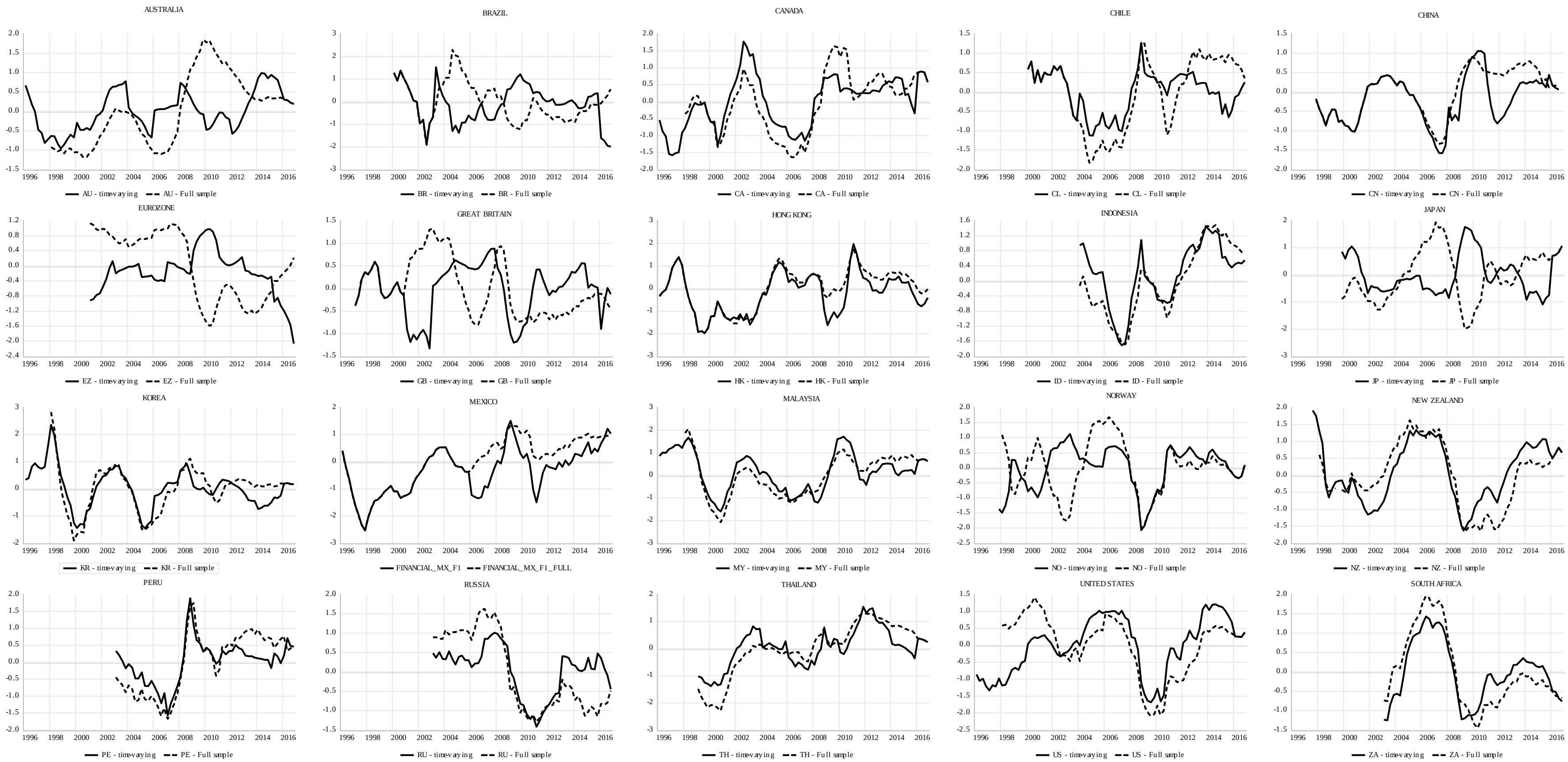


Figure 1c: Time-Varying Versus Full Sample Factor Scores: Monetary Policy Conditions

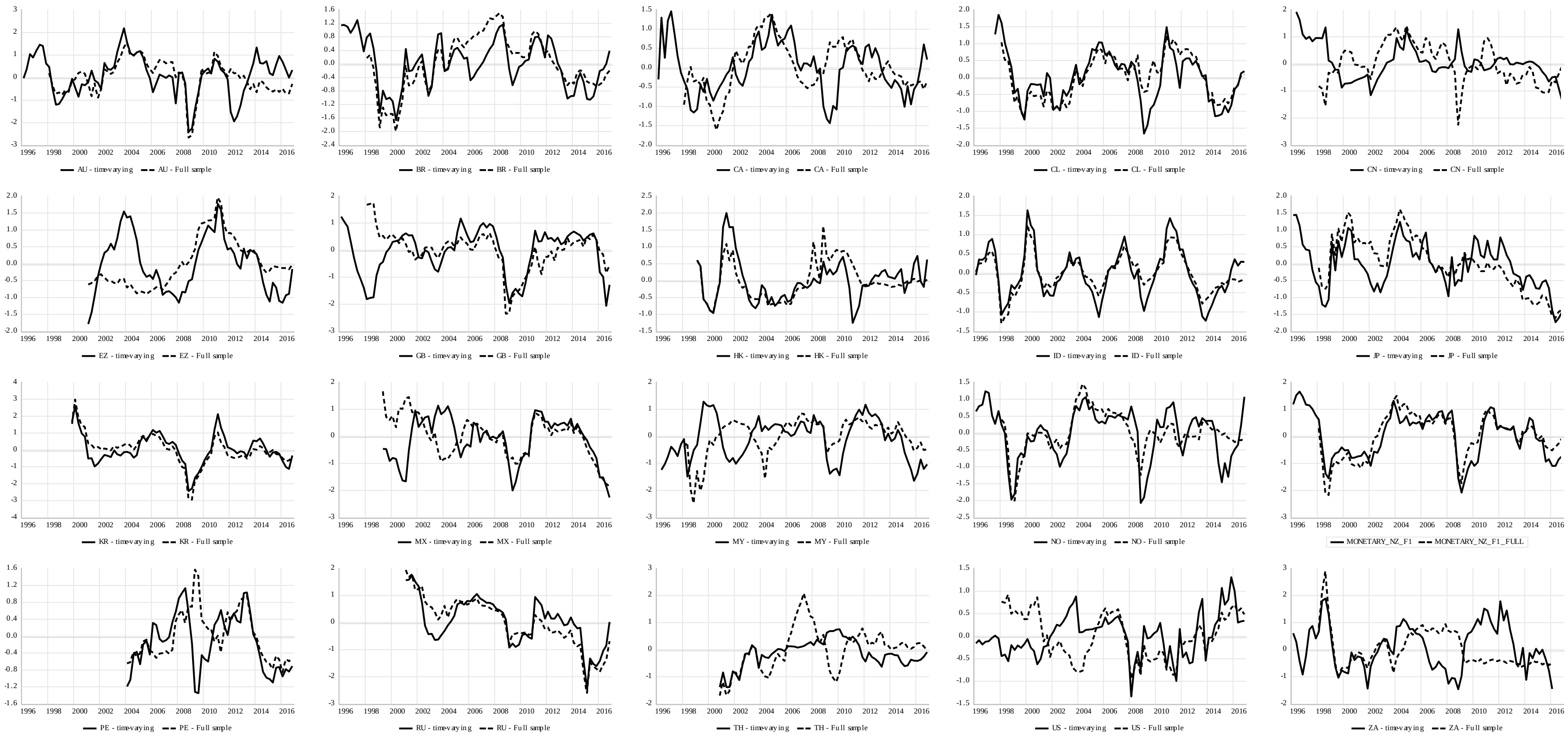
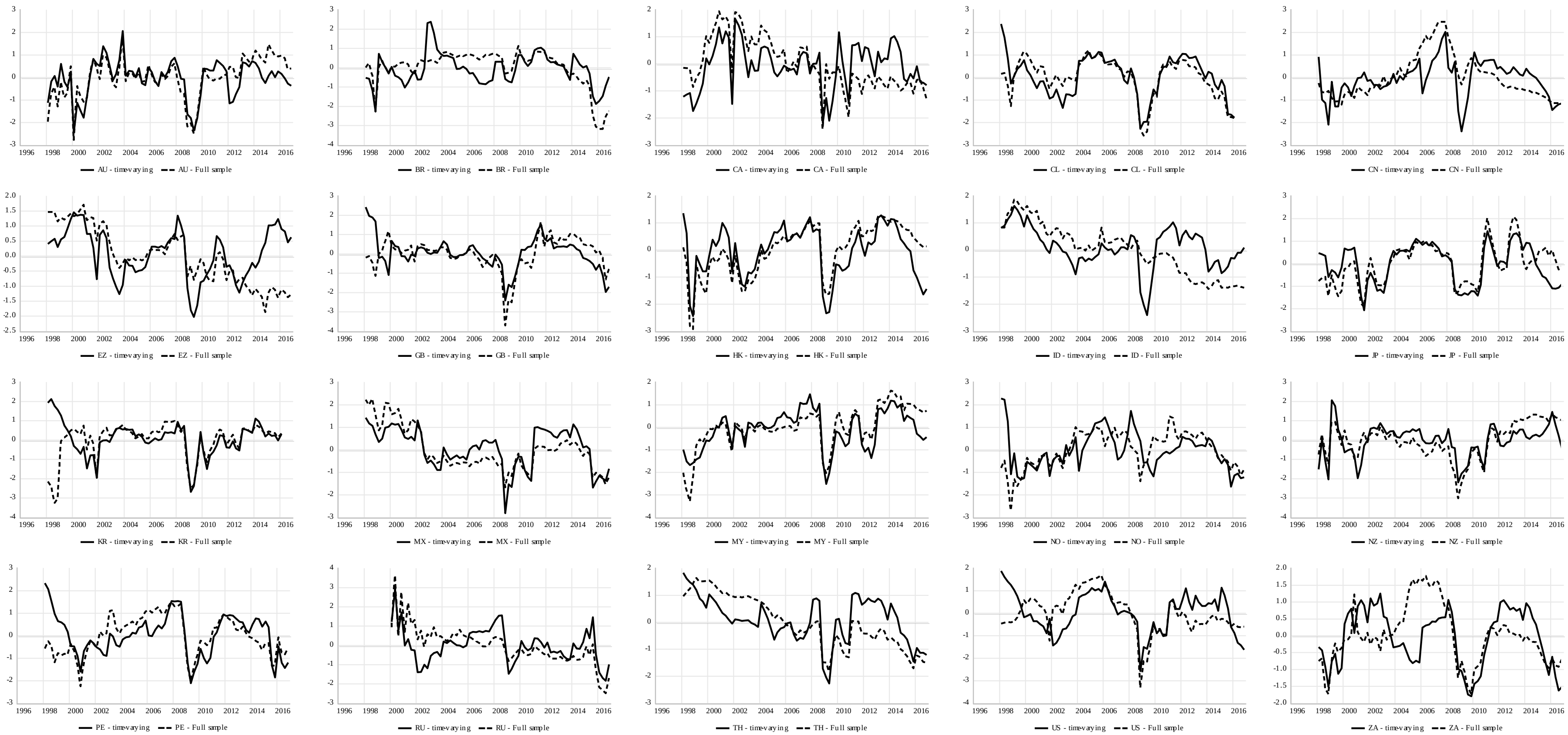
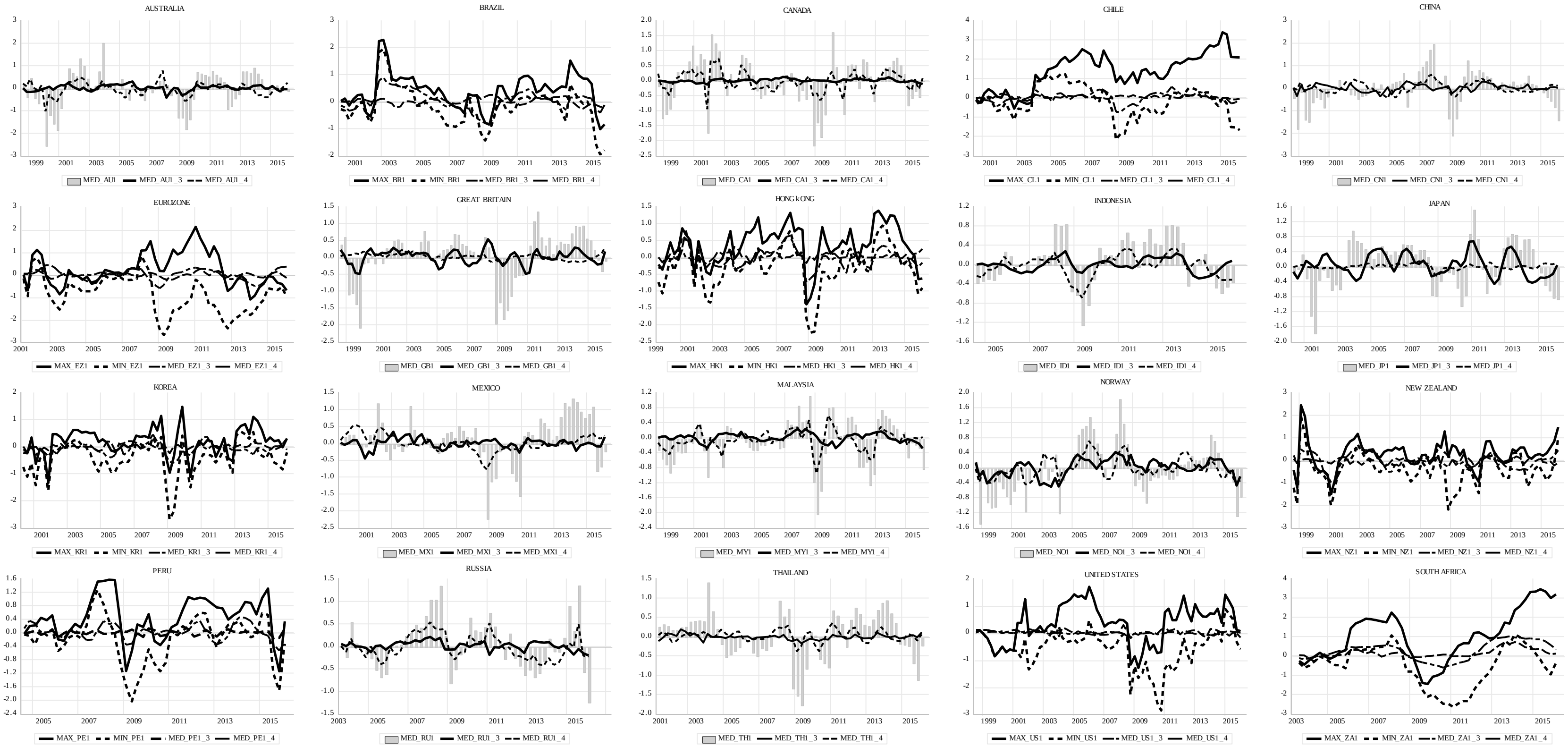


Figure 1d: Time-Varying Versus Full Sample Factor Scores: Real Factor



Note: Time-varying factor scores are based on rolling estimates with a 5 year window for real, monetary, and commodity factors; an 8 year window is used for financial factors. Estimates are shifted 8 quarters at a time and mean estimates for overlapping samples are used to generate time-varying factor scores. Full sample estimates are usually based on the 1996Q1-2016Q4 after data transformations are applied.

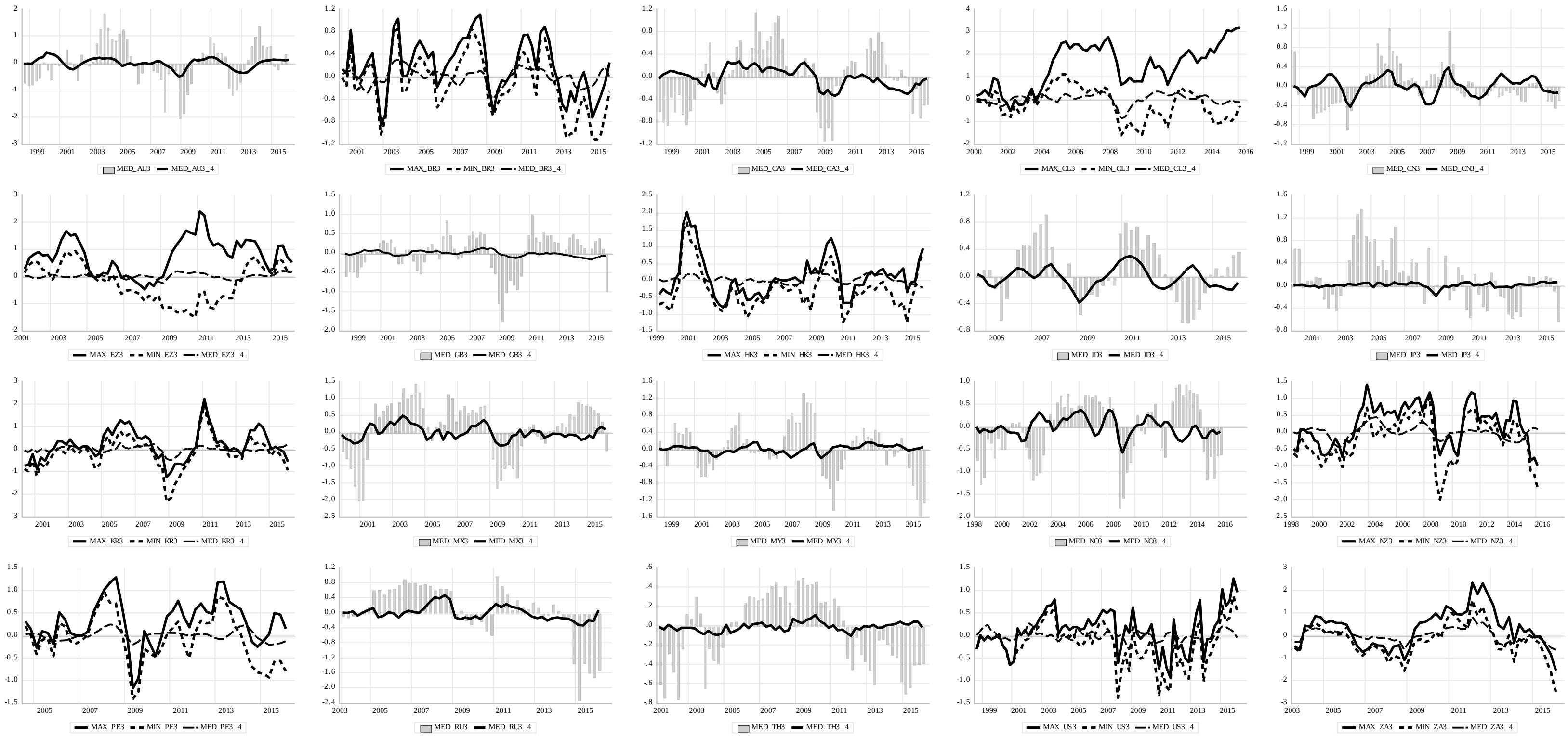
Figure 2: Historical Decompositions: Real Factor



Notes: Country/economy codes are found in Table 1. To conserve space two letter code used in the legend. MED refers to the median estimate; MAX to the largest or highest estimate, MIN to the smallest estimate. Countries/economies where the correlations across various estimated structural shocks was very high (see appendix) only MED estimates are shown. Where correlations were lower (typically less than .70) MIN and MAX estimates are also shown. The economies where this is applicable are: BR (Brazil), Chile (CL), Eurozone (EZ), Hong Kong (HK), Korea (KR), New Zealand (NZ), Peru (PE), United States (US), and South Africa (ZA). The numbers in the legend indicate the type of shock examined. The model (see text) consists of real (1), financial (2), monetary (3), and [global] commodity (4) factors. The first number indicates the factor whose historical decomposition is evaluated with the second number indicating the source of the shock. For example, MED_AU1_3 is the median historical decomposition for Australia of a monetary factor shock (3) on the real factor (1)

.

Figure 3: Historical Decompositions: Monetary Factor



Notes: See notes to Figure 2.

APPENDIX

Country Codes	Country/Economy Name
AU	Australia
BR	Brazil
CA	Canada
CL	Chile
CN	China
EZ	Eurozone
GB	United Kingdom
HK	Hong Kong
ID	Indonesia
JP	Japan
KR	Korea
MX	Mexico
MY	Malaysia
NO	Norway
NZ	New Zealand
PE	Peru
RU	Russia
TH	Thailand
US	United States
ZA	South Africa

Component Members of Commodity Price Groups	
ENERGY	Coal, natural gas, petroleum[1]
FOOD	Butter, fish, rice, sugar, coffee[1]
SEEDS	Barley, wheat, maize, soybean[1]
INDUSTRIALS	Cotton, wool, pulp, rubber, timber (logs & hardwood), softwood, plywood[1]
LIVESTOCK	Lamb, beef[1]
METALS	Aluminium, copper, gold, iron ore, nickel, potash, silver, zinc, lead, tin[1]

[1] Indicates that global pricing may be sourced in more than one location (e.g., coffee in New York, Brazil, and Uganda). All raw price data denominated in USD. Shaded areas indicate SEACEN member central banks.

VARIABLE NAME mnemonics[1]			
REAL FACTOR	FINANCIAL FACTOR	MONETARY FACTOR	COMMODITY PRICES
*_rgdp	*_govch	*_pr	comm_group_1
*_inf	*_pnfa	*_res	comm_group_2
*_cy_inffe	*_eq	*_rb	comm_group_3
*_cy_yfe	*_hp	*_intdif	comm_group_4
*_cag	*_yc		comm_group_5
*_mpu			comm_group_6

[1] See Table 2. Order is the same as in the Table. * is the country code. See the Table in the appendix for the list of country codes. Note that transformations (e.g., level to growth, differencing, application of a filter such as Hamilton's (2017) or the H-P filter) adds letters to the end of each variable name. d means differenced, g means annual growth rate, hp is H-P filtered version, h is Hamilton filtered version.

Data Availability by Factor (Excluding Commodity Prices)

COUNTRY/ECONOMY	REAL	FINANCIAL	MONETARY
AU	98Q1-16Q4	90Q1-16Q4	96Q1-16Q4
BR	98Q1-16Q4[1,12]	03Q1-16Q4[3]	96Q1-17Q1
CA	98Q1-16Q4	92Q1-16Q4	96Q1-16Q4
CL	98Q1-16Q1[12]	04Q1-16Q4[3]	97Q3-17Q2
CN	98Q1-16Q4	08Q1-16Q3[4]	96Q2-17Q2
EZ	98Q1-16Q4	01Q1-17Q1	01Q1-16Q4[11]
GB	98Q1-16Q4	01Q1-16Q4[5]	96Q1-16Q4[11]
HK	98Q1-16Q4	01Q1-16Q4[6]	99Q1-17Q2
ID	99Q1-16Q4	04Q4-16Q4	05Q4-17Q4[11]
JP	98Q1-16Q4	99Q4-16Q4	96Q1-16Q4[9]
KR	98Q1-16Q4	92Q4-17Q1	99Q4-16Q4
MX	98Q1-16Q4[1,12]	07Q1-17Q4[7]	99Q2-17Q2
MY	98Q1-16Q4	92Q4-16Q4	96Q2-16Q4
NO	98Q1-16Q4	97Q4-16Q4[8]	96Q1-16Q4
NZ	98Q1-16Q4	97Q3-16Q4	96Q1-16Q4
PE	98Q1-16Q4[12]	03Q1-16Q4	04Q1-17Q2
RU	00Q1-16Q4[2,10,12]	03Q1-16Q4	01Q1-16Q4
TH	98Q1-16Q4	99Q1-16Q4	00Q4-16Q4
US	98Q1-16Q4	92Q1-16Q4	96Q1-16Q4[11]
ZA	98Q1-16Q4	03Q1-17Q1	96Q1-16Q1

Notes: Data collection began in August 2017 and was completed in March 2018 from various sources listed in the paper. See preceding Table for mnemonics. **1**. 16Q4 when *cy_yfe* and *mpu*; **2**. 97Q1-16Q4 when *cy_yfe, mpu, cy_inffe* are excluded; **3**. 00Q1- if hp excluded; **4**. 97Q4- when *pnfa* excluded; **5**. 97Q1- when *govch* excluded; **6**. 96Q1 when *govch* excluded; **7**. 92Q4- when *hp* excluded; **8**. Sight deposit rate not government short-term interest rate used; **9**. 96Q1- if *pr* excluded; **10**. Very high inflation period (97Q1-97Q4) excluded; **11**. Shadow *pr* used in place of observed *pr* for US (07Q2-16Q1); EZ (08Q3-15Q4); JP (98Q1-16Q4; GB (08Q3-16Q4). Shadow rate is arithmetic mean of Wu-Xia (2016) and Krippner (RBNZ) estimates; **12.** Recorded data end in 16Q1 (15Q2 for BR, CL, MX, PE, RU). Forecasts from an IMA(1,1) used to fill gaps to 16Q4.

Factor Scores: Gaps in Sub-sample Estimates Filled by Full Sample Estimates

COUNTRY/ECONOMY	REAL	FINANCIAL	MONETARY
AU	-	16Q1-16Q4	-
BR	-	00Q1-03Q4	-
CA	-	16Q1-16Q4	-
CL	-	00Q1-03Q4	-
CN	-	97Q4, 16Q3-16Q4	-
EZ	-	-	-
GB	-	97Q1-00Q4	-
HK	-	96Q1-00Q4	99Q1-00Q4
ID	-	-	-
JP	-	16Q1-16Q4	-
KR	-	16Q1-16Q4	-
MX	-	96Q1-05Q4	-
MY	-	16Q1-16Q4	-
NO	-	16Q1-16Q4	-
NZ	-	16Q1-16Q4	-
PE	-	-	-
RU	-	16Q1-16Q4	-
TH	-	16Q1-16Q4	-
US	-	16Q1-16Q4	-
ZA	-	-	-

Note: Normally, samples begin 96Q1 and end 16Q4 for all three factors. This is not the case for some economies (see data availability Table). Gaps were filled when factor scores could be estimated for the full sample occasionally omitting some variables not available for the complete sample.

Proportion of Variation Explained by First Factor: Full Sample Estimates

COUNTRY/ECONOMY	REAL	FINANCIAL	MONETARY
AU	66.4 (2)	74.9 (2)	79.4 (2)
BR	48.9 (3)	56.6 (2)	100
CA	53.6 (3)	82.1 (2)	53.2 (2)
CL	60.6 (3)	100	81.5 (2)
CN	50.6 (3)	100	100
EZ	66.9 (2)	86.8 (2)	87.3 (2)
GB	41.6 (3)	57.5 (2)	79.7 (2)
HK	59.6 (3)	75.7 (2)	92.2 (2)
ID	68 (2)	75 (2)	100
JP	61.1 (2)	69.6 (2)	75.5 (2)
KR	57.4 (2)	57.6 (2)	65.9 (2)
MX	77.9 (2)	81.4 (2)	78.1 (2)
MY	63.5 (3)	81.6 (2)	68.2 (2)
NO	56.6 (3)	88.7 (2)	91.5 92)
NZ	61.9 (3)	66.3 (2)	100
PE	47 (3)	100	74.7 (2)
RU	78.5 (2)	75.5 (2)	100
TH	79.7 (2)	100	81.1 (2)
US	47.9 (3)	77.8 (2)	100
ZA	76 (2)	62.4 (2)	64.2 (2)

Note: Fractions in percent. In parentheses, number of estimated factors (eigenvalues not necessarily greater than one in all cases).

Sub-Sample of Percent Variation Explained by First Factor:
An Illustration for the Monetary Factor

COUNTRY/ECONOMY	~2010-15		~2012-17	
AU	67.2	PR .83	100	PR .80
		RB -.02		RB -.79
		RES -.46		RES -.45
		YC .68		YC .78
BR	100		100	
CA	70.8		61.1	
CL	100		100	
CN	100		100	
EZ	72.7	PR .49	100	PR .72
		RB -.00		RB .66
		RES .78		RES .80
		YC .79		YC .87
GB	73.2	PR -.13	100	PR .75
		RB .91		RB .46
		RES .80		RES -.79
		YC -.83		YC .90
HK	95.3		100	
ID	100		100	
JP	96.1	PR -.04	64.8	PR .13
		RB.78		RB -.29
		RES .45		RES .82
		YC .77		YC .95
KR	100		100	
MX	80.6		87.6	
MY	62	PR -.15	86.1	PR .28
		RB .59		RB .81
		RES .86		RES .88
		YC -.58		YC -.78
NO	100		84.7	
NZ	71.2		70.6	
PE	100		85.8	
RU	85.1		100	
TH	66	PR -.25	88.5	PR .78
		RB -.54		RB .32
		RES .42		RES .78
		YC .66		YC .30
US	100	PR .57	60.3	PR .68
		RB .66		RB .66
		RES na		RES na
		YC -.29		YC .03
ZA	71.3		63.3	

Note: see preceding Table for explanations. PR is the policy rate, RB the real effcctive exchange rate, RES are foreign exchange reserves, and YC is the slope of the yield curve. ~ indicates that the estimated sample is approximate as there were slight differences across countries depending on data availability. For selected cases, factor loadings are shown. *na* means not applicable. For PR raw data are differenced; for the remaining variables Hamilton’s (2017) filter was applied to the log levels of the data. YC is in levels.

Selected Dynamic Factor Model Estimates for Commodity Price Groups

Direction of IRF Estimate	Sign	Notes
ENERGY→ ENERGY	+	Dies out after 10 qtrs
ENERGY → FOOD	+	Temporary: 2 qtrs
ENERGY → SEEDS	+	Temporary: 4 qtrs
ENERGY → INDUSTRIALS	+	Temporary: 4 qtrs
ENERGY → LIVESTOCK	+	Temporary: 7 qtrs
ENERGY → METALS	+	Temporary: 3 qtrs
FOOD → FOOD	+	Permanent
SEEDS → SEEDS	+	Permanent
INDUSTRIALS → INDUSTRIALS	+	Permanent
LIVESTOCK → LIVESTOCK	+	Temporary: 8 qtrs
METALS → METALS	+	Temporary: 8 qtrs
INDUSTRIALS → METALS	+	Temporary: 9 qtrs
SEEDS → FOOD	+	Temporary: 3 qtrs
FOOD → METALS	+	Temporary: 7 qtrs

Commodity Group	No. Factors	Time-varying Notes
Energy – I	1	62.8% lowest, post-GFC
Food – II	2 (#1=91.2%)	50.9% lowest, post-GFC
Seeds – III	1	53.2% lowest, post-GFC
Industrials – IV	2 (#1 = 87.22%)	45.7% lowest, pre-GFC
Livestock – V	1	89.7% lowest. Post-GFC
Metals - VI	2 (#1 = 84.6%)	54.8% lowest, pre-GFC

Range of Simple Correlation Between Estimates of Structural Shocks

Country/Economy	Real Structural Shocks	Monetary Shocks
AU	.91-.94	.81.-.99
BR	.59-.88	.85-.94
CA	.87-.97	.86-.95
CL	*.19*-.54	.22-.53
CN	.94-.98	.80-.92
EZ	.25-.83	*.01*-.92
GB	.76-.84	.85-.98
HK	.62-.96	.78-.92
ID	.74-.87	.78-.84
JP	.84-.98	.74-.98
KR	*.44*-.83	.91-.93
MX	.81-.92	.79-.98
MY	.72-.96	.80-.95
NO	.86-.97	.83-.96
NZ	*.16*-.95	.80-.90
PE	.63-.90	.72-.94
RU	.73-.91	.93-.97
TH	.71-.88	.92-.93
US	*.29*-.87	.80-.94
ZA	*.18*-.92	.79-.95

NOTE: correlation between different standard and structural VAR models as explained in the main body of the paper.

Spillovers: Sign of Estimated Coefficients from Alternative VAR Estimates

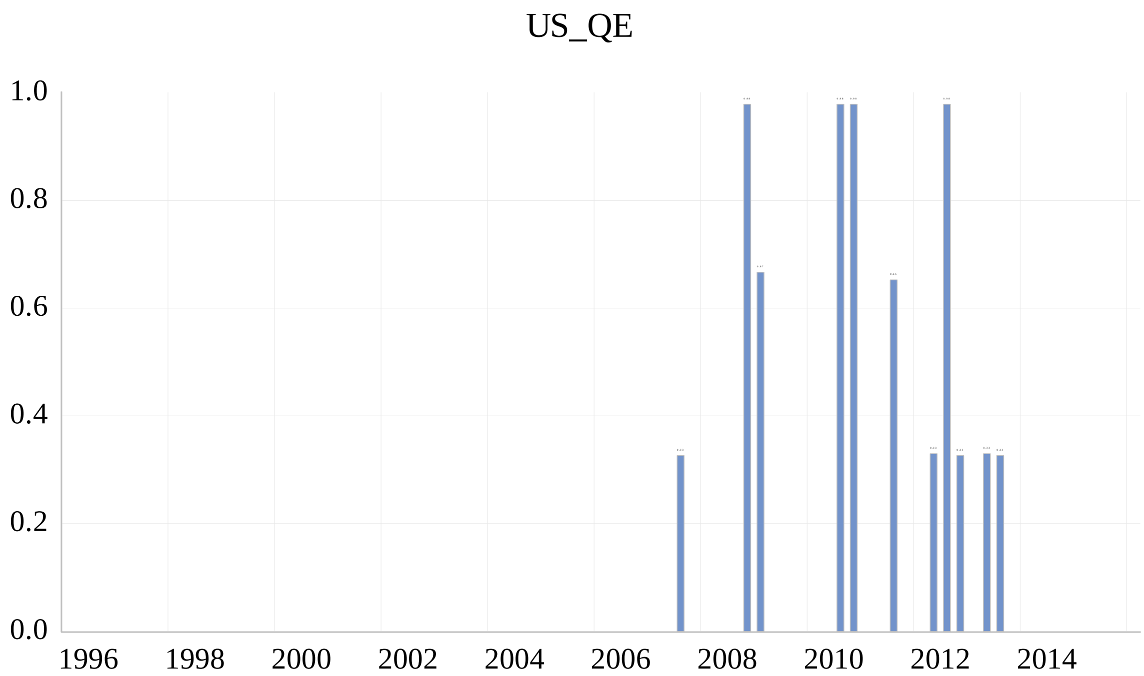
		Factor Impacted		
Country/Economy		Real	Financial	Monetary
AU	Real			
	Financial		-N	
	Monetary		+P	
BR	Real			
	Financial		-N	
	Monetary	-N		
CA	Real			
	Financial	+P		
	Monetary	-N		
CL	Real			-N
	Financial			-N
	Monetary			+N
CN	Real		-N	
	Financial			-N
	Monetary			+N
EZ	Real			
	Financial	+P		
	Monetary			
GB	Real			
	Financial	-N		+P
	Monetary			
HK	Real			-N
	Financial	+P		
	Monetary	-N		
ID	Real	+P		
	Financial			
	Monetary		+N	
JP	Real	+P	+P	
	Financial	+P	+P	
	Monetary			
KR	Real	+P	-N	
	Financial	+P	+P	
	Monetary			
MX	Real		-N	
	Financial		+P	
	Monetary	-N		
MY	Real		-N	
	Financial	+P		
	Monetary		+P	
NO	Real			
	Financial			
	Monetary			
NZ	Real	+P	+P	
	Financial	+P		
	Monetary		+P	

PE	Real	-N	-N	
	Financial			-N
	Monetary		+P	-N
RU	Real	+P		
	Financial			
	Monetary	-N		
TH	Real	+P		
	Financial			
	Monetary	-N		
US	Real			
	Financial	+P/0		0/+P
	Monetary	+P/+P		
ZA	Real			
	Financial			
	Monetary			

Summary

Net Beneficiary	Net Loser	Mixed	No Spillovers
EZ, KR, NZ, EZ→US, CN→US, NZ	BR, CL, CN	AU, CA, CL, GB, HK, ID, JP, KR, MX, MY, PE, RU, TH,	NO, ZA

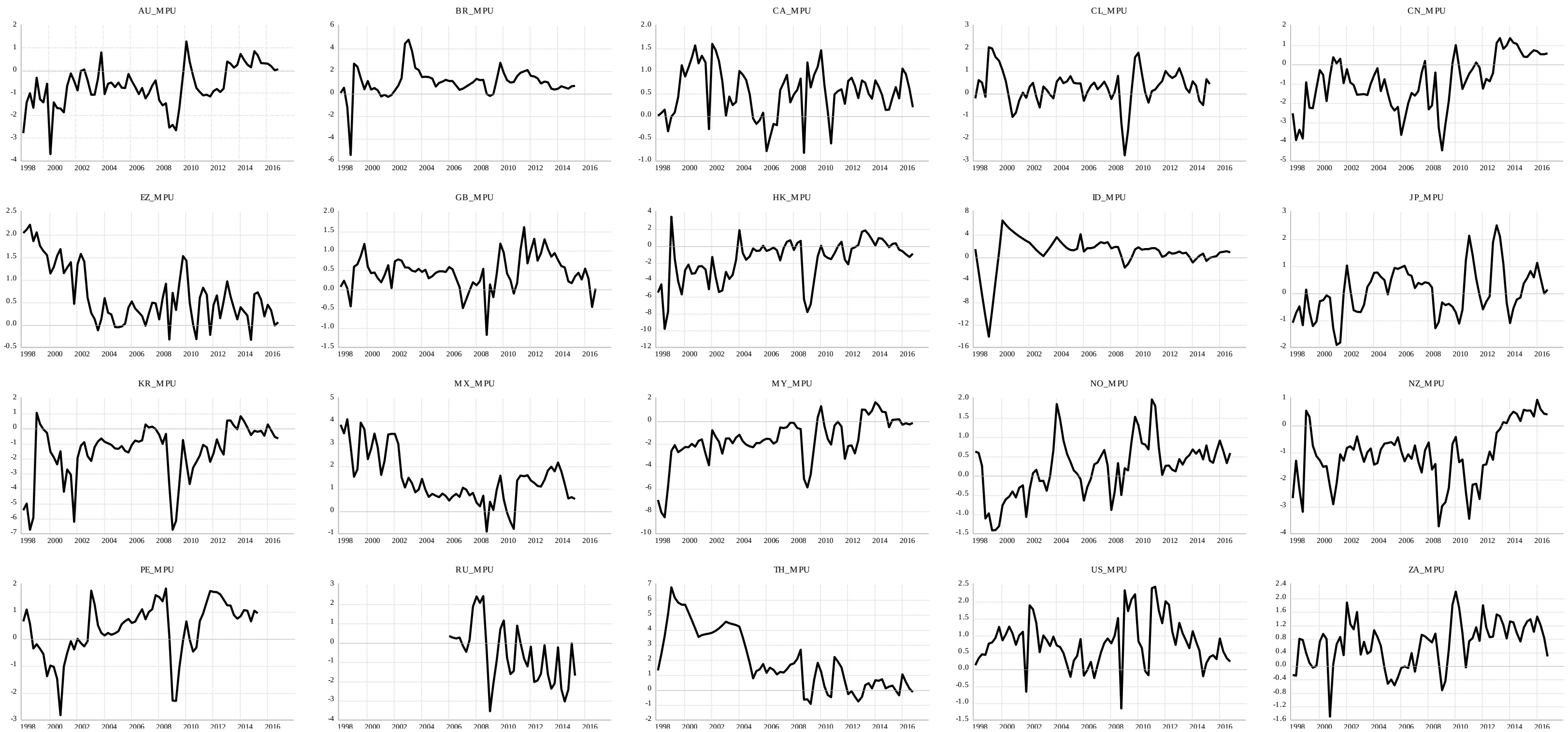
Quantitative Easing in the US



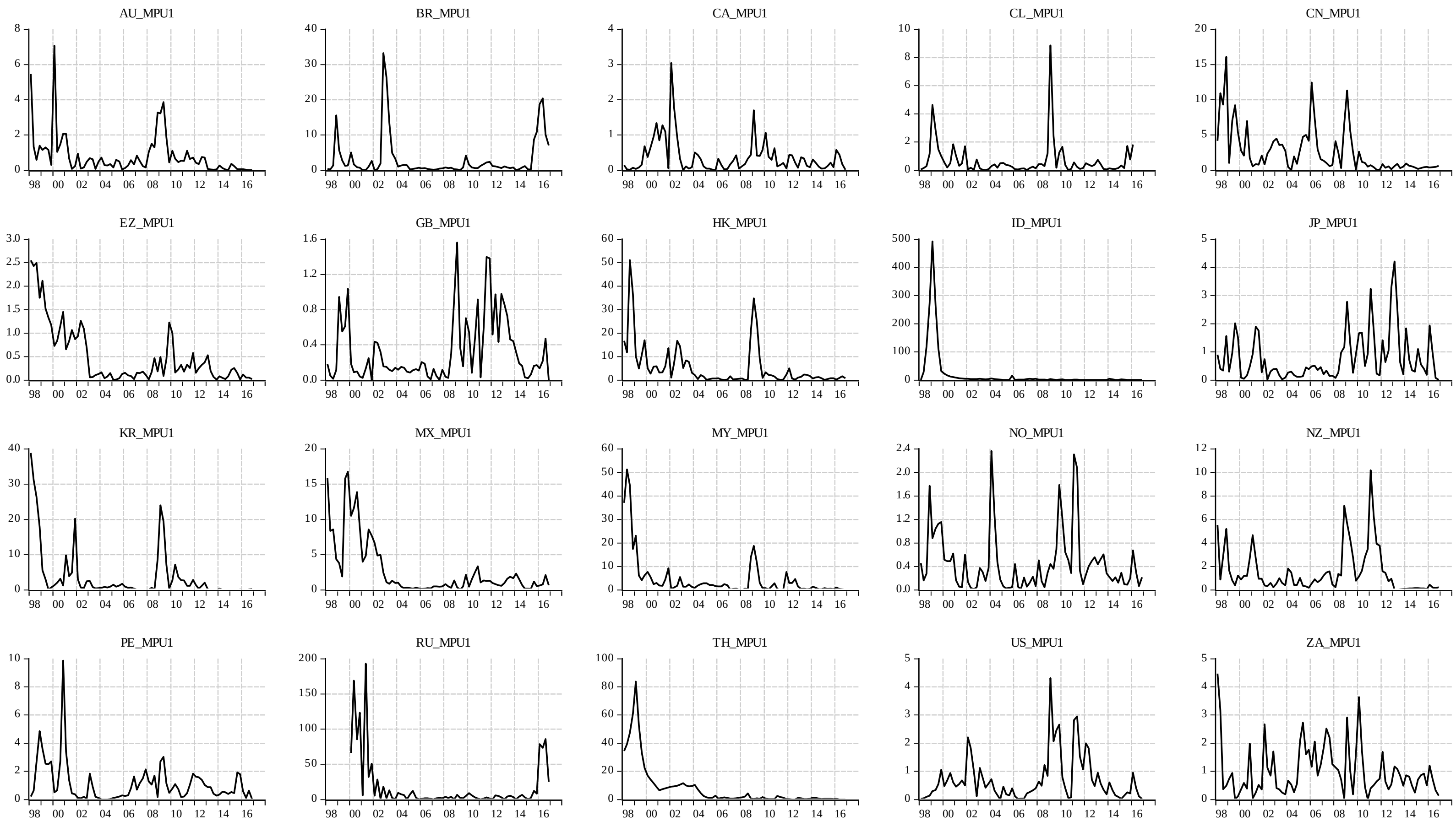
Variable used in panel estimates presented in Table 4.

Monetary Policy Uncertainty: Two Versions

(a)



(b)



Note: In part (a) MPU is the sum of: the difference between Consensus Economics (CE) and WEO inflation forecasts and the difference between CE and WEO real GDP growth forecasts. In part (b) each of the differences in the forecasts is squared.

Table IT Target Ranges and Samples

Country	Start	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
Industrial																												
1. Australia	93.2				2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3	2-3
2. Canada	91.1		2-4	2-4	1.5-3.5	1.5-3.5	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
3. Korea	98.2									8-10	2-4	1.5-3.5	2-4	2-4	2-4	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5	2.5-3.5
4. New Zealand	90.1	3-5	2.5-4.5	1.5-3.5	0-2	0-3	0-3	0-3	0-3	0-3	0-3	0-3	0-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
5. Norway	01.1												2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
6. United Kingdom	92.4			1-4	1-4	1-4	1-4	1-4	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1.5-3.5	1-3	1-3	2	2	2	2	2	2	2	2	2	2	2
Emerging																												
1. Brazil	99.2										6-10	4-8	2-6	1.5-6.5	1.5-6.5	3-8	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5	2.5-6.5
2. Chile	90.3				10-11	9-10	7-8	6-7	5-6	4.5	4.3	3.5	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
3. Indonesia	00.1											3-5	4-6	9-10	4.5-6.5	4.5-6.5	5-7	7-9	5-7	4-6	3.5-5.5	4-6	4-6	3.5-5.5	3.5-5.5	3.5-5.5	3-5	3-5
4. Mexico	99.1										≤13	≤10	≤6.5	≤4.5	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4	2-4
5. Peru	02.1													1-4	1-4	1.5-3.5	1.5-3.5	1.5-3.5	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
6. South Africa	00.1											3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6
7. Thailand	00.2											0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	0.5-3.5	1-4	1-4
Quasi- IT																												
1.Eurozone	99.1										≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2	≤2
2.Japan§	96.1																	0	0	0	0	0	0	0	2	2	2	2
3.United States§§§	12.1																							2	2	2	2	2

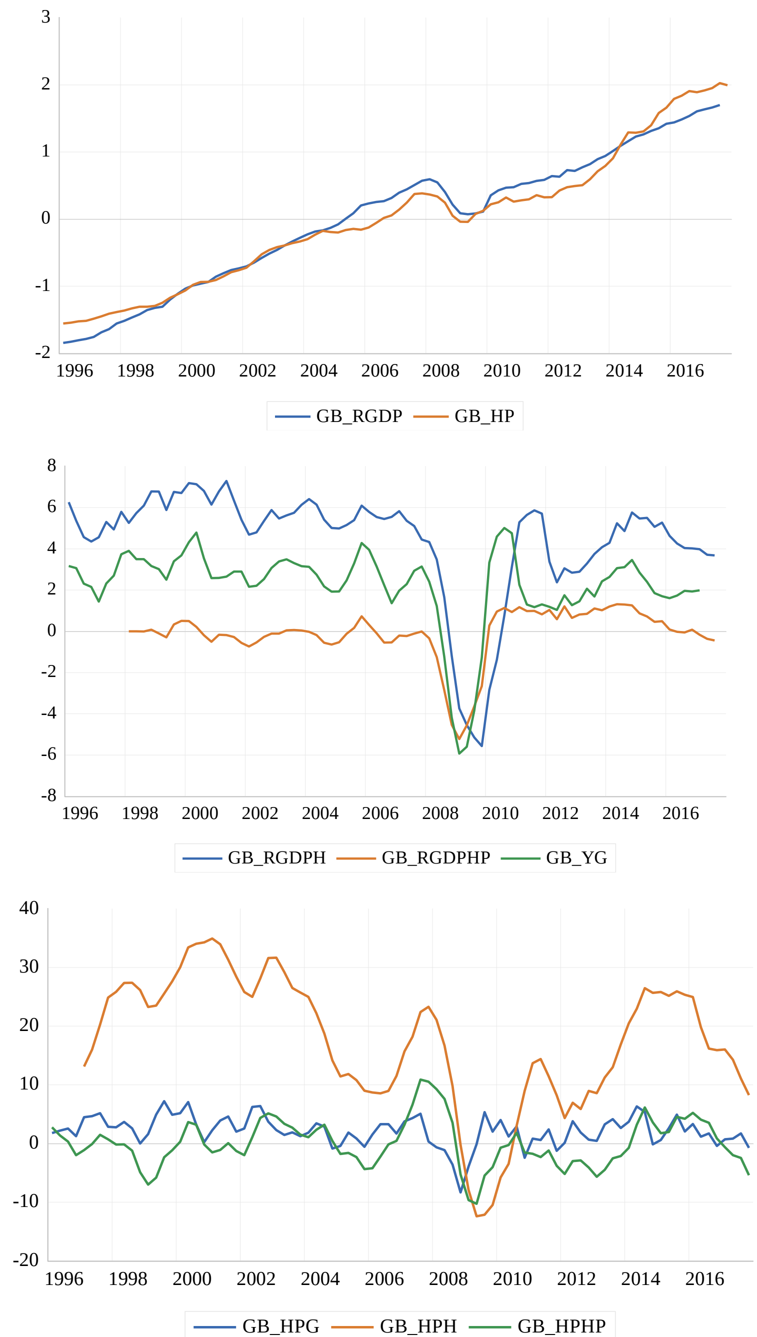
Note: Data were collected from individual central bank web sites through the BIS's central bank hub (www.bis.org/central_bank_hub_overview.htm). Individual studies reviewing the experience to date with inflation targeting and published by several of the central banks were also consulted. Occasionally, some inconsistencies were found in the reporting of target ranges partly because the target range was changed mid-year from time to time (e.g., Brazil) or for reasons that are not clear. The shaded area highlights changes to the inflation target after the first three years of an inflation target. * Economies included Advanced and Emerging groups follow the IMF's World Economic Outlook's definition. § See Bank of Japan, "The Bank's Thinking on Price Stability," Bank of Japan Quarterly Bulletin, 14 (2), 2006, pp. 65–90 (available at http://www.boj.or.jp//en/type/release/zuiji_new/mpo0603a.htm), and since 2013, see http://www.boj.or.jp/en/mopo/outline/qqe.htm/. §§ "The monetary policy strategy already in force since 2000 consists of the following …elements: a definition of price stability [used in the table above], a medium-term inflation forecast…". See http://www.snb.ch/en/iabout/monpol/id/monpol_strat#t7. §§§ Defined as a "longer-Run Goal" of monetary policy. See http://www.federalreserve.gov/monetarypolicy/files/FOMC_LongerRunGoals_20160126.pdf.

Range of Simple Correlations Between Structural Shocks
Across Various Estimated Models

Economy	Real Shocks	Monetary Shocks
AU	.91-.94	.81-.99
BR	.59-.88	.85-.94
CA	.87-.94	.86-.95
CL	.19-.54	.22-.53
CN	.94-.98	.80-.92
EZ	.25-.83	.01-.92
GB	.76-.84	.85-.98
HK	.62-.96	.78-.92
ID	.74-.87	.78-.84
JP	.84-.98	.74-.98
KR	.44-.83	.91-.93
MX	.81-.92	.79-.98
MY	.72-.96	.80-.95
NO	.86-.97	.83-.96
NZ	.16-.65	.80-.90
PE	.63-.90	.72-.94
RU	.73-.91	.93-.97
TH	.71-.88	.92-.93
US	.29-.87	.80-.94
ZA	.18-.92	.79-.95

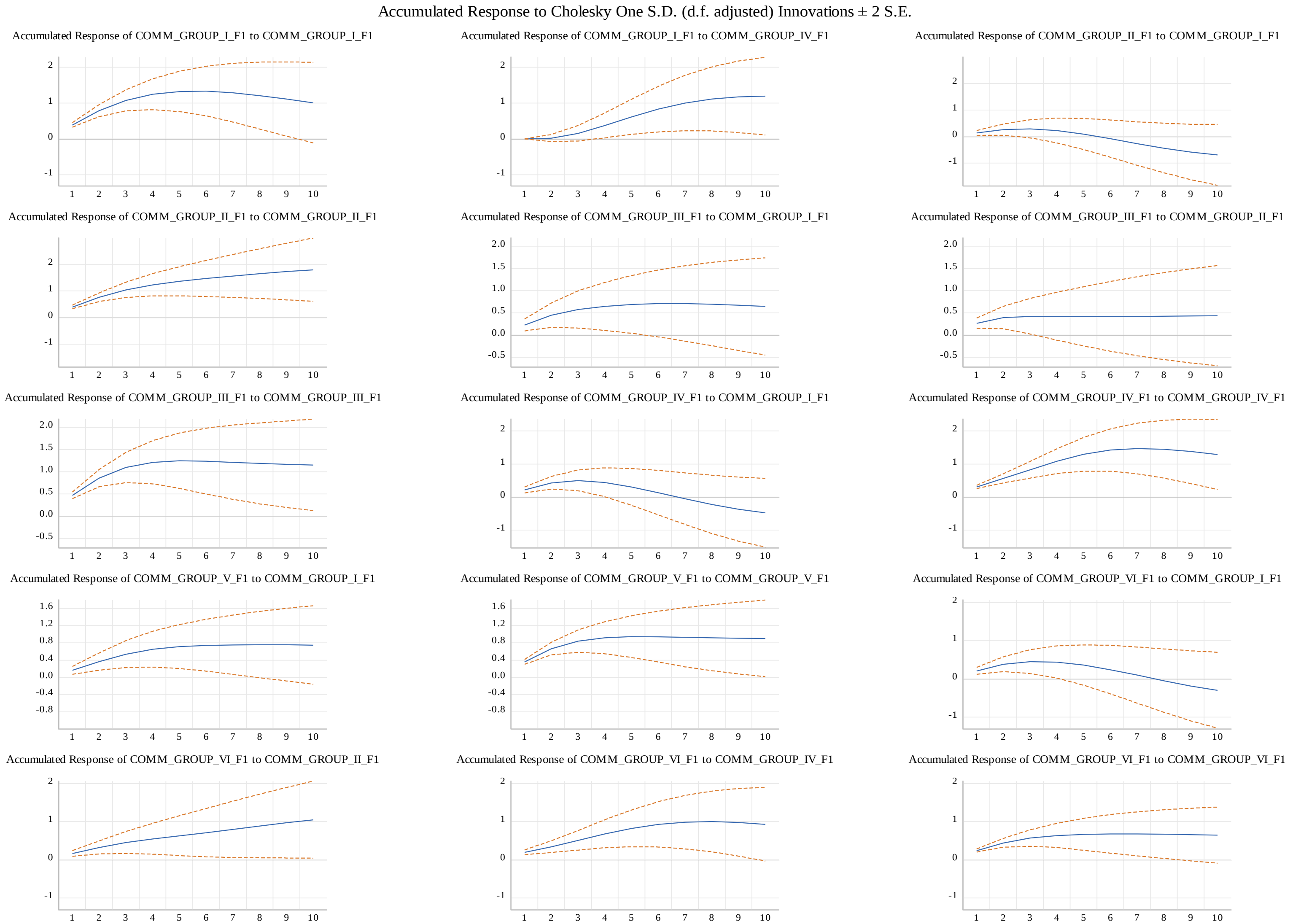
Note: Full sample estimates (see text). Range of unconditional correlations across five different estimates of the time series of structural shocks. In the model where commodity prices are endogenous 4 sets of structural shocks were estimated. See the text for the restrictions imposed to identify the structural shocks.

Illustrating the Impact of Data Transformations: UK Housing Prices



Note: The top figure shows the log level of housing prices. The middle figures shows three versions of real GDP. They are: Hamilton filtered log real GDP (RGDPH), HP filtered (lambda=1600) real GDP (RGDPHP), and the growth rate of real GDP (100 times first log difference in real GDP). The bottom figure shows the same transformations applied to the middle figure to housing prices. Notice that the ‘swings’ in the data are larger than when using either two filter.

Accumulated Impulse Responses to Varieties of Commodity Price Shocks



Note: Commodity groups are defined in an earlier table above. All IRFs rely on time-varying factor scores as explained in the main body of the text.

Alternative Shadow Policy Rates

Sources: See main body of the paper.

Partial Correlations Between VIX and EPU or MPU

	VIX	AU_MPU	BR_MPU	CA_MPU	CL_MPU	CN_MPU	EZ_MPU	GB_MPU	HK_MPU	ID_MPU	JP_MPU	KR_MPU	MX_MPU	MY_MPU	NO_MPU	NZ_MPU	PE_MPU	RU_MPU	TH_MPU	US_MPU	ZA_MPU
VIX	1.00	-0.19	0.10	-0.04	-0.35	0.25	0.30	0.02	-0.28	-0.10	-0.22	-0.02	-0.27	-0.11	-0.04	-0.30	0.19	0.07	-0.03	-0.14	0.34
AU_MPU	-0.19	1.00	-0.09	-0.04	-0.23	0.05	0.15	0.30	-0.29	-0.01	0.05	-0.21	-0.00	0.23	0.53	0.43	0.34	0.46	-0.12	-0.36	0.15
BR_MPU	0.10	-0.09	1.00	0.02	0.36	-0.32	-0.26	0.41	-0.26	-0.21	0.01	-0.03	-0.10	0.31	0.19	-0.15	0.25	0.15	0.46	-0.09	-0.07
CA_MPU	-0.04	-0.04	0.02	1.00	-0.10	0.24	0.30	-0.21	0.04	0.16	-0.32	0.16	0.04	-0.20	0.07	0.20	-0.18	-0.03	-0.01	0.53	0.22
CL_MPU	-0.35	-0.23	0.36	-0.10	1.00	0.02	0.28	0.17	-0.09	0.40	-0.18	-0.01	0.16	-0.09	0.38	0.15	0.36	0.22	-0.41	-0.22	0.33
CN_MPU	0.25	0.05	-0.32	0.24	0.02	1.00	-0.30	0.29	0.06	0.05	-0.08	-0.00	0.37	0.37	0.26	-0.01	-0.03	0.15	-0.01	-0.23	0.23
EZ_MPU	0.30	0.15	-0.26	0.30	0.28	-0.30	1.00	0.19	0.01	0.10	0.09	-0.02	0.17	0.25	-0.13	-0.05	-0.29	0.14	0.08	0.17	0.10
GB_MPU	0.02	0.30	0.41	-0.21	0.17	0.29	0.19	1.00	0.46	-0.16	0.01	0.02	0.10	-0.41	-0.38	0.11	-0.32	-0.30	0.05	0.56	0.05
HK_MPU	-0.28	-0.29	-0.26	0.04	-0.09	0.06	0.01	0.46	1.00	0.40	0.15	0.04	-0.15	0.50	0.37	0.04	0.58	0.28	-0.35	-0.29	-0.11
ID_MPU	-0.10	-0.01	-0.21	0.16	0.40	0.05	0.10	-0.16	0.40	1.00	0.09	0.02	-0.10	-0.15	-0.31	-0.39	-0.30	-0.14	0.74	-0.14	-0.04
JP_MPU	-0.22	0.05	0.01	-0.32	-0.18	-0.08	0.09	0.01	0.15	0.09	1.00	0.22	0.03	-0.15	0.06	-0.08	-0.11	-0.12	-0.04	0.17	0.14
KR_MPU	-0.02	-0.21	-0.03	0.16	-0.01	-0.00	-0.02	0.02	0.04	0.02	0.22	1.00	-0.14	0.33	0.12	0.35	0.35	0.11	0.12	-0.07	-0.17
MX_MPU	-0.27	-0.00	-0.10	0.04	0.16	0.37	0.17	0.10	-0.15	-0.10	0.03	-0.14	1.00	-0.02	-0.27	-0.13	0.14	0.04	0.31	0.12	-0.18
MY_MPU	-0.11	0.23	0.31	-0.20	-0.09	0.37	0.25	-0.41	0.50	-0.15	-0.15	0.33	-0.02	1.00	-0.18	0.04	-0.27	-0.16	0.05	0.29	0.21
NO_MPU	-0.04	0.53	0.19	0.07	0.38	0.26	-0.13	-0.38	0.37	-0.31	0.06	0.12	-0.27	-0.18	1.00	-0.44	-0.51	-0.48	0.26	0.39	-0.04
NZ_MPU	-0.30	0.43	-0.15	0.20	0.15	-0.01	-0.05	0.11	0.04	-0.39	-0.08	0.35	-0.13	0.04	-0.44	1.00	-0.23	-0.32	0.31	-0.21	0.11
PE_MPU	0.19	0.34	0.25	-0.18	0.36	-0.03	-0.29	-0.32	0.58	-0.30	-0.11	0.35	0.14	-0.27	-0.51	-0.23	1.00	-0.30	0.19	0.36	0.24
RU_MPU	0.07	0.46	0.15	-0.03	0.22	0.15	0.14	-0.30	0.28	-0.14	-0.12	0.11	0.04	-0.16	-0.48	-0.32	-0.30	1.00	0.24	0.16	-0.20
TH_MPU	-0.03	-0.12	0.46	-0.01	-0.41	-0.01	0.08	0.05	-0.35	0.74	-0.04	0.12	0.31	0.05	0.26	0.31	0.19	0.24	1.00	-0.06	0.09
US_MPU	-0.14	-0.36	-0.09	0.53	-0.22	-0.23	0.17	0.56	-0.29	-0.14	0.17	-0.07	0.12	0.29	0.39	-0.21	0.36	0.16	-0.06	1.00	0.00
ZA_MPU	0.34	0.15	-0.07	0.22	0.33	0.23	0.10	0.05	-0.11	-0.04	0.14	-0.17	-0.18	0.21	-0.04	0.11	0.24	-0.20	0.09	0.00	1.00

	VIX	AU_EPU	BR_EPU	CA_EPU	CL_EPU	CN_EPU	EZ_EPU	GB_EPU	HK_EPU	JP_EPU	KR_EPU	MX_EPU
VIX	1.00	0.26	0.39	0.33	-0.01	-0.30	-0.30	-0.04	-0.47	0.51	0.17	0.30
AU_EPU	0.26	1.00	-0.35	0.19	-0.10	0.30	0.30	-0.16	0.08	0.31	0.32	-0.10
BR_EPU	0.39	-0.35	1.00	0.08	0.26	0.22	0.22	-0.15	0.31	-0.16	0.17	-0.38
CA_EPU	0.33	0.19	0.08	1.00	0.15	0.33	0.33	0.15	0.22	-0.12	-0.01	-0.23
CL_EPU	-0.01	-0.10	0.26	0.15	1.00	0.25	0.25	-0.24	-0.08	0.14	-0.21	0.25
CN_EPU	-0.30	0.30	0.22	0.33	0.25	1.00	-1.00	0.74	-0.18	0.05	0.05	0.40
EZ_EPU	-0.30	0.30	0.22	0.33	0.25	-1.00	1.00	0.74	-0.18	0.05	0.05	0.40
GB_EPU	-0.04	-0.16	-0.15	0.15	-0.24	0.74	0.74	1.00	0.17	0.06	0.17	-0.44
HK_EPU	-0.47	0.08	0.31	0.22	-0.08	-0.18	-0.18	0.17	1.00	0.47	-0.06	0.15
JP_EPU	0.51	0.31	-0.16	-0.12	0.14	0.05	0.05	0.06	0.47	1.00	-0.25	0.09
KR_EPU	0.17	0.32	0.17	-0.01	-0.21	0.05	0.05	0.17	-0.06	-0.25	1.00	0.28
MX_EPU	0.30	-0.10	-0.38	-0.23	0.25	0.40	0.40	-0.44	0.15	0.09	0.28	1.00

Note: EPU is the economic policy uncertainty index from http://www.policyuncertainty.com/. MPU is the monetary policy uncertainty index explained above. VIX is the CBOE volatility index. The shaded areas indicate partial correlations statistically significant at at least the 10% level.

Selected Unconditional Correlations:
US Factor Score and Factor Scores in Other Economies

ECONOMY	REAL		FINANCIAL		MONETARY	
	full	TV	full	TV	full	TV
AU	0.30*	0.21*	-0.87*	0.36*	-0.02	0.28*
BR	0.35*	0.16	0.49*	-0.62*	-0.28*	-0.66*
CA	0.60*	0.21*	-0.69*	-0.49*	-0.39*	-0.22
CL	0.73*	0.76*	-0.29*	-0.63*	-0.22	-0.36*
CN	0.27*	0.40*	-0.53*	-0.42*	-0.16	-0.22
EZ	0.36*	0.13*	0.54*	-0.64*	-0.51*	-0.29*
GB	0.51*	0.51*	0.17	0.83*	0.52*	0.07
HK	0.14	0.67*	0.23*	0.55*	-0.55*	0.19
ID	0.40*	0.24*	0.06	0.13	-0.40*	-0.25*
JP	0.34*	0.71*	0.86*	-0.85*	-0.30*	-0.18
KR	0.65*	0.53*	-0.48*	-0.42*	0.31*	-0.02
MX	0.20	0.43*	-0.43*	-0.37*	0.06	-0.33*
MY	0.23*	0.48*	-0.43*	-0.54*	0.11	-0.57*
NO	0.49*	0.47*	0.73*	0.72*	0.14	-0.26*
NZ	0.30*	0.46*	0.89*	0.93*	-0.09	-0.31*
PE	0.42*	0.53*	-0.46*	-0.59*	-0.42*	-0.52*
RU	0.43*	0.34*	0.46*	0.54*	-0.21	-0.46*
TH	0.61*	0.42*	-0.25*	-0.22	0.31*	-0.36*
ZA	0.71*	0.19	0.73*	-0.42*	0.16	0.07

*Denotes correlations statistically significant at least at the 10% level. Full means full sample estimates; TV means based on time-varying estimates explained in the paper.