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China's role in global inflation dynamics

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Non-technical summary

The global dimension of inflation has become a popular theme for economic researchers in academia and central banks. It has been shown that inflation rates across countries strongly comove due to domestic inflation rates being determined, among others, by foreign or global common forces. China's role in these developments is, however, still somewhat unclear.

The significance of China for the world economy has risen enormously over the past 20 years in terms of both GDP and trade. Observers have speculated whether (positive) demand effects in China and subsequent positive effects on international price developments (via rising export and commodity prices) or whether supply effects and subsequent price dampening effects (via declining import prices and competitive pressures) have dominated in the past and, hence, what the net effect of these developments was. The goal of this analysis is to examine empirically the role of Chinese supply and demand shocks in global inflation dynamics and to shed light on the transmission mechanism.

We apply a structural dynamic factor model to a large quarterly dataset of 38 countries (including China) between 2002 and 2011 to analyze China's role in global inflation dynamics. We identify Chinese supply and demand shocks and examine their contributions to global price dynamics and the transmission mechanism. Our main findings are as follows. (i) Chinese supply and demand shocks affect prices in other countries significantly. Demand shocks matter slightly more over the sample period than supply shocks. Producer prices tend to be more strongly affected than consumer prices by Chinese shocks. The overall share explained of international inflation by Chinese shocks is notable (about 5 percent on average over all countries but not more than 13 percent in each region). (ii) Both direct channels (via import and export prices) and indirect channels (via greater exposure to foreign competition and commodity prices) seem to matter. (iii) Differences in trade exposure (overall and with China) as well as commodity exposure help explaining cross-country differences in price responses.

Nicht-technische Zusammenfassung

Der globale Zusammenhang zwischen Inflationsraten ist zu einem beliebten Thema für Wirtschaftsforscher in Universitäten und Zentralbanken geworden. So ist etwa gezeigt worden, dass Inflationsraten über Ländergrenzen hinweg einen Gleichlauf aufweisen, weil die heimische Teuerung unter anderem von gemeinsamen ausländischen beziehungsweise globalen Kräften getrieben wird. Die Rolle Chinas innerhalb dieses Wirkungsgeflechts ist jedoch noch weithin ungeklärt.

Die Bedeutung Chinas für die Weltwirtschaft, gemessen an seinem Anteil sowohl am Bruttoinlandsprodukt als auch am internationalen Handel, ist in den letzten 20 Jahren enorm gestiegen. Beobachter spekulieren darüber, ob in der Vergangenheit (positive) Nachfrageeffekte aus China mit preissteigernder Wirkung (etwa über höhere Export- und Rohstoffpreise) dominierten oder aber Angebotseffekte mit preisdämpfendem Effekt (über niedrigere Importpreise und verstärkten Wettbewerbsdruck) und mithin, wie groß der Einfluss Chinas per saldo gewesen ist.

Wir wenden ein strukturelles dynamisches Faktormodell auf einen umfangreichen Satz vierteljährlicher Daten für 38 Länder (einschließlich Chinas) über dem Zeitraum von 2002 bis 2011 an, um die Rolle Chinas in der globalen Inflationsentwicklung zu untersuchen. Wir identifizieren chinesische Angebots- und Nachfrageschocks, schätzen deren Beiträge zur globalen Preisentwicklung ab und beleuchten den Transmissionsmechanismus. Unsere wichtigsten Ergebnisse sind wie folgt. (i) Chinesische Angebots- und Nachfrageschocks üben einen signifikanten Einfluss auf Preise in anderen Ländern aus. Dabei sind Nachfrageschocks im Beobachtungszeitraum etwas bedeutsamer gewesen als Angebotsschocks. Der gesamte Anteil an der globalen Inflation, den chinesische Schocks erklären, ist nicht zu vernachlässigen (rund 5 Prozent im Durchschnitt aller Länder, aber nicht mehr als 13 Prozent in einzelnen Regionen). (ii) Sowohl direkte Wirkungskanäle (über Import- und Exportpreise) als auch indirekte (über internationalen Wettbewerbsdruck und Rohstoffpreise) sind von Bedeutung. (iii) Unterschiede zwischen einzelnen Ländern in der Preisreaktion können auf den Grad der internationalen Handelsverflechtung (insgesamt und mit China) und auf die Bedeutung von Rohstoffen für die Volkswirtschaften zurückgeführt werden.

China's Role in Global Inflation Dynamics*

Sandra Eickmeier† Markus Kühnlenz‡

Abstract

We apply a structural dynamic factor model to a large quarterly dataset covering 38 countries between 2002 and 2011 to analyze China's role in global inflation dynamics. We identify Chinese supply and demand shocks and examine their contributions to global price dynamics and the transmission mechanism. Our main findings are: (i) Chinese supply and demand shocks affect prices in other countries significantly. Demand shocks matter slightly more than supply shocks. Producer prices tend to be more strongly affected than consumer prices by Chinese shocks. The overall share of international inflation explained by Chinese shocks is notable (about 5 percent on average over all countries but not more than 13 percent in each region); (ii) Direct channels (via import and export prices) and indirect channels (via greater exposure to foreign competition and commodity prices) seem both to matter; (iii) Differences in trade (overall and with China) and in commodity exposure help explaining cross-country differences in price responses.

JEL classification: F41, E31, C3

Keywords: Global inflation, China, international business cycles, structural dynamic factor model, sign restrictions

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1 Introduction

The global dimension of inflation has become a popular theme for economic researchers in academia and at central banks. As shown, for example, by Ciccarelli and Mojon (2010) and Mumtaz and Surico (forthcoming), inflation rates across countries strongly comove due to domestic inflation rates being determined, among other things, by external or global forces (e.g. Borio and Filardo (2007), Eickmeier and Pijnenburg (2013)).

At the same time, China's significance for the world economy has increased enormously over the past 20 years in terms of GDP and trade.[1] China's growth has been driven by fundamental changes on both the supply side and the demand side. Labor has been amply supplied at low wages, and in labor-intensive segments, China has achieved a leading market position. Moreover, privatization and trade liberalization have triggered a shift of resources across and within sectors leading to a surge in manufacturing productivity (Zhu (2012)).[2] In addition, China has greatly diversified its export goods and improved the quality of its products. While churning out manufactured goods for consumers worldwide, China has become a major, and often dominant importer of commodities. With incomes on the rise, China's internal demand and appetite for both capital and consumer goods produced abroad has expanded rapidly as well.

It is likely that these developments have affected other countries' (subsequently labeled "foreign" as opposed to Chinese) inflation rates and contributed to their comovement. Most observers have focused on positive demand effects from China on foreign prices through rising export and commodity prices and on price-dampening supply effects through low-cost production in China and subsequently declining import prices as well as lower profit margins as a consequence of competitive pressures. It has also been suggested that the mix of influences might have changed recently with wages in China on the rise (Li, Li, Wu and Xiong (2012)).

Whether positive macroeconomic developments in China are quantitatively important for foreign inflation rates, whether they have affected foreign prices positively or negatively and through which channels is far from clear.

The goal of this analysis is to examine empirically the role of Chinese supply and demand shocks in global inflation dynamics and to shed light on the transmission mechanism. For that purpose, we use a structural dynamic factor model (DFM) which has

[1] China is now the second-largest economy and achieved a 10 percent share of global output in 2011, as measured by current prices and market exchange rates. China's nominal exports have grown at an average annual rate of 22 percent since its accession to the World Trade Organization (WTO) in December 2001, compared with an 11 percent annual expansion of world trade over the same period. As a result, China's share of (nominal) world exports is now almost 11 percent, making it the largest trading nation. Around 12 percent of OECD countries' total imports came from China; in manufactured goods alone, the share is at 19 percent.

[2] A formal growth model based on reallocation between low-productivity state-owned firms and high-productivity private enterprises within the manufacturing sector has been proposed by Song, Storesletten and Zilibotti (2011).

been suggested by Forni, Hallin, Lippi and Reichlin (2000). The DFM allows rich and flexible modelling of the different ways in which shocks propagate throughout the world, while keeping dimensionality manageable. We estimate factors from two separate large datasets, one set of Chinese and one set of foreign quarterly macroeconomic variables from 2002 to 2011. The latter dataset contains more than 800 quarterly macroeconomic variables from 37 advanced and emerging market economies, covering, for each country, several price measures (including consumer and producer prices, exchange rates, commodity prices, labor costs) and other variables which are useful in analyzing the transmission channels (including interest rates, monetary aggregates, real activity variables). We model the Chinese and the global factors together in a vector autoregression (VAR). Chinese supply and demand shocks are then identified by imposing sign restrictions on short-run impulse response functions. We provide results on the shocks' dynamic transmission to foreign consumer and producer prices. We then analyze the propagation mechanism (i) by looking at the impulse responses of variables capturing the transmission channels of Chinese shocks and (ii) by trying to explain cross-country differences in price reactions with differences in country characteristics such as openness, exposure to commodities, the degree of regulation on labor and goods markets and the economic structure. We also carry out variance decompositions of international inflation dynamics in order to assess the importance of Chinese supply and demand shocks over the sample period.

Our main findings are as follows: (i) Chinese supply and demand shocks significantly affect prices in other countries. Demand shocks matter slightly more between 2002 and 2011 than supply shocks. Producer prices tend to be more strongly affected than are consumer prices by Chinese shocks. The overall share of foreign inflation explained by Chinese shocks is notable (about 5 percent on average over all countries but not more than 13 percent in each region); (ii) Direct channels (via import and export prices) and indirect channels (via greater exposure to foreign competition and commodity prices) both seem to matter; (iii) Differences in trade (overall and with China) and in commodity exposure help explaining cross-country differences in price responses.

The rest of the paper is structured as follows. In Section 2, we briefly review the literature that is most relevant to our paper and set out our contributions. We present the DFM framework in Section 3. In Section 4, we provide details on the data. Section 5 presents impulse response results on the international transmission of Chinese supply and demand shocks and contributions made by the shocks to inflation in other countries. It also sheds light on the transmission mechanisms and presents several robustness checks. Section 6 concludes.

2 Related literature and contributions

Our paper is closely related to the recent empirical literature on global inflation, according to which inflation rates comove strongly across countries (Ciccarelli and Mojon (2010), Mumtaz and Surico (forthcoming)). Ciccarelli and Mojon (2010) extract common factors from a large set of advanced economies' inflation rates and find that the first factor alone explains 40-90 percent of inflation and 2-80 percent of detrended inflation, depending on the country. Mumtaz and Surico (forthcoming) pool various inflation rates for advanced countries and estimate both country-specific and world factors using a factor model with time-varying parameters. They find that world factors contribute between virtually nothing and about 10 percent to the variation in inflation rates since 1995.

Other studies analyze the reasons for highly synchronized inflation rates (and output growth), while focusing on the role of China. Osorio and Unsal (2011) examine the international transmission of shocks from China to foreign inflation using a Global VAR model and generalized impulse response functions.[3] They look at the transmission of Chinese output shocks to world commodity prices and to Australasian economies. They find that such shocks, which also raise consumer price inflation and output in China (and hence, can be regarded as Chinese demand shocks), cause world commodity prices to increase temporarily after a delay of two quarters. Direct effects in the transmission to other countries' prices (through higher imported goods prices) are found to be more important than indirect effects (through an increase in commodity prices). Aggregate (domestic and foreign) demand and supply shocks appear to contribute about 60 percent and 40 percent, respectively, to China's inflation. Furthermore, more than 80 percent of China's inflation is explained by domestic shocks, about 2 percent by regional shocks, and the rest by global shocks. Regional shocks (which now include Chinese shocks) do not explain more than 10 percent in any Asian country under investigation and a very small percentage also in New Zealand, but they account for roughly one-fifth of the fluctuations in Australia's prices.

Côté and de Resende (2008) is another very closely related study. It assesses China's role for inflation in 18 OECD countries between 1984 and 2006 by estimating dynamic inflation equations and by analyzing the various transmission channels listed in the introduction by means of counterfactual experiments. The authors find that the overall effect of economic fluctuations in China on inflation in most countries is negative, suggesting that supply effects from expansionary shocks dominate demand effects. The most important transmission channel appears to be competition with domestic suppliers. Moreover, the role of China is found to have increased over time.

Finally, there are studies which focus on one or few individual channels of transmission

[3] Cesa-Bianchi, Pesaran, Rebucci and Xu (forthcoming) and Feldkircher and Korhonen (2012) use Global VARs to assess the transmission of Chinese output shocks to output in other regions also using generalized impulse response functions. They do not look at inflation reactions.

of Chinese shocks to other countries' inflation. Mandel (2013) assesses the relationship between Chinese competition and two components of US import prices: marginal costs and markups. He finds evidence for non-Chinese exporters having experienced a squeeze in markups and having shifted towards higher quality products which resulted in increased marginal costs as a consequence of China entering into exporting. Feyziogulu and Willard (2006), Kumar, Taimur, Decressin, MacDonagh and Feyziogulu (2003), Kamin, Marazzi and Schindler (2006) and Morel (2007) analyze the role of import prices and find a moderate decline in inflation rates in advanced economies and Asia through that channel. Roache (2012) finds a limited role of shocks to Chinese activity for world commodity prices. Aastveit, Bjoernland and Thorsrud (2012) look at the contribution of emerging compared with advanced economies' demand to oil price fluctuations and find the former (particularly demand from emerging Asia) to be more important than the latter.

We make several contributions to the literature. First, and most importantly, our model allows us to include a large number of variables from many countries and, hence, to analyze not only the net effect on inflation of Chinese macroeconomic developments, but also to investigate the transmission mechanism in greater detail than previous studies do. We look at direct channels (via trade) and indirect channels (via commodity prices and greater exposure to foreign competition). Second, we focus on identified, orthogonal shocks, unlike the Global VAR studies presented above which use generalized impulse responses to non-orthogonal shocks which are hard to interpret economically. Third, compared to other studies estimating the impact of foreign influences on domestic inflation based, for example, on Phillips curves (Borio and Filardo (2007), Eickmeier and Pijnenburg (2013)) we fully account for interaction between foreign variables and between foreign and Chinese variables.

3 The structural dynamic factor model

The analysis departs from two N_{CN}- and N_G-dimensional vectors X_t^{CN} and X_t^G. X_t^{CN} includes a large number (N_{CN}) of economic variables for China, and X_t^G, the "global dataset", includes a large number (N_G) of series from other countries. Let $X_t = (X_t^{CN\prime}, X_t^{G\prime})'$ and $N = N_{CN} + N_G$. X_t is modeled using an approximate dynamic factor model (Bai and Ng (2002), Stock and Watson (2002*b*)):

$$X_t = \Lambda' F_t + e_t \tag{3.1}$$

In equation (3.1), $F_t = (f_{1t}, \ldots, f_{rt})'$ and $e_t = (e_{1t}, \ldots, e_{Nt})'$ denote, respectively, a vector of common factors that have a major effect on all foreign and Chinese variables and may thus be regarded as the main (common) drivers of the foreign economies, and a vector of variable-specific (or idiosyncratic) components. The number of common factors is generally much smaller than the number of variables contained in the dataset, i.e. $r << N$. In addition, F_t may contain dynamic factors and their lags. To that extent, equation (3.1) is not restrictive. Common and variable-specific components are orthogonal. The common factors are also assumed to be orthogonal to each other, and the variable-specific components can be weakly correlated with one another and also serially correlated in the sense of Chamberlain and Rothschild (1983). The matrix of factor loadings is $\Lambda = (\lambda_1, \ldots, \lambda_N)$, where λ_i is an r-dimensional vector whose elements measure the effect of each factor on variable i, $i = 1, ..., N$.

It is assumed that the dynamics of the factors can be described using a VAR(p) model:

$$F_t = B_1 F_{t-1} + \ldots + B_p F_{t-p} + w_t, \quad E(w_t) = 0,\ E(w_t w_t') = \Omega. \tag{3.2}$$

Since factors are estimated from demeaned data, there is no need to consider constants in the VAR.

We break down the r-dimensional vector of factors F_t into an r_{CN}-dimensional vector of unobserved (or latent) Chinese factors F_t^{CN} and an $r_G = r - r_{CN}$-dimensional vector of unobserved global factors F_t^G, i.e. $F_t = (F_t^{CN\prime}, F_t^{G\prime})'$. The vector of innovations w_t depends on Chinese and global shocks.

The model can be estimated in six steps. The first step is to estimate the r_{CN} Chinese factors from the Chinese dataset with principal components, which yields $\widehat{F_t^{CN}}$. Second, we remove the influence of the Chinese factors from the international data. This is achieved by regressing each element of X_t^G on $\widehat{F_t^{CN}}$. This helps reducing the dimension of the VAR.[4] Third, we estimate the global factors from the set of residuals from those regressions, which yields $\widehat{F_t^G}$. Fourth, we estimate the matrix of factor loadings Λ by an OLS regression of X_t on $(\widehat{F_t^{CN}}\prime, \widehat{F_t^G}\prime)'$. Fifth, we estimate the VAR (3.2) with OLS equation-wise. Sixth, we identify Chinese supply and demand shocks, as explained in detail below.

The numbers of common global and Chinese factors are determined throughout the paper by the information criterion IC_{p2} of Bai and Ng (2002), which has been shown to perform well in small samples. According to this criterion, we set r_{CN} and r_G to 2. 2 factors explain 39 percent of the variation in the Chinese dataset, and 2 "global" factors explain 25 percent of the variation in the international data (after having removed the Chinese influence). We will show in the robustness check section below that increasing the number of factors does not alter our main results.

To identify the Chinese supply and demand shocks, we first apply a Cholesky decomposition to the covariance matrix of the reduced-form VAR residuals w_t. The orthogonalized shocks v_t are related to the reduced-form residuals as follows: $v_t = \Phi w_t$.

We then rotate v_t and impose sign restrictions to identify Chinese supply and demand

[4] We have repeated the entire analysis without this "cleaning step". Cleaning does not have a major effect on our main results. Results are available upon request.

shocks, which are given by two elements of $\eta_t = Rv_t$. We restrict supply shocks to move Chinese real activity (measured by GDP) and prices (measured by CPI and PPI) in opposite directions, whereas demand shocks are assumed to move them in the same direction. Moreover, the Chinese shocks are restricted to have a stronger impact on Chinese GDP than on all other countries' GDP. All other (r_G global) shocks are, in addition, restricted not to have the same characteristics as the Chinese shocks. The sign restrictions are summarized in Table 1. They are imposed on the contemporaneous impulse responses and the first four lags except for the sign restrictions on relative GDP which are imposed on impact only.

The sign restrictions on Chinese activity and prices are consistent with a large number of theoretical models (e.g. the IS-LM model or new Keynesian models such as Smets and Wouters (2003)) and have been used before in empirical work (e.g. Peersman (2005)). We restrict both consumer and producer prices since they are not based on the same basket of goods (and services). The food component is very important in the Chinese CPI accounting for roughly 30 percent of China's CPI basket (ADB (2011)), whereas other goods such as industrials which have a large weight in trade among advanced economies receive a greater weight in the PPI. Restrictions on one variable relative to another variable (Chinese relative to other countries' GDP in our case) have also been applied in empirical work before in similar (Farrant and Peersman (2006)) and in other contexts (e.g. Eickmeier and Ng (2011), Furlanetto, Ravazzolo and Sarferaz (2012)). We also emphasize that it is less restrictive to apply the sign restrictions on relative GDP rather than, for example, ordering Chinese factors before global factors or vice versa and applying zero contemporaneous restrictions. Our identification scheme allows Chinese factors to react immediately to global shocks and global factors to react immediately to Chinese shocks, which would not have been the case under either of the two possible alternative orderings.

The identification is implemented using the method by Rubio-Ramírez, Waggoner and Zha (2010). It is well known that sign restrictions do not allow us to achieve unique identification of shocks (see Fry and Pagan (2011)). Instead, a large number of models are consistent with the restrictions. We draw rotation matrices until 200 of them yield us shocks consistent with the sign restrictions. We adopt the "Median Target" approach suggested by Fry and Pagan (2007) to pick among all models the one which yields impulse responses of Chinese GDP and prices to the two shocks close to the median impulse responses. For more details on the implementation of the sign restrictions, see Rubio-Ramírez et al. (2010) and Fry and Pagan (2007).

Impulse responses to the Chinese shocks of the individual variables in the large datasets can be computed as weighted averages over impulse responses of estimated Chinese and global factors where the weights are the estimated loadings. We show below median impulse responses and 90% confidence bands which reflect parameter (not model) uncertainty. We assess below how large model uncertainty is and whether not considering it in our baseline poses a problem. The confidence bands are constructed using the bootstrap-after-bootstrap methodology proposed by Kilian (1997) with 400 replications. In the bootstrap, we neglect the uncertainty involved with the factor estimation following Bernanke, Boivin and Eliasz (2005) because of the large cross-section dimensions.[5]

4 Data

Our sample period is 2002Q1-2011Q2 and therefore starts just after China's accession to the WTO in December 2001. We test robustness with respect to the sample period, which we extend back to 1995Q4 in the robustness check section.

The Chinese dataset contains $N_{CN} = 32$ macroeconomic variables. It comprises several activity indicators, price and cost measures, survey-based confidence and expectation measures, monetary aggregates and interest rates.

The global dataset includes data for 37 countries, if available: OECD countries, Brazil, Colombia and several emerging Asian economies (i.e. Thailand, Indonesia, Malaysia, Taiwan and Singapore). Including the last-named group of countries helps us to disentangle Chinese shocks from shocks stemming from the rest of Emerging Asia. The variables considered are interest rates (overnight rates, 3-month money market rates, long-term government bond yields), a broad monetary aggregate M2, real economic activity indicators (GDP, personal consumption, fixed investment, employment, the unemployment rate, exports (total and to China), imports (total and from China), price and cost variables (CPI, PPI, GDP deflator, earnings[6], unit labor costs[7], import and export prices, exchange rates). In addition, several international commodity price aggregates and selected price series for single commodities are included. The overall number of series contained in the global dataset is $N_G = 821$.

For the international dataset, we largely rely on series provided by the OECD's Main Economic Indicators (MEI) database and the IMF's World Economic Outlook (WEO) database. For China, we mainly use official national data as provided by Haver Analytics.

Some series were available only at annual frequency, especially a few series from China, and we interpolated them using the cubic spline method. Since the factor model requires the variables to be stationary, they were transformed accordingly. We include interest rates and unemployment rates in levels and all other variables in quarter-on-quarter differences of the logarithms. Outliers were removed following the procedure proposed by Stock and

[5] Boivin and Ng (2006) show in Monte Carlo simulations that about 30 series are sufficient to obtain accurate factor forecasts using principal components.

[6] According to the OECD definition, earnings include overtime payments and various bonuses in addition to basic wages, whereas employer contributions to social security (which would be included in compensation of employees) are not taken into account.

[7] We use, when available, a smoothed series of the unit labor costs in the manufacturing sector provided by national sources. The smoothed series are published by the OECD.

Watson (2005).[8] Our dataset is unbalanced, i.e. some series are not available over the entire sample period. We use the expectation maximization (EM) algorithm to interpolate these series (see Stock and Watson (2002*a*) for details). We only interpolate (and include) data for which at least five years of data are available. Finally, we normalize each series to have a zero mean and a unit variance.

An overview of the complete datasets is provided in Table A.1.

5 Results

In this section, we first show impulse responses to Chinese supply and demand shocks and variance decompositions of the (key) Chinese variables which we restricted for shock identification (GDP and prices). We then analyze the shock transmission to international prices. We also present variance decompositions for international inflation rates. To limit the number of results shown we provide impulse responses and variance decompositions for consumer and producer prices on average over countries belonging to specific regions: "North America" (US, Canada), "Euro area" (as of 2006: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal), "Other European countries" (Switzerland, Denmark, United Kingdom, Norway, Sweden), "CEECs" (Central and East European countries: Czech Republic, Estonia, Hungary, Poland, Slovenia, Slovakia), "Australia-New Zealand", "Asia ex CN" (Japan, Korea, Thailand, Indonesia, Malaysia, Singapore, Taiwan) and "Latin America" (Chile, Mexico, Brazil, Colombia). Results are aggregated using nominal GDP weights (in US dollar terms based on market exchange rates) averaged over our sample period. To analyze the transmission mechanism, we then provide impulse responses of variables capturing the different transmission channels and relate individual countries' reactions to the shocks to country-specific characteristics. Finally, we carry out robustness checks.

5.1 Chinese supply and demand shocks and transmission to key Chinese variables

Figure 1 shows reactions of key Chinese variables to the Chinese supply and demand shocks. The Chinese supply shock has a permanent positive effect on GDP, which rises on impact by almost 0.1 percent (median response) and then increases further to more than 0.15 percent after seven quarters. The effects of the supply shock on Chinese CPI and PPI are very long-lasting (they decline by about 0.1 percent and 0.2 percent, respectively). The Chinese demand shock has an immediate, but temporary positive effect on Chinese GDP. The maximum of more than 0.2 percent is achieved after one quarter. Chinese consumer

[8] Outliers are here defined as observations of the stationary data with absolute median deviations larger than three times the interquartile range. They are replaced by the median value of the preceding five observations.

and producer prices rise permanently by about 0.3 percent. Overall, the shapes of the impulse responses are broadly as expected.

We also looked at responses of other Chinese variables, which our structural dynamic factor model allows us to do (we do not show them so as not to overload the paper) and which helps us to better understand the characteristics of the identified aggregate supply and demand shocks. We note that the aggregate supply and demand shocks summarize, for example, markup, labor supply and technology shocks and preference and investment shocks, respectively. One notable feature of the (positive) Chinese supply shock is that it leads to an increase in real wages in China which are probably driven by the technology shock component rather than by the markup or labor supply shock components. Those latter shocks would imply a decline in real wages. We will discuss below how this may affect the interpretation of our results for other countries.

Table 2 shows forecast error variance shares of the Chinese variables explained by Chinese supply and demand shocks (first two columns), other global shocks (third column) and idiosyncratic components (last column). The shares were computed from the median impulse responses at the five-year horizon. Chinese supply and demand shocks have some explanatory power for Chinese GDP growth (3 and 12 percent, respectively) and inflation (between 1 and 11 percent, respectively). Global shocks account for 33 percent of Chinese GDP growth and for 16-43 percent of inflation. The finding that demand shocks are more important for inflation in China than supply shocks and the percentage share explained by global shocks of Chinese inflation are broadly in line with Osorio and Unsal (2011). Idiosyncratic components seem to matter quite a lot for Chinese variables which might be due (partly) to the poor quality of Chinese data. We will discuss whether or not this poses a problem in our setup in the robustness section below.

5.2 Transmission of Chinese supply and demand shocks to international prices

Figures 2 and 3 show the effects of the Chinese shocks on foreign consumer and producer prices. After the Chinese supply shock, the CPI declines in almost every region by a maximum of about 0.05 percent after three quarters (median effects). The effects are, however, not significant in North America, and consumer prices in Latin America increase temporarily. The effects on the PPI are even stronger. Producer prices decline by 0.2-0.4 percent; effects are particularly pronounced in Australia-New Zealand.

After the demand shock, the CPI rises significantly in each region with the exception of Latin America. It reaches its maximum of about 0.1 percent after one year. Effects on the CPI and the PPI are particularly strong in North America, Other European countries and Australia-New Zealand. Producer prices do not change significantly or even turn negative temporarily in the CEECs and Latin America.

The finding that the PPI reactions exceed those of the CPI reactions might be explained by the PPI we use being mainly based on tradable manufactured goods. By contrast, in the US, for example, services (excluding energy services) represent 56 percent of the basket underlying the CPI according to the 2009-2010 CPI-U weights, with 31 percent referring solely to the rent of shelter. Another reason could be that any impact on the producer level (which is rather directly affected by external shocks) is not fully passed on to consumers due to imperfect competition. The next sections shed light on the transmission mechanism.

Table 2 shows that Chinese supply shocks explain between 0.4 and 2 (between 1 and 5) percent of the forecast error of foreign consumer (producer) price inflation rates. The percentage shares are particularly large in the euro area and Australasia, whereas they are small in Latin America. Chinese demand shocks tend to explain a larger share than Chinese supply shocks: between 1 percent (in Latin America) and 8 percent (in Other European countries). The shares explained by global shocks are 6-33 percent for CPI inflation and 7-38 percent for PPI inflation, with the bulk, again, accounted for by the idiosyncratic component, which might reflect variable-specific, country-specific or regional factors, broadly in line with the results of Osorio and Unsal (2011) for Australasia.

Overall, our results confirm the strong comovement of inflation rates across countries.[9] However, Chinese shocks seem to be less important than other global shocks for foreign inflation rates. Chinese demand shocks have dominated supply shocks as drivers of international price developments (with some difference across countries and price measures). However, the difference between the contribution of supply and demand shocks is not found to be large. This suggests that the relative size of supply and demand shocks will determine whether deflationary or inflationary effects from China will prevail in the future.

5.3 Transmission mechanism I: Impulse responses of variables capturing transmission channels

We now present impulse responses capturing the various transmission channels through which supply and demand shocks in China can affect prices in other countries.[10] It is possible to distinguish between supply and demand-side channels, on the one hand, and direct (trade-related) and indirect channels, on the other. The supply-side channel can matter for inflation in other countries (directly) through effects on imported goods price developments and (indirectly) through competitive pressures and by lowering margins and bargaining powers in goods and labor markets. Another indirect supply effect would occur if marginal costs increase as foreign producers change the composition of their products

[9] We obtain shares explained by global factors (or shocks) that are somewhat smaller than those found by Ciccarelli and Mojon (2010), who use a similar factor model. This discrepancy is presumably attributable to our estimation of global factors from a much more heterogeneous dataset with different types of variables, whereas their dataset comprises only inflation rates.

[10] Côté and de Resende (2008) provide a useful overview of the channels.

towards higher quality products. The demand channel can have a direct effect on foreign inflation by raising demand for foreign goods and, hence, foreign export prices as well as an indirect effect via higher commodity prices.

It is important to note that Chinese supply shocks may exert both supply-side and demand-side effects abroad, and the same holds for Chinese demand shocks. For example, Chinese supply shocks can lead to an increase in demand for foreign goods or for commodities and therefore an increase in foreign export or commodity prices. Chinese demand shocks, through raising demand for domestic goods, can lead to an increase in foreign import prices which affects supply conditions abroad.

Which channel dominates and whether the overall impact of shocks in China on foreign inflation is positive or negative ultimately need to be solved empirically.

When presenting our results, we differentiate between supply and demand channels, on the one hand, and direct (trade-related) and indirect channels, on the other. We also consider the reaction of monetary policy rates as well as the propagation of the shocks to foreign GDP. Assessing the behavior of GDP after the shocks is interesting *per se* given that the literature on business cycle linkages between China and the rest of the world is still small. Moreover, a weakening or a strengthening of economic activity would imply further downward or upward pressures on prices. We finally note upfront that our modeling framework enables us to look at the effects of shocks on variables capturing the various transmission channels, but not to assess how those changes, in turn, affect consumer and producer price developments.

5.3.1 Transmission mechanism for Chinese supply shocks

Direct transmission The Chinese supply shock seems to be transmitted to foreign prices directly via import prices (Figure 4), consistent, for example, with Feyziogulu and Willard (2006), Kumar et al. (2003), Kamin et al. (2006) and Morel (2007). Import prices decline significantly in all regions except for North America where they temporarily increase (although not significantly). The decline is strongest in Australia-New Zealand (more than 1 percent), followed by Asia and Latin America (both about 0.5 percent). This suggests that the supply-side direct channel is effective.

The demand-side direct channel does, however, not seem to matter in the case of the supply shock, as foreign export prices decline significantly in all regions. Higher Chinese demand for foreign goods would have instead raised export prices.

Indirect transmission The shock also tends to be transmitted indirectly (via competitive pressures), which is consistent with Côté and de Resende (2008) who also find this indirect supply channel to be effective and economically important. Unit labor costs decline in Asia, Australia-New Zealand, North America and the CEECs. Effects are strongest in Asia (almost -0.4 percent). We observe, however, a short-run increase in the other regions. For Latin America, the rise in unit labor costs may have contributed to the rise in the CPI. Similarly, real earnings increase in some countries and decline in others. We recall that we look at aggregate Chinese supply shocks which comprise, e.g., technology, labor supply and markup shocks. This may help interpreting why responses of earnings (and unit labor costs) differ across countries: Positive technology spillover effects possibly exceed negative effects from competitive cost pressures in some countries, but not in others. Another interpretation would be an increase in marginal costs due to a shift towards higher quality products in some countries which would be consistent with Mandel (2013).

We also consider producer prices relative to unit labor costs which reflects firms' profit margins. They go down in all regions, but the decline is not or only marginally significant in North America, Asia and Latin America. For North America, an explanation might be that goods and labor markets are more flexible than in other countries so that prices and wages can adjust quickly.

GDP rises immediately and persistently after the Chinese supply shocks in Australia-New Zealand and Asia, which are major suppliers of commodities and intermediate goods to the Chinese economy. The effects are largest after about one year at 0.1 percent and 0.15 percent, respectively. By contrast, GDP declines initially in all other regions, exerting further downward pressures on foreign prices, and turns insignificant after less than a year.[11]

Moreover, we observe a depreciation of currencies in real effective terms in North and Latin America, and an appreciation and, thus, a worsening of price competitiveness in the other regions.[12] The depreciation in North America may explain why import prices rise there as well (unlike in other regions). North America is typically seen as a large and relatively closed economy, which cannot benefit much from international demand division. Given a large US trade deficit over the entire sample period, a depreciation means a loss of purchasing power and an even higher import bill, thereby dampening GDP.

Finally, monetary policy reacts by lowering interest rates (also relative to inflation) clearly only in Australia-New Zealand, which counteracts the negative reaction of prices to the Chinese supply shocks. Another factor countering the negative effects on prices is the rise of commodity prices to the shocks. Prices of copper, energy and crude oil go

[11] We also note that the negative (Chinese against other countries') GDP correlations are consistent with the international real business cycle model of Backus, Kehoe and Kydland (1992). In this model, positive technology shocks in one country (China) lead to shifts of resources (capital and labor) to the more productive location (China in our case). Consequently, investment, employment and output might decrease in other countries. Similarly, Samuelson (2004) shows that productivity gains in one country brings about a permanent real income per capita loss for its trading partner.

[12] We have replaced the real effective exchange rates with nominal effective exchange rates and re-estimated our model. The responses of the nominal rates to Chinese supply and demand shocks are very similar to the responses of the real rates.

up most strongly, because the Chinese supply shocks trigger an increase in demand for these commodities. Higher commodity prices may also explain the negative GDP effects in the rest of the world excluding Australasia. Overall, the effects on commodity prices are, however, small, and, as we will show below, not very robust across specifications.

5.3.2 Transmission mechanism for Chinese demand shocks

Direct transmission The Chinese demand shock also has clear direct effects on prices in other countries. It raises export prices particularly strongly in North America, Other European countries and Australia-New Zealand (Figure 5). These are also the regions where consumer and producer prices rise most strongly. In Asia, the CEECs and Latin America, however, export prices decline shortly after the shocks, but the response turns insignificant.

Greater demand from China leads to a rise in (nominal) exports to China and in total real exports from all regions pushing export prices up, *ceteris paribus*. (Prices and hence volumes of exports to China are not available.) Exports to China increase in most countries by more than total exports, pointing to direct trade being affected more strongly than trade via third markets.

Import prices in most countries also increase significantly in response to the Chinese demand shock, probably highlighting the effectiveness of the supply-side direct channel, as higher Chinese demand for domestic goods also raises their import prices abroad. On the other hand, higher foreign import prices could also reflect the (indirect) impact of commodity price increases after the Chinese demand shocks, as we will argue below.

Indirect transmission In addition to these direct effects, the Chinese demand shock also affects other countries' consumer and producer prices indirectly. A clear monetary policy reaction is observed for Latin America where policy rates are lowered in response to the Chinese demand shocks (but not for the other regions). This counteracts the negative price reaction in Latin America. Other countries experience ambiguous (and mostly insignificant) reactions of monetary policy rates (despite the observed rise in prices).

The appreciation of currencies in Latin America, the CEECs and in Asia may explain falling export prices (in domestic currencies) as small countries engage in local currency pricing.

Moreover, Figure 5 shows the effects of the Chinese demand shock on various commodity prices. They all increase persistently, and the effects are strongest for crude oil. Especially in Australia-New Zealand as well as in Other European countries (which includes the commodity exporter Norway) the rise in commodity prices has probably contributed to the surge in producer as well as export prices.[13]

[13] The direct and indirect channels are hard to disentangle in this case, as commodities represent a

The latter finding is interesting from two points of view. First, the rise in the price of all commodities after the Chinese demand shock is about ten times greater than the rise in Chinese consumer or producer prices.[14] This suggests that the demand increase is distributed very unevenly across goods and much of it is directed to commodities. Second, Kilian (2009) shows that world aggregate demand shocks are the major drivers of world oil prices. We confirm here that Chinese demand shocks have a strong impact on oil prices. Variance decompositions for commodity price inflation suggest that Chinese demand and supply shocks explain roughly 12 percent of the forecast error variance of crude oil price inflation (the bulk (10 percent) is explained by Chinese demand shocks) and 11 percent of movements of all commodities' prices (Table 2). Shocks to the global factors account for more than 20 percent of the variation in the forecast error of both crude oil and all commodity price inflation. The rest is explained by idiosyncratic factors which, for commodity price inflation, comprise commodity-specific supply and demand shocks and regional- or country-specific shocks. The share explained by Chinese shocks we obtain is consistent with Roache (2012). That study finds, based on a structural VAR estimated over 2000-2011, that Chinese activity shocks account for roughly 7 percent of the variation in world oil prices (and slightly less of the variation in other commodity prices). Our finding regarding the decomposition of oil price developments is also not inconsistent with Aastveit et al. (2012). The share of oil price fluctuations explained by Chinese shocks estimated by us is a bit smaller than the one explained by demand shocks from a larger number of emerging economies, mostly from emerging Asia, estimated by Aastveit et al. (2012) at about 30 percent.

The rise in world commodity prices has probably prevented a positive reaction of GDP in most countries. The Chinese demand shocks are transmitted positively and significantly to GDP only in Australia-New Zealand and Latin America which are commodity net exporters, and in Asia which is a commodity net importer, but where positive trade effects seem to have dominated the negative effects on GDP stemming from commodity prices. Hence, the demand shocks from China also display positive demand effects in the surrounding regions, which have probably pushed prices further upward in these regions. In Latin America, as prices went down, interest rates decreased as well, which can also help explain the positive GDP effect in this region. We note that our estimated foreign GDP effects after Chinese demand shocks are very similar to the GVAR results for Chinese "output shocks" by Feldkircher and Korhonen (2012).[15]

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sizeable portion of overall exports.

[14] Osorio and Unsal (2011) also find an effect (after two quarters) of a Chinese GDP shock on commodity prices which is larger than on consumer prices, although the difference is much smaller than in our case. While commodity prices in their analysis are affected with a time lag, ours react instantaneously to the Chinese demand shocks.

[15] We have also carried out variance decompositions of GDP growth. Chinese demand shocks are more important than supply shocks for all regions. The shares explained by Chinese shocks are between 2

The overall message from this section is that both Chinese supply and demand shocks and channels and both direct and indirect transmission channels seem to matter for inflation in other countries. As byproducts, we find that Chinese shocks account for 11 percent (4 percent) of fluctuations in commodity prices (foreign GDP).

5.4 Transmission mechanism II: Relating price impulse responses to country characteristics

In this section, we exploit the cross-section dimension and relate CPI and PPI impulse responses of individual countries to country characteristics in order to shed more light on the transmission channels. We carry out bivariate OLS and robust regressions (to correct for outliers) of impulse responses of all 37 countries (if available) one year after the Chinese supply and demand shocks on the following determinants: openness (defined as the sum of exports and imports relative to GDP), imports from and exports to China relative to GDP, commodity imports and exports relative to GDP, manufacturing value added relative to GDP, distance of the capital city from Beijing, product market regulation, (regular) employment protection, structural similarity with China. Manufacturing value added and distance are taken from the World Bank World Development Indicators and from the CEPII GeoDist database, respectively. The regulatory variables are taken from OECD (2012) and are measured for 2008 on an index scale of 0-6 from least to most restrictive.[16] The structural similarity of a country j with China is defined as $S_j = \sum_{l=1}^{L} |s_{lj} - s_{lCN}|$, where s_{lj} and s_{lCN} denote the shares of sector l in total exports of country j and China, respectively (see Krugman (1991)).[17] Small values indicate greater structural similarity. The sectors correspond to the groups of goods at the two-digit level of the SITC classification system. The similarity measure is constructed for 2006, and underlying data were taken from the UN Comtrade database.

In Table 3 we show the signs of the significant regression coefficients together with the level of significance. Significant correlations of the trade and commodity price exposure measures, distance, the manufacturing share and product market regulation with the price impulse responses have the expected signs (with the exception of distance with the PPI impulse response functions to the supply shock obtained from the OLS regression). I.e. the

percent (in Latin America) and 6 percent (in North America and Other European countries).

[16] The indicator of product market regulation measures the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. It covers formal regulations in the following areas: state control of business enterprises; legal and administrative barriers to entrepreneurship; and barriers to international trade and investment. The indicator of employment protection measures the procedures and costs involved in dismissing workers with regular contracts and incorporates several basic measures of employment protection strictness, such as notice periods, amount of severance pay and compensation for unfair dismissal.

[17] Typically, this measure is constructed using disaggregated value added figures which are, however, not available for our reference country China. Therefore, we use export data which are also more useful for deriving implications of competition with China on international markets.

larger the trade and commodity exposure and the manufacturing sector and the smaller the distance to Beijing are, the stronger the price response after Chinese shocks. The table also shows that producer price reactions in a country with a sectoral export structure that is similar to China's export structure will be relatively weak after Chinese shocks. Producers from countries which compete with China appear not to raise prices after positive demand shocks or negative supply shocks as much as producers from countries which have a very different export structure compared to and therefore do not compete with China. At the same time, due to low markups producers from countries that compete with China cannot lower prices by as much as producers from countries that compete less with China after negative demand or positive supply shocks.

Overall, we conclude from this section that overall trade exposure, direct trade with China, commodity exposure and, to a less robust extent, the manufacturing share, distance and structural similarity with China help to explain differences across countries in price reactions to the Chinese supply and demand shocks.[18] The regulatory measures in general do not enter the regression equations significantly. The findings from this section that trade and commodity prices are important transmission channels are consistent with section 5.3.

5.5 Robustness analysis

In this section we provide key results from several robustness checks. First we assess the amount of model uncertainty and whether neglecting it in our baseline biases our conclusions. Figures 6 and 7 show point estimates of impulse responses of international prices to Chinese supply and demand shocks from all models consistent with the sign restrictions. It appears from the figure that model uncertainty is not very large, and that accounting for it does not alter our main results.

Second, we repeat the analysis for the longer sample period since 1995Q4.[19] This is to assess whether China's role has changed with its accession to WTO due to, for example, more intense trade in goods with the rest of the world. We start in 1995Q4 because Chinese producer prices which play an important role in our identification scheme are available only since this period. The analysis is performed in a similar way to before, but instead of two global factors we now use three as suggested by the IC_{p2} of Bai and Ng (2002). Moreover, we account for possible breaks in the means of the variables when standardizing.[20]

[18] Openness is also found Bianchi and Civelli (2010) to shape the dynamics of domestic inflation in many countries. The authors use a time-varying parameter VAR approach.

[19] The following robustness checks are carried out with 100 valid models (i.e. models that all satisfy the sign restrictions) and 200 bootstraps.

[20] Some series (mainly nominal series) clearly exhibit breaks in their means. For example, at the beginning of the longer sample, inflation in Mexico was still very high, and central and east European countries were still in the midst of the convergence process. We detect breakpoints by applying the sequential multiple

Third and fourth, it may be criticized that we do not account for subfactors and, hence, give specific transmission channels a too low weight. For this reason, we carry out two additional experiments. We partition the global dataset (after cleaning each variable from the Chinese factors) into a commodity price dataset and a dataset including all other international variables. We then extract a commodity price factor[21] from the former dataset and, as before, two global factors from the latter. Second, we partition the global dataset into a set comprising only variables from Asian countries (without China) as well as Australia and New Zealand and one including all other variables. We extract from them two global factors and two Australasian factors. The numbers of factors were, again, determined by the IC_{p2}. We then model the Chinese factors, the global factors and the subfactors (either the commodity price factor or the Australasian factors) jointly in a VAR.

One could now argue that two Chinese and two global factors are not enough to fully capture international price dynamics and/or that noisy Chinese data might prevent accurate factor estimation. Table 2 has shown that the variance shares explained by these factors were quite low, for Chinese variables too. Boivin and Ng (2006) have indeed shown that factor estimates may not be accurate if the volatility of idiosyncratic components is too large. On the other hand, it might be argued that factor models are particularly well suited to coping with measurement error. This is the case if measurement error is captured by the idiosyncratic component estimated in equation (3.1) and if the idiosyncratic component is then disregarded and only the common factors are used in the remainder of the analysis. Since the volatility of the idiosyncratic component is unobserved, it is unclear *a priori* to what extent this is an issue here. Moreover, it is possible to doubt whether two structural shocks underlying the four factors are indeed Chinese supply and demand shocks. To address these potential criticisms, we re-estimate the model with more, three Chinese and three global, factors, which is our fifth robustness check. Sixth, we replace the two latent Chinese factors with three observable Chinese variables (GDP growth as well as CPI and PPI inflation) and estimate a factor-augmented vectorautoregression (FAVAR) in the manner of Bernanke et al. (2005). This might also help to tie Chinese shocks more closely to observed Chinese variables, at the cost of not exploiting all the available information on the Chinese economy.

Figures 8-10 present impulse responses of international consumer, producer and commodity prices to the Chinese shocks from our baseline (black lines) and from the alternative

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breakpoint test of Bai and Perron (1998) and Bai and Perron (2003) (and use the Gauss routines provided by Pierre Perron on his web page) to all series of our stationary dataset, and we subtract possibly shifted means from these series. See Eickmeier (2009) for a similar treatment of series in a large dimensional factor context.

[21] When we apply the Bai and Ng (2002) criteria to the commodity price dataset, they all suggest the maximum number of factors allowed for (10 in our case). We therefore do not use them here. Instead we simply use one commodity price factor, since it already explains a large bulk (45 percent) of the variation in the commodity price dataset.

experiments (red solid lines: separate commodity price factor, red dashed: separate Australasian factors, blue solid: 1995-2011 sample period, blue dashed: FAVAR, green solid: more (three Chinese and three global) factors). For visibility, we show only median impulse response functions for the robustness checks. Table 4 provides the corresponding variance decompositions.

Overall, our main results are not much affected. The median impulse responses of the robustness checks in most cases lie within the confidence bands of impulse responses from the baseline. A few differences from the baseline are, however, worth mentioning.

First, responses of prices after Chinese demand shocks and of commodity prices after both supply and demand shocks, in general, turn out to be weaker when the model is estimated over the longer sample period. This suggests that, with greater integration of China into the world economy (related to its accession to the WTO), the transmission of Chinese demand shocks to other countries has strengthened, and that this is (at least partly) due to greater demand for commodities from China.

Second, when separate Australasian factors are included in the model, the effects of Chinese demand shocks on foreign consumer prices are slightly stronger than in the baseline. This is also visible from the variance decomposition presented in Table 4. Variance shares explained by Chinese demand shocks now increase to more than 10 percent on average over all countries (compared to 4 percent in the baseline). This suggests that the shock transmission from China to the rest of the world goes partially through Australasia. Differences are, however, unlikely to be significant since confidence bands will overlap. We nevertheless believe that accounting for factors which only load on subsets of our large global dataset is a promising route to follow in future work (see, for example, Aastveit et al. (2012) and Foerster and Tillmann (2013) for insightful applications of such approaches in the global inflation context).

Third, the finding from our baseline that commodity prices rise after the Chinese supply shock (although we found them to rise only to a small extent) does not seem to be very robust. It is indeed not fully clear whether supply shocks in China will result in greater demand for commodities or whether commodities will instead be substituted as production becomes more capital and technology-intensive.

Fourth, the FAVAR suggests a somewhat weaker (but probably not significantly different) short-term reaction by producer prices to the supply shock in most regions. Fifth, in the FAVAR, the forecast error variance of Chinese variables is, by construction, entirely accounted for by contributions from Chinese supply and demand shocks and global shocks. Chinese supply shocks now explain 20 percent of Chinese GDP growth and between 8 and 13 percent of inflation. The contribution of Chinese demand shocks on Chinese variables also increases relative to the baseline, albeit not by as much. The remaining shocks (probably mostly global shocks) are still the dominant driving force of Chinese variables. Variance shares for foreign inflation rates are not much altered compared with the baseline model. Overall, we conclude that our main results are fairly robust.

6 Concluding remarks

We apply a structural dynamic factor model to a large quarterly dataset covering 38 countries (including China) between 2002 and 2011 to analyze China's role in global inflation dynamics. We identify Chinese supply and demand shocks and examine their contributions to foreign price dynamics and their transmission channels. Our contributions to the literature are that we focus on identified Chinese shocks and that we account for interaction between many variables in our model, which allows us to analyze the transmission mechanism in great detail. Our main findings are: (i) Chinese supply and demand shocks significantly affect prices in other countries. Demand shocks matter slightly more over the sample period than supply shocks. Producer prices tend to be more strongly affected than consumer prices by Chinese shocks. The overall share of international inflation explained by Chinese shocks is notable (about 5 percent on average over all countries but not more than 13 percent in each region). This suggests that monetary policy makers should take macroeconomic developments in China into account when stabilizing domestic inflation rates; (ii) Direct channels (via import and export prices) and indirect channels (via greater exposure to foreign competition and commodity prices) both seem to matter; (iii) Differences in trade (overall and with China) and in commodity exposure help explaining cross-country differences in price responses.

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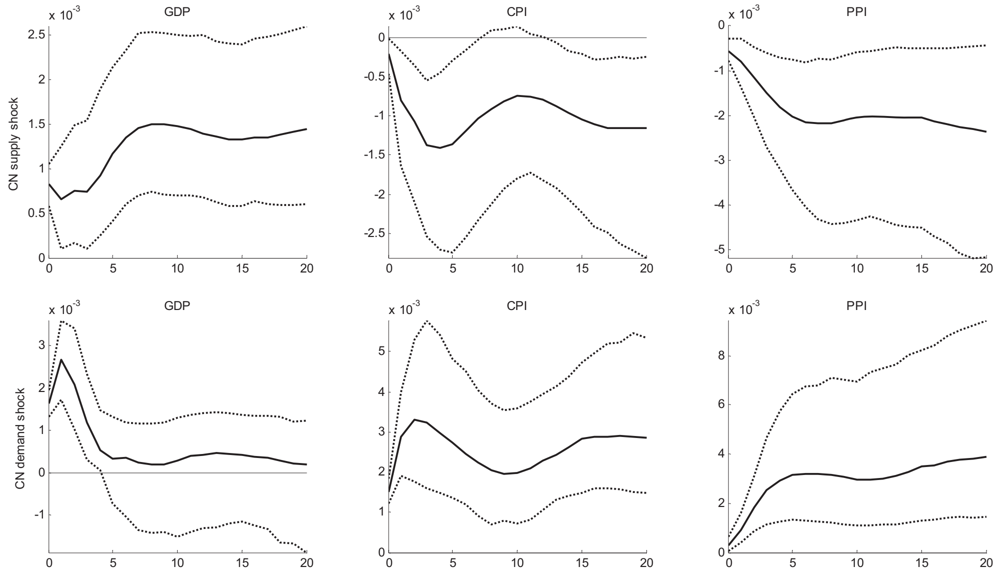
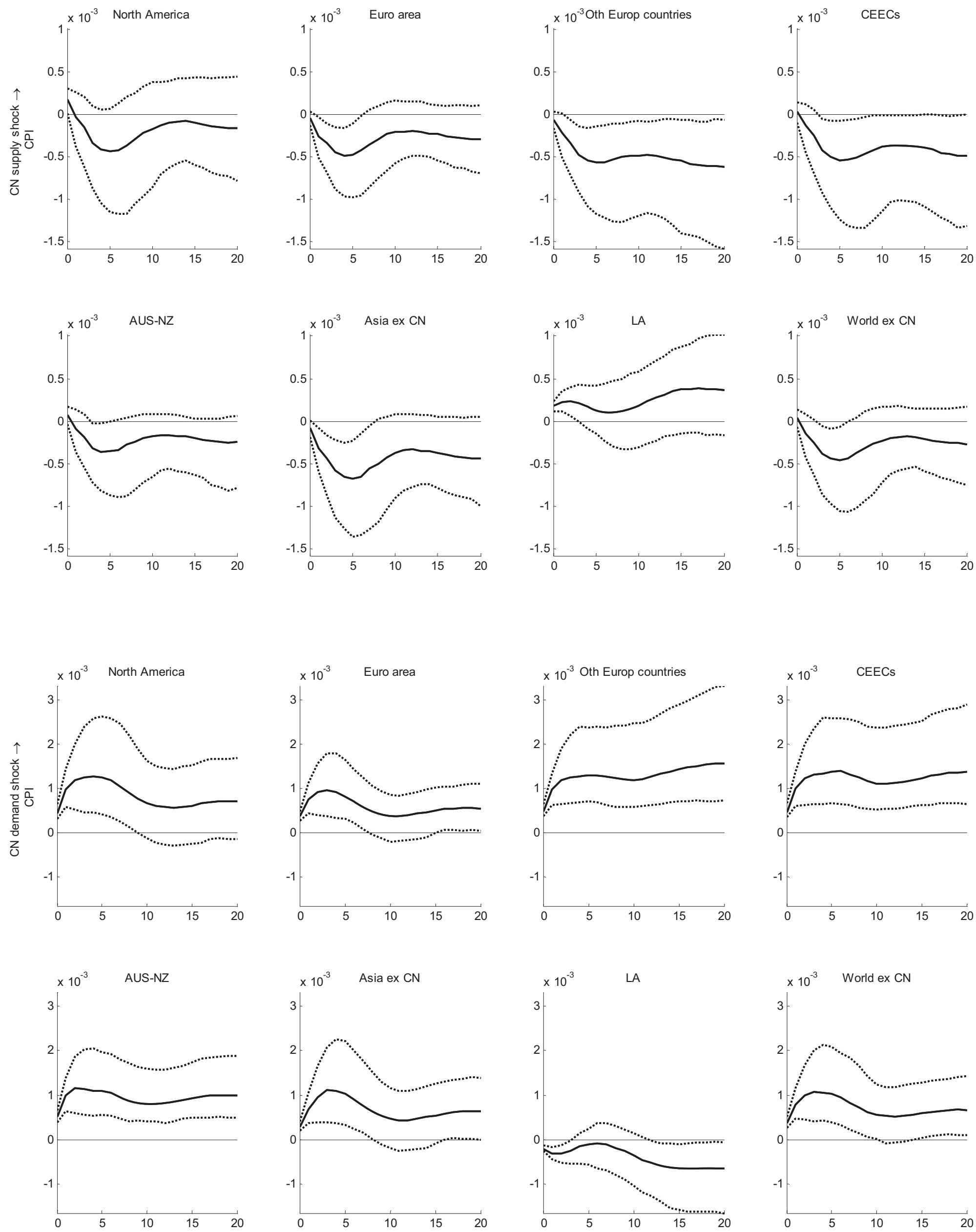
Figure 1: Impulse responses of selected Chinese variables to Chinese supply and demand shocks



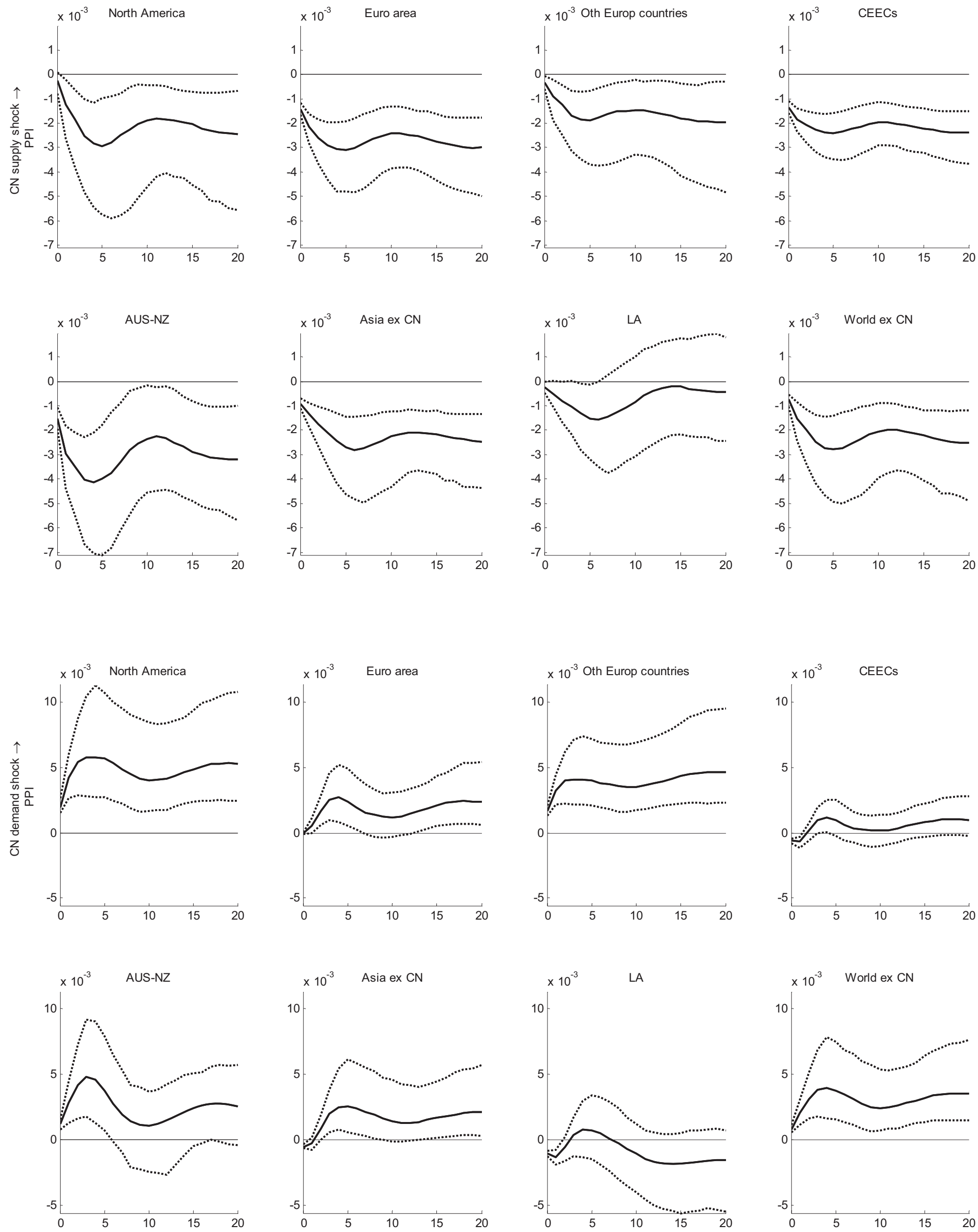
Notes: Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands, solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

Figure 2: Impulse response of CPI to Chinese supply and demand shocks



Notes: Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands, solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

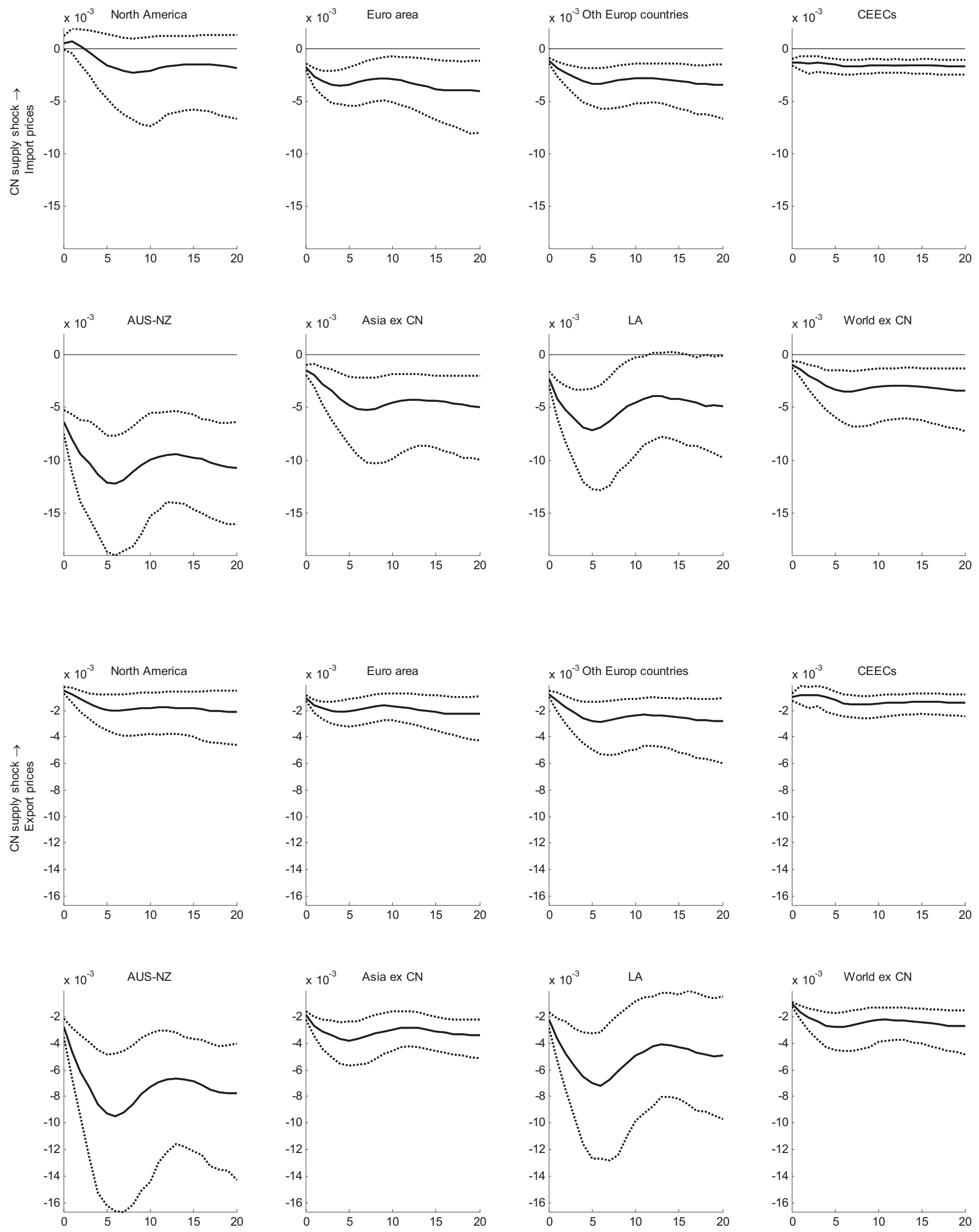
Figure 3: Impulse response of PPI to Chinese supply and demand shocks



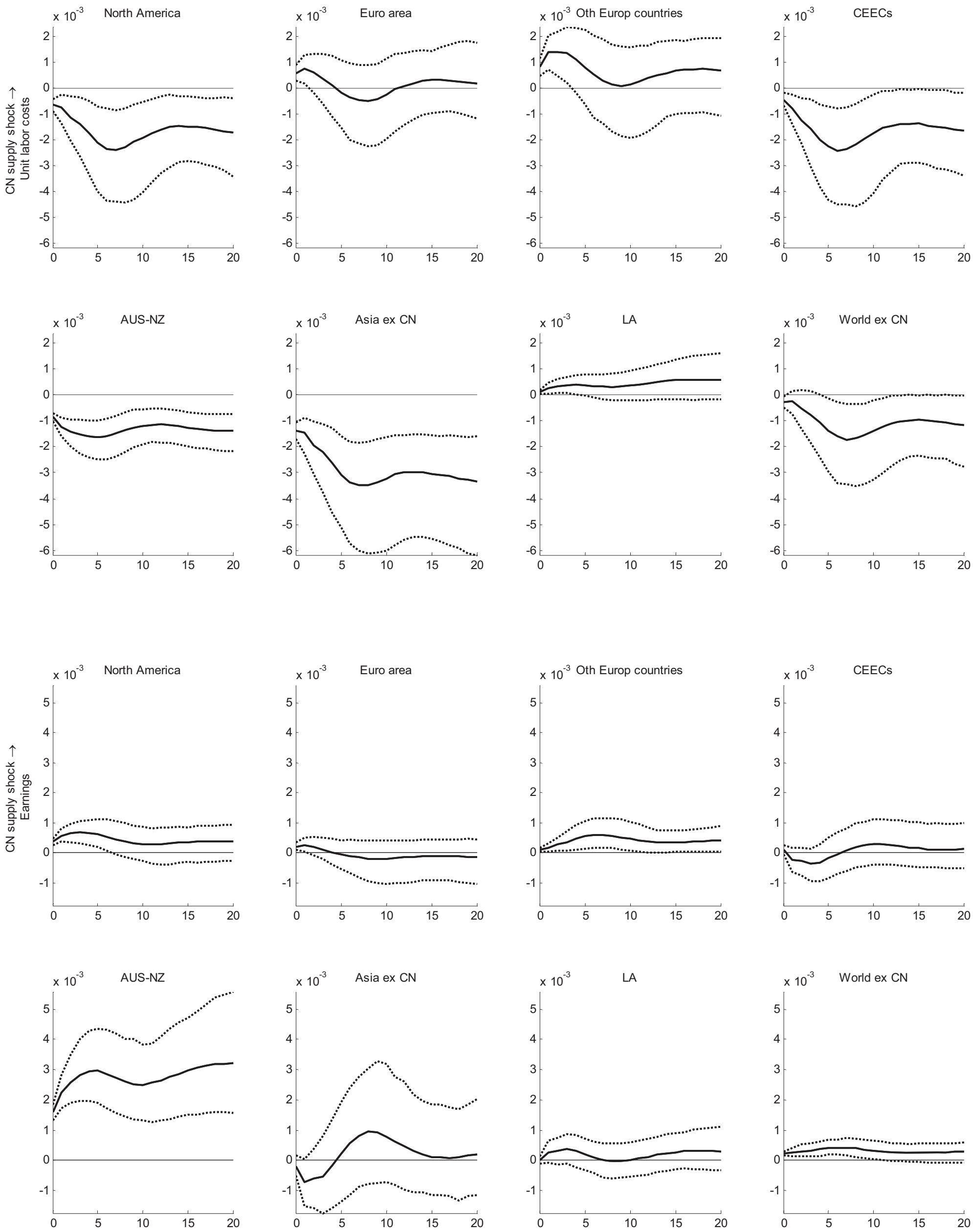
Notes: Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands, solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

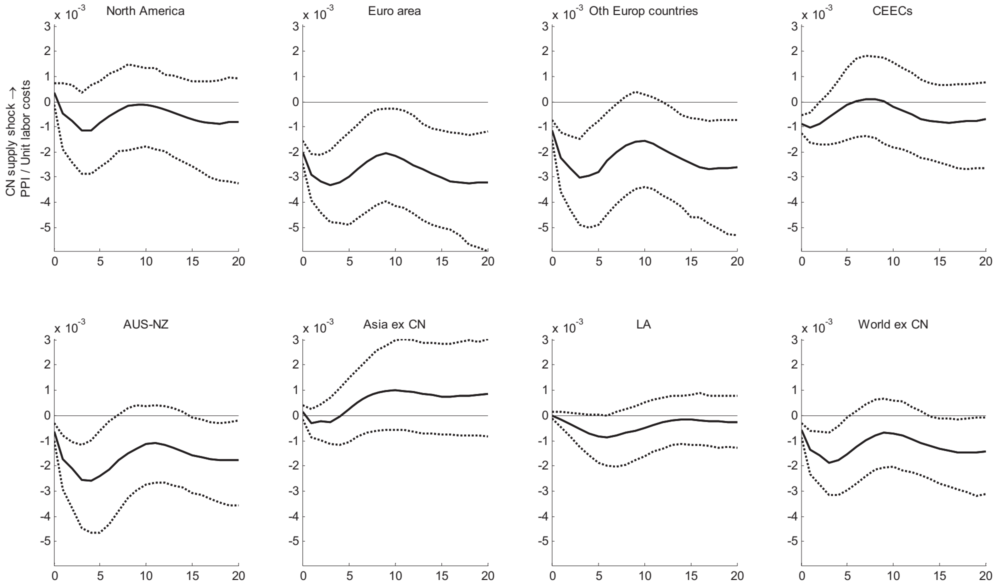
Figure 4: Transmission of Chinese supply shocks to selected international variables

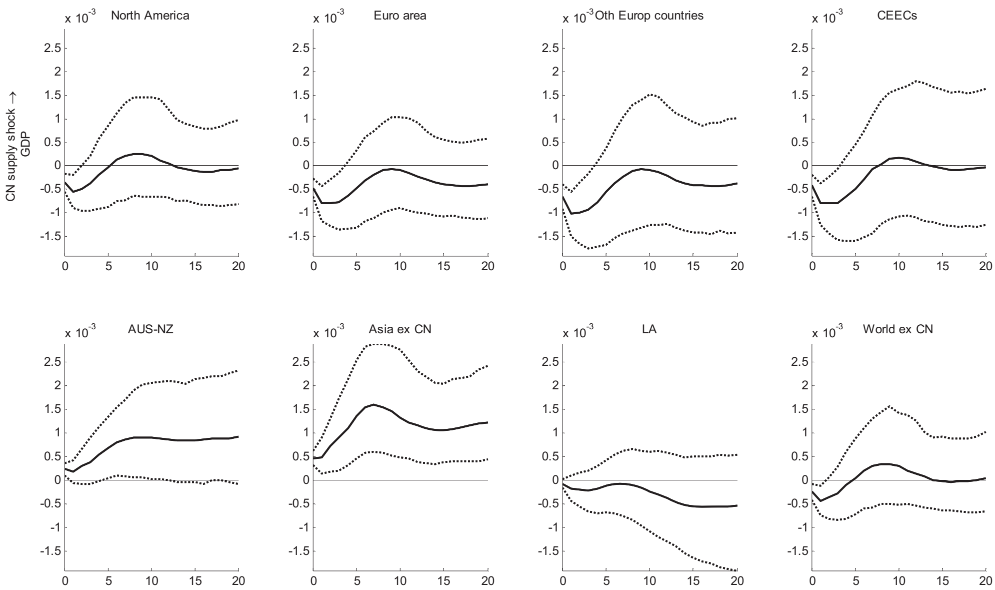
(a) Direct (trade related) transmission

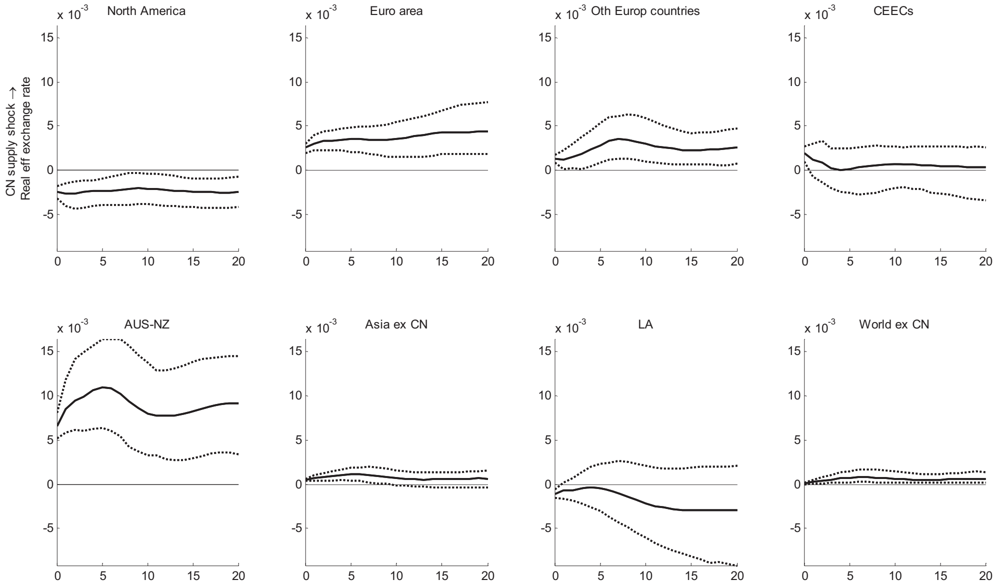


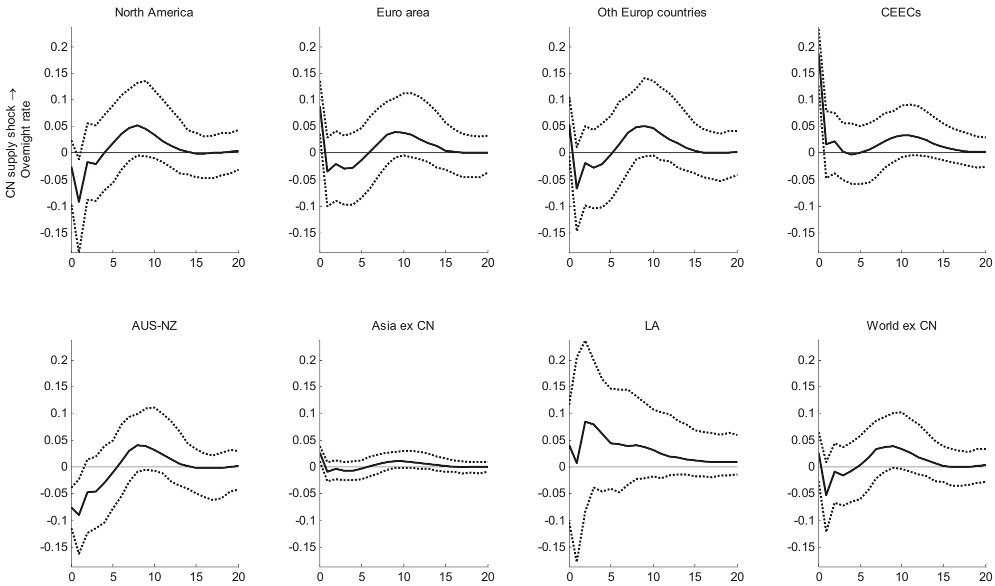
(b) Indirect transmission

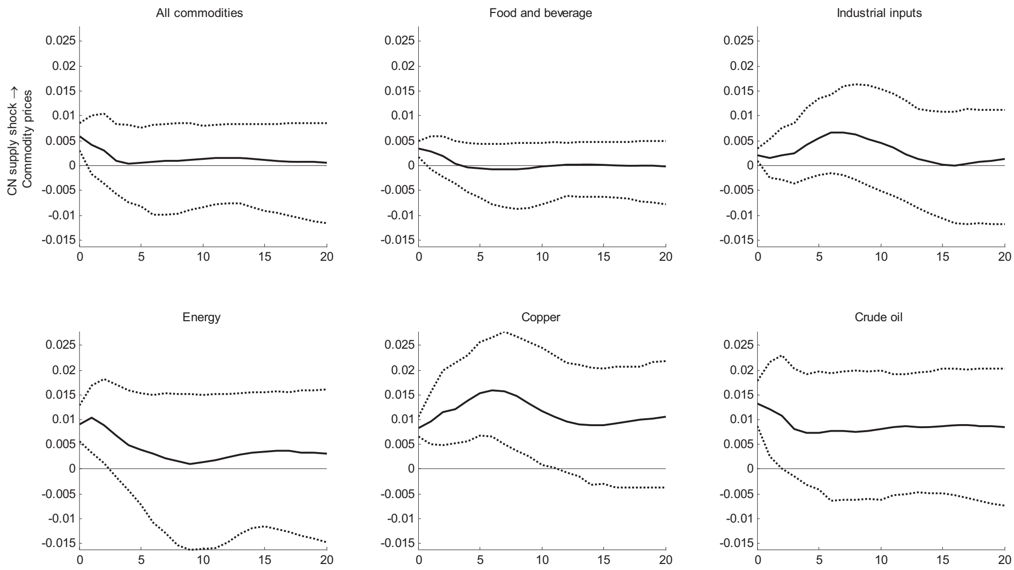



CN supply shock →
PPI / Unit labor costs
x 10^-3
North America
Euro area
Oth Europ countries
CEECs
AUS-NZ
Asia ex CN
LA
World ex CN


CN supply shock →
GDP
x 10^-3
North America
Euro area
Oth Europ countries
CEECs
AUS-NZ
Asia ex CN
LA
World ex CN


CN supply shock →
Real eff exchange rate
North America
Euro area
Oth Europ countries
CEECs
AUS-NZ
Asia ex CN
LA
World ex CN
x 10-3

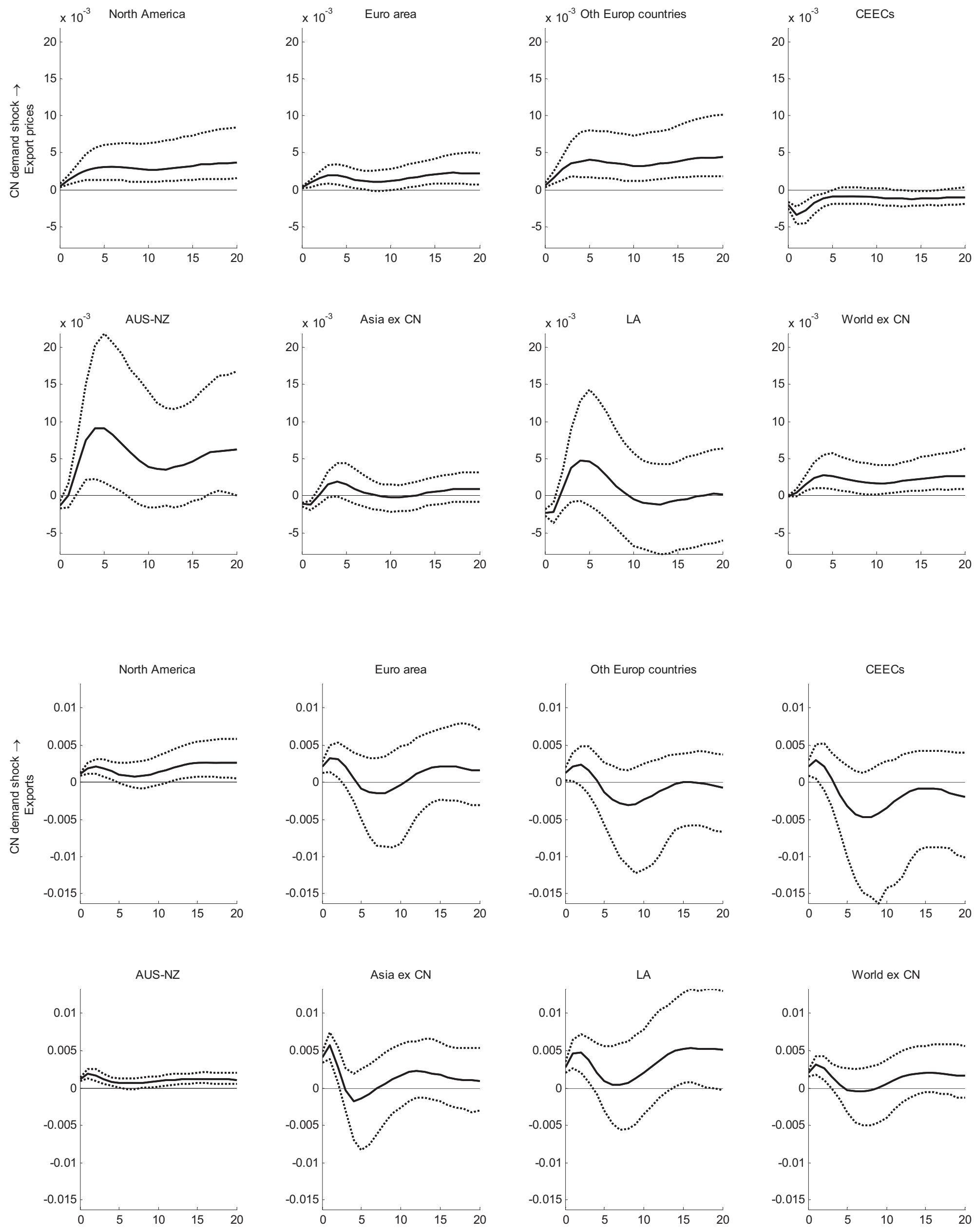

CN supply shock →
Overnight rate
North America
Euro area
Oth Europ countries
CEECs
AUS-NZ
Asia ex CN
LA
World ex CN

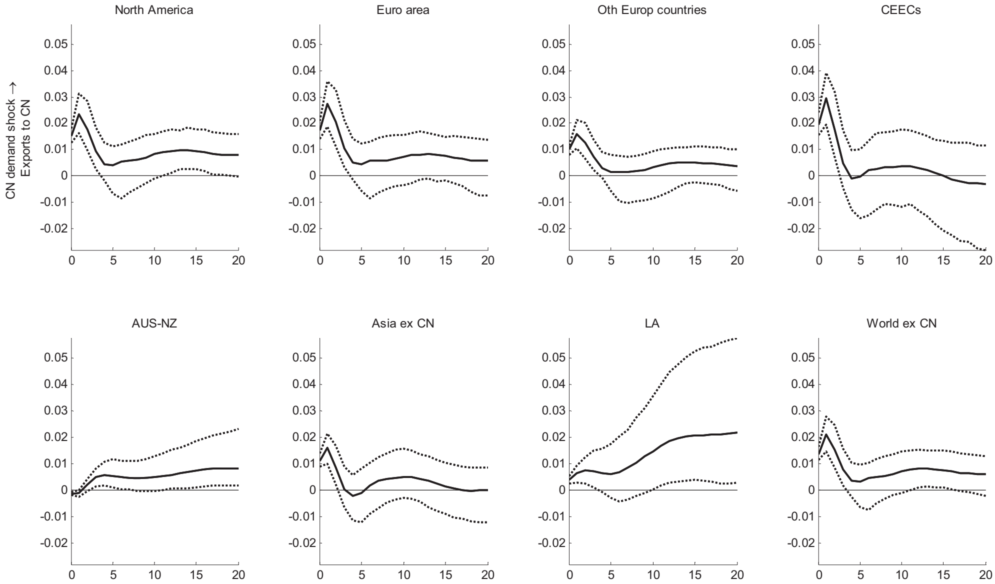


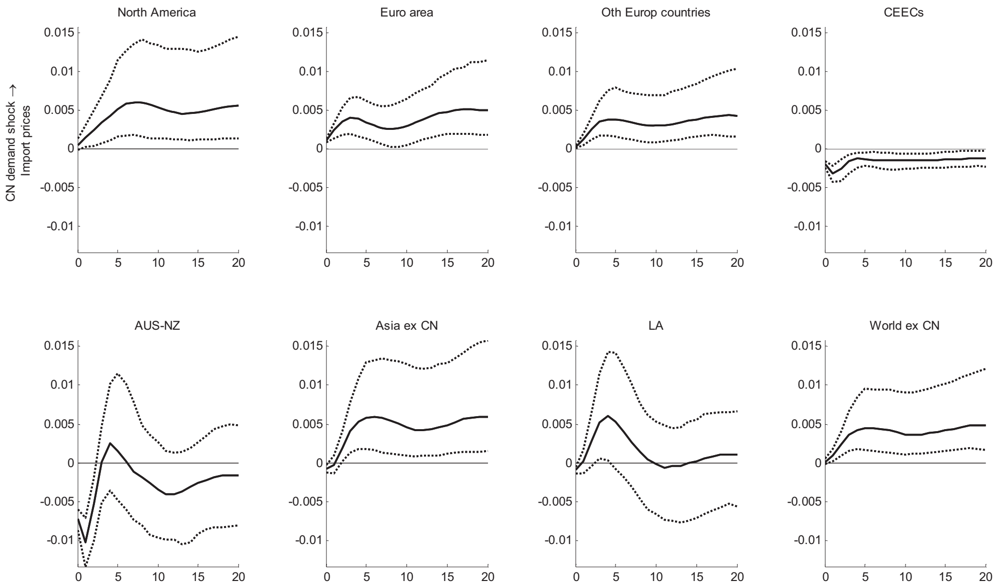
Notes: Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands, solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

Figure 5: Transmission of Chinese demand shocks to selected international variables

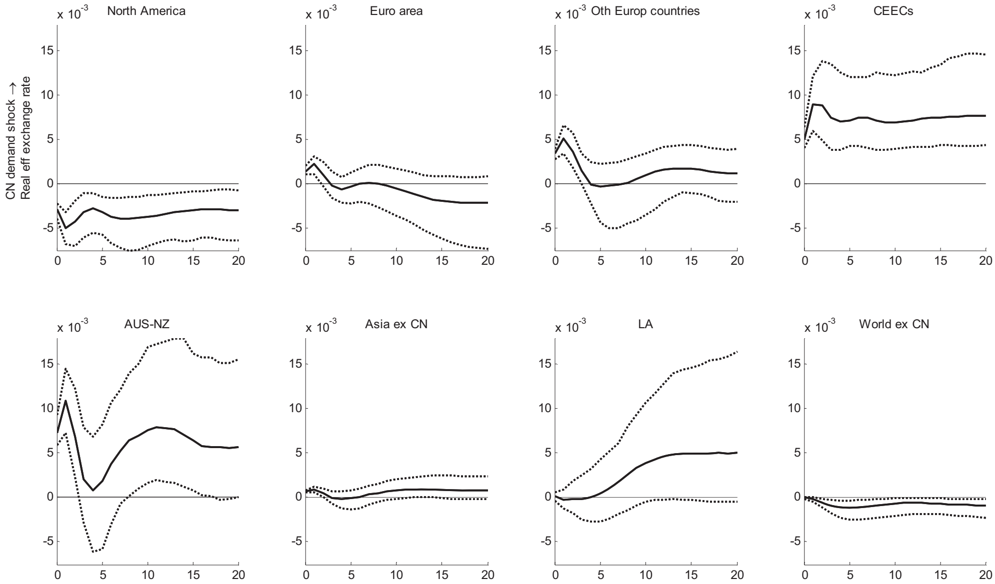
(a) Direct (trade related) transmission

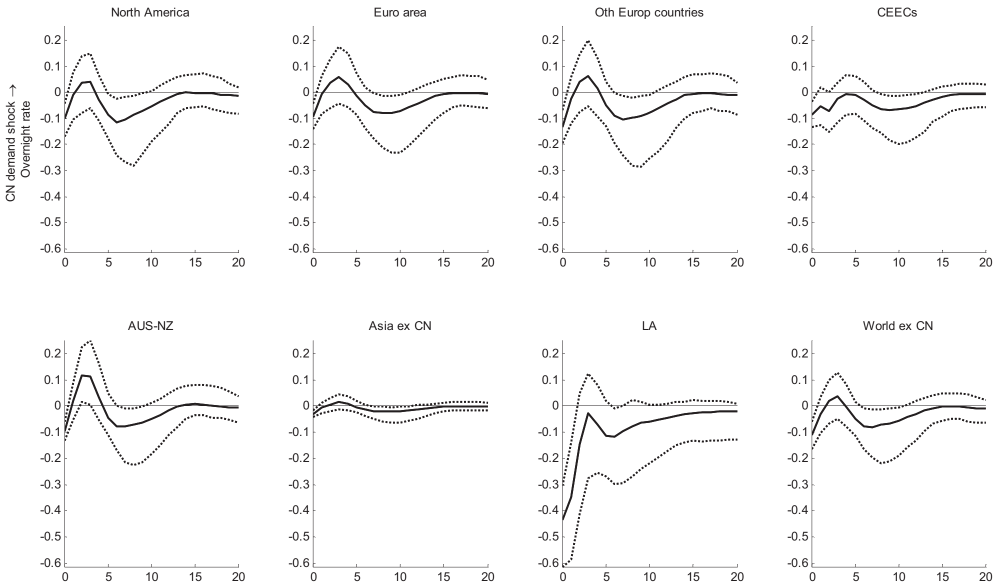


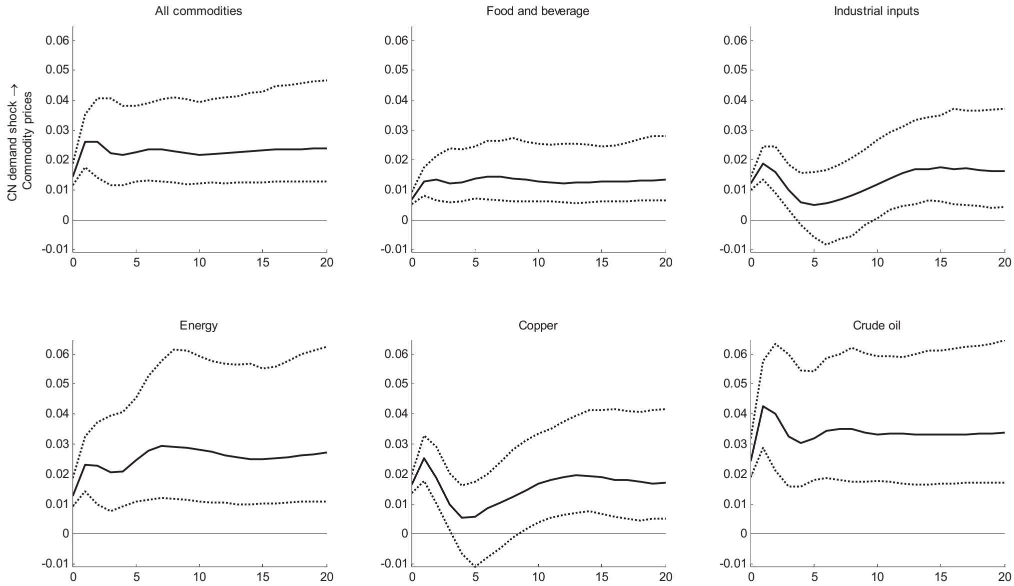

CN demand shock →
Exports to CN
North America
Euro area
Oth Europ countries
CEECs
AUS-NZ
Asia ex CN
LA
World ex CN

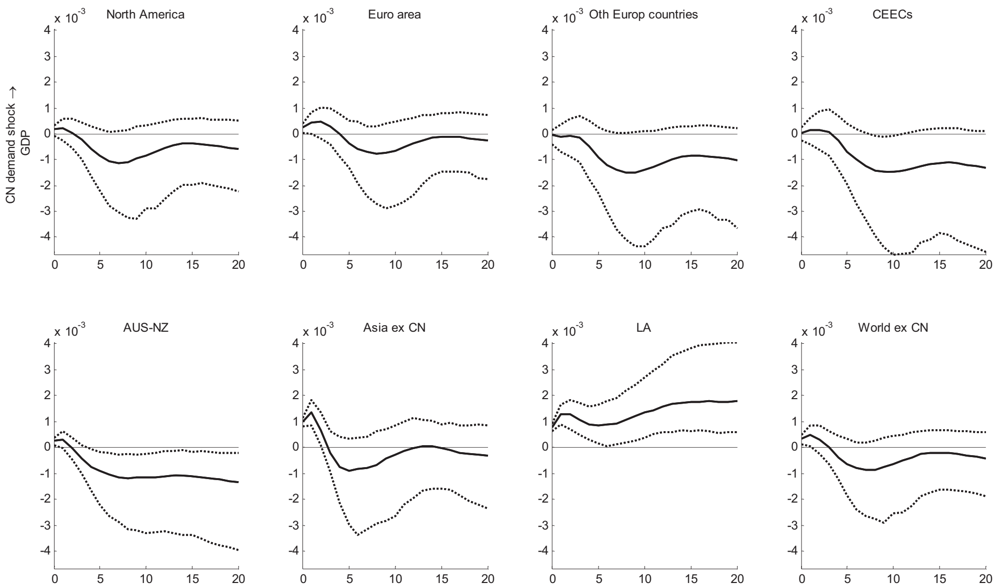

CN demand shock →
Import prices
North America
Euro area
Oth Europ countries
CEECs
AUS-NZ
Asia ex CN
LA
World ex CN

(b) Indirect transmission









Notes: Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands, solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

Figure 6: Model uncertainty – impulse responses of international CPI

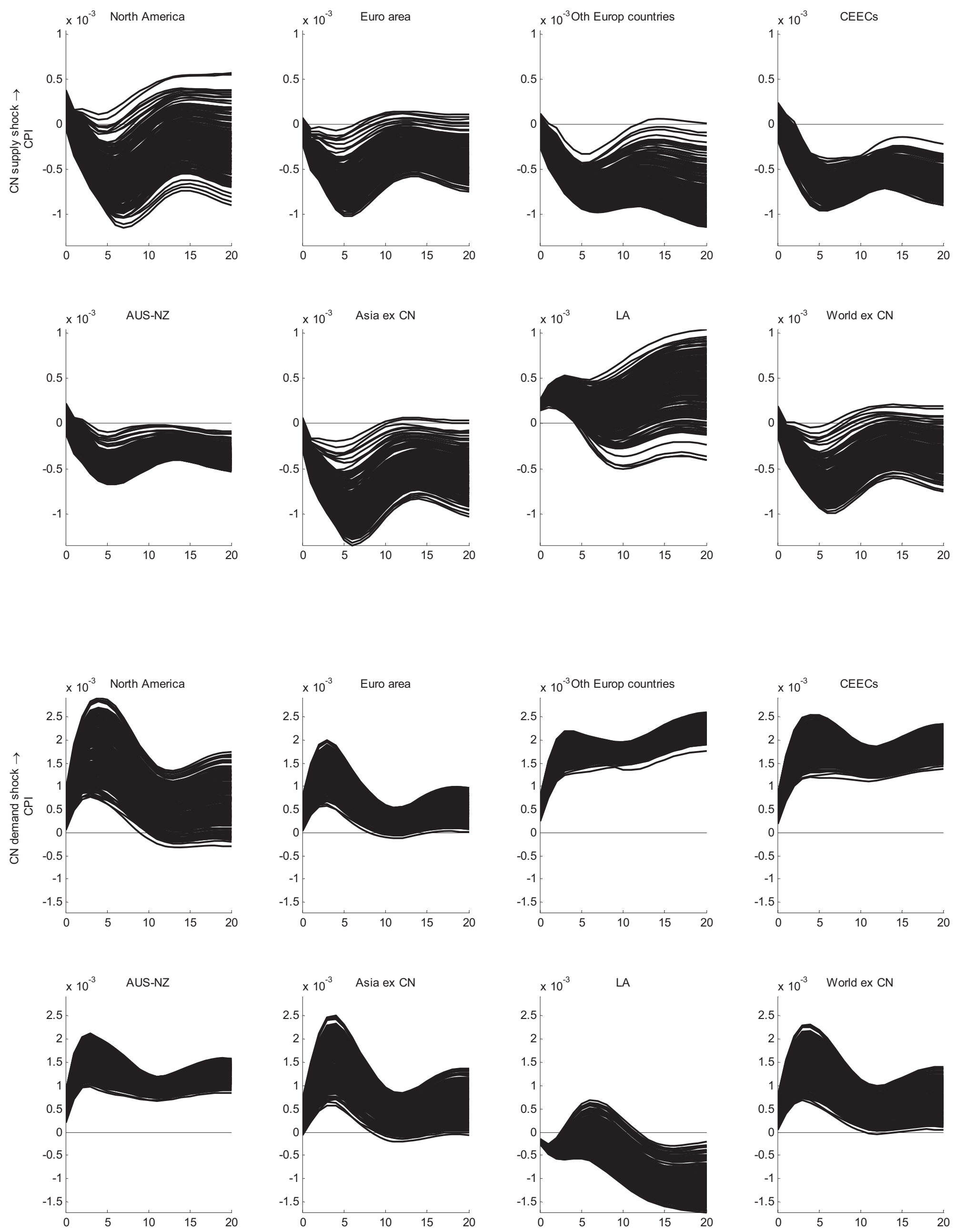


Figure 7: Model uncertainty – impulse responses of international PPI

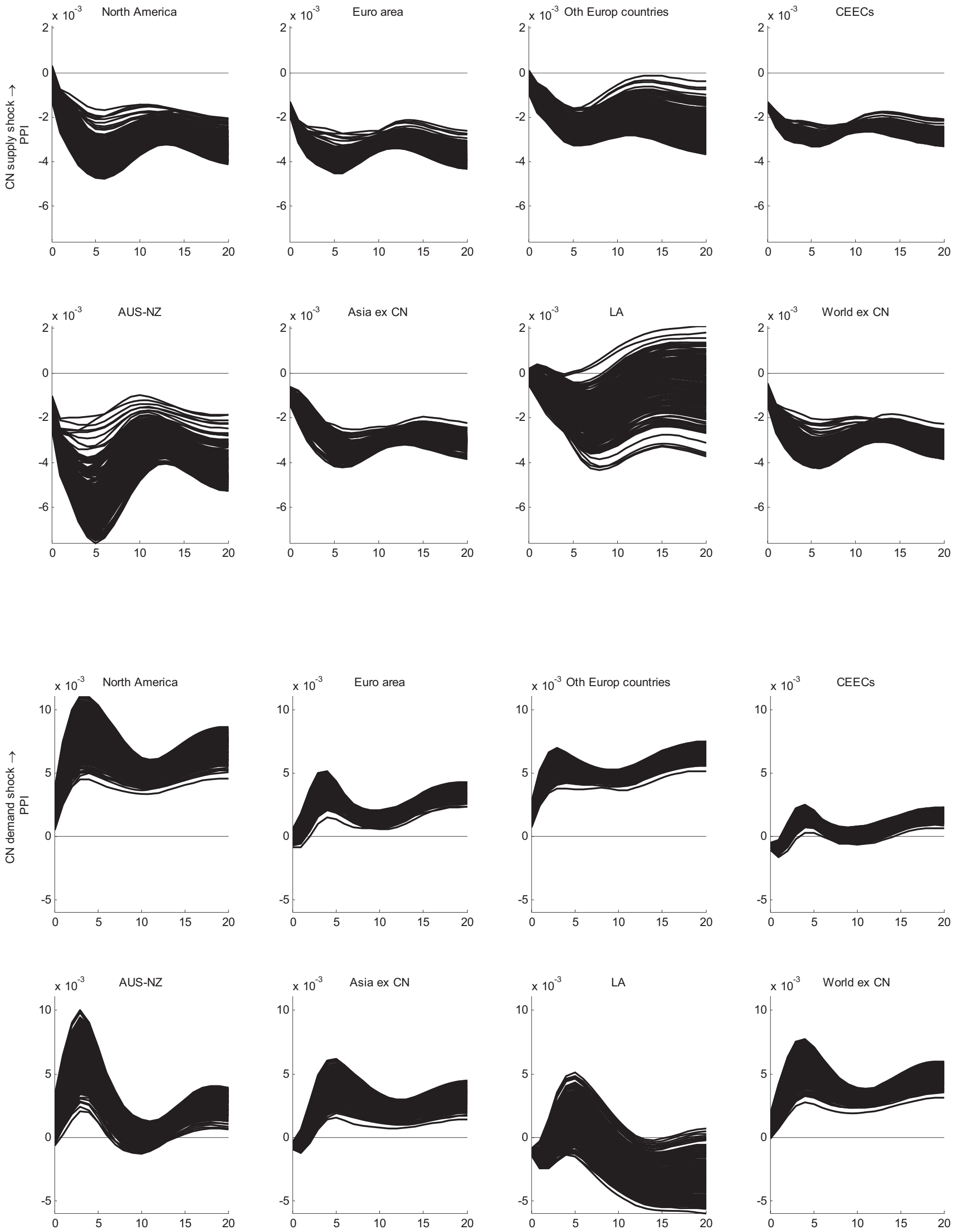


Figure 8: Robustness checks – impulse responses of CPI (black: baseline, red solid: separate commodity price factor, red dashed: separate Australasian factors, blue solid: 1995-2011, blue dashed: FAVAR, green solid: more CN and global factors)

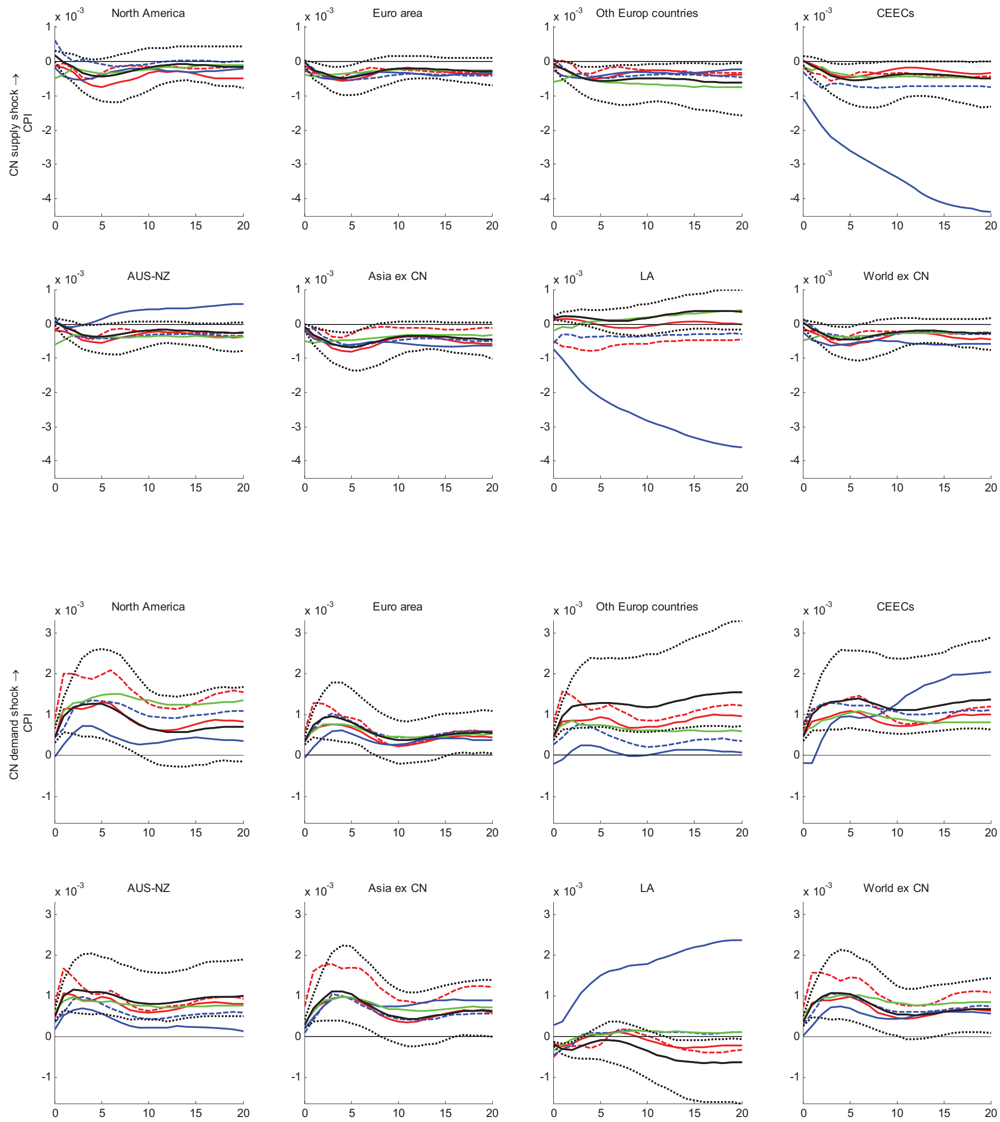


Figure 9: Robustness checks – impulse responses of PPI (black: baseline, red solid: separate commodity price factor, red dashed: separate Australasian factors, blue solid: 1995-2011, blue dashed: FAVAR, green solid: more CN and global factors)

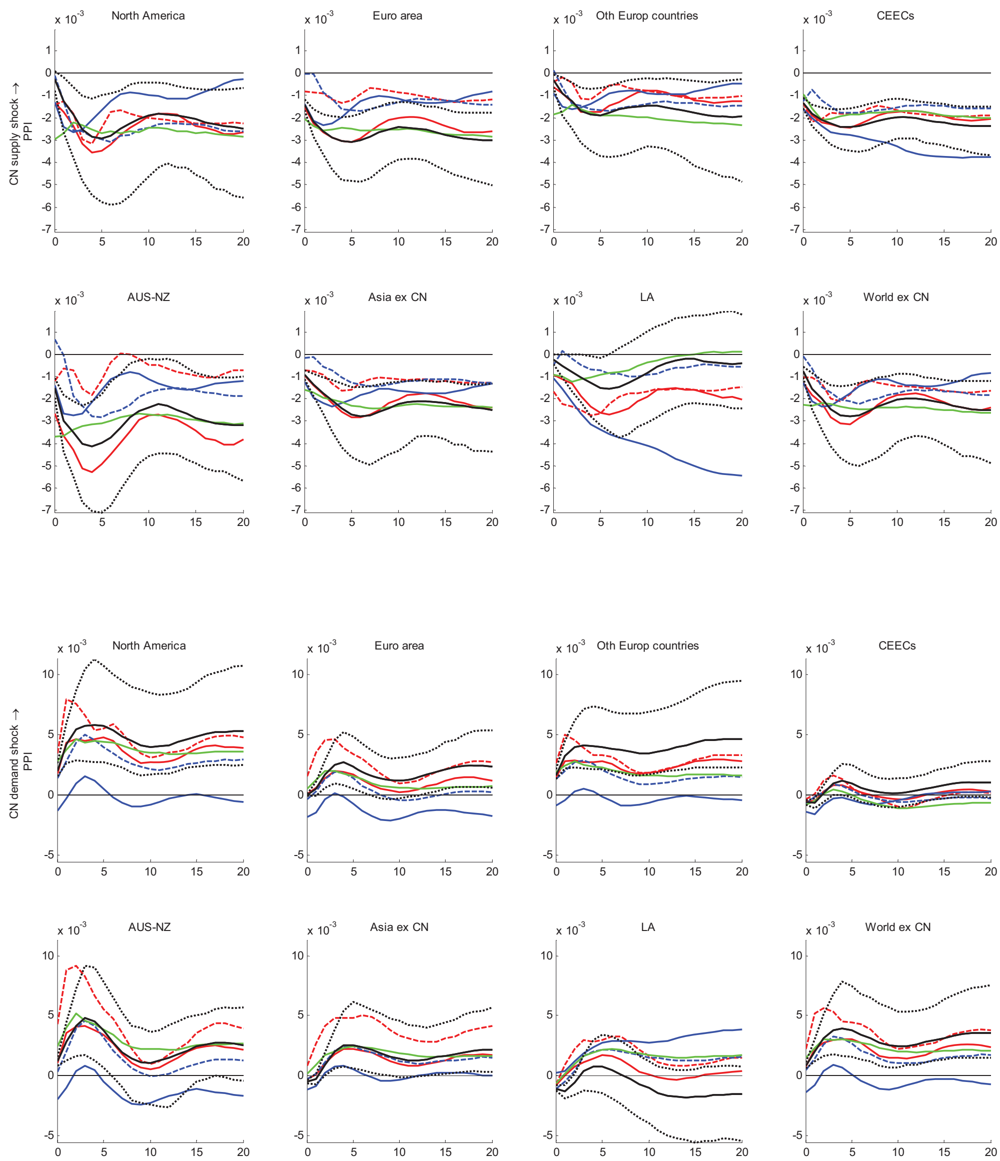


Figure 10: Robustness checks – impulse responses of commodity prices after the Chinese shocks (black: baseline, red solid: separate commodity price factor, red dashed: separate Australasian factors, blue solid: 1995-2011, blue dashed: FAVAR, green solid: more CN and global factors)

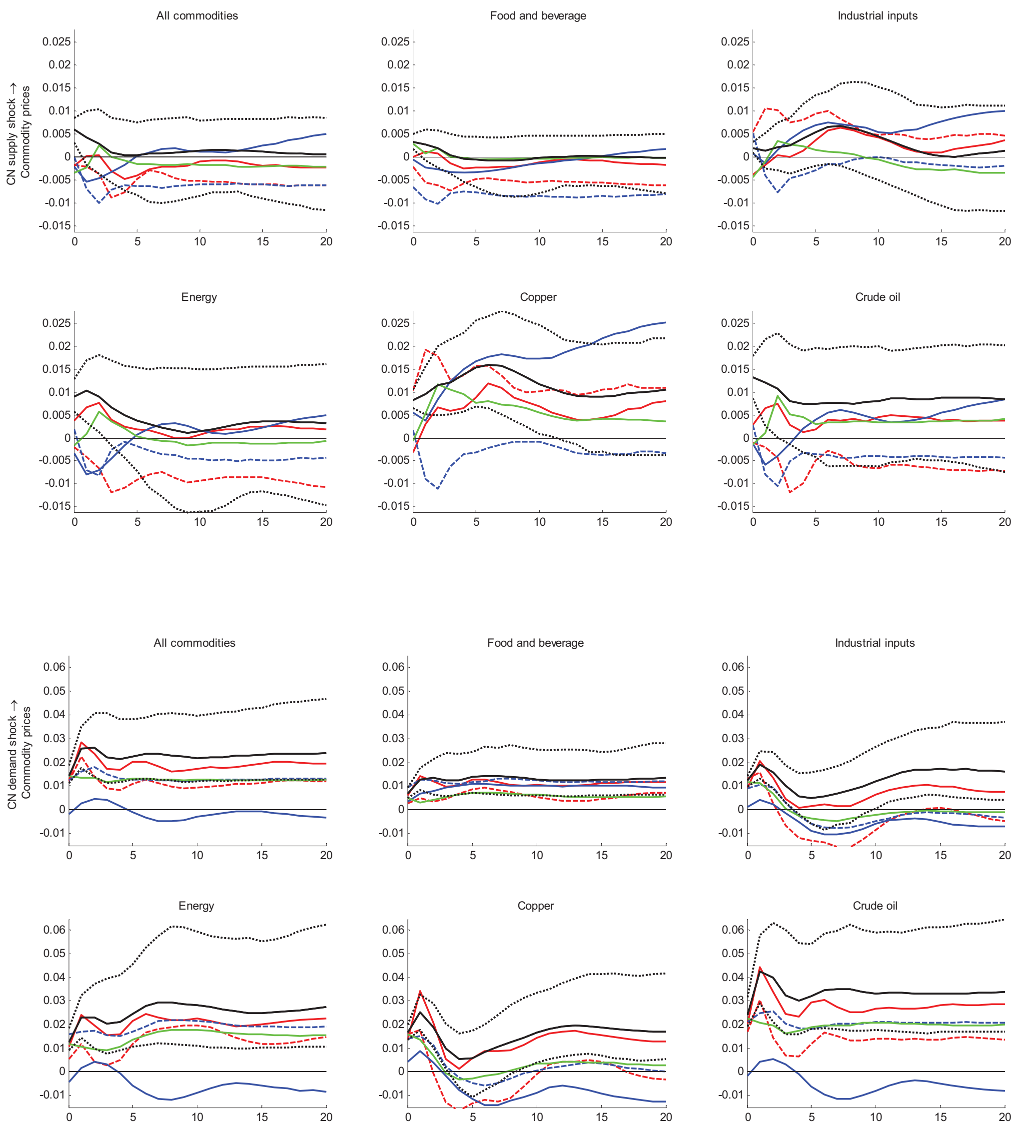


Table 1: Sign restrictions

	CN GDP	CN CPI, PPI	CN GDP/country j's GDP
CN supply shock	≥ 0	≤ 0	≥ 0
CN demand shock	≥ 0	≥ 0	≥ 0

Notes: The sign restrictions are imposed on lags 0-4 after the shocks, except for the restrictions on relative GDPs which are imposed on lag 0 only.'j' refers to all countries other than China.

Table 2: Variance decomposition of selected Chinese variables, international CPI and PPI inflation and commodity price inflation

	CN supply	CN demand	Global	Idiosyncratic
Selected Chinese variables				
GDP growth	2.7	12.4	33.1	51.8
CPI infl	2.3	10.8	42.5	44.5
PPI infl	1.3	3.1	16.4	79.2
CPI inflation				
North America	1.1	3.6	22.2	73.1
Euro area	1.7	5.9	32.6	59.8
Oth Europ countries	1.0	5.5	20.3	73.2
CEECs	0.8	3.5	16.4	79.3
AUS-NZ	0.9	4.7	18.4	76.0
Asia ex CN	1.2	3.4	23.3	72.1
LA	0.4	0.9	5.5	93.1
World ex CN	1.0	3.6	21.4	73.9
PPI inflation				
North America	1.1	4.3	21.1	73.5
Euro area	4.9	5.0	25.3	64.8
Oth Europ countries	1.6	7.9	29.0	61.5
CEECs	2.2	2.2	7.3	88.4
AUS-NZ	3.0	4.7	31.7	60.6
Asia ex CN	3.1	6.8	37.6	52.5
LA	0.7	2.8	14.9	81.6
World ex CN	1.6	3.7	21.8	73.0
Commodity price inflation				
All commodities	1.7	9.3	22.4	66.6
Food and beverage	1.0	4.2	13.1	81.7
Industrial inputs	1.0	7.6	22.5	68.9
Energy	2.2	6.1	17.3	74.4
Copper	0.9	4.2	10.0	84.9
Crude oil	2.3	9.9	22.0	65.8

Notes: The forecast error horizon is five years. The shares are computed based on the median impulse response functions.

Table 3: Correlations between price impulse responses after one year to Chinese shocks and country characteristics

	Supply		Demand		Supply		Demand	
	CPI	PPI	CPI	PPI	CPI	PPI	CPI	PPI
Openness	-***		+***		-***		+***	
IM from CN/GDP	-***		+***		-***		+***	
EX to CN/GDP	-**		+***		-***		+***	+**
Commodity IM/GDP	-***		+***		-***		+***	
Commodity EX/GDP	-**	-**	+**	+***	-***	-*	+***	+*
Manuf. value added/GDP					-***			
Distance		-*	-**		+***		-***	
Product market reg.						+*		
Employment protection								
Structural similarity		-***		+***		-**		+*

Notes: Signs and significance levels (***: 1%, **: 5%, *: 10%) of significant regression coefficients are shown.

Table 4: Robustness checks - variance decomposition of selected Chinese variables, international CPI and PPI inflation and commodity price inflation

	long sample			more CN and global factors			FAVAR		
	CN supply	CN demand	Global	CN supply	CN demand	Global	CN supply	CN demand	Global
Selected Chinese variables									
GDP growth	3.7	19.6	24.7	3.8	9.7	53.5	19.6	15.6	64.8
CPI infl	4.2	12.2	36.6	2.5	7.5	45.7	13.3	20.4	66.3
PPI infl	1.4	4.1	31.6	4.7	2.4	34.1	8.1	7.2	84.7
CPI inflation									
North America	1.1	2.3	20.3	3.1	5.7	41.8	4.6	4.5	34.1
Euro area	1.8	3.5	27.5	4.0	5.8	51.1	3.4	7.2	37.3
Oth Europ countries	1.3	1.8	10.7	5.4	5.3	42.5	2.2	3.3	23.5
CEECs	5.7	2.5	15.0	1.1	3.7	17.7	2.4	5.5	16.8
AUS-NZ	1.0	2.3	18.6	4.7	5.6	46.6	3.0	4.2	29.8
Asia ex CN	0.9	2.0	10.0	3.3	3.9	35.5	2.0	4.2	22.8
LA	2.9	1.6	7.4	1.1	1.9	21.3	3.1	3.2	18.4
World ex CN	1.2	2.1	15.1	3.2	4.7	39.5	2.4	4.2	27.2
PPI inflation									
North America	1.8	3.2	24.3	4.8	5.2	45.8	2.6	4.3	29.8
Euro area	4.3	9.9	49.1	7.4	3.7	36.7	3.7	6.4	39.4
Oth Europ countries	2.4	3.7	27.3	6.3	7.2	50.5	3.2	5.9	32.2
CEECs	3.3	3.8	9.7	1.9	2.0	13.5	2.6	2.1	8.5
AUS-NZ	3.1	7.3	50.1	8.0	7.2	58.1	4.6	7.8	50.4
Asia ex CN	3.3	5.2	25.8	6.1	4.4	48.8	4.0	7.0	54.1
LA	2.1	2.0	10.6	1.9	3.0	33.6	2.5	5.6	26.0
World ex CN	2.5	4.6	28.3	5.5	4.3	41.5	2.7	4.4	31.9
Commodity price inflation									
All commodities	0.9	1.6	18.3	2.2	6.1	37.0	2.5	5.1	16.8
Food and beverage	0.4	1.5	4.7	1.3	2.2	14.3	3.6	5.9	14.1
Industrial inputs	1.4	3.2	34.0	2.5	6.7	37.8	4.5	6.3	30.9
Energy	0.8	1.7	17.3	1.6	3.8	27.1	3.4	6.0	22.4
Copper	1.0	2.0	15.9	1.2	3.4	17.5	1.6	3.0	10.0
Crude oil	0.5	1.2	13.0	2.0	5.9	34.3	2.3	5.1	11.6

	commodity price factor			Australasian factors		
	CN supply	CN demand	Global	CN supply	CN demand	Global
Selected Chinese variables						
GDP growth	2.9	8.4	37.8	6.8	15.4	51.6
CPI infl	2.6	8.0	45.7	2.3	15.2	38.1
PPI infl	2.2	2.8	23.5	5.5	6.4	39.4
CPI inflation						
North America	1.9	5.1	30.3	3.1	13.6	37.0
Euro area	2.3	4.8	34.6	3.7	16.7	39.3
Oth Europ countries	1.4	4.3	22.0	3.3	14.7	38.7
CEECs	0.9	2.8	16.8	1.2	5.4	16.6
AUS-NZ	1.9	6.2	30.6	3.4	14.0	39.6
Asia ex CN	1.8	3.1	25.1	2.4	13.7	28.7
LA	0.4	0.8	5.6	2.4	3.3	14.4
World ex CN	1.7	3.9	24.9	2.8	12.7	33.2
PPI inflation						
North America	2.2	4.9	28.8	3.9	14.3	42.0
Euro area	5.6	3.8	27.6	2.9	16.1	26.4
Oth Europ countries	2.3	6.3	31.9	3.7	18.5	43.1
CEECs	2.5	1.8	8.5	3.2	4.4	12.2
AUS-NZ	5.7	6.1	43.7	4.1	23.4	42.1
Asia ex CN	3.9	4.9	40.0	3.6	16.6	42.6
LA	1.9	2.8	23.3	5.0	7.0	27.3
World ex CN	2.9	3.8	26.4	3.6	14.1	35.6
Commodity price inflation						
All commodities	3.0	14.9	66.0	2.9	10.3	36.6
Food and beverage	1.4	6.3	30.2	1.5	2.4	17.1
Industrial inputs	3.2	12.1	55.0	3.6	14.6	27.3
Energy	2.2	8.0	38.3	2.1	5.4	27.6
Copper	2.7	10.4	54.1	2.7	7.3	16.1
Crude oil	2.5	12.8	48.7	2.5	8.9	33.8

Notes: The forecast error horizon is five years. The shares are computed based on the median impulse response functions.

Table A.1 Data

#		Treatment	Source
	Chinese variables		
1	GDP (real)	1	Haver Analytics
2	Private consumption (real)	1	IMF WEO database
3	Government consumption (real)	1	IMF WEO database
4	Fixed investment (real)	1	IMF WEO database
5	Exports (real)	1	IMF WEO database
6	Imports (real)	1	IMF WEO database
7	CPI	1	BIS
8	PPI	1	Haver Analytics
9	GDP deflator	1	IMF WEO database
10	M0	1	BIS
11	M1	1	BIS
12	M2	1	BIS
13	Money market rate	0	BIS
14	Unit labor costs	1	World Bank (upon request)
15	Nominal effective exchange rate	1	BIS
16	Real effective exchange rate	1	BIS
17	Net increase in loans (Renminbi terms)	1	Haver Analytics
18	Foreign reserves (US dollar terms)	1	Haver Analytics
19	Industrial production	1	Haver Analytics
20	Crude steel production	1	Haver Analytics
21	Cement production	1	Haver Analytics
22	Car sales	1	Haver Analytics
23	NBS Macroeconomic climate index (coincident)	0	Haver Analytics
24	NBS Business climate index	0	Haver Analytics
25	PBoC Industrial enterprise survey	1	Haver Analytics
26	Freight carried railways (tons)	1	Haver Analytics
27	Consumer confidence	0	Haver Analytics
28	Nominal retail sales	1	Haver Analytics
29	Government expenditures (nominal, Renminbi terms)	1	Haver Analytics
30	Government revenue (nominal, Renminbi terms)	1	Haver Analytics
31	Real wages	1	Haver Analytics
32	Real wages manufacturing	1	Haver Analytics
	Commodity prices		
1	HWWI	1	BIS
2	JPM total	1	BIS
3	All commodity	1	IMF
4	Non-fuel	1	IMF
5	Food and beverage	1	IMF
6	Food	1	IMF
7	Beverage	1	IMF
8	Industrial inputs	1	IMF
9	Agricultural raw materials	1	IMF
10	Metals	1	IMF
11	Energy	1	IMF
12	Aluminum	1	IMF
13	Copper	1	IMF
14	Crude oil	1	IMF
15	Soybeans	1	IMF

Table A.1 Data cont.

#		Treatment	Source
	Country data		
37	GDP (real)	1	BIS / Haver Analytics
37	Private consumption (real)	1	BIS / Haver Analytics
37	Fixed investment (real)	1	BIS / Haver Analytics
37	Exports (real)	1	OECD / Haver Analytics
37	Imports (real)	1	OECD / Haver Analytics
37	Exports to China (nominal, US dollar terms)	1	IMF DOTS
37	Imports from China (nominal, US dollar terms)	1	IMF DOTS
37	CPI	1	BIS / Haver Analytics
32	Core CPI	1	OECD / Haver Analytics
33	CPI goods	1	Eurostat / Haver Analytics
33	CPI services	1	Eurostat / Haver Analytics
33	PPI	1	BIS / Haver Analytics
37	GDP deflator	1	BIS / Haver Analytics
36	Overnight rate	0	BIS / Haver Analytics
34	Money market rate	0	BIS / Haver Analytics
32	Long-term government bond yield	0	BIS / Haver Analytics
33	Unit labor costs manufacturing sector	1	OECD / Haver Analytics
36	Import price	1	OECD / Haver Analytics
36	Export price	1	OECD / Haver Analytics
37	Real effective exchange rate	1	BIS / Haver Analytics
30	Real earnings manufacturing sector	1	OECD / Haver Analytics
34	Employment	1	OECD / Haver Analytics
34	Unemployment rate	0	OECD / Haver Analytics
821			

Notes: 1: log difference, 0: level.