CrossMark

Macroeconomic Dynamics, **22**, 2018, 225–254. Printed in the United States of America.
doi:10.1017/S1365100516000158

CHINA'S ROLE IN GLOBAL INFLATION DYNAMICS

SANDRA EICKMEIER AND MARKUS KÜHNLENZ
Deutsche Bundesbank

We apply a structural dynamic factor model to a large quarterly data set 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 as follows: (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 6 percent on the 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 matter. (iii) Differences in trade and in commodity exposure help explain cross-country differences in price responses.

Keywords: Global Inflation, China, Structural Dynamic Factor Model

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 (2012), inflation rates across countries strongly comove because of 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 gross domestic product (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

We wish to thank Knut Are Aastveit, Heinz Herrmann, Ulf Slopek, Mu-Chun Wang, and two anonymous referees as well as the participants of a joint Norges Bank-Bundesbank workshop, of the 4th workshop on Money, Macro and Finance in East Asia and of a seminar at the Reserve Bank of Australia for very helpful comments and discussions. The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the Deutsche Bundesbank. Address correspondence to: Sandra Eickmeier, Deutsche Bundesbank, Wilhelm-Epstein-Str. 14, 60431 Frankfurt, Germany; e-mail: sandra.eickmeier@bundesbank.de.

© 2016 Cambridge University Press 1365-1005/16

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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 et al. (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 are 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) that has been suggested by Forni et al. (2000). The DFM allows rich and flexible modeling of the different ways in which shocks propagate throughout the world, while keeping dimensionality manageable. We estimate factors from two separate large data sets, one set of Chinese and one set of foreign quarterly macroeconomic variables from 2002 to 2011. The latter data set 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, and labor costs) and other variables that are useful in analyzing the transmission channels (including interest rates, monetary aggregates, and 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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

of foreign inflation explained by Chinese shocks is notable (about 6 percent on the 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) 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 (2012) 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 (2013) 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.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

Côté and De Resende (2008) is another very closely related study. It assesses China's role in 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 that focus on one or a few individual channels of transmission of Chinese shocks to other countries' inflation. Mandel (2013) assesses the relationship between Chinese competition and two components of U.S. import prices: marginal costs and markups. He finds evidence for non-Chinese exporters having experienced a squeeze in markups and having shifted toward higher-quality products, which resulted in increased marginal costs as a consequence of China entering into exporting. Kumar et al. (2003), Feyzioglu and Willard (2006), Kamin et al. (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 in world commodity prices. Aastveit et al. (2015) 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 most 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 in the preceding, which use generalized impulse responses to nonorthogonal shocks that are hard to interpret economically. Third, in contrast 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 data set," includes a large number (N_G) of series from other countries. Let $X_t = (X_t^{\mathrm{CN}\prime}, X_t^{G\prime})'$and $N = N_{\mathrm{CN}} + N_G$. X_t is modeled using an approximate

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

dynamic factor model [Bai and Ng (2002), Stock and Watson (2002b)]:

$$X_t = \Lambda' F_t + e_t. \quad (1)$$

In equation (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 data set; i.e., $r << N$. In addition, F_t may contain dynamic factors and their lags. To that extent, equation (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:

$$F_t = B_1 F_{t-1} + \ldots + B_p F_{t-p} + w_t, \quad E(w_t) = 0,\ E(w_t w_t') = \Omega. \quad (2)$$

Because 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 $r_G = r - r_{\mathrm{CN}}$-dimensional vector of unobserved global factors F_t^G; i.e., $F_t = (F_t^{\mathrm{CN}\prime}, F_t^{G\prime})'$. 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 data set with principal components, which yields $\widehat{F_t^{\mathrm{CN}}}$. 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 $\widehat{F_t^{\mathrm{CN}}}$. This helps reduce 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 $(\widehat{F_t^{\mathrm{CN}}}', \widehat{F_t^G}')'$. Fifth, we estimate the VAR (2) with OLS equationwise. Sixth, we identify Chinese supply and demand shocks, as explained in detail in the following.

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. Two factors explain 39 percent of the variation in the Chinese data set, and two "global" factors explain 25 percent of the variation in the international data (after the Chinese influence has been removed). We will show in the robustness

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

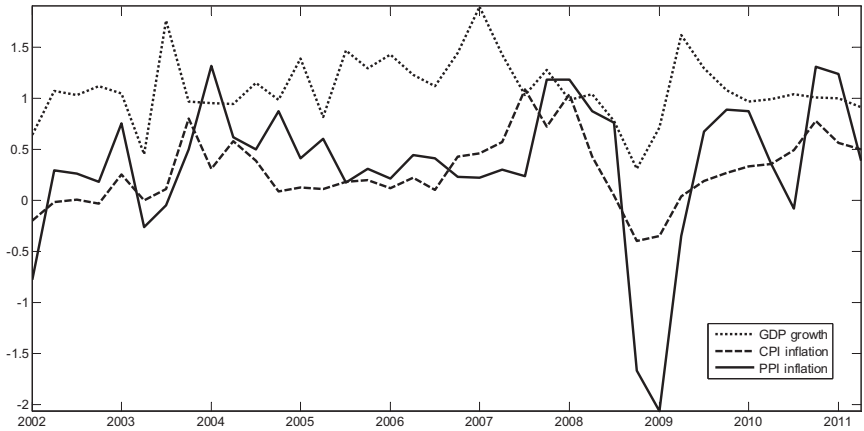


FIGURE 1. Dynamics of key Chinese data series (quarter-on-quarter differences of logarithms of GDP, CPI, and PPI in percent).

check section that follows that increasing the number of factors does not alter our main results.

The factors capture the comovement of the variables and serve us here to reduce the dimension of the data. We do not attempt to identify and, hence, interpret, the factors, but rather shocks from China, which can, via the factors and the idiosyncratic components, affect the variables in X_t. To identify 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 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. These variables are shown in Figure 1. 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

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.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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)].[5] We restrict both consumer and producer prices, because 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 [Asian Development Bank (2011)], whereas other goods such as industrials that have a high 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., Furlanetto et al. (2014), Eickmeier and Ng (2015)]. 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 relative restrictions, which we impose on impact only, allow us to remain as agnostic as possible on the impact on foreign variables, which is what we are most interested in. Another reason for not imposing zero restrictions is finally that state-of-the-art DSGE models (the theoretical counterparts of our empirical model) do not deliver an exact immediate zero impact of shocks.

The identification is implemented using the method of Rubio-Ramirez et al. (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 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 that yields impulse responses of Chinese GDP and prices to the two shocks close to the median impulse responses.[6] For more details on the implementation of the sign restrictions, see Fry and Pagan (2007) and Rubio-Ramirez et al. (2010).

Impulse responses to the Chinese shocks of the individual variables in the large data sets can be computed as weighted averages over impulse responses of estimated Chinese and global factors, where the weights are the estimated loadings. We show in the following median impulse responses and 90% confidence bands that reflect parameter (not model) uncertainty. We assess in the following 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 et al. (2005) because of the large cross-sectional dimensions.[7]

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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 data set 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 data set includes data for 37 countries, if available: OECD countries, Brazil, Colombia, and several emerging Asian economies (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), and price and cost variables (CPI, PPI, GDP deflator, earnings,[8] unit labor costs,[9] import and export prices, and 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 data set is $N_G = 821$.

For the international data set, 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 some series from China, and we interpolated them using the cubic spline method.[10] Because 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 Watson (2005).[11] Our data set 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 (2002a) for details]. We only interpolate (and include) data for which at least five years are available. Finally, we normalize each series to have a zero mean and a unit variance.

An overview of the complete data sets is provided in the working paper version of this paper [Eickmeier and Kühnlenz (2013)].

5. RESULTS

In this section, we first show impulse responses to Chinese supply and demand shocks and variance decompositions of the (key) Chinese variables that we restricted for shock identification (GDP and prices). We then analyze the shock

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

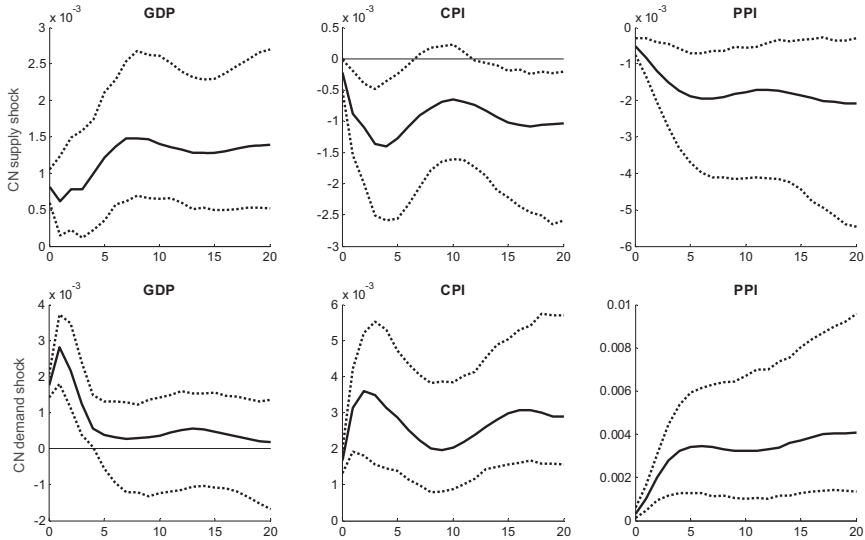


FIGURE 2. Impulse responses of selected Chinese variables to Chinese supply and demand shocks. Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands; solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

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" (the United States, Canada), "Euro area" (as of 2006: Austria, Belgium, Germany, Spain, Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal), "other European countries" (Switzerland, Denmark, the United Kingdom, Norway, Sweden), "CEECs" (Central and Eastern European countries: the Czech Republic, Estonia, Hungary, Poland, Slovenia, Slovakia), "Australia–New Zealand," "Asia ex CN" (Indonesia, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand) and "Latin America" (Brazil, Chile, Colombia, Mexico). Results are aggregated using nominal GDP weights (in U.S.$ 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 2 shows reactions of key Chinese variables to the Chinese supply and demand shocks. The Chinese supply shock has a permanent positive effect on GDP,

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

which rises on impact by almost 0.1 percent (median response) and then increases further to 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 almost 0.3 percent is achieved after one quarter. Chinese consumer 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 in order 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 that is 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 in the following 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 14 percent, respectively) and inflation (between 1 and 13 percent, respectively).[12] Global shocks account for 33 percent of Chinese GDP growth and for 15–40 percent of inflation. 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 following.

5.2. Transmission of Chinese Supply and Demand Shocks to International Prices

Figures 3 and 4 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 0.1–0.4 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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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	14.1	30.8	52.4
CPI inflation	2.5	13.4	39.8	44.3
PPI inflation	1.2	4.0	15.1	79.8
	CPI inflation			
North America	1.2	4.6	20.8	73.4
Euro area	1.9	7.6	30.7	59.8
Other European countries	1.0	6.7	18.7	73.6
CEECs	0.8	4.4	14.7	80.0
AUS-NZ	0.9	5.6	17.0	76.4
Asia ex CN	1.4	4.4	21.6	72.7
LA	0.4	1.0	5.3	93.3
World ex CN	1.2	4.6	20.2	74.1
	PPI inflation			
North America	1.2	5.3	19.3	74.1
Euro area	5.0	6.0	24.4	64.5
Other European countries	1.7	9.6	26.7	62.0
CEECs	2.3	2.6	7.2	87.9
AUS-NZ	3.4	5.9	30.0	60.7
Asia ex CN	3.8	8.9	36.0	51.3
LA	0.9	3.9	17.6	77.6
World ex CN	1.8	4.8	20.1	73.3
	Commodity price inflation			
All commodities	1.7	10.4	20.4	67.5
Food and beverage	1.1	4.8	11.7	82.4
Industrial inputs	1.0	8.7	21.2	69.1
Energy	2.3	6.8	15.9	74.9
Copper	1.0	4.6	9.2	85.2
Crude oil	2.5	10.9	20.3	66.4

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

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 based mainly on tradable manufactured goods. In contrast, in the United States, 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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

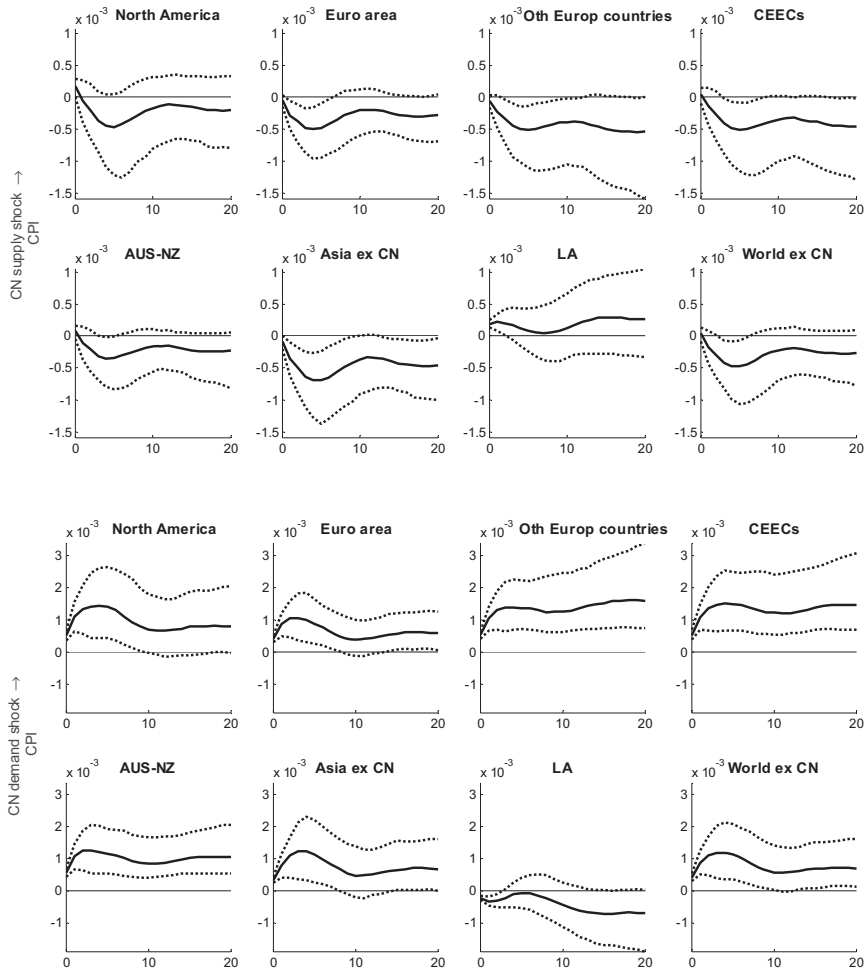


FIGURE 3. Impulse responses of CPI to Chinese supply and demand shocks. Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands; solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

because of 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 8) percent of the forecast error of foreign consumer (producer) price inflation rates.[13] 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 10 percent (in other European countries).[14] The shares explained by

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

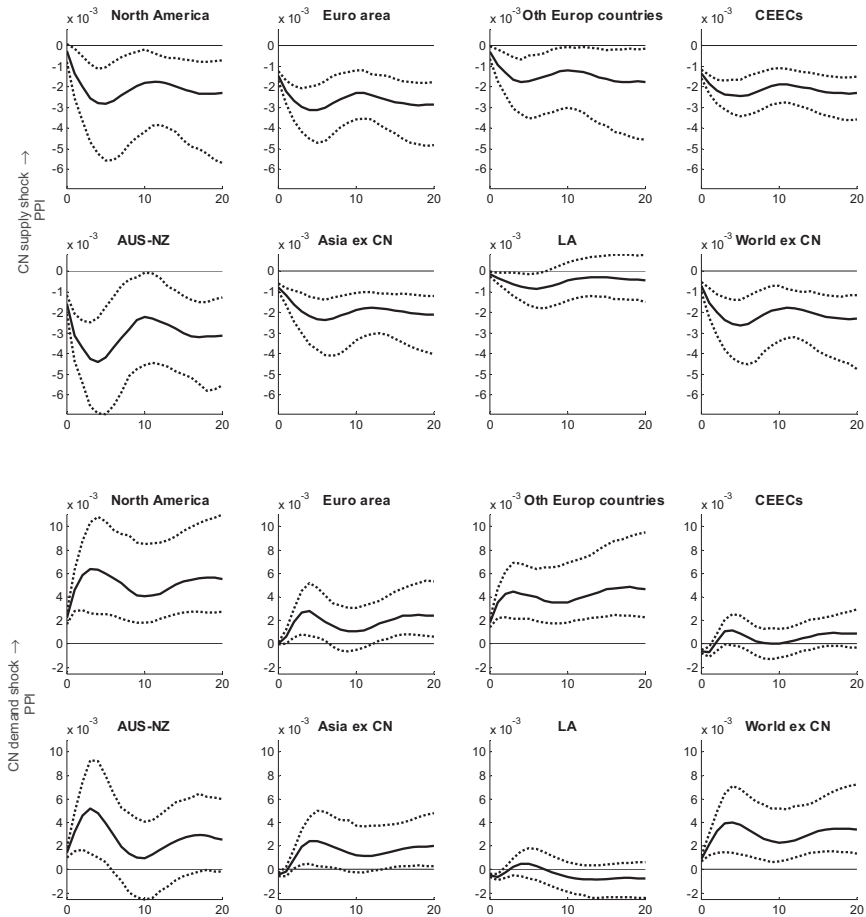


FIGURE 4. Impulse responses of PPI to Chinese supply and demand shocks. Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands; solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

global shocks are 5–31 percent for CPI inflation and 7–36 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 (2013) for Australasia.

Overall, our results confirm the strong comovement of inflation rates across countries.[15] 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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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.[16] It is possible to distinguish between supply- and demand-side channels, on 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 increased as foreign producers changed the composition of their products toward 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 that 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 one hand, and direct (trade-related) and indirect channels, on the other. We also consider 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.[17] We finally note up front 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.

Transmission mechanism for Chinese supply shocks. The Chinese supply shock seems to be transmitted to foreign prices directly via import prices (Figure 5), consistent, for example, with Kumar et al. (2003), Feyzioglu and Willard (2006), 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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

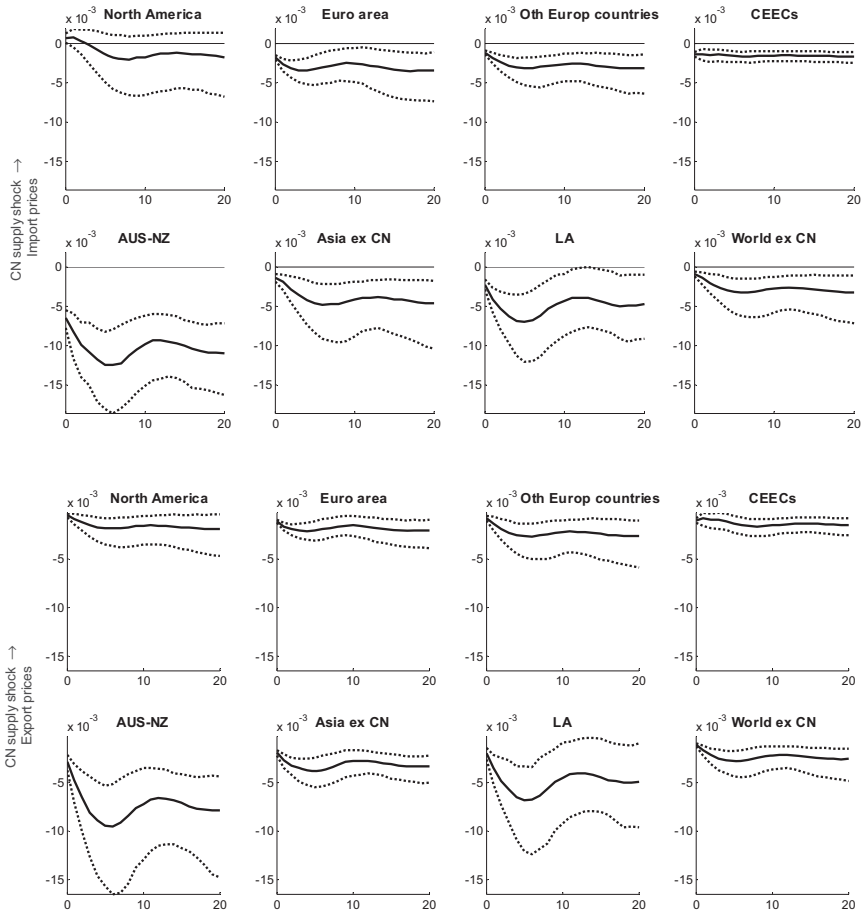


FIGURE 5. Transmission of Chinese supply shocks to selected international variables. Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands; solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

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, however, does not seem to matter in the case of the supply shock, as foreign export prices decline significantly in all regions.

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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

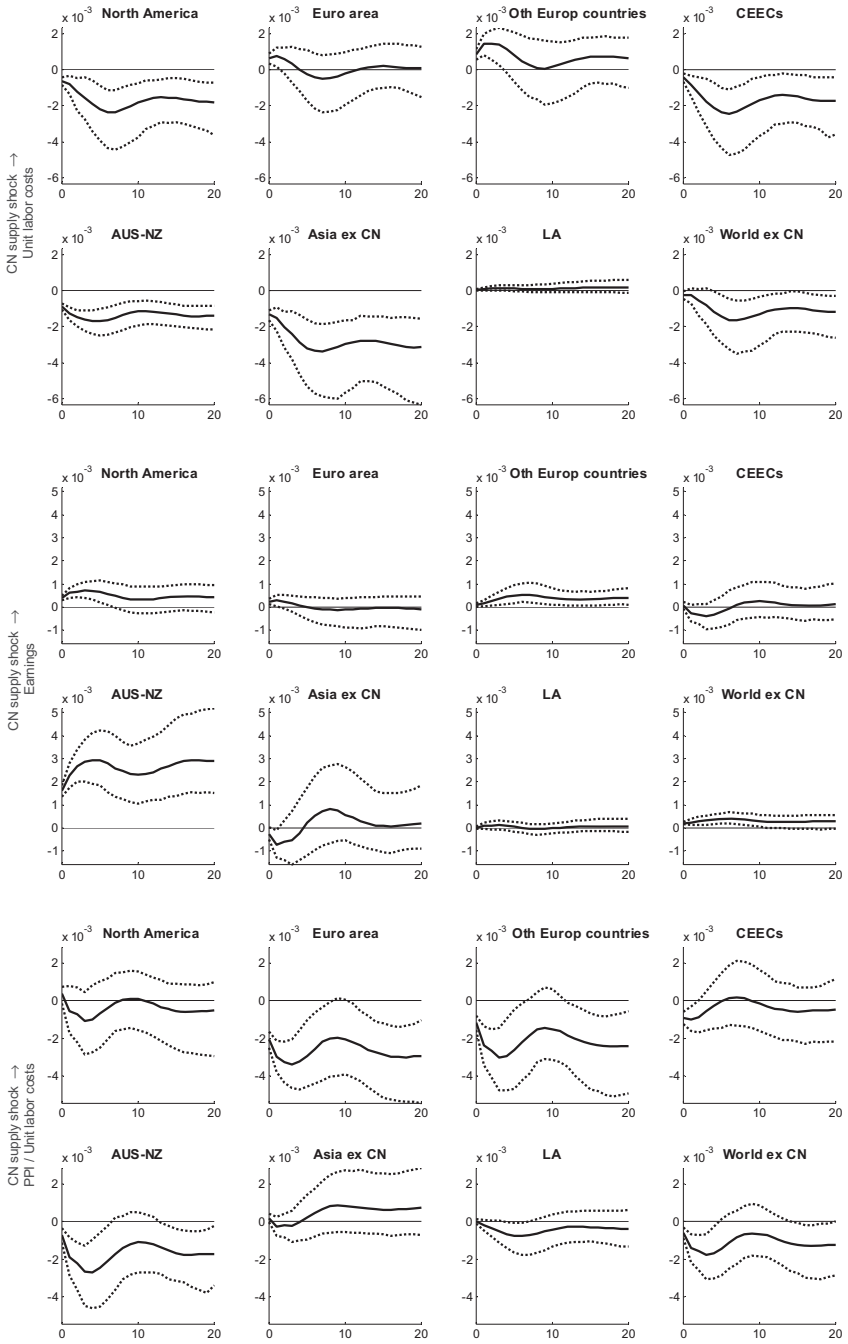


FIGURE 5. Continued.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

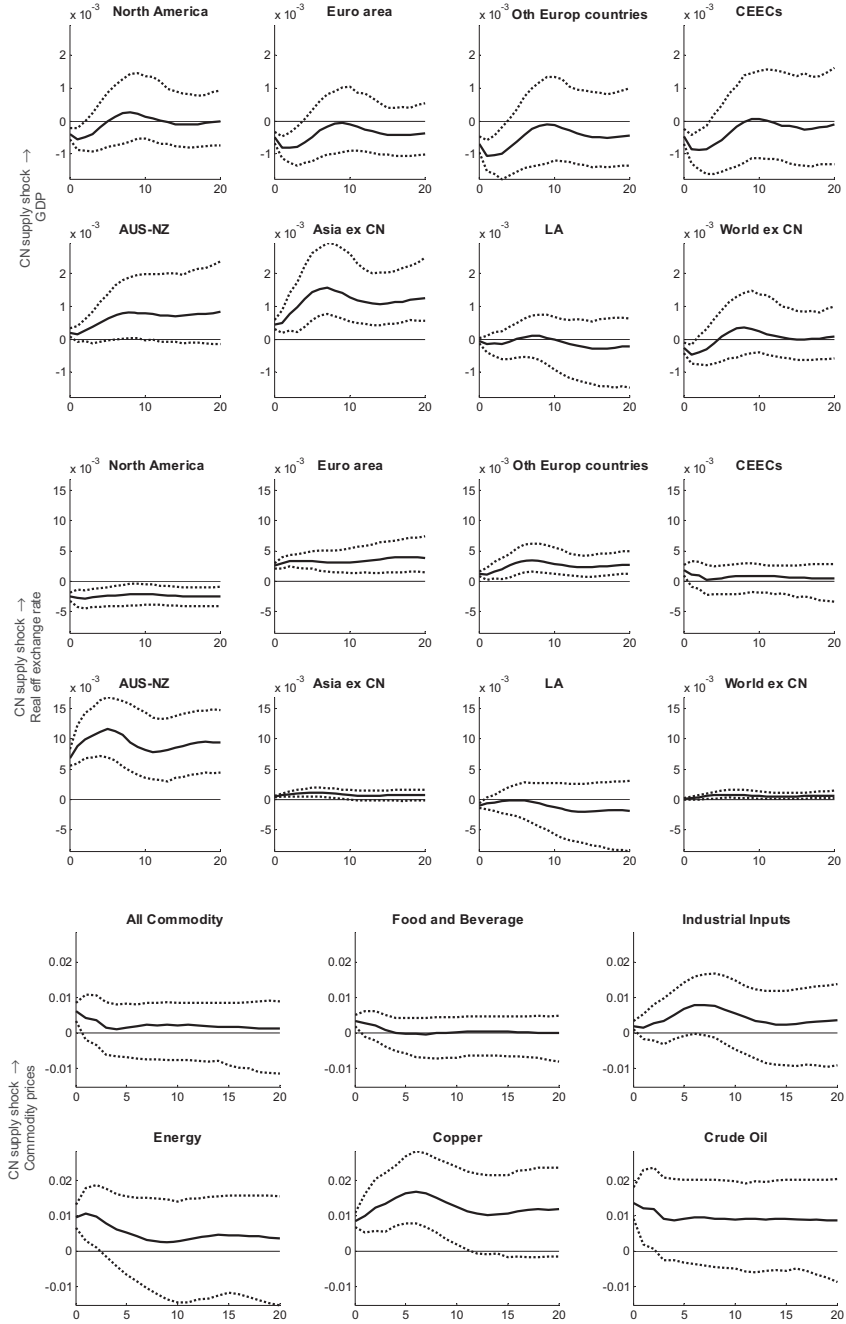


FIGURE 5. Continued.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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 technology, labor supply, and markup shocks. This may help in 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 toward 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, likely because of competitive pressure from China, but the decline is not or only marginally significant in North America and Asia. 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. In contrast, GDP declines initially in all other regions, exerting further downward pressures on foreign prices, and turns insignificant after less than a year.[18]

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.[19] The depreciation in North America may explain why import prices rise there as well (unlike 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 U.S. trade deficit over the entire sample period, a depreciation means a loss of purchasing power and an even higher import bill, thereby dampening GDP.

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 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 discuss later, not very robust across specifications.

Transmission mechanism for Chinese demand shocks. 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 6). 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 becomes 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.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

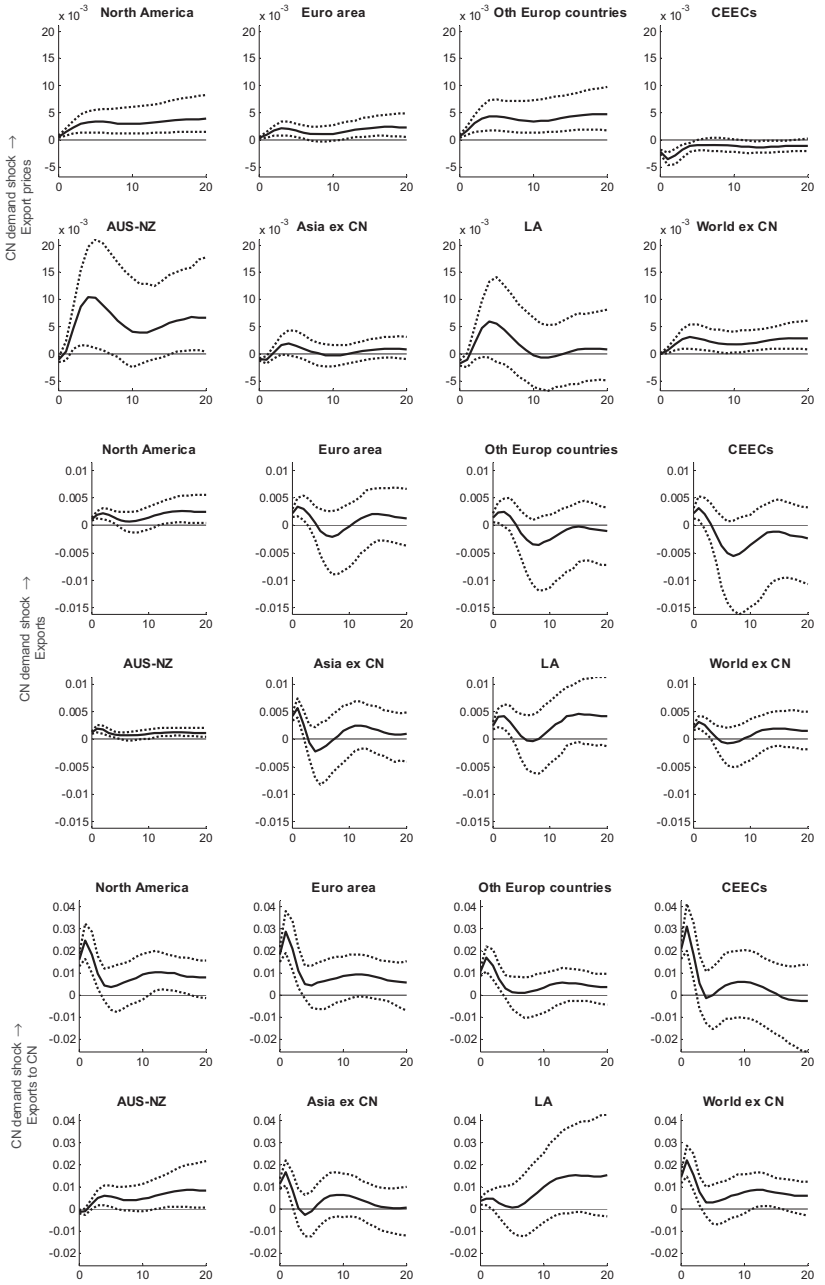


FIGURE 6. Transmission of Chinese demand shocks to selected international variables. Impulse response functions (IRFs) to one standard deviation shock. Dotted lines: 90% confidence bands, solid line: median IRF. The IRFs are constructed using the "Median Target" approach suggested by Fry and Pagan (2011).

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

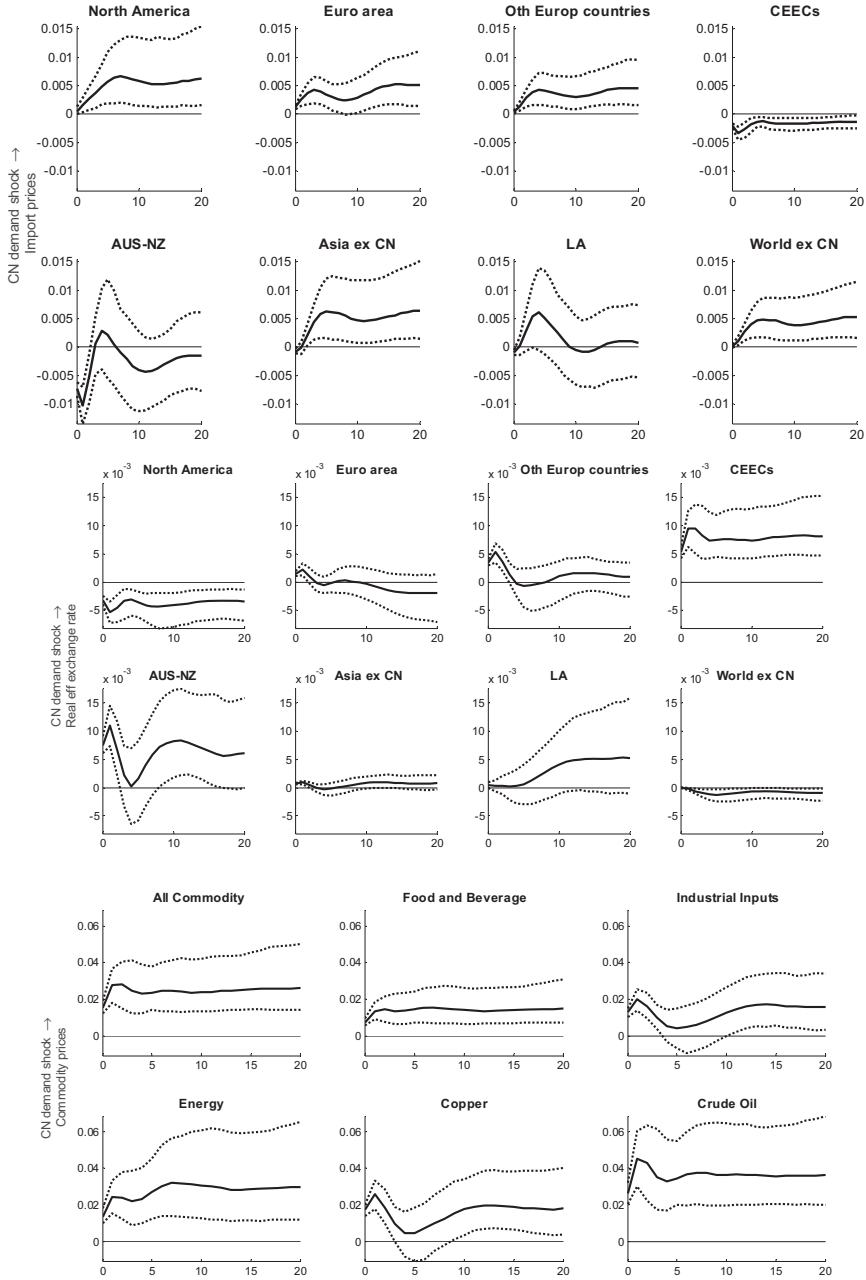


FIGURE 6. Continued.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

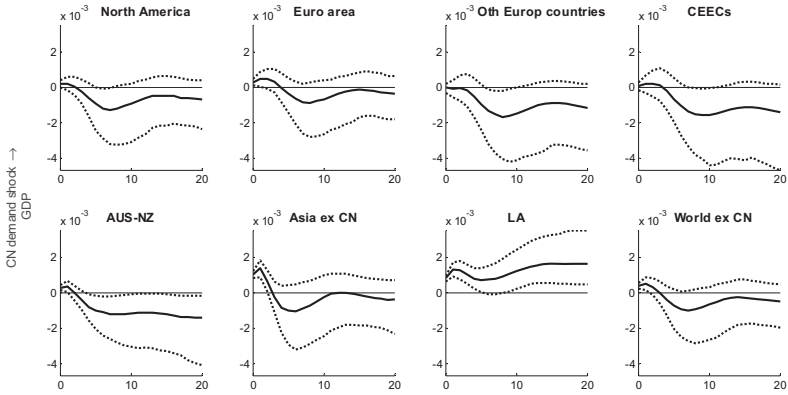


FIGURE 6. Continued.

(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 in the following.

In addition to these direct effects, the Chinese demand shock also affects other countries' consumer and producer prices indirectly. As a result of the Chinese demand shock, we observe a real appreciation in several countries, especially in commodity-exporting regions. This suggests that an improvement in the commodity terms of trade might play a role. Indeed, various commodity prices increase persistently after a Chinese demand shock; the effects are strongest for oil (Figure 6). Especially in Australia–New Zealand and 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.[20]

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.[21] 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 13 percent of the forecast error variance of crude oil price inflation [the bulk (11 percent) is explained by Chinese demand shocks] and 12 percent of movements

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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 that 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. (2015). 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. (2015) 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 global VAR results for Chinese "output shocks" described by Feldkircher and Korhonen (2014).[22]

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 a by-product, we find that Chinese shocks account for 12 percent of fluctuations in commodity prices.

5.4. Transmission Mechanism II: Relating Price Impulse Responses to Country Characteristics

In this section, we exploit the cross-sectional 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, and structural similarity to China. Manufacturing value added and

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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.[23] The structural similarity of a country j to China is defined as $S_j = \sum_{l=1}^{L} \left| s_{lj} - s_{l\mathrm{CN}} \right|$, where s_{lj} and $s_{l\mathrm{CN}}$ denote the shares of sector l in total exports of country j and China, respectively [see Krugman (1991)].[24] 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.[25]

In Table 3 we show the 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 from the PPI impulse response functions to the supply shock obtained from the OLS regression). In other words, the 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 that compete with China appear not to raise prices after positive demand shocks or negative supply shocks as much as producers from countries that have a very different export structure compared with and therefore do not compete with China. At the same time, because of 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 to China help to explain differences across countries in price reactions to Chinese supply and demand shocks.[26] 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 the findings in Section 5.3.

5.5. Robustness Analysis

In this section we provide key results from several robustness checks. For more details, see Section 5.5 in Eickmeier and Kühnlenz (2013).

First, we repeat the analysis for the longer sample period since 1995Q4. This is to assess whether China's role has changed with its accession to the WTO because of, for example, more intense trade in goods with the rest of the world.

Second and third, we account for subfactors loading not on all but on a subset of international variables. We partition the global data set (after cleaning each variable from the Chinese factors) into a commodity price data set and a data

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

TABLE 3. Correlations between price impulse responses after one year to Chinese shocks and country characteristics

	OLS				Robust regression			
	Supply shock		Demand shock		Supply shock		Demand shock	
Country characteristics	CPI	PPI	CPI	PPI	CPI	PPI	CPI	PPI
Openness (sum of exports and imports relative to GDP in %)	−0.00048***	−0.00003	0.00064***	−0.00068	−0.00046***	−0.00019	0.00058***	−0.00026
Imports from China relative to GDP (in %)	−0.01190***	0.00640	0.01782***	0.01351	−0.01127***	0.01038	0.01655***	0.03345*
Eports to China relative to GDP (in %)	−0.00771**	−0.00565	0.01232***	0.03263	−0.00852***	0.01089	0.01331***	0.03986**
Commodity imports relative to GDP (in %)	−0.00702***	0.00028	0.00978***	−0.00005	−0.00806***	0.00185	0.01101***	0.01271
Commodity exports relative to GDP (in %)	−0.00551**	−0.00784	0.00561**	0.03570***	−0.00705***	−0.00425	0.00879***	0.01633
Manufacturing value added relative to GDP (in %)	−0.00307	0.00325	0.00332	−0.00880	−0.00462***	0.00164	0.00351	0.00072
Distance between capital city and Beijing (in kilometers)	0.00000	−0.00002**	−0.00001**	0.00000	0.00001***	0.00000	−0.00001***	0.00000
Product market regulation (index variable, 0–6)	−0.01654	0.02685	−0.01550	−0.14440	−0.01487	0.06233	−0.00584	−0.09788
Employment protection (index variable, 0–6)	−0.02225	−0.01575	0.00456	−0.05354	−0.01549	0.00197	−0.00433	−0.06705
Structural similarity (see text for definition)	−0.01279	−0.28184***	−0.05087	0.43173***	0.04074	−0.17690**	−0.04445	0.21577

Note: Coefficients and significance levels are shown. ***, **, and * represent significance levels of 1%, 5%, and 10%.

set including all other international variables. We then extract a commodity price factor[27] from the former data set and, as before, two global factors from the latter. Next, we partition the global data set into a set comprising only variables from Asian countries (without China) and Australia and New Zealand and one including all other variables. We extract from them two global factors and two Australasian factors. 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.

Fourth, we reestimate the model with more factors, three Chinese and three global. Fifth, we replace the two latent Chinese factors with three observable Chinese variables (GDP growth and CPI and PPI inflation) and estimate a factor-augmented vector autoregression (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.

Overall, our main results are not much affected. 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, and variance shares explained by Chinese demand shocks now increase to more than 10 percent on the average over all countries (compared with 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.

Third, the finding from our baseline that commodity prices rise (although not very strongly) after the Chinese supply shock 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 to 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.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

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 have applied a structural dynamic factor model to a large quarterly data set covering 38 countries (including China) between 2002 and 2011 to analyze China's role in global inflation dynamics. We have identified Chinese supply and demand shocks and examined 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 as follows: (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 6 percent on the 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 explain cross-country differences in price responses.

NOTES

1. China is now the second largest economy, and achieved a 11 percent share of global output in 2012, as measured by current prices and market exchange rates (according to IMF's October 2013 WEO database). According to our calculations based on UN Comtrade data, 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 a 12 percent annual expansion of world trade over the same period. As a result, China's share of (nominal) world exports reached 11 percent in 2011, making it the largest trading nation. Around 12 percent of OECD countries' total imports came from China; in manufactured goods alone, the share was at 17 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 et al. (2011).

3. Cesa-Bianchi et al. (2012) and Feldkircher and Korhonen (2014) 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.

4. We have repeated the entire analysis without this "cleaning step." Alternatively, we have first extracted international factors and then cleaned the Chinese variables from the international factors and extracted Chinese factors from the residuals. Our main results remain unaffected.

5. It might be the case that, after a Chinese supply shock, both output and oil prices rise (due to an increase in oil imports). The latter can lead to an increase rather than a decrease in general prices. This would not be captured by our identified supply shock, but rather by the Chinese demand shock

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

(if output and price impulse responses are positive for a sufficiently large number of quarters). This needs to be kept in mind when interpreting results.

6. We show in Eickmeier and Kühnlenz (2013) that model uncertainty is not very large.

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

8. 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.

9. 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.

10. The China series that were interpolated are private consumption, government consumption, fixed investment, real exports and imports, GDP deflator, unit labor costs, and wages.

11. 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 values of the preceding five observations.

12. One (rather technical) reason for our estimate of a small explanatory power of domestic shocks might be that trend growth in China was particularly strong, but that our factor model requires stationary (and, hence, detrended) data. In future work, it would be interesting to consider stochastic trends when studying dynamic economic relationships between China and other countries.

13. Chinese supply shocks explain a much smaller share than domestic supply shocks. Previous studies for the United States and the Euro area, for instance, find shares of price variation accounted for by domestic supply shocks between one-fifth and one-half [e.g., Peersman (2005), Smets and Wouters (2005), Eickmeier (2009), Peersman and Straub (2009), and Buch et al. (2014)].

14. A historical decomposition for international inflation rates reveals that there have been considerable negative contributions from China's demand shocks in 2005 and 2007 and larger positive contributions between 2007 and 2008.

15. 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 data set with different types of variables, whereas their data set comprises only inflation rates.

16. Côté and De Resende (2008) provide a useful overview of the channels.

17. We have also looked at international monetary policy interest rate reactions to the Chinese shocks, but found them to be mostly insignificant, suggesting that they have not played an important role as a transmission channel up to the end of our sample. We therefore do not plot them in the following.

18. The negative (Chinese against other countries') GDP correlations are consistent with the international real business cycle model of Backus et al. (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 bring about a permanent real income per capita loss for its trading partner.

19. We have replaced the real effective exchange rates with nominal effective exchange rates and reestimated our model. The responses of the nominal rates to Chinese supply and demand shocks are very similar to the responses of the real rates.

20. The direct and indirect channels are hard to disentangle in this case, as commodities represent a sizeable portion of overall exports.

21. Osorio and Unsal (2013) also find an effect (after two quarters) of a Chinese GDP shock on commodity prices that is larger than that on consumer prices, although the difference is much smaller than in our case. Whereas commodity prices in their analysis are affected with a time lag, ours react instantaneously to the Chinese demand shocks.

22. 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

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

are between 2 percent (in Latin America) and 6 percent (in North America and other European countries).

23. 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.

24. 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 for international markets.

25. Monetary and exchange rate regimes can be expected to matter as well for the heterogeneity in countries' reactions to Chinese shocks. This is, however, difficult to capture in our analysis (and we leave it to future work). One reason is that many countries experienced regime changes within our sample period. Moreover, some countries behave as inflation targeters although they have not adopted inflation targeting officially, and, hence, it would not be clear how to classify them.

26. Openness is also found by Bianchi and Civelli (2015) to shape the dynamics of domestic inflation in many countries. The authors use a time-varying parameter VAR approach.

27. When we apply the Bai and Ng (2002) criteria to the commodity price data set, 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, because it already explains a large bulk (45 percent) of the variation in the commodity price data set.

REFERENCES

Aastveit, Knut A., Hilde C. Bjørnland, and Leif A. Thorsrud (2015) What drives oil prices? Emerging versus developed economies. *Journal of Applied Econometrics* 30(7), 1013–1028.

Asian Development Bank (2011) *Asian Development Outlook*, p. 23.

Backus, David K., Patrick J. Kehoe, and Finn E. Kydland (1992) International real business cycles. *Journal of Political Economy* 100(4), 745–775.

Bai, Jushan and Serena Ng (2002) Determining the number of factors in approximate factor models. *Econometrica* 70, 191–221.

Bernanke, Ben S., Jean Boivin, and Piotr Eliasz (2005) Measuring the effects of monetary policy: A factor-augmented vector autoregressive (FAVAR) approach. *Quarterly Journal of Economics* 120, 387–422.

Bianchi, Francesco and Andrea Civelli (2015) Globalization and inflation: Evidence from the time-varying VAR. *Review of Economic Dynamics* 18(2), 406–433.

Boivin, Jean and Serena Ng (2006) Are more data always better for factor analysis? *Journal of Econometrics* 132, 169–194.

Borio, Claudio E.V. and Andrew J. Filardo (2007) Globalization and Inflation: New Cross-Country Evidence on the Global Determinants of Domestic Inflation. BIS working paper 227.

Buch, Claudia, Sandra Eickmeier, and Esteban Prieto (2014) Macroeconomic factors and microlevel bank behavior. *Journal of Money, Credit and Banking* 46(4), 715–751.

Cesa-Bianchi, Ambrogio, Hashem Pesaran, Alessandro Rebucci, and TengTeng Xu (2012) China's emergence in the world economy and business cycles. *Economia, Journal of the Latin American and Caribbean Economic Association* 12(2), 1–75.

Chamberlain, Gary and Michael Rothschild (1983) Arbitrage, factor structure, and mean–variance analysis on large asset markets. *Econometrica* 51, 1281–1304.

Ciccarelli, Matteo and Benoit Mojon (2010) Global inflation. *Review of Economics and Statistics* 92(3), 524–535.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

Côté, Denise and Carlos De Resende (2008) Globalization and Inflation: The Role of China. Bank of Canada working paper 2008–35.
Eickmeier, Sandra (2009) Comovements and heterogeneity in the Euro area analyzed in a nonstationary factor dynamic model. *Journal of Applied Econometrics* 24, 933–959.
Eickmeier, Sandra and Markus Kühnlenz (2013) China's Role in Global Inflation Dynamics. Deutsche Bundesbank discussion paper 07/2013.
Eickmeier, Sandra and Tim Ng (2015) How do credit supply shocks propagate internationally? A GVAR approach. *European Economic Review* 74, 128–145.
Eickmeier, Sandra and Katharina Pijnenburg (2013) The global dimension of inflation—Evidence from factor-augmented Phillips curves. *Oxford Bulletin of Economics and Statistics* 74, 103–122.
Farrant, Katie and Gert Peersman (2006) Is the exchange rate a shock absorber or a source of shocks? New empirical evidence. *Journal of Money, Credit and Banking* 38(4), 939–961.
Feldkircher, Martin and Iikka Korhonen (2014) The rise of China and its implications for emerging markets—Evidence from a GVAR model. *Pacific Economic Review* 19(1), 61–89.
Feyzioglu, Tarhan and Luke Willard (2006) Does Inflation in China Affect the United States and Japan? IMF working paper 06/36.
Forni, Mario, Marc Hallin, Marco Lippi, and Lucrezia Reichlin (2000) The generalized dynamic-factor model: Identification and estimation. *Review of Economics and Statistics* 82, 540–554.
Fry, Renee and Adrian Pagan (2007) Some Issues in Using Sign Restrictions for Identifying Structural VARs. NCER working paper 14.
Fry, Renee and Adrian Pagan (2011) Sign restrictions in structural vector autoregressions: A critical review. *Journal of Economic Literature* 49(4), 938–960.
Furlanetto, Francesco, Francesco Ravazzolo, and Samad Sarferaz (2014) Identification of Financial Factors in Economic Fluctuations. KOF working paper 364.
Kamin, Steven B., Mario Marazzi, and John W. Schindler (2006) The impact of Chinese exports on global import prices. *Review of International Economics* 14, 179–201.
Kilian, Lutz (1997) Small-sample confidence intervals for impulse response functions. *Review of Economics and Statistics* 80, 218–230.
Kilian, Lutz (2009) Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review* 99(3), 1053–1069.
Krugman, Paul (1991) *Geography and Trade.* Cambridge, MA: MIT Press.
Kumar, Manmohan, Baig Taimur, Joerg Decressin, Chris Faulkner-MacDonagh, and Tarhan Feyziogulu (2003) Deflation: Determinants, Risks, and Policy-Option-Findings of an Interdepartmental Task Force. IMF occasional paper 221.
Li, Hongbin, Lei Li, Binzhen Wu, and Yanyan Xiong (2012) The end of cheap Chinese labor. *Journal of Economic Perspectives* 26(4), 57–74.
Mandel, Benjamin R. (2013) Chinese Exports and U.S. Import Prices. Federal Reserve Bank of New York staff report 591.
Morel, Louis (2007) The Direct Effect of China on Canadian Consumer Prices: An Empirical Assessment. Bank of Canada discussion paper 10.
Mumtaz, Haroon and Paolo Surico (2012) Evolving international inflation dynamics: World and country-specific factors. *Journal of the European Economic Association* 10, 716–734.
OECD (2012) *Economic Policy Reforms 2012: Going for Growth*. Paris: OECD Publishing.
Osorio, Carolina and D. Filiz Unsal (2013) Inflation dynamics in Asia: Causes, changes, and spillovers from China. *Journal of Asian Economics* 24, 26–40.
Peersman, Gert (2005) What caused the early millennium slowdown? Evidence based on vector autoregressions. *Journal of Applied Econometrics* 20, 185–207.
Peersman, Gert and Roland Straub (2009) Technology shocks and robust sign restrictions in a Euro area SVAR. *International Economic Review* 50(3), 727–750.
Roache, Shaun K. (2012) China's Impact on World Commodity Markets. IMF working paper 12/115.
Rubio-Ramirez, Juan F, Daniel F Waggoner, and Tao Zha (2010) Structural vector autoregressions: Theory of identification and algorithms for inference. *Review of Economic Studies* 77(2), 665–696.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press

Samuelson, Paul A. (2004) Where Ricardo and Mill rebut and confirm arguments of mainstream economists supporting globalization. *Journal of Economic Perspectives* 18(3), 135–146.

Smets, Frank and Raf Wouters (2003) An estimated dynamics stochastic general equilibrium model of the Euro area. *Journal of the European Economic Association* 1, 1123–1175.

Smets, Frank and Raf Wouters (2005) Comparing shocks and frictions in US and Euro area business cycles: A Bayesian DSGE approach. *Journal of Applied Econometrics* 20(2), 161–183.

Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti (2011) Growing like China. *American Economic Review* 101, 202–241.

Stock, James H. and Mark W. Watson (2002) Forecasting using principal components from a large number of predictors. *Journal of the American Statistical Association* 97, 1167–1179.

Stock, James H. and Mark W. Watson (2002) Macroeconomic forecasting using diffusion indexes. *Journal of Business and Economic Statistics* 20, 147–162.

Stock, James H. and Mark W. Watson (2005) Implications of Dynamic Factor Models for VAR Analysis. NBER working paper 11467.

Zhu, Xiaodong (2012) Understanding China's growth: Past, present, and future. *Journal of Economic Perspectives* 26(4), 103–124.

https://doi.org/10.1017/S1365100516000158 Published online by Cambridge University Press