The effects of external shocks on the business cycle in China: A structural change perspective

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Abstract
We study the effects of external shocks on the business cycle in China and its sectors (agriculture, industry, and services) in terms of real GDP growth using several small dimensional VAR models with Cholesky identification for the period 1996–2014. We show that China—in particular its industrial sector—is susceptible to shocks, which can be related to a trade channel, a financial channel, and a confidence channel of business cycle transmission from major trading partner countries to the Chinese economy. If interpreted from the perspective of ongoing structural change and rebalancing in China, our findings can be interpreted as the result of a still very dominant industrial sector, and a previously export- and investment-driven growth model. Tertiarization in China could be one way of increasing the economy's future resilience to external shocks. However, the future structure of both the industrial and service sectors may be very decisive.

Keywords: International transmission channels, Transmission of shocks, Structural vector autoregression, Structural change

JEL classification: F43, F44, C32

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1. Introduction

China has managed to develop from being a low-income country in 1990 toward middle-income status today in terms of gross domestic product (GDP) per capita in an astonishingly short period of time. This fast development process in China has been based on a very traditional structural transformation process: huge migration of cheap labor from the agricultural (low-productivity) sector, particularly from western parts of China, to newly developed industrial (high-productivity) centers, particularly in the eastern parts of China. In addition, China could profit from special factors, such as cheap imports of technology and knowledge from Western companies via joint venture-constrained foreign direct investments (FDIs).

However, China has now entered a new stage of structural change - an early phase of so-called de-industrialization or tertiarization. This new structural transformation has been affirmed and supported by the Chinese government (see the 12th and 13th Five Year Plans) because of the rising negative economic and social side effects of rapid industrialization. This structural transformation is also considered by some to be part of a necessary and fundamental rebalancing process in China.

In the course of this development, the service sector (which often is characterized as a sector with lower productivity compared to the industrial sector) has recently surpassed the industrial sector in China for the first time in terms of employment, as well as value added. Moreover, rebalancing is (intentionally) associated with a gradual shift from net exports to advanced economies toward domestic consumption, domestic investment, and intraregional exports (sometimes understood as a decoupling from industrial or advanced countries).

This characterizes China as an economy on the cusp of a new developmental path. The question that arises is what consequences this structural transformation will have in and for China. Theoretical arguments suggest that this rebalancing process may produce a reduction in economic growth, a decline in the current account surplus and thus in foreign reserves, and an increase in inflation (see Wagner, 2013).

In this paper, we investigate the effects of external shocks on real growth and confidence in China and its sectors (agriculture, industry, and services). We find convincing evidence for the existence of trade, financial, and confidence channels between major trading partner countries and China, and especially China's industrial sector. First, we find a significant positive transmission of foreign real GDP growth shocks from major trading partner countries to China, especially its industrial sector. In contrast the agricultural and service sectors' real growth remains unaffected by these shocks. Hence, the trade channel seems to work through China's industrial sector. Second, financial shocks also especially affect growth in the industrial sector, but are also significant at an economy-wide level. Finally, we find support for the existence of a confidence channel. Our analysis is based on two measures of confidence in China: Business confidence and consumer confidence are clearly affected by trade and financial shocks, and could hence increase the impact of shocks working through trade and financial channels. In particular, a decrease in consumer confidence could be a way in which external shocks affecting the industrial sector could be transmitted into other subsectors of the Chinese economy and have negative effects on consumer spending. Our results are supported by the corresponding Granger-causality tests and variance decompositions. To our knowledge, we are the first to investigate the effect of external shocks at a sectoral level in China. We also extend previous research by analyzing potential confidence channels.

Altogether, the shocks have significant effects on the Chinese economy, but the effect on growth rates is generally short-lived..

The rest of the paper is structured as follows. We first give a very brief overview of the rebalancing discussion, and the impact of structural change on economic growth and stability. We also review the literature on business cycle transmission and the main transmission channels. Our empirical analysis starts with a description of the data, and how we obtain our measure of aggregated real GDP growth and liquidity conditions in trading partner countries. We briefly present our econometric framework and explain the identification scheme. We then present the empirical evidence for each channel in turn. We close with a summary of our results and propose policy implications.

2. Literature review

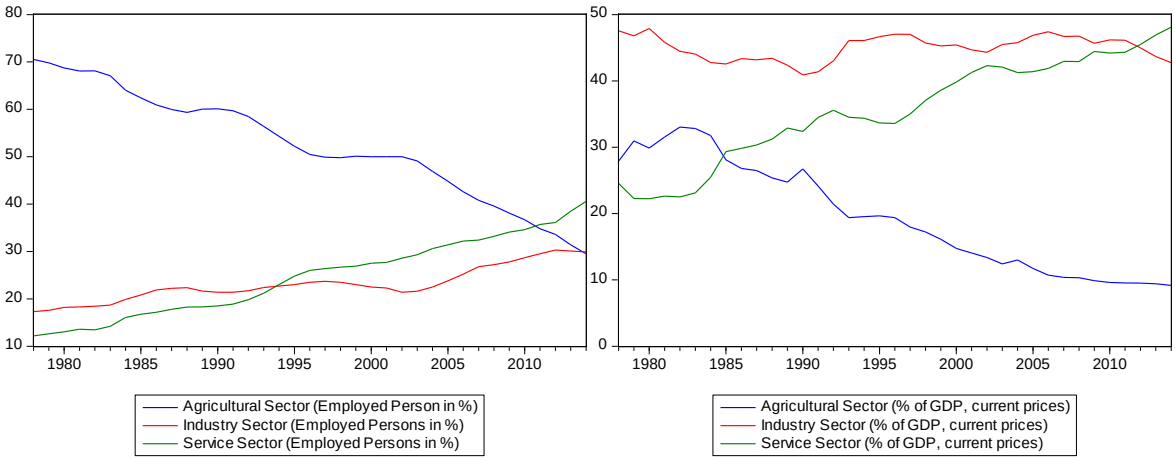
Our study relates to different lines of literature. First, there is a connection to the discussion on rebalancing the Chinese economy. De-industrialization is from this perspective seen as a shift from an export-driven towards a consumption-driven business model in China. Our analysis shows that consumer confidence in China is currently also strongly affected by developments outside China, which could also have implications for the prospects of a growth model that relies to a greater extent on domestic consumption. Second, structural change is part of a rebalancing process (see below) and thus there is a link to the structural change literature as we interpret our findings from the perspective of early de-industrialization in China. We show that industrialization and China's integration in world trade has probably increased the responsiveness of the Chinese industrial sector to external shocks. De-industrialization could, under certain conditions, reduce the responsiveness of the Chinese economy. Finally, our study extends the literature on empirical business cycle transmission. In particular, we systematically analyze different transmission channels for China and its three main sectors. In what follows, we briefly summarize the main arguments and findings in each strand of the literature, and show the connections with previous empirical literature.

2.1. Rebalancing the Chinese economy

The term "structural change" is here understood as the changing relative importance of the agricultural, industrial, and service sectors, measured either in terms of value added or employment. A stylized fact of structural change processes is that the agricultural, industrial, and finally the service sector alternate in being the dominant economic sector. The process toward a dominant service sector can be called de-industrialization or tertiarization.

Wagner (2013) compares the share of the service sector in China to that in developed and developing countries from a historical perspective. He concludes that the share of the service sector in Chinese GDP is (too) small in comparison with other developed and developing countries when they were at the same stage of economic development. Using the example of Germany, he shows that a dominant industrial sector can prevail for an extended period of time, but it is questionable that this will be the case in China as the country urgently needs rebalancing (see Wagner 2013, 2015).

Fig. 1 displays the employment and value added shares of the agricultural, industrial, and service sectors in China from 1978 to 2013. In terms of employment share, the service sector started to dominate the industrial sector in 1994. In terms of value added, this was only the case in 2014.



Source: Datastream, own calculations.

Fig. 1. Sectoral employment and value-added shares in the Chinese economy (1978–2014).

Wagner (2015) points out that after two decades of very high economic growth rates, China has reached the so-called mid-income range and must implement fundamental structural reforms to avoid getting stuck in the middle-income trap. Many others assume that the growth model pursued in China, together with measures taken to deal with the consequences of the financial and economic crisis as a result of the United States (US) subprime crisis, have led to imbalances in the Chinese economy, requiring a so-called rebalancing.

Following earlier work by Blanchard and Giavazzi (2006), rebalancing in the case of China includes a decrease in savings, while the authors stress the importance of private savings, an increase in the supply of services, particularly health services, and an appreciation of the Renminbi. Albert, Jude, and Rebillard (2015) define rebalancing as a reallocation from investment toward consumption, from manufacturing toward services, and from an extensive toward an intensive growth model.

Hence, tertiarization must be seen as an integrated element of China's rebalancing process.

2.2. Structural change and its impact on economic growth and stability

Looking at the possible consequences of rebalancing for economic growth in China, most previous research suggests that growth will most likely slow down as a result of tertiarization. Wagner (2013, 2015) points out that the decrease in economic growth associated with tertiarization has negative effects due to Baumol's cost disease (see also Qin, 2006). Baumol and Bowen (1965, 1966) and Baumol (1967) show that rising wages in the service sector are generally not accompanied by corresponding increases in efficiency so that the overall economic growth in a society with an increasing service sector will slow down. Recent research by Moro (2012, 2015) shows in the framework of a two-sector general equilibrium model calibrated for the US, that tertiarization reduces GDP growth and volatility. Hence, tertiarization generally has negative effects on economic growth, but positive effects on economic stability.

2.3. Previous studies

Besides the transmission of monetary policy shocks (see, for instance, Bernanke and Blinder, 1992, Sims, 1992 or, more recently, Chen, Filardo, He, and Zhu, 2015, for the transmission of unconventional US monetary policy), the transmission of business cycles has long been a subject

of study in macroeconomics. In most studies, the focus is on the transmission of business cycles between regions, or from systemically relevant countries to other countries or regions (see Poirson and Weber [2011] for a survey of these studies).[1]

The general finding of this stream of studies is that the US is the main source of growth spillovers (see Poison & Weber, 2011). Fewer studies have focused on the transmission channels, i.e., channels through which shocks are transmitted from one country or region to another. Using model-based simulation analyses, Helbling et al. (2007) find that most of the US spillover effects are trade related and the effects are relatively small. Interestingly, to obtain larger effects, simulations need to be done with disturbances correlated around the world. These correlations of disturbances could, according to the authors, be connected to growing trade or financial integration and may be especially relevant in times of financial crisis. Larger spillover effects are, for instance, found by Arora & Vamvakidis (2006). The view that the trade channel may be the key transmission channel for economic developments in the US (see also Bagliano & Morana, 2011) is challenged by Bayoumi and Swiston (2009), who point out that most of the spillovers stem from financial rather than from trade variables. This view is supported by Galesi and Sgherri (2009), who also find support for the short-run importance of financial variables. Other macro variables are more important over a longer time horizon.

Two studies that are related to our analysis investigate the macroeconomic transmission of external shocks to the emerging economies of China, Emerging Asia and Latin America. Utlaut and van Roye (2010) find that an increase in real world GDP growth results in an increase in real GDP growth in both an average Emerging Asia country and China, while the response in Emerging Asia is more pronounced. They also find significant responses to a contractive interest rate shock and a worsening of financial conditions. Here, the resulting negative impact of global financial conditions on China is stronger than on Emerging Asia. The reactions of Emerging Asia and China to each other are far less pronounced. Hence, the authors conclude that economic activities in Emerging Asia can mostly be explained by world output and general financial conditions.

The research of Erten (2012) extends the analysis of Utlaut and van Roye (2010), although in contrast to the latter, it does not focus on global GDP, but takes a more differentiated perspective differing between shocks from US GDP, Eurozone GDP, and Latin American GDP. The authors find that in comparison, Chinese GDP is least affected by the respective shocks. Also, shocks to Eurozone GDP growth have a stronger impact on China than on the US. Looking at the variance decompositions, more than half of the variation in Latin America is explained by external shocks, while slightly less than half is explained by external shocks in the case of the US and China. Both studies use Bayesian vector autoregression (VAR) models for their analyses.

Poirson and Weber (2011) also discuss the different forms of VAR models in the analysis of cross-country growth spillovers. They distinguish between four different types of VAR model: Bayesian VARs, factor-augmented VARs, global VARs, and VARs based on regional groupings. The four approaches differ in the way the identification of the shocks is achieved.

Bayesian VARs use priors for cross-country correlations to achieve identification. In contrast factor-augmented VARs summarize the cross-country co-movements of several factors in one or more common factors. Global VARs reduce the individual countries' spillovers to a share in a

[1] See Vasishtha and Maier (2013) for such a systematization of the literature.

weighted average for each variable of interest. The fourth and last approach consists of estimating a traditional structural VAR for a smaller set of countries to preserve degrees of freedom.

Our approach is related to the second stream of literature on business cycle transmission from systematically relevant countries to other countries. We do not explicitly account for monetary policy outside China. We consider economic developments in China's major trading partner countries as systematically relevant to a transmission of shocks to the Chinese economy. We use similar variables to those in Utlaut and van Roye (2010) and Erten (2012), but we extend the variable set by studying the response of Chinese confidence measures, and we clearly relate our choice of variables to the trade, financial, and confidence channels. In contrast to the approach in the two studies mentioned above, we focus solely on the effects of external shocks on China, while also extending the previous literature by an analysis of the three main sectors of the Chinese economy—agriculture, industry, and services—and by explicitly considering a confidence channel for China.

2.4. Channels of business cycle transmission

We distinguish between four potential channels of business cycle transmission.[2] First, there is the trade channel. Higher import demand in a relevant country will increase exports in the other country and lead to higher business cycle synchronization. Empirically this link can be regarded as well established (see Baxter & Kouparitsas, 2005; Clark & van Wincoop, 2001; Frankel & Rose, 1998). In this channel, productivity advances could be transmitted via vertical integration (Arkolakis & Ramanarayanan, 2009; Kose & Yi, 2001). These two effects could increase international business cycle transmission. However, inter-industrial specialization will lead to smaller effects of spillovers if industry-specific shocks occur (see, amongst others, Frankel & Rose, 1998).

These arguments could also be applied to China. In a first step, demand for Chinese intermediate products could have increased the effect of growth spillovers on the Chinese economy. The international division of labor and joint venture-induced spillovers of productivity may have additionally increased the business cycle transmission. As China's industry becomes more diversified over time and develops partly away from the fabrication of intermediate goods and toward more sophisticated production technologies and goods, for example the aircraft industry and the "Made in China 2025" initiative (see State Council of the People's Republic of China, 2015), the response to industry-specific shocks will probably decrease.

Second, we have an exchange rate channel of business cycle transmission. Here, the theoretical and empirical implications depend on the type of shocks and the frictions in the economy. Generally, a shock that causes the domestic currency to depreciate will render domestic products more competitive and lead to rising exports.

Third, there is a financial channel. Rising financial integration allows investors to diversify their portfolios by investing in different markets. Also, arbitrage will lead to more synchronized financial prices. Johansson (2010) and Wang, Tsai & Wei (2014), for instance, find that China's financial market integration has indeed increased. Eickmeier (2007) points out that there may also be negative effects of financial integration. If capital is mobile, it will be reallocated to economies where it is used most productively, which could lead to a loosening of business cycle co-movements after industry-related shocks.

[2] See also Eickmeier (2007).

Finally, there is a so-called confidence channel. If there is imperfect information concerning the development of foreign variables or the transmission of shocks to these variables to the domestic economy and there are costs in terms of forming expectations, domestic agents will make persistent expectation errors. These errors will add to the effects that would be transmitted via trade and financial markets, influencing domestic consumption and investments. Whether the confidence channel strengthens or weakens the effects of the other channels depends on whether agents under- or overestimate these spillovers.

3. Data and econometric framework

3.1. Data description

As previously in Utlaut and van Roye (2010) and Erten (2012), we focus on the short-run impact of external factors on China's growth at the economic level, but also shed light on transmission at a sectoral level. We focus on the financial channel, the trade channel, and the confidence channel.

To analyze the trade channel, we calculate a common measure for GDP growth in China's major trading partner countries. For this purpose, we use quarterly time series from 1992Q1 to 2014Q4 for the US, the Euro Area, the United Kingdom (UK) and Japan. These countries can be identified as China's major trading partners, receiving the major share of Chinese exports. Hence, a slowdown in the economic growth of these countries (proxied by their quarter-on-quarter change in GDP growth) is also expected to affect Chinese GDP growth.

For the countries mentioned, we first collect data for nominal GDP. Based on data from the World Bank database, the selected countries represent at least over 60% of global GDP (in current US dollars) over the whole sample period. Moreover, the Euro Area and the UK encompass almost 90% of the economic activity in the European Union over the whole sample. Hence, we believe that a sufficiently large share of economic activity of relevant markets is covered in our analysis. In addition, we collect quarterly data for the implicit GDP deflator to calculate real GDP.

We include two measures related to global financial conditions to assess the financial channel of business cycle transmission. We use the Chicago Board of the Exchange Volatility Index (VIX) to measure general financial conditions and risk. Furthermore, we collect three-month interbank interest rates to mirror liquidity conditions in the banking sectors of major trading partner countries. For China, we collect quarterly data on nominal GDP as well as nominal GDP data for the three sectors. In addition, we collect an implicit GDP deflator for China to calculate real economic activity. Finally, we collect two measures of business and consumer confidence in China. We use the Business Climate Index for the industrial sector and future consumer income confidence. All data are taken from Datastream or the EABCN database.[3] All data except for the interest rates and the VIX are already seasonally adjusted or treated with the X12-ARIMA procedure.

To obtain a single measure for the trading partners' series, the first step consists of aggregating the country-specific time series to a single time series for all selected trading partners. The aggregation method we use has previously been applied by other authors: The methodological principles were first explained in Beyer, Doornik, and Hendry (2000, 2001), and more recently reconsidered by Beyer and Juselius (2010). Applications of this method can be

[3] For a detailed description of the data sources, we refer the interested reader to Table 28 in the Appendix.

found in Giese and Tuxen (2007), Belke, Bordon, and Hendricks (2010), Belke, Bordon, and Volz (2013), and Gattini, Pill, and Schuknecht (2012). Hence, this method can be considered well-established in the economics literature.

For a detailed discussion of aggregation issues, we refer the reader to Beyer et al. (2000, 2001), and Beyer and Juselius (2010). In brief, Beyer et al. (2001) conclude that there are four possible aggregation methods, either aggregating levels or growth rates of the series with either constant or flexible (i.e., changing) weights, and with a fixed or variable exchange rates. Beyer et al. (2001) conclude that aggregation with growth rates and changing weights delivers the most reliable results. Moreover, Beyer and Juselius (2010) show that instead of real weights, which are recommended in Beyer, Doornik and Hendry (2001), it may be better to use nominal weights. However, a critical point is the transformation with variable or fixed exchange rates if purchasing power parity is not fulfilled.

In a first step, we use nominal GDP weights to construct the aggregated series of nominal GDP Y_t and the GDP deflator P_t. Following the literature cited above, with nominal output as $Y_{i,t}$ and the implicit deflator as $P_{i,t}$, real output $X_{i,t}$ is defined as $X_{i,t} \equiv \frac{Y_{i,t}}{P_{i,t}}$ for countries $i = 1, \dots, n$ and $t = 1, \dots, T$. The corresponding growth rates are denoted by $\Delta y_{i,t}$, $\Delta x_{i,t}$, and $\Delta p_{i,t}$, where lower case letters denote the log of the corresponding capitals, so that, for instance, $\Delta y_{i,t} = y_{i,t} - y_{i,t-1} = \Delta log Y_{i,t}$. The weight of country i in period $t-1$ is given by:

$$w_{i,t-1} = \frac{E_{i.c,t-1} \cdot Y_{i,t-1}}{\sum_{i=1}^{n} (E_{i.c,t-1} \cdot Y_{i,t-1})},$$

where $E_{i.c,t}$ is the exchange rate of country i at time $t-1$ vis-à-vis a common currency, *c*, which in our case will be the US dollar in current prices.

In a second step, growth rates for every variable and country, measured in the domestic currency, are calculated and aggregated using the weights $w_{i,t-1}$, such that:

$$\Delta y_t = \sum_{i=1}^{n} (\Delta y_{i,t} \cdot w_{i,t-1}), t = 1, \dots, T,$$

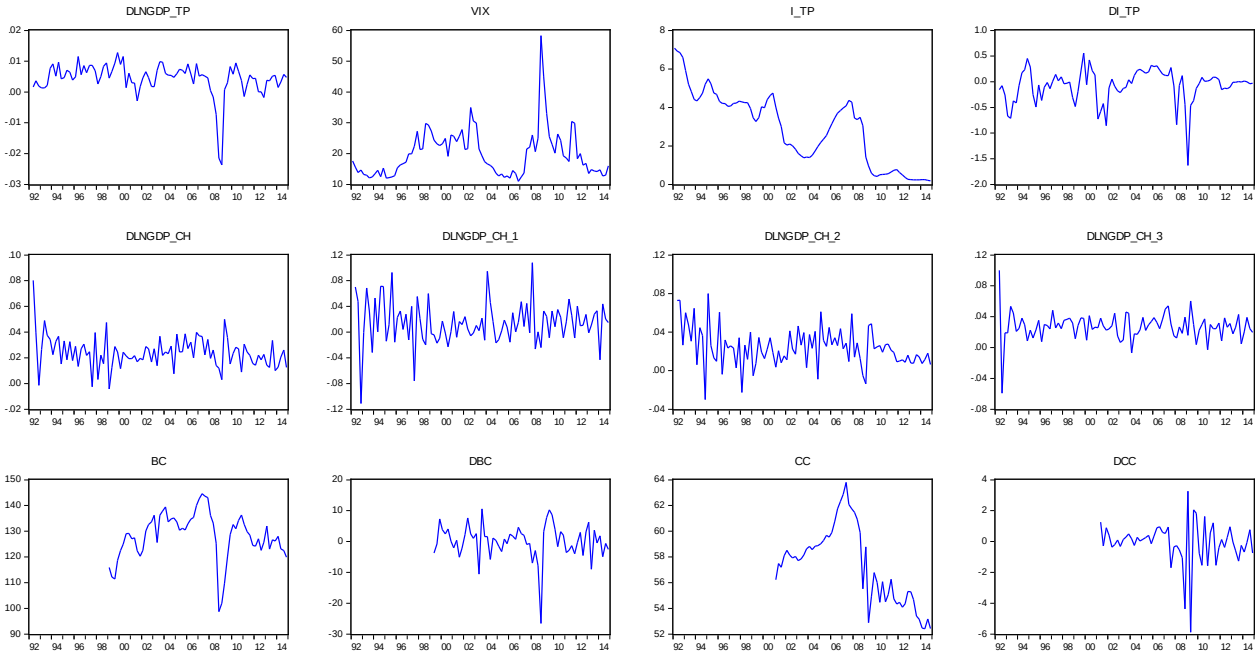
where $\Delta y_{i,t}$ are the individual countries' growth rates for the relevant variables (here nominal GDP), measured in national currencies. This procedure is followed for nominal GDP and the implicit GDP deflator with nominal GDP weights. For instance, in the case of nominal GDP, an index is calculated as:

$$Index_T = 100 \cdot \prod_{t=2}^{T} (1 + \Delta y_t)$$

with $Index_1 = 100$. As we use lagged weights, like Beyer et al. (2001), a weight for the initial period is missing. Therefore we set $w_{i,0} = w_{i,1}$, as in Beyer et al. (2001). We are able to calculate real GDP implicitly by calculating $X_t = \frac{Y_t}{P_t}$. The interest rates are aggregated using real GDP weights, but without calculating growth rates.

We calculate Chinese real GDP by means of the aforementioned Chinese implicit GDP deflator. Here, our results rely on the assumption that the GDP deflator reliably captures the development of prices in all sectors on average.

Fig. 2 displays the economic developments in China's trading partner countries in terms of real GDP (difference of logs), short-term interest rates (in levels and first differences), VIX (in levels), and for the real GDP development in China (difference of logs), as well as disaggregated data for the agricultural, industry and service sector in China between the second quarter of 1992 and the fourth quarter of 2014. Confidence measures for business confidence (BC) and consumer confidence (CC) are displayed in levels and first differences depending on the availability of data.



Source: Datastream and EABCN, own calculations.

Fig. 2. First differences of logs of variables for aggregated trading partners and China over 1992Q2–2014Q44.

Real GDP growth in trading partner countries is relatively stable over the whole period, while there is a strong decline during the financial crisis. This strong decline in real growth rates corresponds to exceptionally high values of the volatility index, VIX. Our measure of short-term interest rates shows that liquidity conditions ease in trading partner countries for most of our sample. Furthermore, we see that lower levels of the volatility index generally correspond to more stable or higher growth rates in trading partner countries. Looking at China's growth rates at the level of the whole economy, we first observe higher volatility prior to and during the Asian crisis around 1997 and afterwards. During the financial crisis, we observe the most considerable slowdown in economic growth in China since its entry to the World Trade Organization (WTO) 2001, with a relatively fast rebound in China. The development in business confidence in the industry sector closely resembles real growth developments in trading partner countries and suggests a close relationship. The effect of the financial crisis is also clearly visible in the confidence measures. While consumer confidence in terms of future income expectations shows a

[4] D = first difference; LN = log; GDP = real gross domestic product; I = interest rate; TP = trading partner; CH = China as a whole; CH_1 = China's agricultural sector; CH_2 = China's industry sector; CH_3 = China's service sector; BC = business confidence; CC = consumer confidence.

rising trend prior to the financial crisis, it does not recover fully afterwards and seems to have suffered considerably.

Based on the visual impression of developments in China and its sectors, these do not seem to be related particularly closely to the external developments described. However, the effect of the financial crisis is clearly visible. We also observe that after the financial crisis, growth in the industry sector slows down considerably, while service sector growth remains relatively stable.
When looking at the sector level in China, we have to bear in mind that the shares of the sectors in Chinese GDP are different (see Fig. 1). As the industry sector dominates China's economy for most of the sample, it is no surprise that the industry sector resembles China's overall real growth pattern the closest.

From this prima facie analysis, we can determine that the growth pattern of the industry sector seems to be most representative of the developments in China's growth as a whole. This is not a surprise as China has so far followed a growth model based on the production and export of intermediate industrial products. Generally, lower growth rates in China's industry sector seem to correspond to higher levels of perceived risk and lower growth rates in the trading partner countries. However, at this point of our analysis we would not overstress the importance of external shocks for China's growth from this descriptive analysis.

[Insert Table 1 about here]

Table 1 displays the unit root tests for the time series considered. We see that an analysis in first differences is generally unproblematic as all the time series can be regarded as stationary in first differences. VIX and BC are even stationary in levels. I_TP should be considered with caution. Although it is not reasonable that interest rates are non-stationary in the long run, the unit root tests clearly indicate non-stationarity. Hence, when using I_TP we should test the stability properties of the model.

3.2. Econometric framework

The VAR methodology used in the econometric analysis can be regarded as a work horse in empirical economics as it became popular after the publication of Sims (1980). A major advantage of VAR models is that all variables can be taken as endogenous, which allows us to test different assumptions concerning causality without imposing a concrete model structure separating exogenous and endogenous variables. This, however, has also led to criticism of VAR models as atheoretical. Another disadvantage is that degrees of freedom quickly become scarce if the number of lags and variables is extended. For our model, it is thus advantageous to combine the developments in China's major trading partner countries in just two aggregated index time series and the VIX.

For illustrative purposes, we formulate the model with the trading partners' real GDP growth and real Chinese GDP growth. The corresponding vector is:

$$x'_t = (DLNGDP\_CH, DLNGDP\_TP)'.$$

The sample period is 1996:01–2014:04. We choose 1996 as a starting point as this coincides with the strategic plan to develop infrastructure and other heavy industries in China (see Chang, Chen, Waggoner, and Zha, 2015). The structural VAR representation with p lags is:

$$A_0 y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t,$$

where A_i is a 2×2 coefficient matrix and c is a 2×1 vector containing constant terms. $\varepsilon_t = (\varepsilon_{1,t}, \varepsilon_{2,t})'$ is a vector with the properties:

$$E(\varepsilon_t) = 0$$
$$E(\varepsilon_t, \varepsilon_\tau) = \begin{cases} \Omega \; for \; t = \tau \\ 0 \quad else \end{cases}.$$

Ω in this case is a 2×2 symmetric positive definite matrix. We can obtain consistent estimates of the coefficients of A_i by estimating each equation with ordinary least squares (OLS). We assume that A_0^{-1} has a recursive structure and the reduced from errors e_t can be decomposed according to e_t=$A_0^{-1}\varepsilon_t$. This ordering implies that the variables ordered last affect the variables ordered before them.

$$e_t = \begin{bmatrix} e_t^{DLNGDP_{CH}} \\ e_t^{DLNGDP_{TP}} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ 0 & a_{22} \end{bmatrix} \cdot \begin{bmatrix} \varepsilon_t^{DLNGDP_{CH}} \\ \varepsilon_t^{DLNGDP_{TP}} \end{bmatrix}$$

In what follows, we replace $DLNGDP\_CH$ with the corresponding sector variables or confidence measures and $DLNGDP\_TP$ will be replaced with the respective external variables.

4. Results

4.1. The trade channel

We first explore the existence of a trade channel between China and its major trading partner countries. For this purpose, we estimate a bivariate VAR model with the vector:

$$x_t = (DLNGDP_{Ch}\; DLNGDP_{TP})'.$$

We order the trading partner variable last as we expect that shocks arise in the trading partner countries and then affect the Chinese economy. Lag length criteria propose a lag order of between two and four lags. However, we detect a few outliers, which we correct with dummy variables.[5] The dummies we set can be explained by the financial crisis and its aftermath, and the beginning of the Asian crisis. After setting the dummies, there is almost no indication of autocorrelation of the residuals and heteroscedasticity is clearly rejected. The residuals can even be considered to be normally distributed (see Table 2). However, for this model, but also for the following models, we obtain the same results without the corresponding dummies. We are also aware that for our models normally distributed residuals are not necessarily required.

[Insert Table 2 about here]

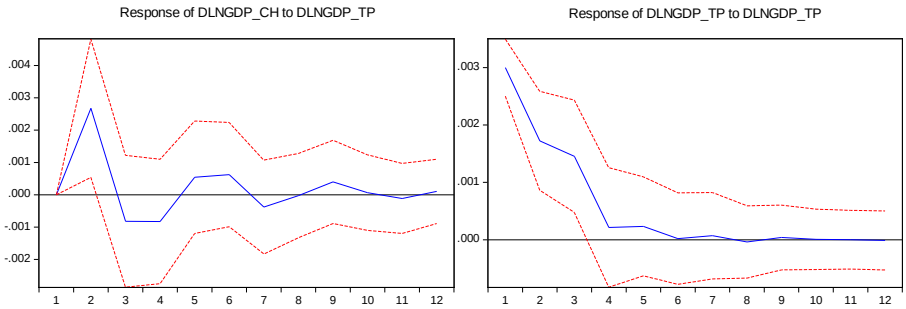
The chosen lag length is further supported by Granger causality tests, which indicate that DLNGDP_TP significantly Granger causes DLNGDP_CH at lags four to six (see Table 3). The

[5] See A1 in the Appendix for the dummies we use and for possible explanations.

possibility that Chinese real GDP growth Granger causes GDP growth in trading partner countries is however rejected (results for these tests not displayed).

[Insert Table 3 about here]

The impulse response functions also show that a positive shock to real GDP growth in trading partner countries positively affects real GDP growth in China. The response is relatively strong, but is short-lived as the effect on growth rates cancels out after about two quarters.



Source: Own calculations.
Fig. 3. Impulse response of DLNGDP_CH to DLNGDP_TP.

Variance decompositions further support the interpretations based on the Granger causality tests and the impulse response functions. After 12 quarters, more than 10% of the variation in Chinese GDP can be explained by variations in the trading partner's real GDP developments. In contrast, only about 3% of the variation in the trading partners' GDP measure is explained by developments in China (see Table 4).

[Insert Table 4 about here]

In the next step, we strive to obtain a more detailed picture of the transmission of demand shocks via a trade channel to the Chinese economy. For this purpose, we now use the disaggregated sectoral real growth rates of the agricultural, industrial, and service sectors. The vector for the corresponding four variables VAR is now:

$$x_t = (DLNGDP_{Ch_1} DLNGDP_{Ch_3} DLNGDP_{Ch_2} DLNGDP_{TP})'.$$

Thus, we implicitly assume that demand shocks from trading partner countries are transmitted to the industrial sector, and are then further transmitted into the service sector and the agricultural sector. Although most services are non-tradable, we assume that the service sector supports the industry sector (industry-related services) to a certain degree. However, our results are generally robust to different orderings of the real sectoral growth rates.

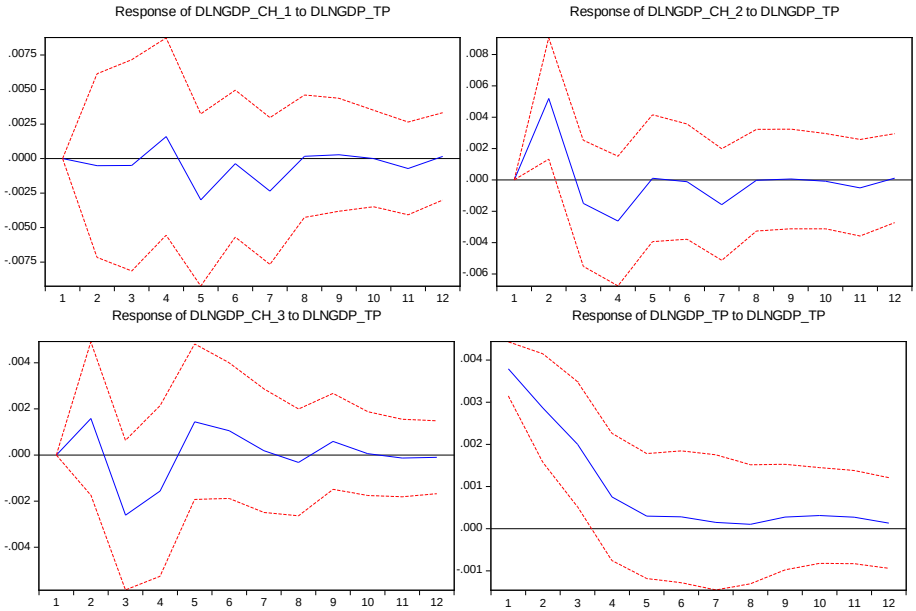
The lag length criteria recommend between one and four lags. In this model, we can establish acceptable residual properties with just one dummy variable, which can be explained by the Asian crisis. After correcting this single outlier, we can reject residual autocorrelation, as well as heteroscedasticity. Again, the residuals can even be considered to be normally distributed. The residual diagnostics are displayed in Table 5.

[Insert Table 5 about here]

Granger causality tests indicate that shocks in trading partner countries' GDP only affect the industry sector at lags of two and four. The agricultural and service sectors remain unaffected (see Table 6).

[Insert Table 6 about here]

This picture is also supported by the corresponding impulse response functions. We find a significant response only in the case of the industrial sector. The response is similar to that we obtained in the previous model, that is, the demand shock has a strong but short-lived impact on real growth in the industrial sector. While the service sector shows a similar pattern in terms of the shape of the impulse response, there is no significant impact. The agricultural sector is clearly unaffected by external shocks (see Fig. 4).



Source: Own calculations.

Fig. 4. Impulse response of DLNGDP_CH_1, DLNGDP_CH_2, and DLNGDP_CH_3 to DLNGDP_TP.

The variance decompositions also support the assumption that the industry sector especially is affected by the shocks considered. After 12 quarters, approximately 12.3% of the variation in the Chinese industrial sector can be explained by variations in the trading partners' GDP. For the service sector, the share is considerably smaller, with only around 7.4% explained and only around 2.2% of the variation in the agricultural sector explained by the corresponding variations (see Table 7).

[Insert Table 7 about here]

4.2. The financial channel

We turn now to the financial channel. The first bivariate VAR is estimated with the vector:

$$x_t = (DLNGDP_{Ch}\, VIX)'.$$

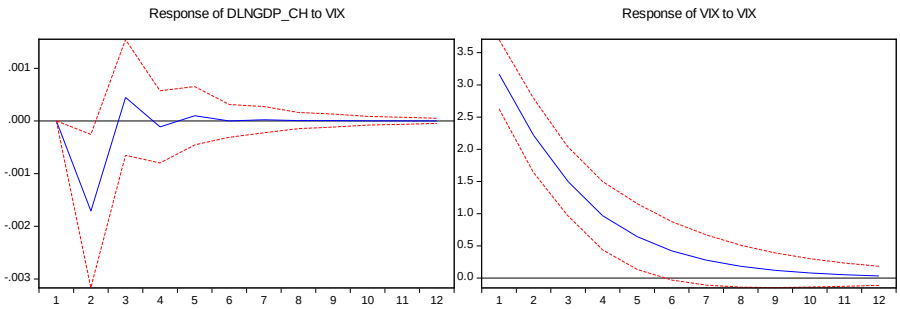
The lag length criteria again recommend between one and four lags. The volatility index, in particular, shows a couple of outliers (extremely high values in the second quarter of 2003, the fourth quarter of 2008, and the third quarter of 2011). We correct these values with dummy variables. We achieve a fairly well specified model with a lag length of two lags. Table 8 shows that there is some indication of autocorrelation in the second lag, but not too much. Heteroscedasticity is rejected. Again the residuals can be considered to be normally distributed.

[Insert Table 8 about here]

Looking at the Granger causality tests (see Table 9), we see that there is some evidence that the VIX Granger causes real Chinese GDP growth at lags one to four. The evidence is strongest for the second lag.

[Insert Table 9 about here]

The relationship is also supported by the corresponding impulse response in Fig. 5, in which we observe a negative response of real Chinese GDP growth for about two quarters.



Source: Own calculations.

Fig. 5. Impulse response of DLNGDP_CH to VIX.

The variance decompositions in Table 10 show that only around 2.83% of the variance in Chinese real GDP growth is explained by variations in the VIX. However, we have to bear in mind that we have removed extreme positive values from the VIX, such that the above value probably corresponds to more normal times in the absence of extreme financial turmoil.

[Insert Table 10 about here]

From the more disaggregated perspective, we estimate the four VAR variables:

$$x_t = (DLNGDP_{Ch_1} DLNGDP_{Ch_3}\, DLNGDP_{Ch_2}\, VIX)'.$$

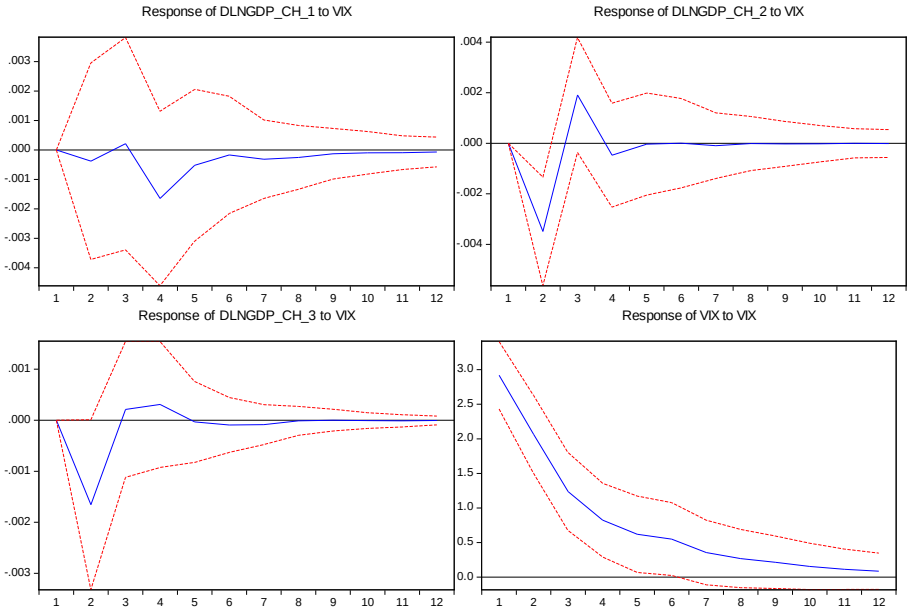
Again we correct outliers with dummy variables. At a lag length of two, we find practically no residual autocorrelation and heteroscedasticity. The residuals can even be regarded as normally distributed. Table 11 displays the residual diagnostic tests.

[Insert Table 11 about here]

The Granger causality tests in Table 12 strongly support the view that the financial channel also works especially through the Chinese industrial sector. The VIX Granger causes real growth in the industrial sector at lags one to four.

[Insert Table 12 about here]

The impulse response functions in Fig. 6 show the same picture. The response in the service sector resembles the response in the industrial sector, but the effect is only significant in the industrial sector. There is no significant response in the agricultural sector.



Source: Own calculations.

Fig. 6. Impulse response of DLNGDP_CH_1, DLNGDP_CH_2, and DLNGDP_CH_3 to VIX.

The variance decompositions in Table 13 show that the VIX does not significantly explain variations in agricultural sector growth. About 4.1% of the variation of the industrial sector is explained by variations in the VIX. Variations in the service sector are also not significantly explained.

[Insert Table 13 about here]

As a possible means of transmission, we assess the impact of liquidity conditions in trading partner countries on the Chinese variables. The corresponding vector for this model is:

$$x_t = (DLNGDP_{Ch}\ I\_TP)'.$$

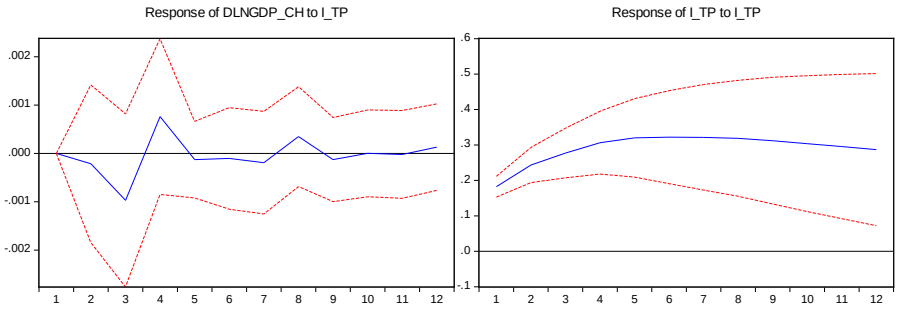
The necessary residual properties can be established with four lags and three dummies, which account for extreme interest rate movements in times of crisis. Table 14 displays the residual properties.

[Insert Table 14 about here]

The Granger causality tests displayed in Table 15 do not indicate that interest rates affect Chinese GDP growth.

[Insert Table 15 about here]

The same is valid for the impulse response functions shown in Fig. 7 and the variance decompositions in Table 16.



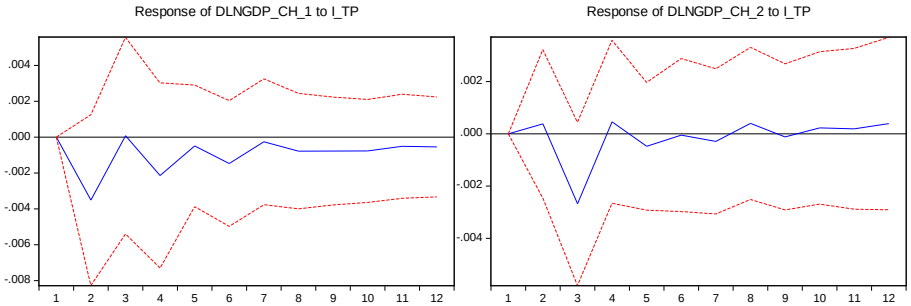
Source: Own calculations.
Fig. 7. Impulse response of DLNGDP_CH to I_TP.

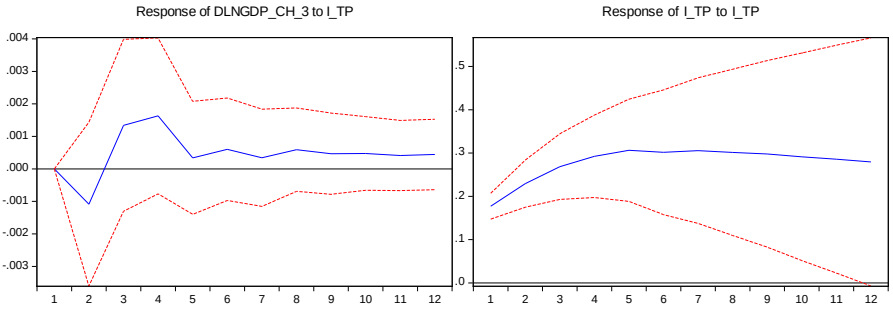
[Insert Table 16 about here]

Specifying a corresponding model with the vector for the disaggregated sectors does not alter the impression that the measure of liquidity conditions does not affect growth in China, while there is very limited evidence from the Granger-causality tests (see Table 17) that the agricultural and the service sectors could be affected.

[Insert Table 17 about here]

Fig. 8 displays the corresponding impulse response function and Table 18 the variance decompositions.





Source: Own calculations.

Fig. 8. Impulse response of DLNGDP_CH_1, DLNGDP_CH_2, and DLNGDP_CH_3 to I_TP.

[Insert Table 18 about here]

4.3. The confidence channel

Finally, we turn to possible confidence channels. We first assess the impact of the external variables on business confidence in China's industrial sector. As the business confidence, BC, was already stationary in levels, we can estimate the bivariate VAR with the vector:

$$x_t = (BC\ DLNGDP\_TP)'.$$

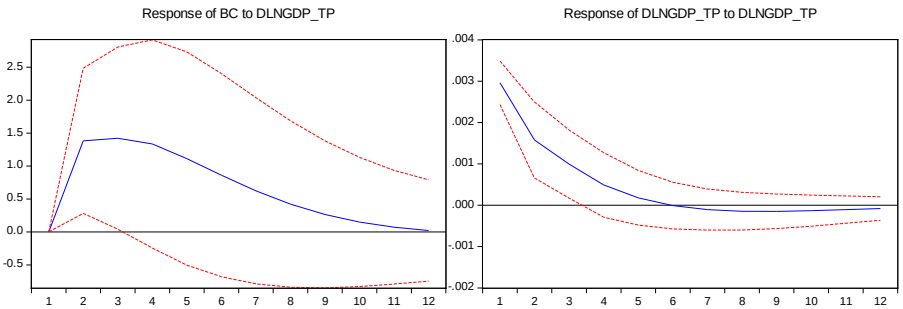
Due to the limited availability of data for business confidence, we are restricted to the investigation of the period from the first quarter of 1999 until the fourth quarter of 2014. With three dummies related to the financial crisis and a lag length of two lags, we can establish the necessary residual properties as shown in Table 19.

[Insert Table 19 about here]

The Granger-causality tests displayed in Table 20 show that real growth in trading partner countries clearly Granger-causes business confidence in China's industrial sector.

[Insert Table 20 about here]

This picture is further supported by the corresponding impulse response function, which shows that the effect is significant for about three quarters before it cancels out (see Fig. 9).



Source: Own calculations.

Fig. 9. Impulse response of BC to DLNGDP_ TP.

The variance decompositions displayed in Table 21 show that almost one fifth of the variance in business confidence in the industrial sector can be explained by variations in trading partners' real growth.

[Insert Table 21 about here]

We also test the effect of the VIX on business confidence in China. While the impulse response shows that an increase in the VIX leads to a decrease in business confidence, neither the Granger causality tests nor variance decompositions indicate a strong impact on business confidence. Nor do we find significant evidence for an impact of the interest rate. Thus, we would tend to assume that business confidence is solely affected by GDP developments in trading partner countries.

We now look at the impact of the external shocks on consumer confidence. Here we only have data from the first quarter of 2001 onwards. Also, consumer confidence, CC, is found to be non-stationary so that we perform our estimation in first differences with dCC. The vector for the bivariate VAR is:

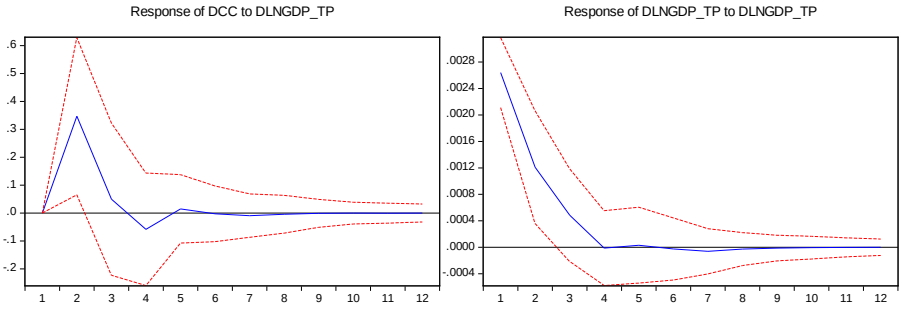
$$x_t = (DCC\ DLNGDP_{TP})'.$$

With three lags and two dummies, we achieve the necessary residual properties as shown in Table 22.

[Insert Table 22 about here]

The Granger causality tests (see Table 23) strongly support the hypothesis that a change in real GDP growth in the trading partner countries leads to a change in Chinese consumer confidence. We also find that consumer confidence in China Granger-causes the real GDP growth in trading partner countries (results not displayed). This can be taken as an indication that China has also become an important market for goods produced in its major trading partner countries. The impulse response function also shows a clear effect of growth in trading partner countries on consumer confidence in China. Fig. 10 displays the corresponding impulse response.

[Insert Table 23 about here]



Source: Own calculations.

Fig. 10. Impulse response of dCC to DLNGDP_ TP.

Variance decompositions (see Table 24) show that about 11% of the variation in the change in Chinese consumer confidence can be explained by variations in real GDP in China's trading partner countries.

[Insert Table 24 about here]

Finally, we investigate the effect of the VIX on consumer confidence in China. The corresponding vector is:

$$x_t = (DCC\ VIX)'.$$

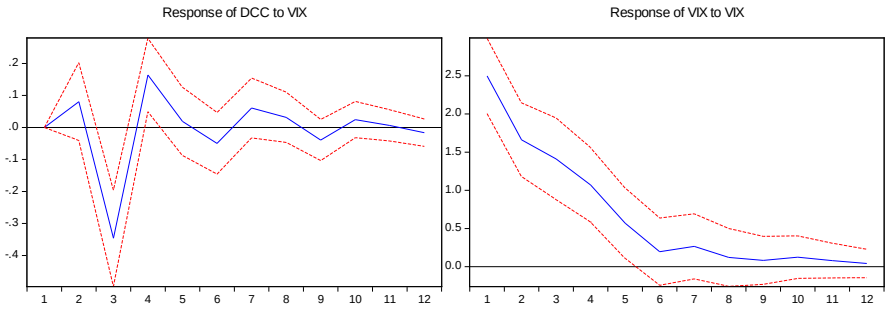
With three lags and three dummies, we are again able to establish the necessary residual properties (see Table 25).

[Insert Table 25 about here]

The Granger causality tests indicate that the VIX Granger causes changes in China's consumer confidence at lag lengths of two to four (see Table 26).

[Insert Table 26 about here]

Fig. 11 shows the corresponding Granger causality tests. We observe a deterioration in consumer confidence after a period of around three quarters in response to an increase in risk perception.



Source: Own calculations.
Fig. 11. Impulse response of dCC to VIX.

The variance decompositions (see Table 27) show that the VIX accounts for about 13.6% of the variation in consumer confidence after 12 quarters.

[Insert Table 27 about here]

4.4. Has the transmission channel changed over time?

As we have only a rather small sample, it is difficult to perform a reliable subsample analysis. Also, the period under investigation could be characterized as fully belonging to the industrialization period, with perhaps slight signs of de-industrialization toward the end.

The general conclusions we draw are also valid for the full sample of 1994 to 2014. That is, demand and financial shocks significantly Granger-cause real Chinese GDP growth and the disaggregated perspective shows that this is mainly because the industry sector is affected.

Thus, we are generally able to reproduce our results from the baseline sample considering the impulse responses, the Granger-causality tests, and the variance decompositions. However, we observe that the results become slightly more significant if we exclude the earlier years of our sample. We interpret this as indicating that the impact of shocks has actually increased over time, which is in line with China becoming more integrated in the world economy.

In terms of our results, they question the perspective of rebalancing toward a more (domestic) consumption-driven model without accounting for global developments. In particular, consumer confidence in China seems to be affected both by external demand shocks and financial shocks. Hence, greater consumer spending will currently only be possible if China is able to relax the relation between future income expectations in China and global economic developments.

5. Conclusion and policy implications

In this paper, we have investigated the effect of external shocks on China's total real growth and real growth in its main sectors from the perspective of structural change and rebalancing. Generally, China is significantly affected in the short run by external shocks. Shocks appear to work through the trade, financial, and confidence channels alike. When we dummy out extreme values, the impact of trade and financial shocks appears to be somewhat smaller in comparison to the results in previous literature (see Erten, 2012). However, we are generally able to reproduce the qualitative results of previous analyses and our results are robust if we remove our dummy variables. What is more, we extend our analysis to a subsector analysis and find that the industrial sector especially is affected by external shocks. This can be explained by the fact that this is the most relevant sector for Chinese exports. While the agricultural sector is less important for China's overall growth perspective, an important result from our research is that the agricultural and the service sectors have thus far not been affected at all by external shocks, while there is limited evidence that liquidity conditions have had some effect on these two sectors according to our empirical models (see Table 17). Hence tertiarization could have a positive effect on China's resilience to external shocks as long as the major share of services is not industry-related to a large extent. On the other hand, we find strong evidence for the existence of confidence channels, which are affected by trade and financial shocks. While the concrete way in which confidence is affected is not clear, a possible explanation might be that the industrial sector is still very important for overall growth in China (see Fig. 1). Hence, investors and consumers closely observe the performance of China's industry, which is in turn affected by global developments. Thus, external shocks influence future income expectations, and hence consumption and demand in general.

While we do not wish to overinterpret our findings, some general policy implications seem to be quite clear. With a still very dominant industrial sector, China is directly affected by global events that affect demand for Chinese exports. Policymakers and companies could consider diversifying production. This could lead to a less strong impact of external shocks. The financial channel could work in different ways. Possible mechanisms could be portfolio reallocations in times of financial stress (flight to quality) and the withdrawal of capital or just a reduction in current and future FDI. This could perhaps be reduced by further developing domestic capital markets and domestic financing, hence reducing the dependence on international capital, and—through sound equity markets—offering domestic savers a possibility to invest their

savings. Finally, the management of expectations will necessarily play a very prominent role. Creating confidence in the resilience of the Chinese economy, and ensuring financial and economic stability in China, for example by means of macroprudential policies, could also have beneficial effects.

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Tables

Table 1
Unit root tests.

Time Series	Levels		First differences	
	ADF (SIC)	PP	ADF (SIC)	PP
LNGDP_CH (trend & intercept)	-1.437	-1.299	-10.516***	-10.433***
LNGDP_CH_1 (trend & intercept)	-1.448	-1.523	-11.604***	-12.746***
LNGDP_CH_2 (trend & intercept)	-0.718	-0.684	-10.193***	-10.070***
LNGDP_CH_3 (trend & intercept)	-2.374	-2.251	-9.147***	-9.435***
LNGDP_TP (trend & intercept)	-2.253	-1.716	-4.120***	-4.061**
VIX (intercept)	-3.615***	-3.589***	-8.278***	-10.925***
I_TP (intercept)	-1.531267	-1.373	-4.583***	-4.540***
BC (intercept) (1999:01-2014:04)	-3.801***	-2.814*	-6.681***	-6.681***
CC (intercept) (2001:01-2014:04)	-0.496	-1.146	-11.295***	-10.850***

Source: Own calculations.

Table 2
Diagnostic tests for the trade channel for China.

Variables	DLNGDP_CH DLNGDP_TP		
Lags	4		
Dummies	1997:03 2008:04 2009:01 2009:02		
Residual autocorrelation test: (H0: No serial autocorrelation)	Lags	p-value	
	1	0.093	
	2	0.228	
	3	0.507	
	4	0.989	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.993		
Univariate normality			
	Skewness	Kurtosis	Normality (p-value)
DLNGDP_CH	0.018	2.937	0.992
DLNGDP_TP	-0.08	3.403	0.742

Table 3
Granger causality tests for the trade channel for China.

Null: DLNGDP_TP does not Granger cause DLNGDP_CH	
Lags	96Q1–14Q4[a]
1	0.304
2	0.154
3	0.236
4	0.005***
5	0.010***
6	0.021**

[a] Models includes dummies for 1997:03, 2008:04, 2009:01, 2009:02;
*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 4

Variance decompositions for the trade channel for China.

Quarters	Decomposition of	DLNGDP_CH	DLNGDP_TP
1	DLNGDP_CH	100.000	0.000
		(0.000)	(0.000)
	DLNGDP_TP	4.262	95.738
		(4.665)	(4.665)
2	DLNGDP_CH	89.820	10.180
		(6.707)	(6.707)
	DLNGDP_TP	3.398	96.602
		(4.488)	(4.488)
4	DLNGDP_CH	88.599	11.401
		(6.415)	(6.415)
	DLNGDP_TP	3.003	96.997
		(4.525)	(4.525)
8	DLNGDP_CH	89.196	10.804
		(6.789)	(6.789)
	DLNGDP_TP	3.197	96.803
		(5.861)	(5.861)
12	DLNGDP_CH	89.253	10.747
		(7.058)	(7.058)
	DLNGDP_TP	3.243	96.757
		(6.917)	(6.917)

Table 5

Diagnostic tests for the trade channel for China's subsectors.

Variables	DLNGDP_CH_1 DLNGDP_CH_3 DLNGDP_CH_2 DLNGDP_TP		
Lags	4		
Dummies	1997:03		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags 1 2 3 4	p-value 0.147 0.141 0.751 0.618	
Heteroscedasticity test (H0: No cross terms)	p-value 0.203		
Univariate normality			
	Skewness	Kurtosis	Normality (p-value)
DLNGDP_CH_1	0.607	3.694	0.045
DLNGDP_CH_3	0.080	3.492	0.655
DLNGDP_CH_2	-0.155	2.843	0.827
DLNGDP_TP	-0.379	3.762	0.160

Table 6

Granger causality tests for the trade channel for China's subsectors.

Null: DLNGDP_TP does not Granger-cause DLNGDP_CH_1		Null: DLNGDP_TP does not Granger-cause DLNGDP_CH_2	Null: DLNGDP_TP does not Granger-cause DLNGDP_CH_3
Lags	96Q1–14Q4[a]	96Q1–14Q4[a]	96Q1–14Q4[a]
1	0.7290	0.1520	0.6158
2	0.8691	0.0986*	0.4669
3	0.8884	0.1959	0.4440
4	0.8719	0.0111**	0.3942

[a] Models include dummy for 1997:03;

*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 7

Variance decompositions for the trade channel for China's subsectors.

Quarters	Decomposition of	DLNGDP_CH_1	DLNGDP_CH_2	DLNGDP_CH_3	DLNGDP_TP
1	DLNGDP_CH_1	100.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
	DLNGDP_CH_2	0.174	99.289	0.537	0.000
		(2.125)	(3.196)	(2.453)	(0.000)
	DLNGDP_CH_3	4.278	0.000	95.722	0.000
		(4.764)	(0.000)	(4.764)	(0.000)
	DLNGDP_TP	2.183	20.029	4.561	73.227
		(3.714)	(7.795)	(4.530)	(8.590)
2	DLNGDP_CH_1	98.997	0.729	0.238	0.035
		(3.507)	(2.306)	(2.408)	(1.610)
	DLNGDP_CH_2	0.1981	87.929	0.792	11.081
		(2.676)	(7.368)	(3.451)	(6.420)
	DLNGDP_CH_3	4.169	0.723	93.570	1.537
		(4.820)	(2.846)	(6.188)	(3.347)
	DLNGDP_TP	1.965	20.451	2.994	74.590
		(3.936)	(8.407)	(3.875)	(9.055)
4	DLNGDP_CH_1	93.548	1.945	4.120	0.388
		(6.913)	(3.969)	(5.282)	(3.353)
	DLNGDP_CH_2	4.263	80.526	2.047	13.164
		(5.050)	(7.994)	(4.650)	(6.354)
	DLNGDP_CH_3	8.905	0.640	84.440	6.014
		(5.762)	(3.143)	(7.991)	(5.356)
	DLNGDP_TP	3.602	18.375	2.840	75.182
		(4.965)	(7.920)	(5.022)	(9.452)
8	DLNGDP_CH_1	90.613	2.259	5.010	2.118
		(8.379)	(4.960)	(5.705)	(4.370)
	DLNGDP_CH_2	5.819	79.750	1.918	12.513
		(5.861)	(8.677)	(4.849)	(5.993)
	DLNGDP_CH_3	10.125	2.700	79.921	7.254
		(5.984)	(4.261)	(8.850)	(5.625)
	DLNGDP_TP	7.875	17.783	4.093	70.249
		(7.478)	(7.530)	(5.882)	(10.431)
12	DLNGDP_CH_1	90.116	2.627	5.081	2.176
		(9.205)	(5.684)	(5.871)	(4.645)
	DLNGDP_CH_2	5.967	79.766	1.940	12.327
		(6.367)	(9.199)	(5.106)	(6.157)
	DLNGDP_CH_3	10.239	2.811	79.556	7.394
		(6.169)	(4.964)	(9.537)	(5.673)
	DLNGDP_TP	7.986	18.047	4.338	69.630
		(7.492)	(7.929)	(6.054)	(10.845)

Table 8
Diagnostic tests for the financial channel (VIX) for China.

Variables	DLNGDP_CH VIX		
Lags	2		
Dummies	2002:03, 2008:04, 2011:03		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.958	
	2	0.025	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.237		
Univariate normality			
	Skewness	Kurtosis	Normality (p-value)
DLNGDP_CH	0.166	3.381	0.667
DLNGDP_TP	0.602	3.864	0.031

Table 9
Granger causality tests for the financial channel (VIX) for China.

Null: VIX does not Granger cause DLNGDP_CH	
Lags	96Q1–14Q4[a]
1	0.072*
2	0.042**
3	0.100*
4	0.075*

[a] Models include dummies: dum0203, dum0804, dum1103; *,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 10
Variance decompositions for the financial channel (VIX) for China.

Quarters	Decomposition of	DLNGDP_CH	VIX
1	DLNGDP_CH	100.000	0.000
		(0.000)	(0.000)
	VIX	0.227	99.773
		(2.102)	(2.102)
2	DLNGDP_CH	97.329	2.671
		(2.224)	(2.224)
	VIX	0.673	99.327
		(3.022)	(3.022)
4	DLNGDP_CH	97.170	2.830
		(2.426)	(2.426)
	VIX	0.613	99.387
		(3.934)	(3.934)
8	DLNGDP_CH	97.161	2.839
		(2.474)	(2.474)
	VIX	0.604	99.396
		(4.225)	(4.225)
12	DLNGDP_CH	97.161	2.839
		(2.477)	(2.477)
	VIX	0.604	99.396
		(4.242)	(4.242)

Table 11
Diagnostic tests for the financial channel (VIX) for China's subsectors.

Variables	DLNGDP_CH_1 DLNGDP_CH_3 DLNGDP_CH_2 VIX		
Lags	2		
Dummies	1997:03, 2002:03, 2008:01, 2008:04, 2011:03		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.825	
	2	0.650	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.812		
Univariate normality			
	Skewness	Kurtosis	Normality (p-value)
DLNGDP_CH	0.390	3.629	0.204
DLNGDP_CH	0.072	3.518	0.633
DLNGDP_CH	0.447	3.299	0.246
VIX	0.295	3.977	0.127

Table 12
Granger causality tests for the financial channel (VIX) for China's subsectors.

Null: VIX does not Granger-cause DLNGDP_CH_1		Null: VIX does not Granger-cause DLNGDP_CH_2	Null: VIX does not Granger-cause DLNGDP_CH_3
Lags	96Q1–14Q4[a]	96Q1–14Q4	96Q1–14Q4
1	0.699	0.088*	0.293
2	0.732	0.004***	0.117
3	0.775	0.002***	0.253
4	0.257	0.000***	0.303

[a] Models include dummies for 1997:03, 2002:03, 2008:01, 2008:04, 2011:03;
*,**,*** indicate rejection of the null at 10%, 5%, and 1% levels

Table 13
Variance decompositions for the financial channel (VIX) for China's subsectors

Quarters	Decomposition of	DLNGDP_CH_1	DLNGDP_CH_2	DLNGDP_CH_3	VIX
1	DLNGDP_CH_1	100.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
	DLNGDP_CH_2	0.001	99.994	0.005	0.000
		(1.765)	(2.572)	(1.920)	(0.000)
	DLNGDP_CH_3	3.916	0.000	96.084	0.000
		(4.558)	(0.000)	(4.558)	(0.000)
	VIX	0.351	0.261	3.788	95.599
		(2.317)	(1.989)	(4.254)	(5.171)
2	DLNGDP_CH_1	99.507	0.242	0.250	0.001
		(2.851)	(2.124)	(1.850)	(0.449)
	DLNGDP_CH_2	0.378	95.210	0.765	3.647
		(2.568)	(4.549)	(3.232)	(2.376)
	DLNGDP_CH_3	3.754	2.408	92.159	1.679
		(4.459)	(3.893)	(6.257)	(1.675)
	VIX	3.555	0.435	3.700	92.310
		(4.828)	(2.890)	(4.694)	(6.915)
4	DLNGDP_CH_1	98.146	0.926	0.672	0.256
		(4.696)	(3.418)	(3.171)	(0.737)
	DLNGDP_CH_2	2.438	92.783	0.998	3.780
		(4.293)	(5.952)	(3.737)	(2.409)
	DLNGDP_CH_3	6.056	2.343	89.999	1.603
		(4.936)	(3.927)	(6.518)	(1.630)
	VIX	2.798	2.366	11.489	83.347
		(4.582)	(5.347)	(8.284)	(9.681)
8	DLNGDP_CH_1	97.961	0.993	0.779	0.267
		(5.366)	(3.885)	(3.424)	(0.774)
	DLNGDP_CH_2	2.598	92.243	1.118	4.041
		(4.556)	(6.375)	(3.815)	(2.571)
	DLNGDP_CH_3	6.520	2.326	89.557	1.597
		(5.231)	(4.018)	(6.928)	(1.634)
	VIX	3.189	3.276	11.498	82.037
		(4.775)	(6.670)	(8.408)	(10.453)
12	DLNGDP_CH_1	97.959	0.994	0.780	0.267
		(5.527)	(4.049)	(3.434)	(0.785)
	DLNGDP_CH_2	2.600	92.228	1.120	4.052
		(4.592)	(6.426)	(3.830)	(2.594)
	DLNGDP_CH_3	6.522	2.326	89.555	1.598
		(5.249)	(4.070)	(6.981)	(1.640)
	VIX	3.192	3.306	11.502	82.001
		(4.785)	(6.744)	(8.424)	(10.505)

Table 14
Diagnostic tests for the financial channel (I_TP) for China.

Variables	DLNGDP_CH I_TP		
Lags	4		
Dummies	2001:01, 2008:01, 2009:01		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.381	
	2	0.795	
	3	0.310	
	4	0.970	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.103		
Univariate Normality			
	Skewness	Kurtosis	Normality (p-value)
DLNGDP_CH	-0.056	3.336	0.819
I_TP	-0.057	5.403	0.000

Table 15
Granger causality tests for the financial channel (I_TP) for China.

Null: I_TP does not Granger cause DLNGDP_CH	
Lags	96Q1–14Q4[a]
1	0.579
2	0.833
3	0.910
4	0.670
5	0.818
6	0.836

[a] Models include dummies for 2001:01, 2008:01, 2009:01;
*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 16
Diagnostic tests for the financial channel (I_TP) for China's subsectors.

Variables	DLNGDP_CH_1 DLNGDP_CH_3 DLNGDP_CH_2 I_TP		
Lags	4		
Dummies	1997:03, 2001:01, 2008:01, 2009:01		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.168	
	2	0.291	
	3	0.268	
	4	0.640	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.209		
Univariate Normality			
	Skewness	Kurtosis	Normality (p-value)
DLNGDP_CH_1	0.537	3.391	0.126
DLNGDP_CH_3	-0.165	3.204	0.788
DLNGDP_CH_2	-0.200	3.376	0.620
I_TP	0.144	4.613	0.014

Table 17
Granger causality tests for the financial channel (I_TP) for China's subsectors.

Null: I_TP does not Granger cause DLNGDP_CH_1		Null: I_TP does not Granger cause DLNGDP_CH_2	Null: I_TP does not Granger cause DLNGDP_CH_3
Lags	96Q1–14Q4[a]	96Q1–14Q4[a]	96Q1–14Q4[a]
1	0.126	0.463	0.076*
2	0.130	0.787	0.061*
3	0.139	0.505	0.060*
4	0.089*	0.372	0.265

[a] Models include dummies for 1997:03, 2001:01, 2008:01, 2009:01;
*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 18
Variance decompositions for the trade channel for China.

Quarters	Decomposition of	DLNGDP_CH_1	DLNGDP_CH_2	DLNGDP_CH_3	I_TP
1	DLNGDP_CH_1	100.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
	DLNGDP_CH_2	0.021	99.947	0.032	0.000
		(2.117)	(2.795)	(1.944)	(0.000)
	DLNGDP_CH_3	2.624	0.000	97.376	0.000
		(3.964)	(0.000)	(3.964)	(0.000)
	I_TP	0.506	2.546	9.588	87.360
		(2.370)	(3.740)	(6.160)	(7.147)
2	DLNGDP_CH_1	95.045	0.002	3.053	1.899
		(5.397)	(1.880)	(4.317)	(2.424)
	DLNGDP_CH_2	2.114	97.441	0.382	0.063
		(3.992)	(4.821)	(3.073)	(1.159)
	DLNGDP_CH_3	2.563	0.742	95.985	0.709
		(4.028)	(2.808)	(4.982)	(1.879)
	I_TP	0.759	7.661	7.230	84.350
		(2.866)	(6.528)	(5.919)	(8.578)
4	DLNGDP_CH_1	91.229	0.473	5.802	2.497
		(7.108)	(3.298)	(5.524)	(3.058)
	DLNGDP_CH_2	4.189	90.323	2.575	2.913
		(5.125)	(6.9132)	(5.275)	(3.616)
	DLNGDP_CH_3	4.022	0.905	92.156	2.917
		(4.580)	(3.516)	(5.940)	(2.991)
	I_TP	0.533	13.307	5.574	80.586
		(3.614)	(9.358)	(6.732)	(10.989)
8	DLNGDP_CH_1	89.676	0.845	6.637	2.842
		(8.305)	(4.276)	(6.479)	(3.369)
	DLNGDP_CH_2	5.415	89.059	2.782	2.744
		(6.353)	(8.260)	(6.102)	(3.913)
	DLNGDP_CH_3	4.130	1.708	90.818	3.344
		(5.014)	(4.476)	(6.862)	(2.987)
	I_TP	0.579	20.706	9.366	69.348
		(5.111)	(14.364)	(10.255)	(16.022)
12	DLNGDP_CH_1	89.259	0.984	6.684	3.074
		(9.158)	(5.153)	(6.722)	(3.652)
	DLNGDP_CH_2	5.813	88.642	2.771	2.774
		(7.006)	(9.168)	(6.489)	(4.370)
	DLNGDP_CH_3	4.112	1.940	90.222	3.726
		(5.168)	(4.958)	(7.414)	(3.191)
	DLNGDP_TP	0.951	25.953	10.337	62.759
		(5.998)	(17.697)	(11.479)	(19.103)

Table 19

Diagnostic tests for the confidence channel (trade shocks) with business confidence.

Variables	BC DLNGDP_TP		
Lags	2		
Dummies	2008:04, 2009:01, 2009:02		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.041	
	2	0.201	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.8166		
Univariate normality			
	Skewness	Kurtosis	Normality (p-value)
BC	-0.190	3.400	0.674
DLNGDP_TP	-0.499	3.477	0.206

Table 20

Granger causality tests for the confidence channel (trade shocks) with business confidence.

Null: DLNGDP_TP does not Granger cause BC	
Lags	1999Q1–14Q44
1	0.010***
2	0.028**
3	0.005***
4	0.013**
*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels	

Table 21

Variance decompositions for the confidence channel (trade shocks) with business confidence.

Quarters	Decomposition of	BC	DLNGDP_TP
1	BC	100.000	0.000
		(0.000)	(0.000)
	DLNGDP_TP	6.172	93.828
		(6.192)	(6.192)
2	BC	92.929	7.071
		(5.047)	(5.047)
	DLNGDP_TP	5.052	94.948
		(5.971)	(5.971)
4	BC	85.781	14.219
		(9.836)	(9.836)
	DLNGDP_TP	6.799	93.201
		(6.089)	(6.089)
8	BC	81.488	18.512
		(13.361)	(13.361)
	DLNGDP_TP	11.967	88.033
		(8.757)	(8.757)
12	BC	81.317	18.683
		(13.641)	(13.641)
	DLNGDP_TP	12.478	87.522
		(9.275)	(9.275)

Table 22

Diagnostic tests for confidence channel (trade shocks) with consumer confidence.

Variables	DCC DLNGDP_TP		
Lags	3		
Dummies	2008:04, 2009:01		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.011	
	2	0.059	
	3	0.022	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.125		
Univariate normality			
	Skewness	Kurtosis	Normality (p-value)
DCC	-0.073	2.917	0.970
DLNGDP_TP	-0.591	4.415	0.025

Table 23

Granger causality tests for the confidence channel (trade shocks) with consumer confidence.

Null: DLNGDP_TP does not Granger cause DCC	
Lags	2001Q1–14Q [a]
1	0.000***
2	0.000***
3	0.001***
4	0.001***

[a] Models include dummies for 2008:04, 2009:01

*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 24

Variance decompositions for the confidence channel (trade shocks) with consumer confidence.

Quarters	Decomposition of	DCC	DLNGDP_TP
1	DCC	**100.000**	**0.000**
		(0.000)	(0.000)
	DLNGDP_TP	**0.316**	**99.684**
		(2.662)	(2.662)
2	DCC	**88.839**	**11.161**
		(7.878)	(7.878)
	DLNGDP_TP	**12.753**	**87.247**
		(8.113)	(8.113)
4	DCC	**88.959**	**11.041**
		(7.132)	(7.132)
	DLNGDP_TP	**24.639**	**75.361**
		(11.907)	(11.907)
8	DCC	**88.935**	**11.065**
		(7.229)	(7.229)
	DLNGDP_TP	**24.901**	**75.099**
		(12.643)	(12.643)
12	DCC	**88.936**	**11.065**
		(7.243)	(7.243)
	DLNGDP_TP	**24.907**	**75.093**
		(12.797)	(12.797)

Table 25

Diagnostic tests for the confidence channel (VIX shocks) with consumer confidence.

Variables	DCC VIX		
Lags	3		
Dummies	2002:03, 2008:04, 2011:03		
Residual autocorrelation test (H0: No serial autocorrelation)	Lags	p-value	
	1	0.070	
	2	0.173	
	3	0.347	
Heteroscedasticity test (H0: No cross terms)	p-value		
	0.1812		
Univariate Normality			
	Skewness	Kurtosis	Normality (p-value)
DCC	-0.357	2.951	0.407
VIX	0.604	3.039	0.577

Table 26

Granger causality tests for the confidence channel (VIX shocks) with consumer confidence.

Null: VIX does not Granger cause DCC	
Lags	2001Q1–14Q4 [a]
1	0.171
2	0.013**
3	0.000***
4	0.000***

[a] Models include dummies for 2002:03, 2008:04, 2011:03;
*,**,*** indicate rejection of the null at the 10%, 5%, and 1% levels

Table 27

Variance decompositions for the confidence channel (VIX) with consumer confidence.

Quarters	Decomposition of	DCC	VIX
1	DCC	100.000	0.0000
		(0.000)	(0.000)
	VIX	9.539	90.461
		(7.650)	(7.650)
2	DCC	99.192	0.807
		(1.55766)	(1.55766)
	VIX	10.421	89.579
		(8.586)	(8.586)
4	DCC	84.437	15.563
		(6.22169)	(6.22169)
	VIX	9.213	90.787
		(7.308)	(7.308)
8	DCC	84.063	15.937
		(6.41242)	(6.41242)
	VIX	9.344	90.656
		(7.573)	(7.573)
12	DCC	83.908	16.092
		(6.537)	(6.537)
	VIX	9.332	90.668
		(7.617)	(7.617)

Table 28
Data sources.

Series	Source
GDP	
China, GDP	Datastream (DS Mnemonic: CHGDP...A)
China, GDP – Primary industry	Datastream (DS Mnemonic: CHGDPPN.A)
China, GDP – Secondary industry	Datastream (DS Mnemonic: CHGDPSN.A)
China, GDP – Tertiary industry	Datastream (DS Mnemonic: CHGDPTN.A)
US, GDP	Datastream (DS Mnemonic: USGDP...B)
Eurozone, GDP	Datastream (DS Mnemonic: EKGDP...B) and data from EABCN (http://www.eabcn.org/area-wide-model)
UK, GDP	Datastream (DS Mnemonic: UKGDP...B)
Japan, GDP	Datastream (DS Mnemonic: JPGDP...B)
GDP deflators	
China, price deflator	Datastream (DS Mnemonic: CHXPGDP.F)
US, implicit price deflator	Datastream (DS Mnemonic: USGDPIPDE)
Eurozone, implicit price deflator	Datastream (DS Mnemonic: EKGDPIPDE) and data from EABCN (http://www.eabcn.org/area-wide-model)
UK, implicit price deflator	Datastream (DS Mnemonic: UKGDPIPDE)
Japan, implicit price deflator	Datastream (DS Mnemonic: JPGDPIPDE)
Interest rates	
US, interbank rate – 3-month (London) (month average)	Datastream (DS Mnemonic: USINTER3)
European Monetary Union, Euro Interbank Offered Rate – 3-month (mean), euro	Datastream (DS Mnemonic: EMINTER3)
UK, interbank rate – 3-month (month average)	Datastream (DS Mnemonic: UKINTER3)
Japan, 3-month interbank rate (EP)	Datastream (DS Mnemonic: JPINTER3)
Exchange rates	
Euro to US dollar exchange rate	Datastream (DS Mnemonic: EMXRUSD.)
Pound sterling to US dollar exchange rate	Datastream (DS Mnemonic: UKXRUSD.)
Yen to US dollar exchange rate	Datastream (DS Mnemonic: JPXRUSD.)
VIX	
CBOE Spx volatility VIX (New)	Datastream (DS Mnemonic: CBOEVIX)
Confidence measures	
China business climate index: Industry	Datastream (DS Mnemonic: CHNBCIINR)
China consumer confidence – future income confidence	Datastream (DS Mnemonic: CHCNFFUIF)
Data were either already seasonally adjusted or we used the x12_arima procedure to achieve seasonal adjustment (We did not seasonally adjust the VIX). If data were of a lower frequency than quarterly, we used averages of the sub-periods. All calculations were performed with the greatest care. Chinese GDP Data were downloaded in May 2015.	

TableA1
Dummy variables.

Dummy	Comment
1997:03	Beginning of the Asian Crisis (see Chang et al., 2015, p. 41)
2001:01	Dummy to account for outliers in China's GDP time series
2002:03	Outlier in VIX, possibly related to WorldCom Inc. Bankruptcy
2008:01	Dummy to account for outliers in China's GDP time series
2008:04	Financial crisis
2009:01	Financial crisis
2009:02	Financial crisis
2011:03	Outlier in VIX, possibly related to concerns about Europe's debt crisis