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China's Impact on World Commodity Markets

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Abstract

Shocks to aggregate activity in China have a significant and persistent short-run impact on the price of oil and some base metals. In contrast, shocks to apparent commodity-specific consumption (in part reflecting inventory demand) have no effect on commodity prices. China's impact on world commodity markets is rising but, perhaps surprisingly, remains smaller than that of the United States. This is mainly due to the dynamics of real activity growth shocks in the U.S, which tend to be more persistent and have larger effects on the rest of the world.

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I. INTRODUCTION

China is now a major participant in world commodity markets. The impact of China's economic activity and its policies related to strategic reserve holdings, trade, and the environment are often seen as having a large impact on commodity prices. In turn, these commodity price changes can affect inflation and the terms of trade at the global level, with possibly large effects on other emerging and developing economies.

Understanding the scale of China's impact on commodity prices is useful from a number of perspectives. First, it can help market participants better assess the balance of risks for prices, based on their own evaluation of prospects in China. Second, at a broader level, it can enhance policymakers' collective understanding of the driving forces of commodity price changes. Recent discourse related to commodity market developments has increasingly focused on the role of financial speculation, the effects of which are sometimes estimated to be the unexplained part of commodity price changes once supply and demand factors are accounted for. However, this relies on an accurate assessment of these factors, including the changing role of China.

This paper aims to enhance our understanding of China's impact on commodity markets with a focus on the spillover of aggregate activity and commodity-specific demand shocks. This is clearly not the whole China story. This approach does not capture the effects of higher trend growth in per capita incomes and the changing commodity intensity of demand. The paper provides two contributions to the empirical literature on the impact of economic activity on commodity prices. First, it applies the supply-demand structural framework developed by Kilian (2009) and extended by Helbling (2012) to a broader range of commodities, including crude oil and base metals. This approach uses vector autoregressions (VARs) to focus on the effect of shocks to supply, different types of demand, and U.S. financial variables on prices. Second, it isolates the impact of China and compares it to that of the United States over the same period.

There have been surprisingly few attempts to quantify the impact of Chinese demand on global commodity prices. In part, this reflects the rapid changes in China's role in world markets, some of which have occurred only in recent years. Some authors have described how the composition of growth in China, particularly high investment rates that support industrialization and urbanization, have contributed to a large and growing demand for commodities (Yu, 2011). The broader literature linking real activity and commodity prices is much larger. For the last two decades, research has tended to use reduced form approaches as earlier structural models struggled to identify supply and demand shocks or performed poorly in and out of sample (e.g., Gilbert 1990, Tomek and Myers 1993).

One example of a reduced form model of non-oil commodity prices that attempts to incorporate global supply and demand developments is Borensztein and Reinhart (1994). They find a short-run price elasticity of demand of between 0.5 to 0.7 (or equivalently, that a 1 percentage point rise in world industrial production leads to a rise in prices of about 1½ to

2 percent). Helbling (2012) adopts a vector autoregression approach excluding supply and finds larger effects. He finds the same 1 percentage point global output shock leading to a cumulative rise in real non-oil commodity prices of about 7 percent after 12 months. He claims this is consistent with a sum of demand and price elasticities (absolute value) of roughly 0.15 in a simple static demand-supply model. For a crude oil model including supply, he finds the same output shock results in oil prices rising by about 9 percent. Kilian (2009) finds that a 1 percentage point shock to global aggregate demand (measured using deflated dry cargo freight shipping prices) leads to an increase in the real price of oil of about 1 percent after 12 months.

The plan of this paper is as follows. Section 2 presents an overview of China's role in world commodity markets. Section 3 outlines the model that will be used for the estimations. Section 4 describes the salient features of the data. Section 5 will set out the main results. Section 6 will provide brief concluding remarks.

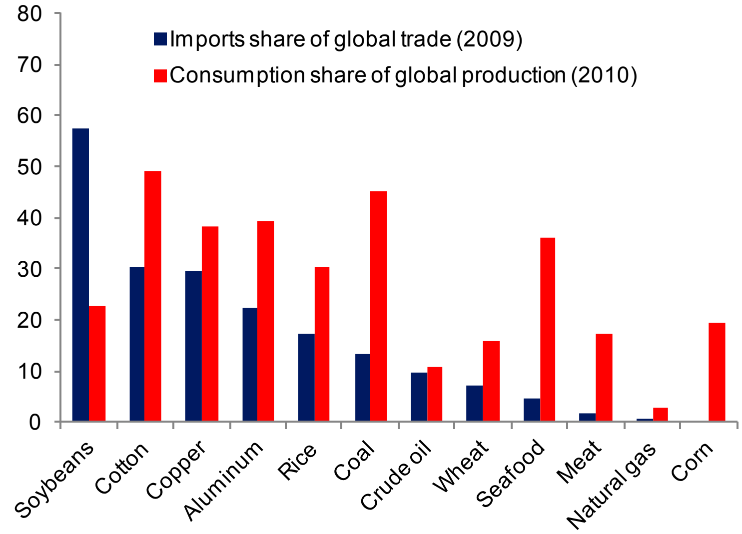
II. A Brief Overview of China's Role in World Commodity Markets

A. Long-Term Structural Trends

China is a large consumer of a broad range of primary commodities. As a percent of global production, China's consumption during 2010 accounted for about 20 percent of non-renewable energy resources, 23 percent of major agricultural crops, and 40 percent of base metals. These market shares have increased sharply since 2000, mainly reflecting China's rapid economic growth. History has shown that as countries become richer, their commodity consumption rises at an increasing rate before eventually stabilizing at much higher levels. This is often described as the S-curve.

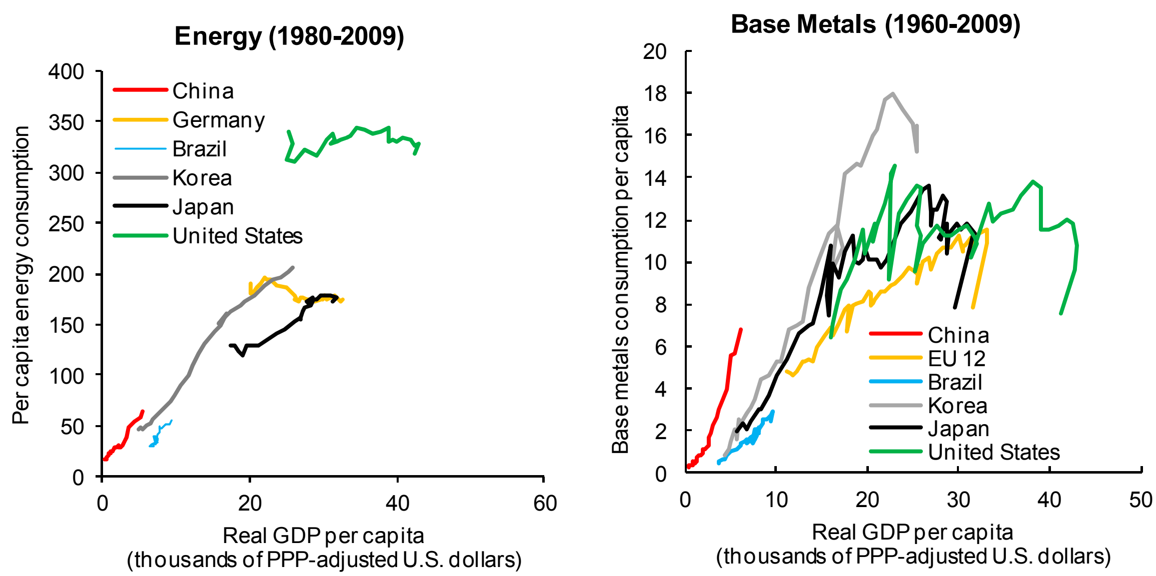
But this cannot explain all of the increase in China's commodity consumption. China's commodity intensity of demand has been growing particularly fast and is now unusually high. Intensity is sometimes measured by commodity consumption per capita and this is shown, alongside real GDP per capita, for China and five other G-20 economies since 1980 for energy and 1960 for metals in Figure 2. Moving along the line in a northeast/ east direction traces the evolution of commodity intensity forward through time, from the first year in the sample to 2009. Based on this small sample of countries, China's energy consumption is shown to be relatively high given its stage of economic development. For example, China consumes about 35 percent more than Korea and twice the level of Brazil at comparable income levels. The difference is even larger for base metals, where China consumes significantly more than Korea and Brazil at the same income.

Figure 1. China's Share of Selected Global Commodity Markets
(In percentage)



Source: United States Department of Agriculture, United Nations COMTRADE database, World Metal Bulletin Statistics, and author's calculations.

Figure 2. Energy and Base Metal Intensity

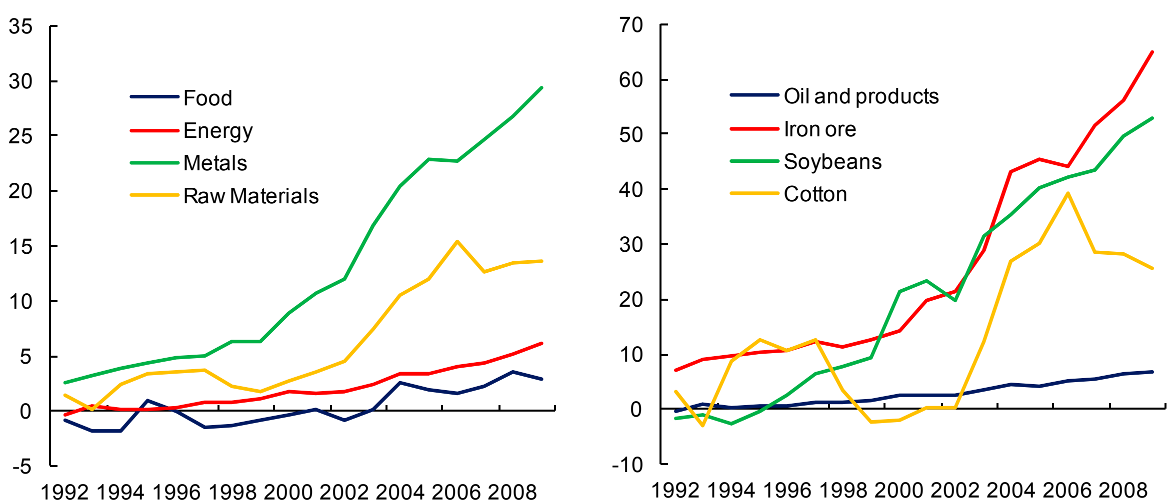


Source: International Energy Agency, World Bank Development Indicators, author's calculations.
1/ Energy consumption in millions of British thermal units. Metals consumption is an IMF trade-weighted average of aluminum, copper, lead, nickel, tin, and zinc in kilograms.

China's unusually fast growing commodity intensity likely reflects the rapid expansion in the tradable export sector and large-scale fixed asset investment—particularly since 2000 (Yu, 2011). Both activities are commodity intensive. For example, Ye (2008) estimates that just over ½ of China's copper usage is accounted for by infrastructure investment and construction, with ⅓ accounted for by consumer and industrial goods. It is beyond the scope of this paper to assess the root causes of China's structure of economic growth and the high commodity intensity that results, but previous studies have highlighted the role of structural factors and domestic policy distortions (IMF, 2011a).

China's role in international commodity trade only matters to the extent that it affects the relative distribution of supply and demand of different commodities across countries. For example, China's strategic policy decision to strive for self-sufficiency in key grains but rely on imports of oilseeds has likely had major implications for global agricultural trade patterns. In terms of broad commodity groups, China has come to play a dominant role in base metals markets and, to a somewhat lesser extent, agricultural raw material markets. In contrast, China has not yet assumed a large role in global food and energy markets although its share of world imports is rising gradually (Figure 3).

Figure 3. China's Share of Global Commodity Trade
(Net imports percent of world imports) 1/



Source: United Nations COMTRADE database
1/ Commodity groups are IMF Primary Commodity Price Index-weighted. Net imports are calculated as commodity *i* imports less commodity *i* exports as a percent of world commodity *i* imports. A positive (negative) number indicates that China is a net importer (exporter).

B. Short-term Fluctuations

At higher frequencies, China's influence on commodity markets will mainly reflect the business cycle, seasonality, and unanticipated transitory changes in its supply-demand balance. In general, we should expect unanticipated shocks to have a larger impact (all else equal), since market participants may be able to adjust commodity inventories to smooth out the effects of anticipated fluctuations in supply and demand. As a result, this paper considers the effect of unanticipated demand shocks and also leaves aside supply-side spillovers which may be important in some cases.

Broadly speaking, there are two types of demand shocks that can be accommodated using this approach. First, those relating to aggregate economic activity. As activity increases, the demand for commodities as an input into the production process should also rise. Second, commodity-specific demand shocks that are unrelated to aggregate activity. These are best measured by apparent consumption. A number of examples of such shocks can be identified in China over recent years. Perhaps the most important is the effect of changes in the desired stockholding of the state agencies that manage a significant proportion of China's commodity inventories. As an example of the possible scale of their activities, it is widely believed that China's State Reserve Bureau purchased about 235,000 tons of copper during the first quarter of 2009 just before fiscal stimulus measures were implemented, accounting for about 65 percent of copper inventories held in London and Shanghai Exchange warehouses at the end of 2008 (Financial Times, 2009). Other recent notable commodity-specific demand shocks have resulted from temporary demand substitution, including due to electric power shortages leading to temporarily higher oil and diesel demand to fuel generators.

Capturing the effects of both types of demand shocks requires different variables. For aggregate activity, industrial production is an obvious choice. Gross domestic product is an alternative variable, but this is only available at a quarterly frequency and in China for many years, only at an annual frequency. Commodity-specific demand shocks can be measured using apparent consumption. This is defined as domestic commodity production plus imports minus exports. This will require a specification to allow for appropriate identification and this is discussed next.

III. Econometric Methodology: A Structural VAR Approach

A. Aggregate Activity Shocks

I estimate a reduced form VAR with recursive shock identification based largely on Kilian (2009) and adapted by Helbling (2012). The baseline VAR estimating the impact of aggregate activity shocks includes seven endogenous variables: world primary production of commodity (Q_W), world excluding country *i* industrial production (X_{RoW}), country *i* industrial production (X_i), country *i* apparent consumption (C_i), the real short-term U.S. interest rate (R), the U.S. dollar real effective exchange rate ($REER$), and the real price of the commodity (P/P^{US}). There is no economic reason to expect that these variables should be cointegrated and this is indeed confirmed by Johansen cointegration tests (not shown). As a result, the first difference of the log of these variables is used in this specification model with the exception of real interest rates which is simply first differenced (see section 4 for details). The vector of endogenous variables Z can then be written as:

$$Z_t' = \left[\Delta\ln\left(Q_{W,t}\right) \quad \Delta\ln\left(X_{RoW,t}\right) \quad \Delta\ln\left(X_{i,t}\right) \quad \Delta\ln\left(C_{i,t}\right) \quad \Delta R_t \quad \Delta\ln\left(REER_t\right) \quad \Delta\ln\left(P_t/P_t^{US}\right)\right] \quad (1)$$

A recursive ordering will provide sufficient restrictions on the contemporaneous relationships between the variables to exactly identify the structural shocks from the reduced-form residuals, denoted by εt. These shocks include: a supply shock; a non-China aggregate activity shock; a China aggregate activity shock; a China commodity-specific demand shock; an exchange rate shock; and a real commodity price shock. This final shock may be interpreted—consistent with Kilian (2009)—as a commodity-specific demand shock in the rest of the world. The ordering of these shocks is described by (1).

This ordering leads to intuitive and reasonable short-run restrictions. For the baseline specification (1), the first restriction is that the commodity supply curve is vertical in the very short run. In other words, shifts in the demand curve elicit no changes in supply during the same month. This can be justified by appealing to non-negligible adjustment costs and uncertainty related to the persistence of the demand shock, both of which are likely to mean that the supply response will lag.

The second and third restrictions relate to industrial production. It is assumed that output in the rest of the world is unaffected contemporaneously by an output growth shock in China. It is also assumes that China's industrial production responds to the real effective U.S. dollar exchange rate and real commodity price shocks with a lag. These timing restrictions can be rationalized with rigidities in the responses of both domestic Chinese activity and domestic end-user prices to changes in global market prices.

The fourth restriction is that aggregate activity shocks can impact apparent commodity consumption and that this causality does not run in reverse during the same month. For example, precautionary stock-building by the state reserve agency or temporary changes in demand related to the availability of substitute commodities are unlikely to bring about an immediate change in broad economic activity. Finally, the real effective U.S. dollar exchange rate does not respond contemporaneously to commodity price shocks.

The sensitivity of the results to these recursive orderings will depend on the contemporaneous correlations of each of the variables (and the reduced from residuals from the estimated VAR). These are presented in section 4.

B. Choice of Variables

The inclusion of most of these variables in a reduced form supply-demand model is intuitive. Using industrial production as a measure of "real" aggregate demand is common in the literature, although alternatives have also been used, such as Kilian's (2009) index of freight costs. The inclusion of the U.S. dollar exchange rate is to control for changes in purchasing power and currency hedging, while the interest rate can affect inventory demand (see Helbling 2012 for an overview). Alternative specifications of (1) also used the real bilateral renminbi - U.S. dollar exchange rate in place of the U.S. dollar REER, although this variable had little explanatory power for any of the other variables and results are not reported.

Why estimate a model that explicitly identifies a China demand shock? It might be argued that if the commodity market is globally integrated, the same demand shock should have approximately the same impact regardless of its origin. This would mean a global model with shocks calibrated to China's participation in the market would provide sufficient insights. There are at least three reasons to move beyond this approach. First, the commodity intensity of industrial production, investment, and consumption are very different across countries. For example, a given quantum shock to industrial output in China might involve a much large increase in the need for commodity inputs than an equivalent shock in other countries. Second, the dynamic nature of the shock itself. If a country's demand shocks tend to dissipate relatively quickly, then a given demand shock would tend to have less of a price impact than a calibrated global average which may be more persistent. Third, the spillover of the domestic demand shock to activity and demand in the rest of the world which can vary enormously based on underlying trade and financial linkages.

IV. DATA

Data are sampled at a monthly frequency. Oil supply is world crude oil production (excluding natural gas liquids) as reported by the United States Energy Information Agency. Base metal supply refers to the production of refined products and apparent consumption is defined as domestic production plus imports minus exports. All metals supply and demand data are sourced from World Metal Bulletin Statistics. Rest of the world industrial production data are PPP GDP-weighted aggregates based on nationally reported indexes. China's industrial production and apparent consumption for both the U.S. and China are seasonally adjusted using the U.S. Census Bureau's X-12 procedure. The U.S. industrial production series is already seasonally adjusted. The ex-post real interest rate is the consumer price index-deflated Federal Funds effective interest rate average for each month. The real effective U.S. dollar exchange rate is sourced from the International Monetary Fund (IMF). Commodity prices are U.S. dollar spot prices as reported by the IMF, deflated by the U.S. consumer price index.

Selecting an appropriate sample period when Chinese macroeconomics variables are included in the regression is challenging. China's economy continues to experience deep structural change, a fact that can lead to unstable and possibly unreliable estimation results. Some important structural breakpoints are identifiable, such as China's entry into the WTO, but many, including the changing composition of growth and the evolving role of the financial sector, are not.

This paper focuses on a sample period that starts in January 2000 and ends in September 2011. (The exception is crude oil, for which China's apparent consumption statistics begin in January 2002. All of the crude oil estimations were run excluding this variable from January 2000 and the results were quantitatively similar.) The start date is close to WTO entry and corresponds approximately to the point at which GDP growth began to increase following the Asian crisis of the late 1990s. Shorter sample periods may provide a more up-to-date perspective on China's role in global commodity markets, but at the expense of degrees of freedom, an important consideration for over-parameterized VAR models.

Summary statistics for the variables used in the estimations are provided in Table 1. Over the 2000-2011 period, it is not possible to reject the null hypothesis that the log of each variable, with the exception of tin production, is non-stationary. In contrast, the first difference of the logs of all variables show clear evidence of being stationary.

Table 1. Variables Used in the VARs: Summary Statistics, January 2000 to September 2011
(100x monthly first differences of logs, unless otherwise specified)

	Mean	Standard deviation	Skew	Unit root test p-values: Log level	Log level with trend	Log difference
World excl. U.S. Industrial Production	0.33	0.89	-1.28	0.94	0.01	0.00
World excl. China Industrial Production	0.16	0.76	-2.30	0.68	0.02	0.00
United States Industrial Production	0.02	0.75	-1.89	0.30	0.65	0.00
China Industrial Production	1.11	2.27	0.39	0.14	0.05	0.00
Bilateral real exchange rate RMB/USD	0.18	0.62	0.58	0.54	0.61	0.00
U.S. dollar real effective exchange rate	-0.12	1.38	0.51	0.64	0.87	0.00
Oil supply	0.09	0.87	-0.01	0.53	0.04	0.00
Oil consumption - China	0.66	7.27	0.13	0.51	0.02	0.00
Oil consumption - United States	-0.05	2.63	0.05	0.35	0.98	0.00
Oil real price	0.99	8.81	-1.16	0.43	0.38	0.00
Aluminum supply	0.43	3.34	0.07	0.95	0.18	0.00
Aluminum consumption - China	1.26	7.50	0.20	0.84	0.00	0.00
Aluminum consumption - United States	-0.02	16.17	0.27	0.06	0.09	0.00
Aluminum real price	0.28	5.43	-0.80	0.38	0.21	0.00
Copper supply	0.20	3.19	0.17	0.79	0.33	0.00
Copper consumption - China	1.17	13.62	0.27	0.79	0.00	0.00
Copper consumption - United States	-0.34	8.93	0.53	0.91	0.09	0.00
Copper real price	1.10	7.56	-0.95	0.82	0.41	0.00
Lead supply	0.26	5.15	-0.07	0.97	0.26	0.00
Lead consumption - China	1.60	18.37	0.05	0.85	0.00	0.00
Lead consumption - United States	-0.10	7.07	0.48	0.00	0.00	0.00
Lead real price	1.11	8.55	-0.80	0.84	0.65	0.00
Nickel supply	0.44	4.49	-0.10	0.99	0.43	0.21
Nickel consumption - China	2.44	21.34	-0.10	0.80	0.00	0.00
Nickel consumption - United States	-0.04	16.83	-0.10	0.00	0.00	0.00
Nickel real price	0.66	9.82	-0.46	0.63	0.37	0.00
Tin supply	0.25	8.31	-0.05	0.83	0.00	0.00
Tin consumption - China	0.78	27.73	-0.66	0.90	0.00	0.00
Tin consumption - United States	-0.55	36.70	0.24	0.00	0.00	0.00
Tin real price	0.97	6.88	-0.40	0.83	0.54	0.00
Zinc supply	0.33	4.98	-1.24	0.93	0.04	0.00
Zinc consumption - China	0.83	15.58	-1.34	0.84	0.00	0.00
Zinc consumption - United States	-0.14	14.40	-0.52	0.01	0.00	0.00
Zinc real price	0.40	7.32	-0.44	0.56	0.63	0.00
Federal Funds interest rate 1/	-0.05	0.53	0.35	0.84	0.91	0.00

Source: Haver Analytics, CEIC, World Metal Bulletin Statistics, Energy Information Agency, author's calculations.
1/ First difference of the level.

The lag lengths used in each of the estimations were based on the results from information criteria (IC) which are not shown. In most cases, likelihood ratio tests indicated longer lengths of up to 12 months, but this tended to produce unstable dynamics and non-intuitive results, particularly as the impulse response horizon lengthened. In almost all cases, standard ICs selected a lag length of between 3 and 6 months. All the results that follow are based on models with a lag of 5 months. Results are quantitatively similar when lag lengths are modified in the 3-6 month range.

Correlations of the residuals from the reduced-form VARs tell us how important the recursive ordering is for the results that follow (see Table 2 which shows correlations for most commodities in this study). For those bivariate relationships where the ordering is not obvious at face value, correlation coefficients (*r*) are typically low. This includes the correlation between China's apparent consumption and the real commodity price (cross-commodity average $r = 0.03$) and between consumption and China's industrial production (average $r = 0.14$). One important exception is that the correlation between China's consumption and global supply was large and statistically significant for some commodities, especially lead ($r = 0.60$) and nickel ($r = 0.28$). This does not appear to reflect differences in the China's share of global production which could cause this high correlation given the way apparent consumption is defined (domestic production plus imports minus exports). China's production share is quite high for lead (40 percent over the last five years) and lower for nickel (20 percent), but this is within the range of the other metals with much lower correlations, including aluminum (35 percent) and copper (22 percent). But even if the contemporaneous correlation is high, this most likely represents consumption (including stockbuilding) reacting to changes in supply, given the adjustment lags in mine output.

Similar results are obtained for the United States (not shown), with the correlation of reduced form residuals in almost all cases below 0.3, with the exception of U.S dollar exchange rate and real commodity price pair.

Table 2. Correlations of Residuals from Reduced-Form VARs, January 2000 to September 2011

	Supply	RoW IP	China IP	China consumption	Real interest rate	U.S. dollar exchange rate
Crude oil						
RoW industrial production	0.03					
China industrial production	-0.04	0.27				
China commodity consumption	0.15	0.38	0.02			
Real interest rate	-0.03	0.03	0.12	-0.12		
U.S. dollar exchange rate	-0.04	-0.07	-0.15	0.03	0.13	
Real commodity price	-0.09	0.16	0.22	0.04	-0.34	-0.24
Aluminum						
RoW industrial production	0.12					
China industrial production	0.14	0.34				
China commodity consumption	0.15	0.30	0.16			
Real interest rate	-0.05	-0.02	0.06	-0.15		
U.S. dollar exchange rate	-0.16	-0.03	-0.19	-0.04	0.15	
Real commodity price	0.02	0.22	0.24	0.10	-0.20	-0.45
Copper						
RoW industrial production	-0.11					
China industrial production	0.09	0.28				
China commodity consumption	0.00	0.08	0.16			
Real interest rate	0.01	-0.07	0.11	0.11		
U.S. dollar exchange rate	-0.12	-0.04	-0.11	0.12	0.07	
Real commodity price	-0.02	0.30	0.33	-0.15	-0.07	-0.42
Lead						
RoW industrial production	0.17					
China industrial production	0.19	0.32				
China commodity consumption	0.60	0.14	0.09			
Real interest rate	-0.01	-0.08	0.06	0.07		
U.S. dollar exchange rate	-0.13	-0.02	-0.16	-0.08	0.12	
Real commodity price	0.10	0.30	0.15	0.06	0.01	-0.32
Nickel						
RoW industrial production	0.13					
China industrial production	0.08	0.32				
China commodity consumption	0.28	0.21	0.17			
Real interest rate	0.08	-0.05	0.05	0.25		
U.S. dollar exchange rate	-0.07	0.00	-0.09	-0.08	0.01	
Real commodity price	-0.13	0.13	0.11	-0.02	-0.06	-0.38
Tin						
RoW industrial production	0.03					
China industrial production	0.05	0.34				
China commodity consumption	0.31	0.09	0.21			
Real interest rate	-0.05	-0.01	0.05	-0.01		
U.S. dollar exchange rate	-0.04	-0.05	-0.13	0.02	0.14	
Real commodity price	-0.11	0.13	0.17	0.04	0.01	-0.39

V. RESULTS

All of the results that follow come from estimates of the reduced form VAR using the vector *Z* described in (1) with 5 lags and the recursive ordering described in section 3 over the sample period January 2000 through September 2011 (and starting in January 2002 for crude oil).

A. Block Exogenity Tests

Block exogeneity tests of (1) confirm that lagged values of the country activity and demand variables are useful for forecasting (i.e., these variables Granger cause) at least one other variable in the system. Specifically, the reduced form (1) was estimated using a specification that dropped all of the lagged values of one particular variable from each of the other equations in the system, with the exception of its own equation. For 7 variables and equations (N=7), each with 5 lags (P=5), this imposed a total of 30 ((N-1) x P) restrictions on the unrestricted system. The null hypothesis that all of the other variables were block exogenous to the variable dropped was then tested using a log likelihood test, for which the critical values are distributed as chi-squared with ((N-1) x P) degrees of freedom. Results from the tests for activity and demand variables are shown in Table 3.

Table 3. Granger Causality Test Critical Values [1]/

	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
China VAR							
RoW industrial prod.	44.36 **	59.15 ***	41.39 *	29.00	45.83 **	35.30	52.56 ***
China industrial prod.	44.48 **	36.34	22.89	53.21 ***	31.46	24.99	18.92
China apparent demand	197.81 ***	44.74 **	39.84	36.37	38.35	67.95 ***	46.52 **
United States VAR							
RoW industrial prod.	77.01 ***	84.60 ***	35.70	54.45 ***	71.56 ***	62.85 ***	54.63 ***
US industrial prod.	56.03 ***	92.03 ***	73.47 ***	69.31 ***	77.21 ***	64.87 ***	82.07 ***
US apparent demand	50.79 **	36.85	85.63 ***	35.31	49.50 **	54.65 ***	47.65 **

1/ Null hypothesis that the other 6 variables in the 7 variable specification (2) are block exogenous to the listed variable. Rejection of the null at the 1 percent, 5 percent, and 10 percent levels denoted by ***, **, and * respectively.

The evidence from these tests is mixed for China. In some cases, China's demand variables appear to be useful for forecasting, including crude oil, but not for some commodities, including copper. Notwithstanding these results, all of the China variables from (1) are retained in the VAR for the impulse response analysis to ensure a comprehensive assessment of the China effect. But this is already one indication that the high-frequency impact of China on commodity markets may be somewhat smaller than broadly perceived. This is particularly true when compared to the United States, for which it was possible to reject the null of no Granger causality in almost every case.

B. Effects of real activity growth rate shocks

A shock to real activity in China has a large and statistically significant impact on oil and copper prices, with less of an effect for other commodities. Table 4 shows that a one-time 1 percentage point (unit) shock to the real month-on-month growth rate of China's industrial production leads to an increase in the real price of oil by about 2½ percent after 4 quarters, with some slight moderation thereafter. The impact of the same activity shock on copper is to increase the real price by almost 2¼ percent after 4 quarters, again with subsequent slight moderation in price effects.

The price responses of other base metals to the China demand shock was, in general, smaller and statistically insignificant (although tin was borderline significant). In some cases, this reflects a production response for commodities with higher short-run supply elasticities. For example, the level of aluminum production increases by a statistically significant 0.4 percentage points 4 quarters after an initial activity growth rate shock in China. In part, this reflects the large aluminum smelting capacity in China and ready global availability of bauxite, the main raw material input for refined aluminum. In all other cases, including crude oil, short-run supply elasticities appear to be much lower, with the production response to a China activity shock insignificant in both statistical and economic terms.

Table 4. Cumulative Impulse Responses for Real Commodity Prices 1/
(Responses to 1 percentage point shocks to the growth rate of China's industrial production)

	Real price level response of:						
	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
1 quarter	2.21	0.76	1.87	-0.07	0.58	1.12	0.47
	(1.06)	(0.49)	(0.78)	(0.83)	(1.06)	(0.71)	(0.78)
2 quarters	2.37	0.98	2.54	1.26	1.56	1.70	0.78
	(1.50)	(0.73)	(1.12)	(1.16)	(1.53)	(1.08)	(1.14)
4 quarters	1.90	0.89	2.27	1.01	1.44	1.70	0.35
	(1.06)	(0.71)	(1.07)	(1.13)	(1.76)	(1.11)	(1.31)
8 quarters	2.03	0.72	2.05	0.79	1.41	1.44	0.31
	(1.01)	(0.59)	(0.93)	(0.95)	(1.60)	(0.91)	(1.32)
	Variance decomposition						
1 quarter	6.90	3.18	7.64	0.72	0.55	3.01	0.65
	(4.32)	(3.41)	(4.82)	(2.05)	(2.15)	(3.73)	(2.78)
2 quarters	6.74	4.47	7.80	2.90	3.49	3.76	0.85
	(3.62)	(3.55)	(4.28)	(2.99)	(3.29)	(3.87)	(3.02)
4 quarters	6.85	4.43	7.24	3.01	3.42	3.81	1.09
	(3.48)	(3.70)	(3.94)	(3.15)	(3.76)	(3.51)	(2.97)
8 quarters	6.98	4.51	7.25	3.15	3.48	3.89	1.16
	(3.60)	(3.79)	(3.86)	(3.27)	(5.06)	(3.48)	(3.02)

1/ Standard errors in parentheses.

The impacts of real activity growth rate shocks in China on global commodity prices are somewhat lower than those found for the United States, despite China's increasing presence in global commodity markets (Table 5). For example, a one-time unit shock to the real month-on-month growth rate of industrial production in the U.S. leads to an oil price response about five times as large as that due to a China shock after 4 and 8 quarters. During the 2000-09 period, the U.S. share of global crude oil consumption was 25 percent, about 3 times as large as China's share (BP World Energy, 2010). By 2009, this ratio had declined to about 2.2, suggesting that China's oil market impact had grown. The price responses of base metals to a U.S. shock are also larger, but only statistically significant at short intervals, such as over 2 quarters (see, for example, the price response of aluminum and copper).

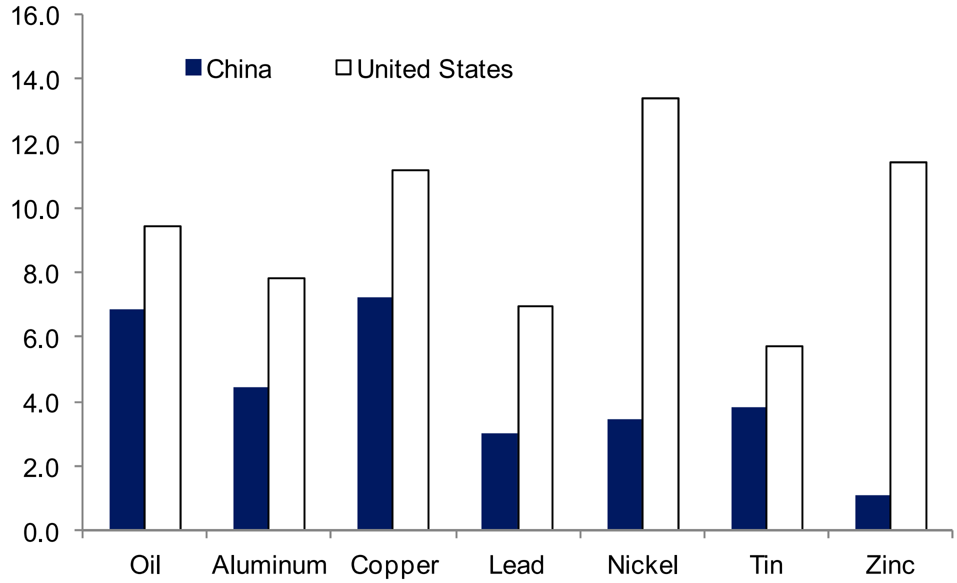
Table 5. Cumulative Impulse Responses for Real Commodity Prices 1/
(Responses to 1 percentage point shocks to the growth rate of U.S. industrial production)

	Real price level response of:						
	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
1 quarter	4.91	1.60	4.29	1.85	9.45	1.58	3.63
	(2.32)	(1.41)	(2.05)	(2.52)	(2.94)	(1.99)	(2.16)
2 quarters	9.34	4.83	7.88	2.70	9.25	4.74	3.56
	(3.24)	(2.24)	(3.26)	(3.52)	(4.45)	(3.13)	(3.19)
4 quarters	9.88	6.03	7.63	3.07	9.76	6.98	1.88
	(3.85)	(3.12)	(4.42)	(4.74)	(6.52)	(4.19)	(4.83)
8 quarters	11.00	6.29	6.18	2.73	9.16	6.60	1.29
	(4.60)	(3.94)	(5.15)	(5.05)	(7.87)	(4.95)	(6.04)
	Variance decomposition						
1 quarter	5.11	2.01	9.56	3.27	12.39	2.42	10.60
	(3.85)	(2.73)	(4.90)	(3.11)	(5.66)	(3.09)	(5.14)
2 quarters	9.30	6.46	11.77	6.68	13.05	5.10	11.57
	(4.82)	(4.50)	(5.59)	(3.92)	(5.34)	(3.65)	(4.52)
4 quarters	9.45	7.83	11.13	6.96	13.37	5.74	11.40
	(4.43)	(4.60)	(5.16)	(3.65)	(4.68)	(3.63)	(4.13)
8 quarters	9.47	7.86	11.46	7.03	13.46	5.80	11.44
	(4.54)	(4.70)	(5.43)	(3.83)	(4.68)	(3.78)	(4.53)

1/ Standard errors in parentheses.

A broader view on China's impact on commodity prices is obtained from variance decompositions, as this also includes the volatility of China's growth rate shocks which have been relatively high over the 2000-11 period, as suggested by Table 1. Again, the impact on crude oil and copper tend to be the largest with China demand shocks explaining about 7 percent total price variance over 4 quarters (Figure 4). In this sense, China's impact is more comparable with the U.S., which explained about 9 to 11 percent of variance over the same horizon for these same commodities.

Figure 4. Contribution of China and United States Aggregate Activity Shocks to Total Commodity Price Variance (percent)



Source: author's calculations

What can explain the larger impact of U.S. aggregate activity shocks on commodity prices relative to China, controlling for consumption shares and shock volatilities? The key explanation is the dynamic process of activity growth rate shocks in each country and the spillover effect to activity in the rest of the world. For China, the persistence of an initial one-time activity growth shock is weak and has tended to dissipate quickly (columns 6 and 8 in Table 6). In contrast, for the U.S, shocks to growth tend to be much more persistent with an initial unit shock leading to a rise in the level of activity (compared to the no-shock baseline) by about 2¼ percent after 4 quarters (columns 2 and 4 in Table 6).

Spillover effects also contrast sharply. An initial activity shock in the U.S. boosts activity in the rest of the world about 1½ percentage points after 4 quarters (columns 1 and 3 in Table 6). The impact of a growth shock in China is small and statistically insignificant (columns 5 and 7 in Table 6). This suggests that U.S. growth is important for world final demand and can trigger higher commodity consumption across countries, likely including China given its role as a major exporter. In contrast, China-specific shocks do not yet materially affect activity and commodity consumption in the rest of the world, perhaps indicating China's effect on final demand in other countries, while growing, remains small.

Overall, the commodity price impact estimates in Tables 4 and 5 are somewhat larger than those found by recent studies, particularly for the U.S. In particular, using a similar model, Helbling (2012) finds that a global activity shock leads to an 8 quarter response of oil and a base metal index separately of about 7 percent. These responses are of roughly the same magnitude as found for a U.S. shock in the estimates above and would imply a smaller China impact based purely on consumption shares.

Table 6. Cumulative Impulse Responses for Industrial Production [1/]
(Responses to 1 percentage point shocks to the growth rate of U.S. or China IP)

	U.S. activity growth rate shock				China acitivty growth rate shock			
	Oil model		Copper model		Oil model		Copper model	
	RoW IP	U.S. IP	RoW IP	U.S. IP	RoW IP	China IP	RoW IP	China IP
1 quarter	0.38	0.94	0.36	0.98	0.09	0.40	0.08	0.35
	(0.16)	(0.14)	(0.16)	(0.15)	(0.05)	(0.11)	(0.05)	(0.11)
2 quarters	1.29	1.58	1.32	1.63	0.18	0.32	0.17	0.40
	(0.33)	(0.27)	(0.35)	(0.28)	(0.12)	(0.12)	(0.12)	(0.11)
4 quarters	1.57	2.25	1.69	2.39	0.25	0.38	0.22	0.41
	(0.56)	(0.57)	(0.59)	(0.59)	(0.16)	(0.10)	(0.16)	(0.09)
8 quarters	1.73	2.46	1.69	2.47	0.20	0.38	0.16	0.40
	(0.79)	(0.89)	(0.82)	(0.92)	(0.13)	(0.09)	(0.12)	(0.08)

1/ Standard errors in parentheses.

C. Effects of Commodity-Specific Country Demand Shocks

Commodity-specific demand shocks (controlling for economic activity) have no major effect on commodity prices (either in terms of their size or statistical significance). This was a consistent result across all commodities and for both China and the United States. Hence the results are not shown.

What can explain the absence of price effects from country-specific demand shocks? One possible explanation is that these shocks are perceived to be temporary and are accommodated by changes in inventories elsewhere, dampening the effect on prices. The time series properties of these shocks suggests that they are indeed partially unwound quickly; the cumulative effect on the level of commodity-specific demand more than halves after two quarters (i.e., for a unit shock, the cumulative change in demand is less than 0.5 percent higher).

This rapid unwinding is also true of shocks to real activity in China (Table 6), but in this case the additional demand is likely to reflect actual use of the commodity (and a subsequent decline in world inventories, holding short-term supply constant). In contrast, while commodity-specific demand shocks may also represent higher consumption, they may also reflect increased Chinese precautionary demand for inventories. If this increased demand is quickly unwound, physical supply and demand are left broadly unchanged, which again would dampen the price effect. This would be particularly true if inventory holders in China were price sensitive and there is evidence to suggest that this is true, as shown next.

D. Effects of Price Shocks on Commodity Demand—Counter-cyclical Inventories?

Indeed, in terms of short-run shocks, causality seems to run from prices to China's apparent consumption rather than the other around. No such effects were found for the United States. A unit shock to the real commodity price leads to a decline in apparent consumption of about

¼ to ½ percent for some base metals, with statistical significance for copper and lead (Table 7). Crude oil is an important exception, with no meaningful effect of price shocks on apparent commodity consumption.

Table 7. Cumulative Impulse Responses for Apparent Consumption 1/
(Responses to 1 percentage point shock to the real commodity price)

	Real price level response of:						
	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
1 quarter	0.08	-0.21	-0.28	-0.44	0.10	-0.73	-0.14
	(0.09)	(0.16)	(0.20)	(0.20)	(0.25)	(0.37)	(0.21)
2 quarters	-0.12	-0.26	-0.69	-0.40	0.25	-0.23	-0.39
	(0.11)	(0.24)	(0.25)	(0.23)	(0.34)	(0.41)	(0.24)
4 quarters	0.01	-0.29	-0.56	-0.33	-0.01	-0.28	-0.32
	(0.10)	(0.21)	(0.25)	(0.17)	(0.34)	(0.30)	(0.25)
8 quarters	-0.01	-0.29	-0.55	-0.38	0.00	-0.29	-0.30
	(0.08)	(0.19)	(0.23)	(0.16)	(0.33)	(0.28)	(0.27)
	Variance decomposition						
1 quarter	0.34	4.48	1.23	3.31	2.49	5.59	0.20
	(1.71)	(3.76)	(2.36)	(2.51)	(2.98)	(3.64)	(1.55)
2 quarters	3.38	6.73	2.28	3.10	3.21	7.40	1.44
	(3.91)	(4.71)	(2.58)	(2.86)	(3.06)	(3.56)	(2.73)
4 quarters	4.75	6.96	2.71	3.47	3.43	7.91	1.80
	(4.36)	(4.73)	(2.61)	(2.66)	(2.79)	(4.18)	(2.71)
8 quarters	4.88	6.97	2.74	3.55	3.44	7.88	1.81
	(4.52)	(4.88)	(2.81)	(2.74)	(2.82)	(4.62)	(3.10)

1/ Standard errors in parentheses.

This result does not apply to industrial production; in other words, there is no effect on broad activity in China from commodity price shocks (including crude oil). With the exception of oil, this may be expected as an unanticipated change in the price of just one raw material input—for example, an idiosyncratic increase in the price of lead—is unlikely to change production incentives across a broad range of sectors. A second reason why price shocks may affect apparent consumption in China, but not broad activity, is related to inventory behavior. Inventory holdings in China have exhibited price-sensitive behavior in recent years, with large commodity price declines associated with a subsequent rise in both imports and inventories. Consistent with this pattern, a sudden rise (fall) in the price of a specific commodity may encourage inventory holders to reduce (accumulate) inventories if there were expectations that this shock would have only a temporary effect on the price level.

E. Effects of Monetary Policy Shocks

What other factors explain commodity price movements, aside from “real demand” shocks?

There has been much recent debate about the effect of U.S. monetary policy—particularly quantitative easing—on commodity prices. (1) allows an assessment of the impact of some monetary policy-related variables, including short-term U.S. interest rates and the U.S. dollar exchange rate, on commodity prices. Table 8 shows the response of commodity prices to: (i) a one-time 100 basis point increase in the average monthly real Federal Funds effective interest rate; and a one-time 1 percentage point appreciation in the U.S. dollar real exchange rate. These one-time shocks to the first difference translate into a persistent change in the level of these variables. Both of these shocks, *a priori*, we should expect to lead to lower commodity prices.

Like Helbling, I find that interest rates have a small, negative, and short-lived effect on prices, consistent with short-term inventory dynamics, but only for crude oil and, to a lesser extent aluminum. I find that an exchange rate shocks (i.e., a real appreciation of the U.S. dollar) has a large, negative, and persistent effect on the prices of all commodities. Like Helbling, the impact peaks at around 4 quarters, but the cumulative impact still remains above the 1 percentage point anticipated by static demand models and purchasing power considerations (even taking into account dynamics of the exchange rate itself).

Table 8. Cumulative Impulse Responses for Commodity Prices [1]/
(Responses to real U.S. real interest rates and the U.S. dollar REER shocks)

	Real price level response to U.S. real interest rate shock of:						
	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
1 quarter	-6.46	-3.04	-0.05	3.25	1.84	1.29	4.20
	(3.00)	(1.77)	(2.84)	(3.20)	(3.93)	(2.48)	(2.84)
2 quarters	-5.22	-2.62	3.00	8.20	6.88	4.48	8.55
	(4.68)	(2.99)	(4.56)	(4.73)	(6.14)	(4.12)	(4.55)
4 quarters	0.78	1.95	8.00	12.43	12.93	7.37	12.37
	(4.80)	(3.59)	(5.21)	(5.55)	(7.62)	(4.94)	(5.92)
8 quarters	-1.31	0.66	6.76	9.67	11.00	5.60	11.82
	(3.94)	(3.02)	(4.91)	(4.28)	(7.17)	(3.83)	(6.58)
	Real price level response to U.S. real effective exchange rate shock of:						
	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
1 quarter	-3.99	-2.15	-4.10	-3.47	-3.45	-2.83	-3.76
	(1.06)	(0.65)	(1.02)	(1.13)	(1.33)	(0.90)	(1.02)
2 quarters	-4.52	-3.39	-4.83	-3.39	-4.03	-4.22	-3.97
	(1.72)	(1.08)	(1.70)	(1.72)	(2.14)	(1.52)	(1.69)
4 quarters	-3.45	-2.31	-2.70	-0.87	-1.73	-3.71	-1.96
	(2.04)	(1.42)	(2.17)	(2.14)	(2.99)	(2.09)	(2.37)
8 quarters	-3.21	-2.08	-2.58	-1.42	-1.61	-3.13	-1.95
	(1.52)	(1.12)	(1.87)	(1.52)	(2.52)	(1.47)	(2.31)

1/ One-time shocks of a 100 basis points increase in the real Federal Funds effective interest rate; and a 1 percentage point appreciation in the U.S. dollar real exchange rate, separately.

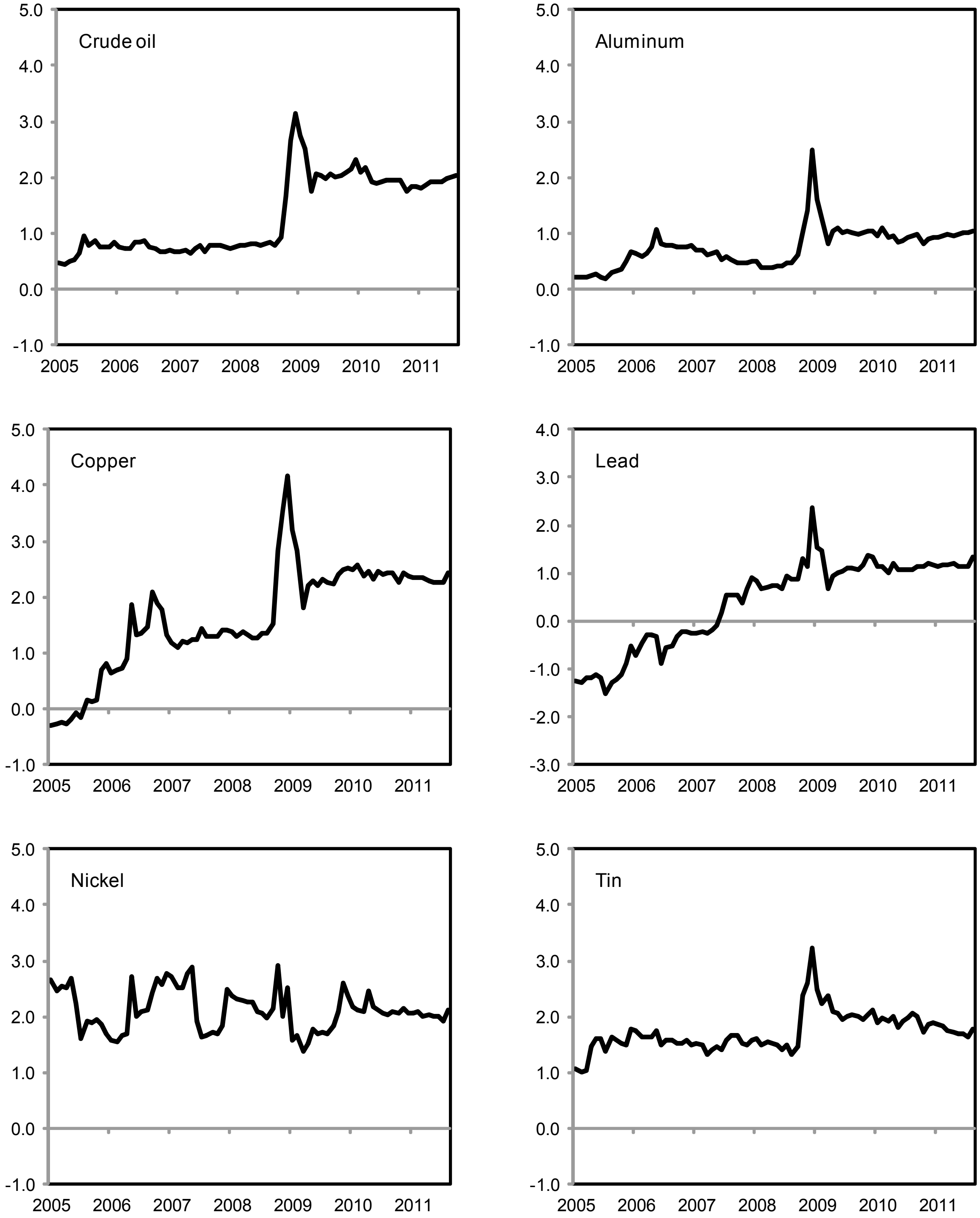
F. Robustness Tests

One legitimate concern about the exercises presented here is that they may not fully capture the rapidly evolving nature of China's participation in world commodity market. In other words, China's impact should be growing rapidly over time. To address this issue, I assess the stability of the parameter estimates over time by replicating Helbling's recursive estimations for each VAR as described by (1). Specifically, each VAR is estimated using an initial sample of Jan-2000 through Dec-2005 (and Jan-2002 through Dec-2005 for crude oil) which provides 72 months of observations. Resulting VARs are then estimated for samples successively one month longer until the full sample is reached. The 4-quarter impulse responses of the commodity price to demand shocks in China from each of these recursive estimations, with the end of the sample represented by the date on the horizontal axis, are shown in Figure 5.

Recursive estimations show that, in general, the impact of China on global commodity prices has been steadily increasing over the last 5 years and that estimates based on historical samples may be underestimating China's current impact. The spike in the estimated impulse responses during the final quarter of 2008 is caused by the significant falls in commodity prices and the decline in industrial production during the post-Lehman Brothers bankruptcy period. Recursive estimations that include separate dummy variables for October, November, and December 2008 smoothed out the evolution of the impulse responses, but the results were qualitatively and quantitatively similar.

A second battery of robustness tests involved reversing the ordering of the country industrial activity and apparent commodity consumption variables. The purpose of this exercise is to gauge the sensitivity of the results to the ordering of the recursive identification discussed in section 3.1. The impulse responses from the same VAR but with the ordering switched for these two variables (shown for China output shocks in Table 9) were very close to those obtained with the original specification (Table 4). This was true for both China and the United States and all shocks and confirms that the results are no sensitivity to the ordering.

Figure 5. Recursively Estimated 4-quarter Commodity Real Price Impulse Reponses to a China Activity Shock [1/]
(Responses to 1 percentage point shocks to the growth rate of U.S. industrial production)



1/ Dates along the horizontal axis refer to the end date of the sample period. All sample periods begin January 2000. Zinc is not shown.

Table 9. Cumulative Impulse Responses for Real Commodity Prices: Robustness Test [1/]
(Responses to 1 percentage point shocks to the growth rate of China's industrial production)

	Real price level response of:						
	Oil	Aluminum	Copper	Lead	Nickel	Tin	Zinc
1 quarter	2.15	0.75	2.12	-0.04	0.53	0.90	0.46
	(1.07)	(0.48)	(0.78)	(0.83)	(1.07)	(0.71)	(0.78)
2 quarters	2.43	0.99	2.75	1.26	1.48	1.69	0.75
	(1.51)	(0.73)	(1.15)	(1.16)	(1.53)	(1.10)	(1.15)
4 quarters	1.96	0.90	2.30	1.00	1.33	1.72	0.23
	(1.08)	(0.71)	(1.10)	(1.12)	(1.73)	(1.14)	(1.32)
8 quarters	2.07	0.72	2.11	0.79	1.32	1.41	0.21
	(1.02)	(0.60)	(0.95)	(0.95)	(1.57)	(0.94)	(1.32)
	Variance decomposition						
1 quarter	6.33	3.10	9.28	0.70	0.51	2.18	0.64
	(4.25)	(2.46)	(5.00)	(2.19)	(1.69)	(2.51)	(1.90)
2 quarters	6.33	4.45	9.16	2.78	3.43	3.68	0.82
	(4.04)	(3.13)	(5.61)	(3.67)	(2.50)	(2.72)	(2.61)
4 quarters	6.51	4.43	8.59	2.90	3.37	3.77	1.09
	(3.69)	(2.99)	(5.85)	(3.70)	(2.32)	(2.70)	(2.55)
8 quarters	6.67	4.53	8.59	3.03	3.42	3.89	1.16
	(4.03)	(3.13)	(6.25)	(3.82)	(2.34)	(2.81)	(2.59)

1/ Standard errors in parentheses. VAR specification in which the ordering of China's industrial production and apparent consumption in specification (1) are reversed.

VI. Conclusion

China is becoming increasingly important for commodity markets. Its role in the market and its impact on world trade and prices varies by commodity; in particular, China has become the dominant importer of base metals and agricultural raw material, with a smaller, but growing role, in food and energy markets.

I find that shocks to aggregate activity in China have a significant and persistent short-run impact on the price of oil and some base metals. In contrast, shocks to apparent consumption (in part reflecting inventory demand) have no effect on commodity prices. China's impact on world commodity markets is rising but remains smaller than that of the United States. This is mainly due to the dynamics of real activity growth shocks in the U.S, which tend to be more persistent and have larger effects on the rest of the world.

One caveat to these findings—and the results from studies that use similar VAR techniques—is that the effect of supply shocks may be understated. The finding that supply shocks have little price effects is counterintuitive and at odds with other empirical approaches (e.g., IMF, 200b). There appears to be strong evidence that periods of supply shortfalls, particularly those that are long-lasting—can have large effects on real commodity prices, but this is not well picked up by the techniques used in this paper. Kilian (2009) suggests that precautionary demand (or the unexplained proportion of price variance) is soaking up supply effects as they are often anticipated in advance. This argument has merit, but it is not a full and satisfactory answer.

Looking ahead, commodity market developments will increasingly be determined by China—the only question is how big the China effect will be. Understanding how Chinese demand for commodities will change if and when its economy rebalances (away from investment and exports towards consumption) remains the biggest challenge for future research in this area.

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