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Price Dynamics in China

Nathan Porter

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Price Dynamics in China

Prepared by Nathan Porter[1]

Authorized for distribution by Nigel Chalk

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Abstract

Chinese inflation, particularly non-food inflation, has been surprisingly modest in recent years. We find that supply factors, including those captured through upstream foreign commodity and producer prices, have been important drivers of non-food inflation, as has foreign demand for Chinese goods. Domestic demand and monetary conditions seem less important, possibly reflecting a large domestic output gap generated by many years of high investment. Inflation varies systemically within China, with richer (and urban) provinces having lower, more stable, inflation, but this urban inflation also influence that in lower-income provinces. Higher Mainland food inflation also raises inflation in non-Mainland China.

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Author's E-Mail Address: nporter@imf.org

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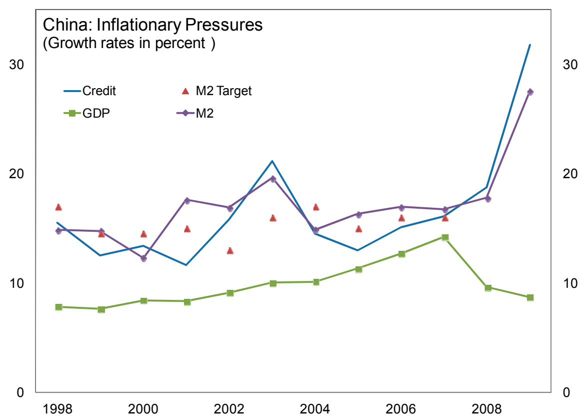
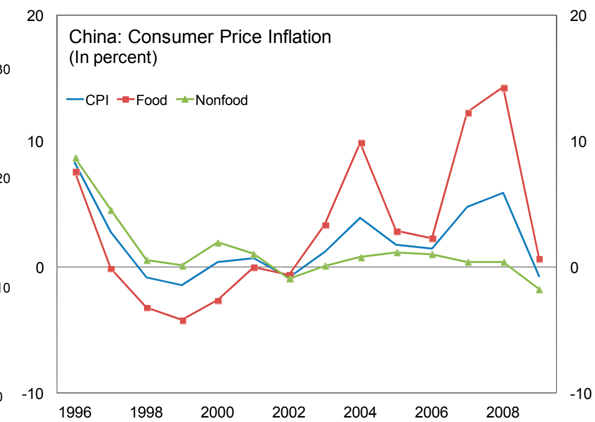
I. Introduction

Chinese inflation has been surprisingly moderate over the past decade or more. China's headline CPI inflation has remained below 5 percent since the late-1990s, with non-food inflation rising even more modestly—never above 2 percent. This is despite rapid economic growth, and credit growth exceeding nominal GDP growth in many years. Food inflation has, however, generally been volatile and much higher than nonfood with spikes in food inflation often coinciding with supply disruptions. This paper examines the factors that drive inflation in greater-China. In particular, we relate movements in nonfood inflation to aggregate demand factors—such as movements in the output gap and monetary conditions—as well as supply consideration—such as movements in input prices, global prices, the occurrence of natural disasters, and fluctuations in productive capacity. We also investigate the extent of inflationary spillovers across Mainland provinces and between the economies of greater China.





To understand inflationary dynamics at a national level, we estimate both a New Keynesian Phillips curve as well as a Bayesian VAR. Each approach has its strength. The former is motivated by firms' price setting behavior and emphasizes the role of inflationary expectations, while the latter allows considerable flexibility in documenting the impact of cost pressures, that is the transmission of shocks to upstream stream prices to downstream prices. Taken together the results from these two approaches suggest that while domestic demand pressure have played a limited role in driving past inflation, foreign demand pressures have been important. Although an unconventional finding, the relatively large role played by foreign demand is perhaps unsurprising given China's history of externally-oriented growth, and limited consumption demand. The results also suggest that cost pressures from upstream prices are important to understanding producer price and nonfood consumer inflation. Food inflation, on the other hand, seems to be driven by somewhat independent factors but does influence other consumer prices. Both inflation expectations and lagged inflation significantly affect current inflation, although lagged inflation is dominant.

Inflation patterns differ considerably within China, reflecting China's size and internal diversity. Richer and more urban provinces tend to have lower inflation and more persistent (especially food) inflation. These same provinces also seem to drive national inflation, with considerable inflationary spillovers to lower income provinces. Given the significant (and growing links) between mainland China and Hong Kong SAR and Taiwan Province of China, mainland food inflation also transmits significantly to these other economies.

Our conclusions broadly concur with previous studies on Chinese inflation, although they differ in some specific aspects. Yiping and others (2010) using VAR and VECM methodologies find the output gap, asset prices, and monetary conditions are important for explaining inflation. As they do not control explicitly for the impact of foreign demand, it is likely that their estimated impact from domestic demand at least partly captures our foreign demand impact. Zhang and Law (2010), on the other hand, study the relative importance of supply and demand shocks on food inflation. They find that demand shocks have played a major role in Chinese inflation, and that headline inflation partially reverts to non-food inflation but the reverse is not true. Their latter conclusion is consistent with our conclusion that the spillovers from food inflation are limited and relatively transitory. The former conclusion, which differs substantially from the conclusion of this paper likely reflects their choice of proxy for supply variables.

The paper proceeds as follows: Section II outlines a model of optimal price setting and relates inflation to movements in marginal costs and aggregate demand. Given the difficulty in measuring potential output for a dynamic economy like China's, Section III goes on to examine different measures of potential output and Section IV examines the empirical relationship between these measures and inflation through estimated New Keynesian Phillips Curves. In Section V we examine the interaction between various components of inflation, supply and demand factors, as well as foreign prices using a Bayesian VAR framework. Section IV investigate how price dynamics differ within greater-China and documents significant spillovers.

II. What Factors Should Drive inflation?

At the heart of the New Keynesian Phillips Curve (NKPC) literature is the optimal price setting behavior of firms. Based on this inflation should reflect the anticipated (present value of) the marginal costs that those firms face (see Rotenberg and Woodford, 1997; Gali and Gertler, 1999). Inflation is then driven by anticipated increases in costs which could arise from supply shocks (e.g., foreign commodity prices, or extreme weather damaging agricultural supply) or the impact of demand pressures on local input prices.

A simple NKPC framework assumes that prices are sticky and firms are only able to optimally set their price at randomly chosen periods (occurring with probability 1-θ). At the point at which the firms can reset, they choose to set their price equal to the expected discounted value of marginal costs. The new price level set by the firms free to re-optimize is then equal to:

$$p_t^* = (1-\beta\theta)\sum_{k=0}^{\infty} E_t\,(\beta\theta)^k\{mc_{t+k}^n\}.$$

Since $\pi_t = p_t - p_{t-1}$, this then leads to the standard closed-economy NKPC (where $\lambda = (1-\theta)(1-\beta\theta)/\theta$):

$$\pi_t = \lambda mc_t + \beta E_t\{\pi_{t+1}\}.$$

This framework can be further extended so that at any point in time a fraction of firms set their prices in an adaptive way based upon past prices (see Gali and Gertler, 1999). This leads to inflation then being determined by both backward and forward-looking behavior:

$$\pi_t = \lambda mc_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1}, \tag{1}$$

Estimating such a model, however, requires a measure of both the marginal costs that firms face and expected inflation. There are a number of options to simplify the problem. Rotenberg and Woodford (1997) argue that, under certain conditions[2], the output gap could be a suitable proxy for marginal costs. Gali and Gertler (1999) on the other hand, proxy marginal costs with the labor share of income, s_t (assuming Cobb-Douglas technology this should be proportional to marginal costs). To overcome the lack of information on expected inflation, it is common to re-express (1) as an expectation (moment condition) and estimate it using Generalized Method of Moments (GMM) techniques, instrumenting expected inflation with past inflation and other exogenous variables.

The simple NKPC outlined above is derived under the assumption the economy is closed to outside trade. Gali and Lopez-Salido (2001) show that in an open economy where there are imported inputs, then marginal costs are a function of domestic costs and the gap between imported input prices and the costs captured by domestic wages:

$$mc_t = mc_t^d + \phi(p_{Mt} - w_t) \tag{2}$$

where domestic marginal cost is proxied by the labor share of income and the parameter ϕ indicates how changes in imported prices relative to wages affect marginal costs and inflation. Depending on the substitutability of domestic and imported inputs, it is possible that ϕ is either positive or negative. This then leads to a more comprehensive NKPC relationship for an open economy

$$\pi_t = c + \lambda\left(mc_t^d + \phi(p_{Mt} - w_t)\right) + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1}. \tag{3}$$

In Section IV we will use this theoretical framework to model Chinese inflation with this discussion as the theoretic backdrop; it will also motivate the structure of the Bayesian VAR model estimated in Section V. To do this, we will need a proxy for domestic marginal costs we will follow Rotenberg and Woodford and use the output gap as our proxy. Before doing so, however, we need to introduce measures of China's output gap, given its potential importance in modeling Chinese inflation.

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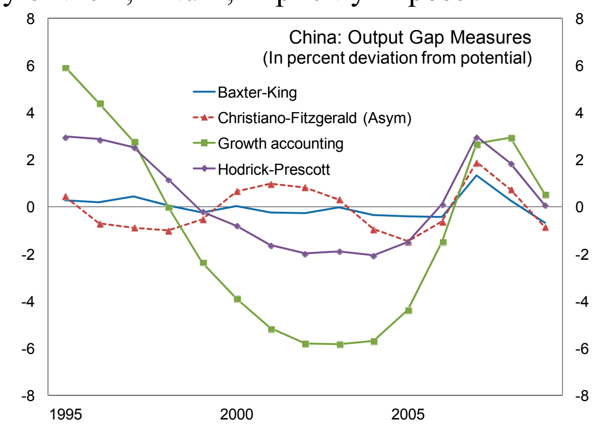
[2] The log of marginal cost is proportional to the output gap in a framework without variable capital. While this is not true in a world with variable capital, Gali and Gertler (1999, p. 201) note that simulations suggest "that the relationship remains very close to proportionate."

III. How Has China's Output Gap Evolved?

With China such a fast changing and dynamic economy, measuring the output gap is a difficult undertaking. In this section we describe several measures of the output gap including those based on statistical filters (including Hodrick-Prescott, Baxter-King, and Christiano-Fitzgerald filters) as well as a measure based on a simple growth accounting exercise (see Box 1 for details).

Each gap measure has its own advantages and disadvantages. The gap based on growth accounting has the advantage of being linked to movements in factor inputs in China but it also depends on a number of assumptions, including factor shares, potential capacity utilization and total factor productivity growth. The filter-based measures are naive time series that avoid any economic assumptions but many of them, in turn, implicitly impose symmetry on the cycle and an assumption that the economy spends a similar amount of time above potential as it does below potential. In addition, they require econometric assumptions to identify the periodicity of the cycle and are also very sensitive to the end point of the sample period. As a result, these statistical filters may be less suited to a fast changing emerging economy like China. With these caveats, we proceed by modeling inflation using these alternate measures of the output gap.



The alternate output gap measures share some similarities in their dynamics although the growth accounting methodology leads to greater amplitude in the behavior of the output gap. All the various measures show output rising above potential in the late-1980s with a subsequent crash in the early 1990s. It then took several years for output to rise again above potential but then the combination of rapid investment following the Asia crisis and a decline in capacity utilization rates led to large negative output gaps until 2006–07. The positive output gap was eliminated with the downturn following the global financial crisis and, with the rapid expansion in investment during 2008–09, aggregate measures of the output gap are likely to remain negative for the near future given the extent of investment in recent years.

Box 1. Growth Accounting and Measuring Potential Output

The growth accounting measure of the output gap is constructed using standard growth accounting techniques. In particular we assume a Cobb-Douglas production function of the following form.

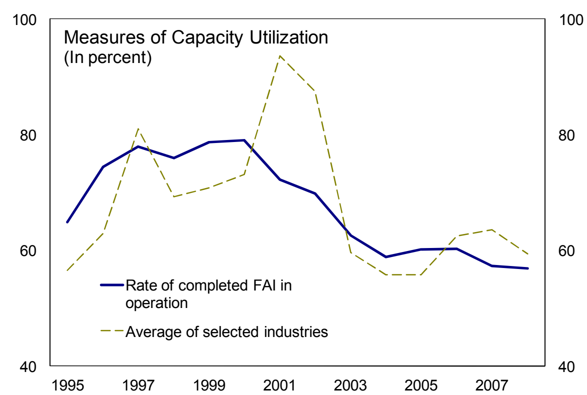
$$Y = A(uK)^{\alpha_K}(HL_u)^{\alpha_L}L_r^{1-\alpha_K-\alpha_L},$$

where u is the rate of capacity utilization, L_u is urban labor supply, L_r is rural labor supply, and H is a measure of human capital. The implicit assumption is that urban and rural labor are different factors, and while the two are—at some level—substitutes given China's flexible labor market, they contribute to aggregate output in different ways. Consequently given measures of the factor inputs, we are able to estimate total factor productivity growth ($\hat{a}$) for given factor shares as follows:

$$\hat{a} = \hat{y} - \alpha_K(\hat{u} + \hat{k}) - \alpha_{L_u}(\hat{h} + \hat{l}_u)(1 - \alpha_K - \alpha_{L_u})\hat{l}_R,$$

where the lower case "hated" variables refer to growth rates.

To measure productivity growth we assume that urban and rural labor supplies can be measured by their respective populations, while human capital is captured by the level of average education estimated by Holz (2005). We assume for the purpose of this exercise a 50 percent of income share for capital, and a 40 percent share for the higher skilled urban labor. The assumption on the capital share reflects China's heavily capital intensive production structure and is the same as the base case assumption made by Zhang and others (2009), although it is lower than share assumed by Aziz (2008) and Bosworth and Collins (2008). The urban labor coefficient reflects the share of labor income earned by urban residents.[1] Capacity utilization is measured as the share of new fixed asset investment put into use, and while this has declined over time it reflects the average of capacity utilization within several key industrial sectors.[2] The exercise also assumes a depreciation rate of 0.075 percent, slightly higher than the 0.06 assumed by Aziz (2008) and Bosworth and Collins (2008). The initial capital stock for 1978 is estimated using the perpetual inventory method based on aggregate data for 1973–1977 with the initial steady state capital-output ratio of 2.2 (close to that used by Aziz (2008)).



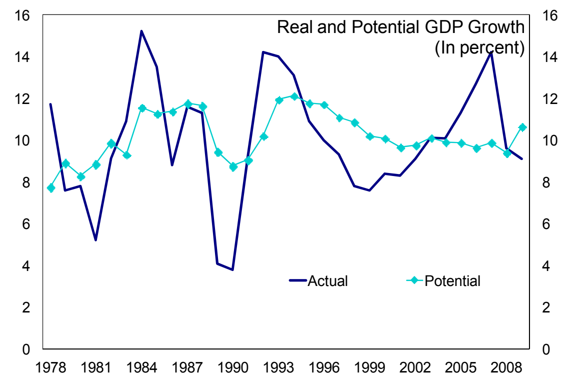
The resulting estimates suggest a significant contribution from total factor productivity

(TFP) to growth, with estimated potential output growth since 2000 at almost 10 percent. In particular, TFP growth is estimated to have averaged 3½ percent between 1978 and 1995, and while this subsequently slowed, it only did so by slightly more than 1 percentage point. In measuring potential output growth, we assume capacity utilization is maintained at its peak (of around 80 percent), and potential TFP growth of 3.6 percent until 1995, and 2.2 percent subsequently.

Growth Accounting for China 1/
(Contributions to growth)

	1978-1995	1998-2009
GDP Growth	10.1	9.8
Capital stock 2/	8.7	10.6
Quality-adjsuted urban labor	5.5	5.7
Rural labor	0.5	-1.3
TFP	3.5	2.3

1/ Assumes capital share of 0.5 and skilled (urban) labor share of 0.4, and a geometric depreciation rate of 0.075.
2/ Adjusted for capacity utilizaton.



[1] Based on Household Survey data, urban household income averaged almost 80 percent of total household income between 2007–2009.

[2] The average measure is the average of measured capacity utilization in cement, pig iron, steel, iron alloy, cars and automobiles.

IV. Estimating A New Keynesian Phillips Curve For China

We now estimate such a relationship, based on the NKPC framework described above to try and capture the determinants of nonfood inflation (a measure of core inflation) in China. For foreign input prices we use the import deflators from the IMF's World Economic Outlook database, expressed in renminbi terms. To proxy marginal costs we examine all of the measures described in Section III as well as the foreign input price gap. We estimate the model using GMM with data from 1996 to 2009 using lags of the output gap, inflation, wage inflation, foreign prices, world coal and oil prices, broad money growth, capacity utilization, and the difference between 3 and 1 year lending rates. The estimated relationships suggest small longer-run deflationary pressure (indicated by a negative constant) of about 0.2 percentage points, possibly reflecting China's large (and initially untapped) labor force and the pressure from substantial continuous productivity growth. Other results are broadly consistent across output gap measures, with each suggesting a limited impact of the output gap on inflation, but inflation expectations, lagged inflation, and relative foreign cost pressures all significantly increasing domestic inflation. Although the estimated importance of inflation expectations differs across models, the importance of lagged inflation and the foreign price gap are remarkably similar.[3]

Table 1: New Keynesian Phillips Curve--Growth Accounting Gap

Method: Generalized Method of Moments
Sample (adjusted): 1996 2008

Variable	Coefficient	t-Statistic	pvalue
C	0.00	-1.81	0.11
Output Gap (GA)	0.02	0.93	0.38
Foreign Price Gap	0.31	15.74	0.00
Expected Inflation	0.12	2.69	0.03
Lagged Inflation	0.63	21.38	0.00
R-squared	0.84		
Adjusted R-squared	0.75		
S.E. of regression	0.01		
Durbin-Watson stat	1.92		

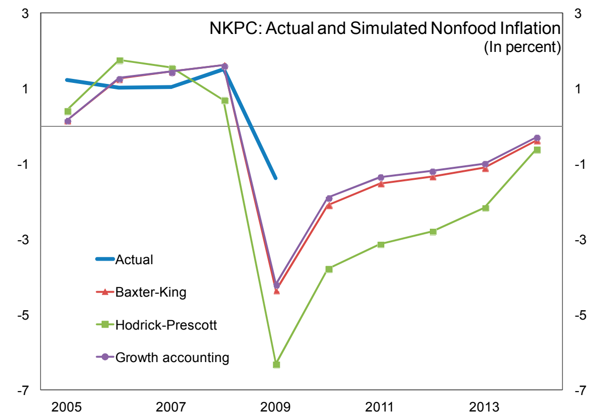
Table 2. NKPC for Nonfood Inflation: Estimation Summary

	Constant	Gap	Expected Inflation	Lagged Inflation	Foreign Price Gap	t Validity 1/
Growth Accounting						
Coefficient	0.00	0.02	0.12	0.60	0.31	3.19
pvalue	0.11	0.38	0.02	0.00	0.00	0.67
Baxter-King						
Coefficient	0.00	0.07	0.12	0.65	0.32	3.18
pvalue	0.01	0.67	0.11	0.00	0.00	0.67
Christiano-Fitzgerald (Asymetric)						
Coefficient	0.00	0.11	0.36	0.60	0.36	3.90
pvalue	0.00	0.53	0.00	0.00	0.00	0.56
Hodrick-Prescott						
Coefficient	0.00	-0.06	0.24	0.64	0.36	3.19
pvalue	0.00	0.04	0.00	0.00	0.00	0.67

1/ J test for instrument validity. Ho: is that the overidentifying restrictions are valid.

[3] Estimating the same models with total CPI (unreported) results in a larger estimated impact of the output gap in inflation, a larger impact of inflation expectations, and a generally smaller estimated impact of the foreign price gap. The differences possibly suggest an important role for food price expectations, and reflect the lower imported input component of domestic food.

Dynamic simulations of these models suggest the estimated NKPCs provide a good explanation of China's non-food inflation in recent years, although the models predicted too large a fall in core inflation following the global financial crisis. Looking forward, the models suggest at most modest inflation pressures given the expected path for the output gap and foreign inflation, even if the forecast error in 2009 is removed.



V. Estimating a Bayesian Vector Autoregression Model for China

VAR models are common in empirical macroeconomics given their strength in documenting the interrelations across variables and in forecasting. In this section, we estimate a Steady State Bayesian VAR, which uses priors on steady state behavior to help pin down estimates of the posterior distribution over the these steady state values.

A. Methodology and Empirical Implementation

VAR models are common in macroeconomics for forecasting and documenting empirical regularities. The additional advantage from using a steady state BVAR, is that placing priors on steady state values tends to improve the estimation efficiency and forecasting performance of the model. (Villani, 2005). The estimation procedure also produced estimates of the steady state values for the modeled variables. This methodology has previously been applied the study of Latin American growth dynamics (Osterholm and Zettelmeyer, 2007).

Our model of Chinese inflation is estimated with quarterly data from 1996Q1 to 2010Q1, and is structured into three blocks:

- ***External Variables:*** This includes the US output gap, commodity prices, and the nominal effective exchange rate.
- ***Domestic Variables:*** This block encompasses the domestic output gap, producer price inflation, food and nonfood consumer price inflation, and housing prices.
- ***Policy Variables:*** The policy variables examined are the one year benchmark lending rate, and broad money growth.

In estimating the VAR, a structural break is allowed for in the steady state values in 2004 to reflect the impact of WTO accession (in 2002) and other structural changes that occurred to

China in the second half of the last decade.[4] The structural shocks are identified by the following block ordering assumption: both domestic and policy variables respond to contemporaneous shocks in the external variables and policy variables respond contemporaneous domestic shocks. The measures of China's output gap used in this baseline estimation is that based on the growth accounting technique described above while US potential output is derived from WEO data. The nominal effective exchange rate is treated as an external rather than policy variable since the bilateral US$ rate has traditionally been the focus of policy and the basket is dependent on movements in international cross-rates. The priors on the steady state values are such that both foreign and domestic output gaps are assumed to decline toward zero over time, commodity price inflation rises in line with WEO projections, and domestic variables move back toward their longer run values. Priors on other parameters are assumed to be broadly in line with the "Minnesota priors" (Litterman, 1986).

B. Results

Impulse Response Functions

The impulse response functions show that China's growth and inflation outturns are highly dependent on growth and price developments in the rest of the world.[5]

- A 1 percent rise in ***the foreign output gap*** leads to an increase of over ½ percent immediately in the domestic output gap, with the impact rising to around 1 percent in the second year. Foreign output is also an important driver of domestic producer and consumer prices. A 1 percent shock to the foreign output gap raises producer prices by more than 2 percent, food prices by around 1 percent, and nonfood prices by around ½ percent in the first year. Interestingly, the estimated impact of domestic demand on nonfood inflation is very small, consistent with the NKPC results discussed above.

- ***Nominal appreciation*** seems to have a modest pass-through to producer prices (but with little effect on consumer prices) reflecting the fact that imports are dominated by intermediate goods and the size of consumption good imports is relatively small.

- An increase in ***world commodity prices*** feeds through to both higher producer prices and higher nonfood inflation; they appear, however, to have little impact on food price inflation.

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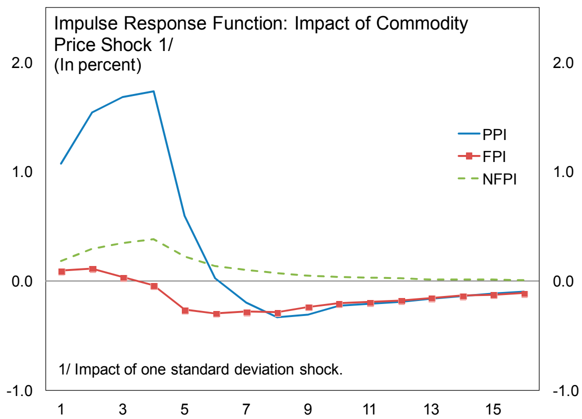
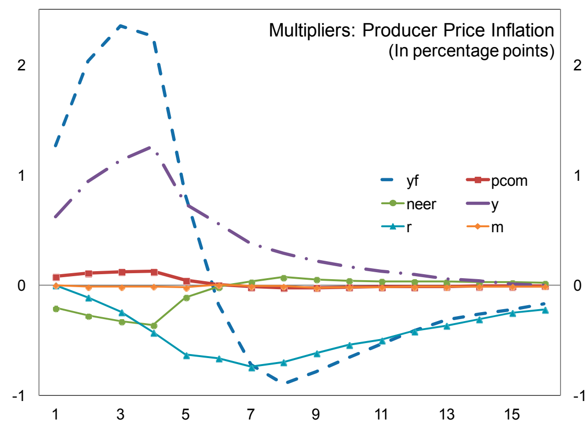
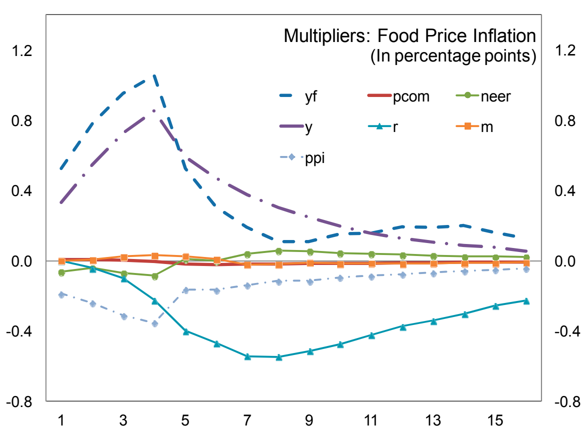
[4] Results are little changed if a break in mid-2005 is allowed for to reflect the impact of the change in the exchange rate regime at that time.

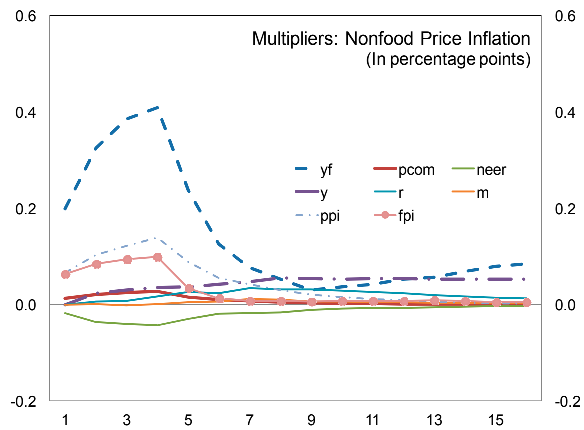
[5] In the text we present the multiplier of various domestic variables from foreign variables, with the impulse response functions and the corresponding confidence intervals displayed in the Appendix.

- ***Monetary policy*** has a mixed effect on inflation. Money growth appears to have surprisingly little impact on inflation. On the other hand, interest rates do affect producer prices and food inflation within 1 to 2 years, although little impact on nonfood inflation.









The Policy Response Function

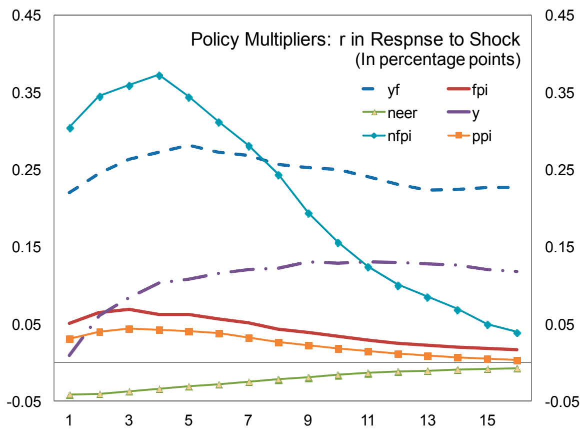
The BVAR framework also generates information about the empirical relationship between policy variables and macroeconomic variables—loosely speaking the central bank's implied policy reaction function. The BVAR's results suggest the following:

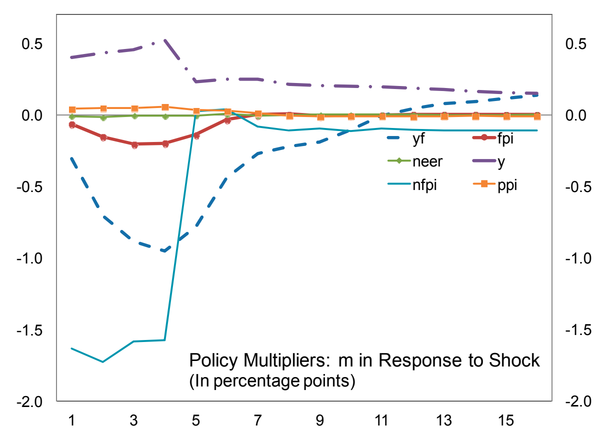
- *Policy variables are tightened following a positive foreign output shock, but appear to slightly accommodate domestic output shocks*. A 1 percent increase in foreign output leads to an increase in domestic interest rates of around ¼ percent. However, the interest rate and monetary growth do not appear to tighten significantly following a shock to domestic output.

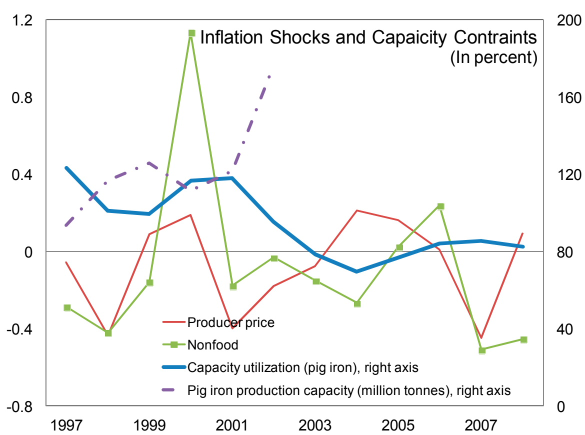
- *Policy variables do react forcefully to an increase in nonfood inflation.* However, it is unclear whether this reflects a greater concern attached to nonfood inflation or is rather an artifact of the experience in China whereby nonfood inflation tends to move very little through the cycle and is relatively unresponsive to small changes in policy rates.

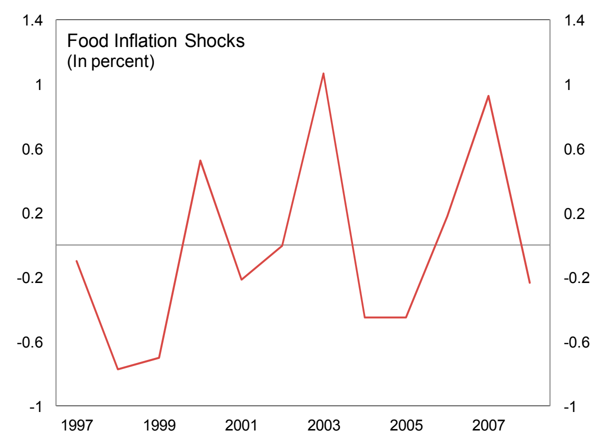
- *The interest rate response to an inflationary shock is considerably more persistent than the monetary growth response*. This seems to reflect the considerable inertia seen in the setting of benchmark interest rates.

- *Interest rates tend to offset changes in the nominal effective exchange rate.* In particular, a nominal appreciation is typically met by lower interest rates although monetary growth also slows. This would be consistent with interest rates moving to maintain relatively stable monetary conditions.





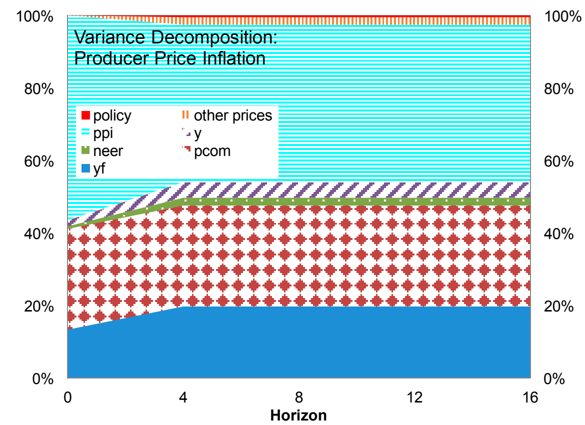


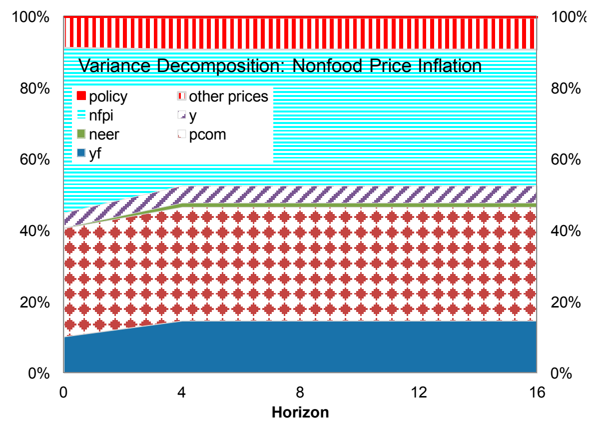


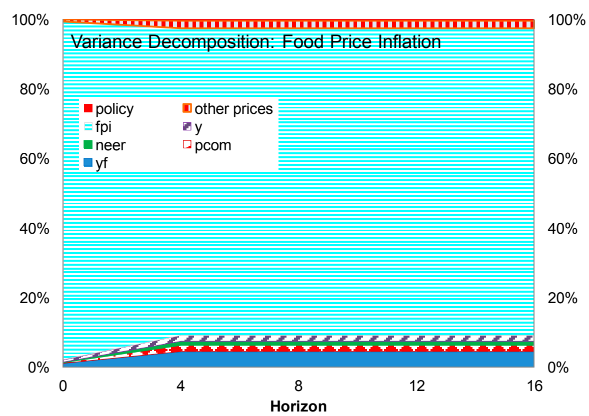
The BVAR framework also permits the identification of historical structural shocks to each of the various inflation measures. At times, these shocks are both large and positive. While clearly interpreting these shocks is difficult, some of the largest positive shocks appear to coincide with supply events, possibly suggesting a supply side interpretation. In particular, the largest shock to producer prices and nonfood inflation occurred in 2000–02 and seems to be related to capacity constraints in the production of pig iron. The shocks to food inflation, on the other hand, have coincided with domestic agricultural shortages: an outbreak of the blue ear pig disease in 2007–08, and a peak in natural disasters in 2003.[6]

Variance Decompositions

Decomposing the volatility in the inflation series, reinforces the message that foreign shocks are particularly important drivers of domestic producer and nonfood consumer price inflation.







- One quarter of the variance in ***producer prices*** is explained by changes in world commodity prices and a further 20 percent derives from movements in foreign demand.

- Commodity prices also explain around one-third of the variance of ***nonfood consumer prices*** in China, while the foreign output gap accounts for slightly more than 10–15 percent of volatility. Other prices and the domestic output gap do appear to have some influence on nonfood consumer prices although these effects are relatively small (accounting for 9 and 5 percent of nonfood price volatility, respectively).

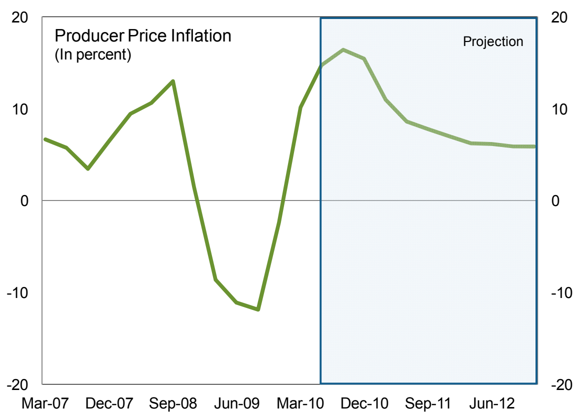
- The variance of domestic ***food inflation***, on the other hand, appears to be relatively unaffected by both domestic and foreign supply and demand shocks. Rather it is lagged food prices that are most important indicating the food price supply shocks are orthogonal to other variables in the model and they have a highly persistent effect over time.

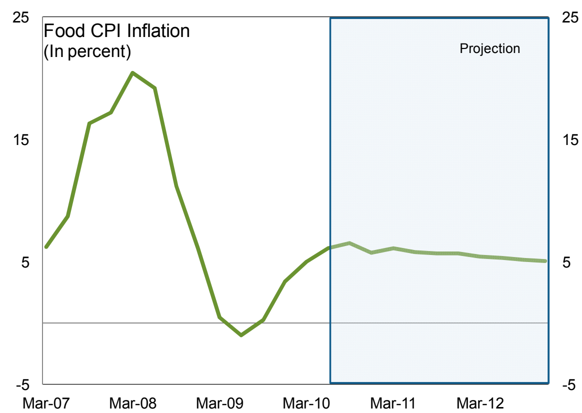
[6] 2003 saw the largest area (particular non-forest area) destroyed by fire and the most damage created by air and water pollution since 2000 (China Statistical Yearbook).

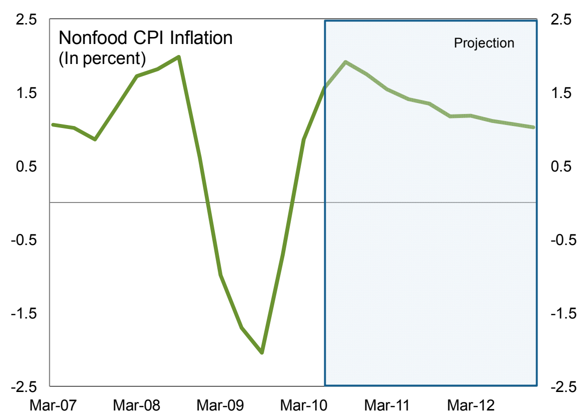
Projections

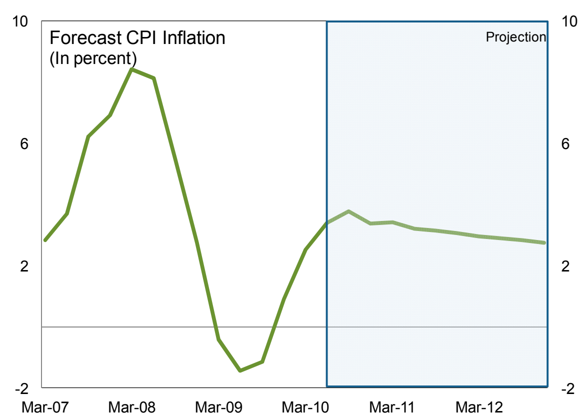
The BVAR provides a suitable framework for forecasting inflation and allows us to make forecasts that are conditional on projections of how we believe economic forces in the rest of the world will evolve (drawing on the IMF's WEO projections).

Using the BVAR model to predict inflation over the next couple of years we find that there is very little sign of inflationary risks on the horizon. The WEO assumed paths for foreign output and commodity prices suggest a gradual decline in the negative foreign output gap and, after a spike in 2010, a steady moderation in commodity prices (see Appendix). Using this as a baseline assumption, the BVAR would project that domestic inflation will peak in the second half of 2010 at close to 4 percent, falling to 3¼ percent by the end of the year, and then to 3 percent by end-2011.





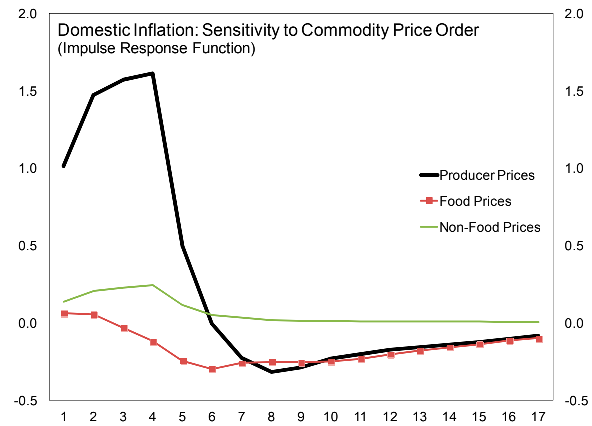


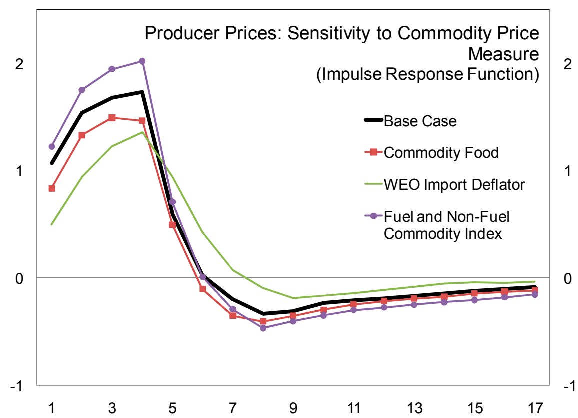


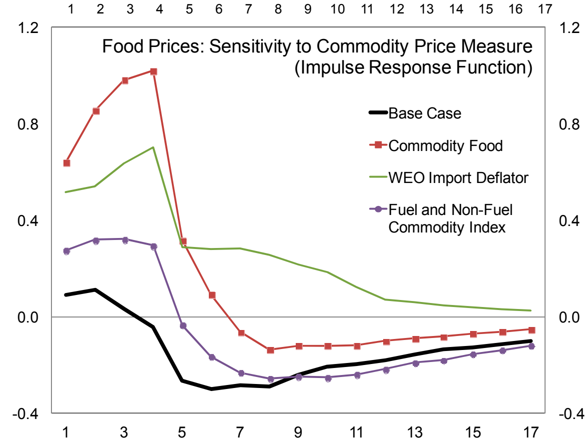
C. Robustness

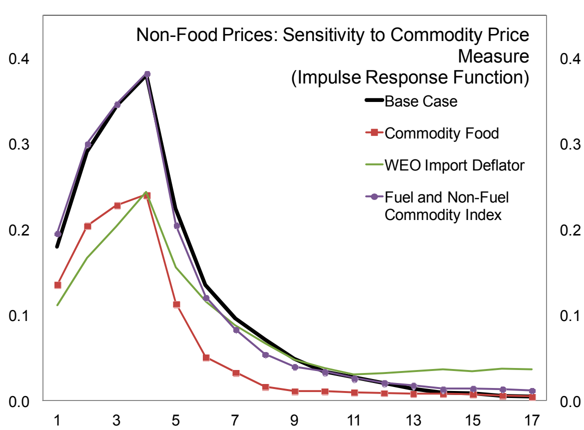
The results of the above VAR analysis depend on the order of the variables specified and the choice of the commodity price variable. In this section we undertake some limited sensitivity analysis, finding that in general the results presented above are robust to changes in measured commodity prices or the ordering of policy variables.

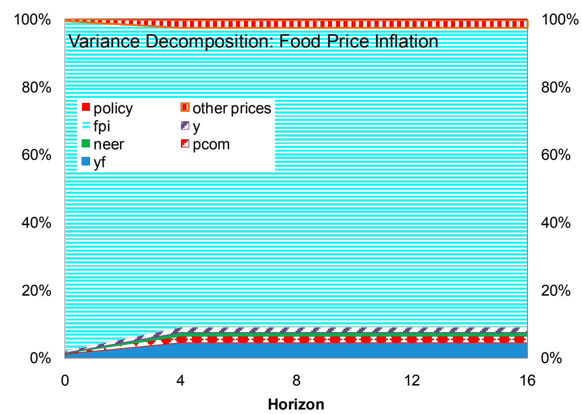
The impact of external commodity prices is generally consistent alternatives—a total (fuel and non fuel) index, a general import deflator, or the IFS Food commodity price index—although the commodity food index enhances the estimated impact of commodity prices on domestic food inflation. This includes a larger share of the variance accounted for by international commodity prices, although the share accounted for by other factors is little changed. The results are also relatively robust to allowing Chinese domestic demand conditions to affect commodity prices contemporaneously (to below the domestic output gap), although the estimated impact on producer prices becomes slightly larger and that on consumer prices slightly smaller.



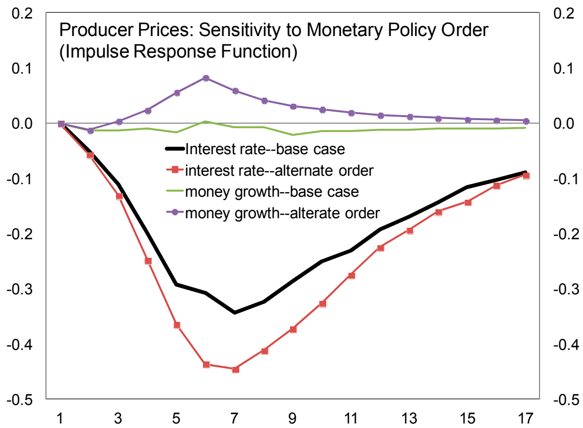


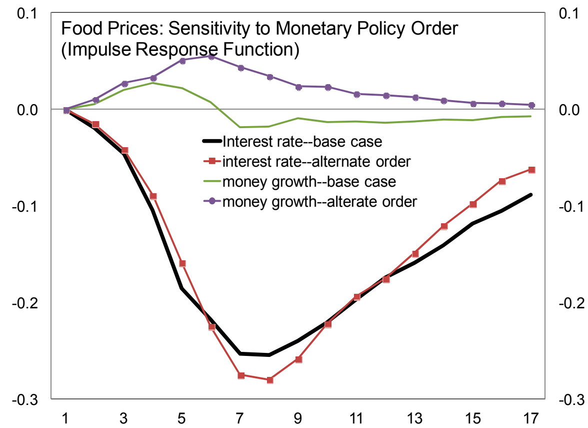






The ordering of the policy variable—interest rate and money growth—may also affect the results. Switching their order (placing money growth above the interest rate) tends to enhance the measured impact of the monetary shocks on producer and food prices, the impact is relatively small. The impact of interest rate changes remains much the same. Although not reported in the interests of space, treating the nominal appreciation as a policy variable (ordering it last), removes much of the disinflationary pressure from the appreciation, with the impact less than 10 percent of that under the baseline case shown above.



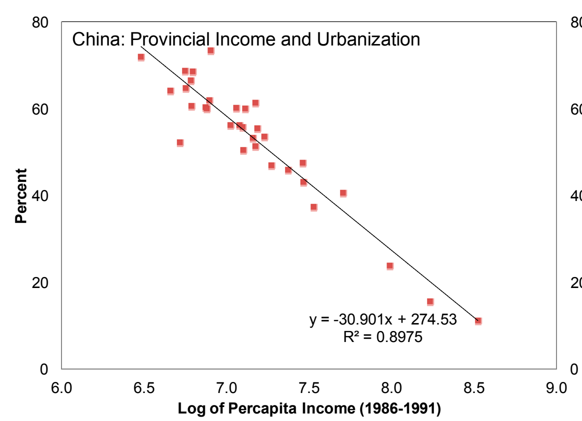


VI. Provincial Inflation Spillovers

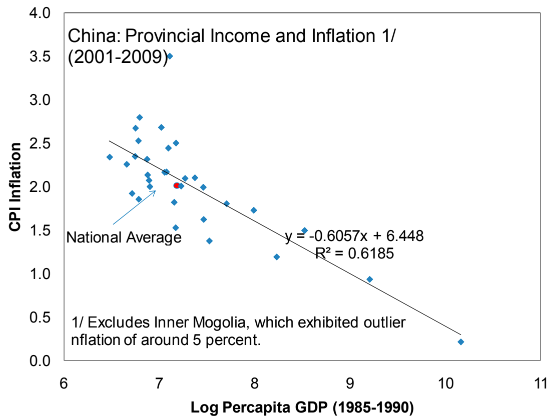
As a large country China differs considerably across provinces. Provinces differ in, amongst other things, their income and production structure, and urban density. This heterogeneity potentially gives rise to considerably different inflation dynamics and may lead to spillovers across provinces. This section outlines how inflation patterns differ within China, and how inflation might transmit across provinces.

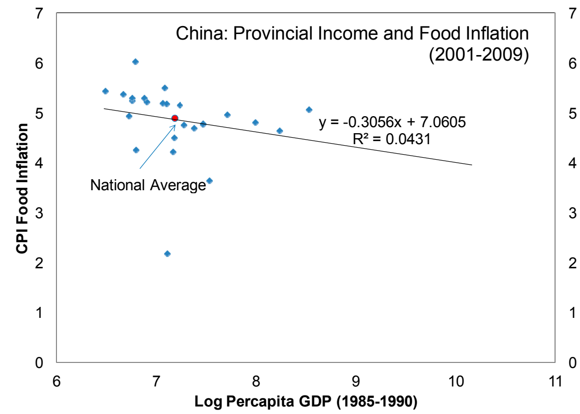
A. Stylized Facts: Inflation Patterns Across Provinces

Inflation patterns differ substantially across provinces. In particular, the level of inflation seems to vary systematically within China by the level of provincial income, although this could also reflect either the extent of urbanization in the province, which varies with income. [7] The principal driver of this inflationary pattern seemingly results from non food inflation, rather than food inflation.

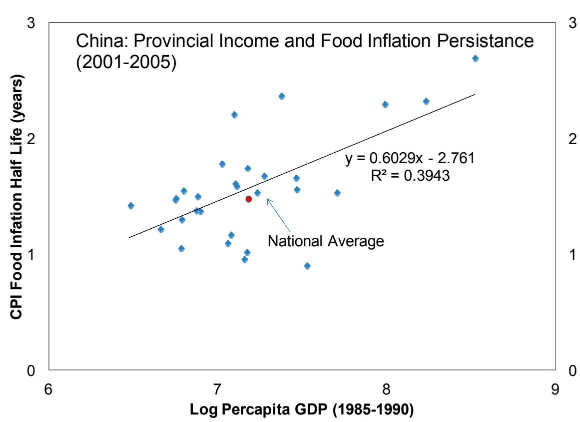


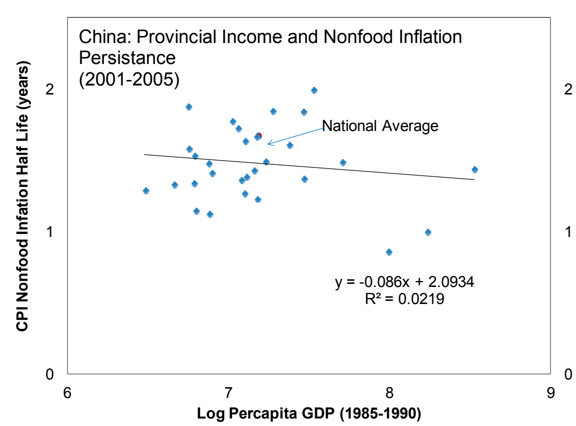
[7] Although historical GDP per capita (1986–1990) is shown in the chart, this is very highly correlated though time (over 0.9 for subsequent 5-year periods).

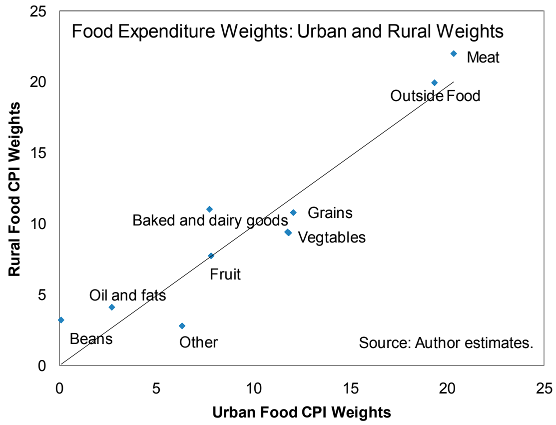


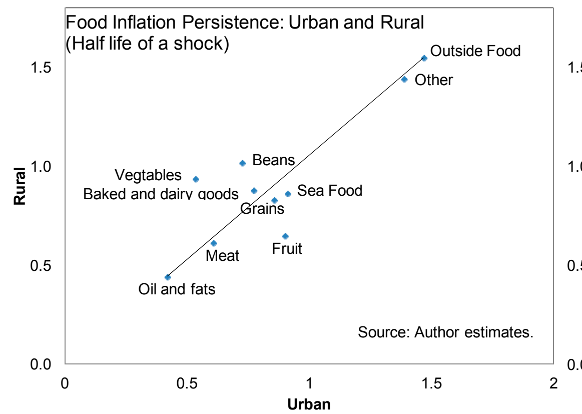


Beyond the level, the persistence of inflation also differs considerably within China, although this is more prominent in food inflation, possibly reflecting income differences. So, while the average level of food inflation varies little across provinces, shocks to food inflation have a more persistent impact in high income provinces. Given the close relationship between income and the extent of urbanization, this persistence pattern could reflect differences between urban and rural households—either a higher weight on the consumption of more persistent food items in urban households, or more persistent price movements in those communities. However, the estimated weights and persistence of the various items in the consumption basket (using national urban and rural CPI data) are surprisingly similar across the two types of households. Consequently the relevant difference may be based more on income, masked by measurement errors, or reflect differences at a more disaggregated level.







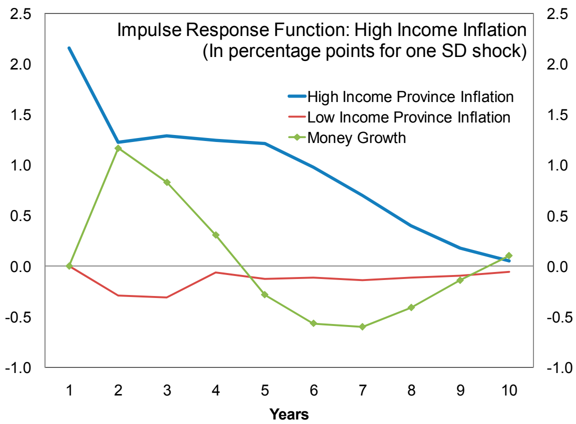


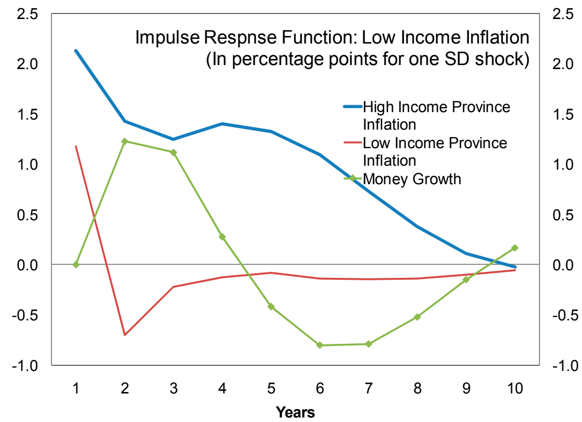
B. Spillovers Within Mainland China

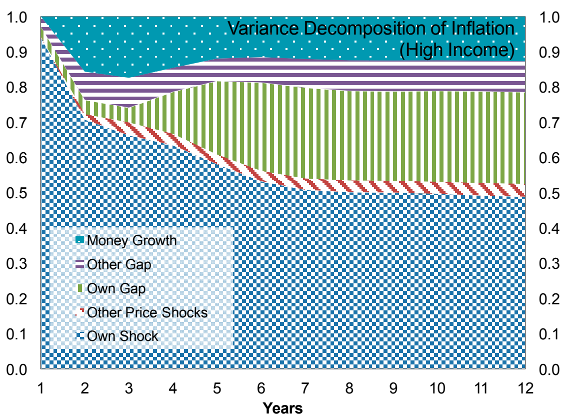
How do inflation dynamics differ across different income levels? To answer this, we estimate a VAR for total CPI inflation in which spillovers from high income provinces to low income provinces are allowed for.[8] While the limited data available requires considerable aggregation, which limits detailed conclusions that come from this exercise, the patterns documented above suggest that the exercise should illuminate some broad pattern of how inflationary dynamics move across provinces. The results suggest that inflation in low income provinces are considerably dependent on developments in the higher income provinces.

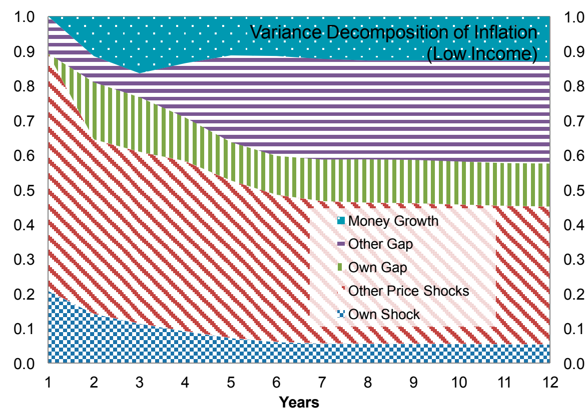
Shocks to inflation in high income provinces are highly persistent, and generate significant spillovers to low income provinces. In particular, a shock to high income provincial inflation initially has a similar impact on both high and low income province inflation. Inflationary shocks originating in low income provinces have a significant short-term impact in these provinces, but they do not seem to have a broader impact. Shocks to monetary conditions (captured by aggregate money growth) affect inflation in both types of provinces similarly. The variance decompositions also suggest that shocks originating in high income provinces are the major drivers in volatility in both types of provinces, with shocks from low income provinces playing a minor role even in those provinces.

[8] To control for other factors, the VAR also includes foreign inflation in domestic prices (based on changes in the WEO import deflator for China), the output gap derived using a HP filter from output of both high and low income provinces, and national money growth. Provinces are divided between high and low income based on whether their 1986–1990 per capita GDP was less than Y1,090 (90 percent of median per capita GDP) or not. This results in 19 of 31 provinces being classified as high income, with the remainder classified as low income. The VAR is estimated with annual data from 1988 to 2009. High income variables are ordered above low income variables given the importance of migrant remittance flows and that production is concentrated in high income provinces.









What may account for these cross provincial patterns? The importance of high income (and urban) provinces in driving inflation could easily reflect their large share in the national consumption basket and the importance of remittance income from these areas. Although it is impossible to be conclusive about why the level and persistence of inflation differs systematically with income using aggregate data, one possibility is that it reflects the substitution possibilities available within China.[9] If more urban and richer areas of China have access to more alternate supply chains, then one would expect their inflation to be both lower and more persistent. If this is so, a rise in the price from one supplier could more easily be substituted for with a lower price item by urban residents, lowering average inflation and making it more stable. Although there may be alternative explanations for these patterns, substitution possibilities fit with results above.

C. Spillovers to Other Parts of China

Mainland inflation is likely to spill over into inflationary pressures in both Hong Kong SAR and Taiwan Province of China. Considerable trade links, particularly related to domestically

[9] I would like to thank Steve Barnett for suggesting this possibility.

consumed food, exit between the Mainland and these economies.[10] These links are likely to generate cross-border inflationary spillovers. Table 3 shows the result of estimated new-Keynesian Phillips curves (akin to those in Section IV), augmented with food inflation from the nearest Mainland province, either Fujian or Guangdong. This specification can be thought of permitting mainland inflation to directly impact the marginal costs of supplying each of these economies.

The estimated Phillips curves suggest similar factors drive inflation in these parts of China as on the Mainland. There is, however, a larger role for aggregate demand through the output gap to affect the inflation which, at least in Taiwan Province of China, reflects the heavily industrial nature of its economy. While lagged inflation may play a similar role as on the Mainland, expected inflation surprisingly seems no more important than on the Mainland. Given the limited manufacturing production taking within Hong Kong SAR, it is possibly unsurprising that imported input prices are less important than domestic wages for Hong Kong inflation. Nonetheless, higher food inflation in the nearest neighbor province significantly raises domestic inflation in both the non-Mainland economies, although the net spillover for Taiwan Province of China is economically small reflecting its smaller mainland ties.

[10] In 2009, around 30 percent of Hong Kong SAR's food imports come from the Mainland, while food imports from China account for around 8 percent of Taiwan Province of China's total imports and 55 percent of imports for mainland China.

Table 3. NKPC for Hong Kong SAR and Taiwan Province of China CPI Inflation: Estimation Summary

Gap Measure	Constant	Gap	Expected Inflation	Lagged Inflation	Foreign Price Gap	Mainland Food Inflation 1/	Adj-R^2	Instrument Validity 2/
Hong Kong SAR								
Baxter-King								
Coefficient	-0.01	0.72	0.12	0.54	-1.39	0.59	0.64	3.09
pvalue	0.00	0.00	0.04	0.00	0.00	0.00		0.93
Hodrick-Prescott								
Coefficient	-0.01	0.12	0.39	0.45	-0.13	0.21	0.75	3.31
pvalue	0.00	0.00	0.00	0.00	0.11	0.00		0.91
Taiwan Province of China								
Baxter-King								
Coefficient	0.00	0.21	0.23	0.58	0.05	0.04	0.86	3.20
pvalue	0.65	0.00	0.00	0.00	0.00	0.00		0.92
Hodrick-Prescott								
Coefficient	0.00	0.28	0.19	0.44	0.04	0.04	0.73	2.98
pvalue	0.00	0.00	0.01	0.00	0.05	0.00		0.94

1/ Nearest neighbor Mainland province (Guangdong for Hong Kong SAR and Fujian for Taiwan Province of China). The instrument list includes lagged national and nearest neighbor provincial food inflation.
2/ J test for instrument validity. Ho: is that the overidentifying restrictions are valid.

VII. Conclusions

This paper investigates the drivers of inflation in China. Consistent with theory, cost pressures—reflected in domestic and foreign input prices—and expected inflation play an important role in explaining producer and nonfood consumer inflation. While direct domestic demand pressures have little impact on overall nonfood inflation, foreign demand pressures (as measured by the foreign output gap) play a substantial role. Moreover, domestic demand pressures indirectly influence nonfood inflation through their impact on domestic producer and food prices. Beyond the impact of supply factors detected through input prices, the "structural shocks" identified through our Bayesian VAR also seems somewhat related to some ad hoc shocks to supply conditions in key industrial and agricultural sectors. While nonfood inflation seems to respond little to policy variables, movements in these policy variables seem to have a larger impact on inflation in other prices, thereby indirectly influencing nonfood prices. These results are generally robust to changes in the type of commodity price used and the ordering of policy variables.

Although the results of this work suggest a limited role for direct demand pressures on nonfood inflation, the results may be dependent on measures of the output gap. This could reflect difficulties in measuring the output gap for such a rapidly changing economy as

China. Moreover, using a more structural model to estimate the output gap jointly with inflation may also be worthwhile and improve the ability of the output gap to forecast inflation. Although undertaking such an exercise would require a careful specification of the policy setting framework as well as modeling of supplies shocks.

Appendix: Estimated Impulse Response Functions and Steady State Distributions

Figure A1. Estimated Impulse Response Functions

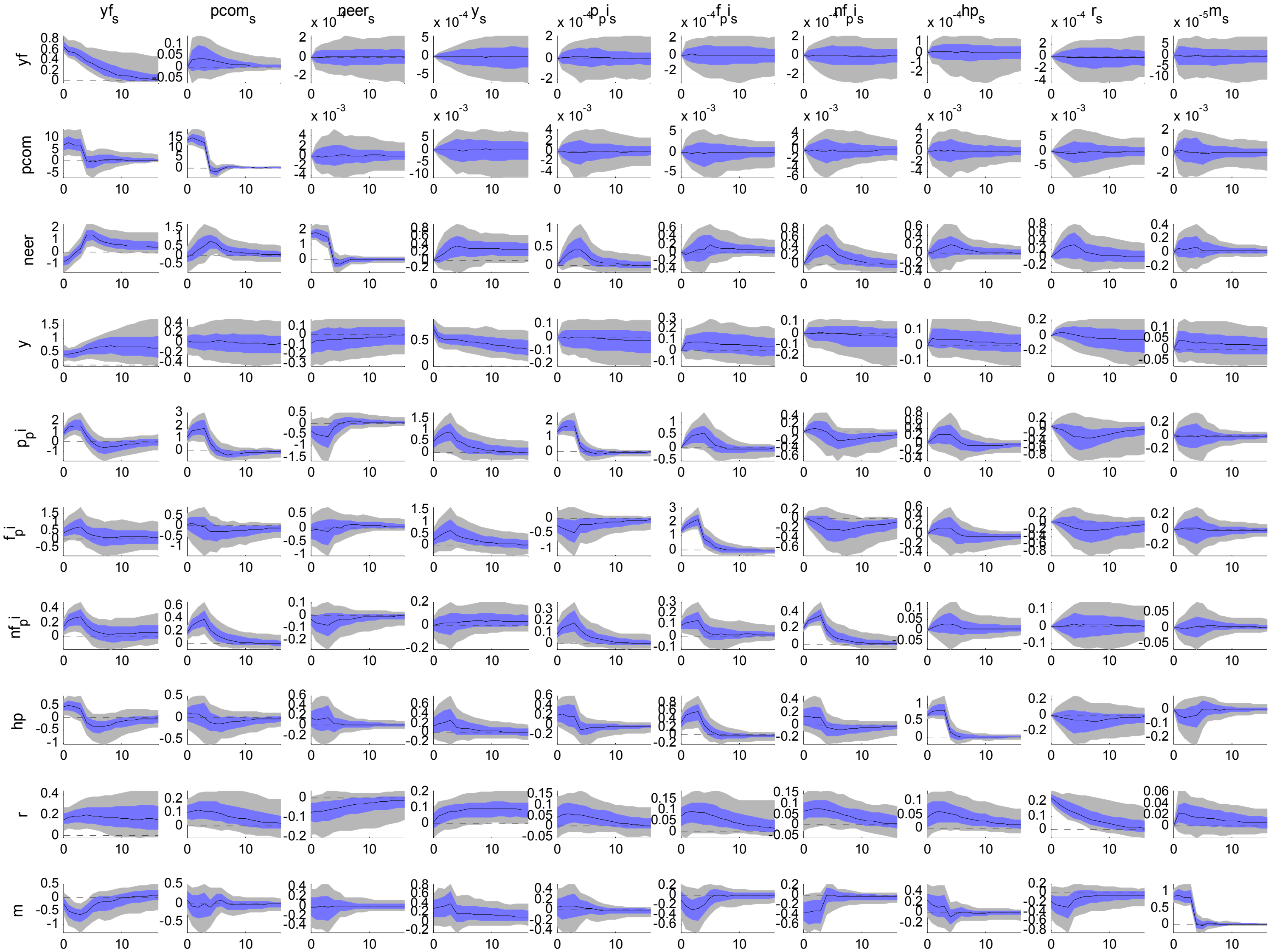
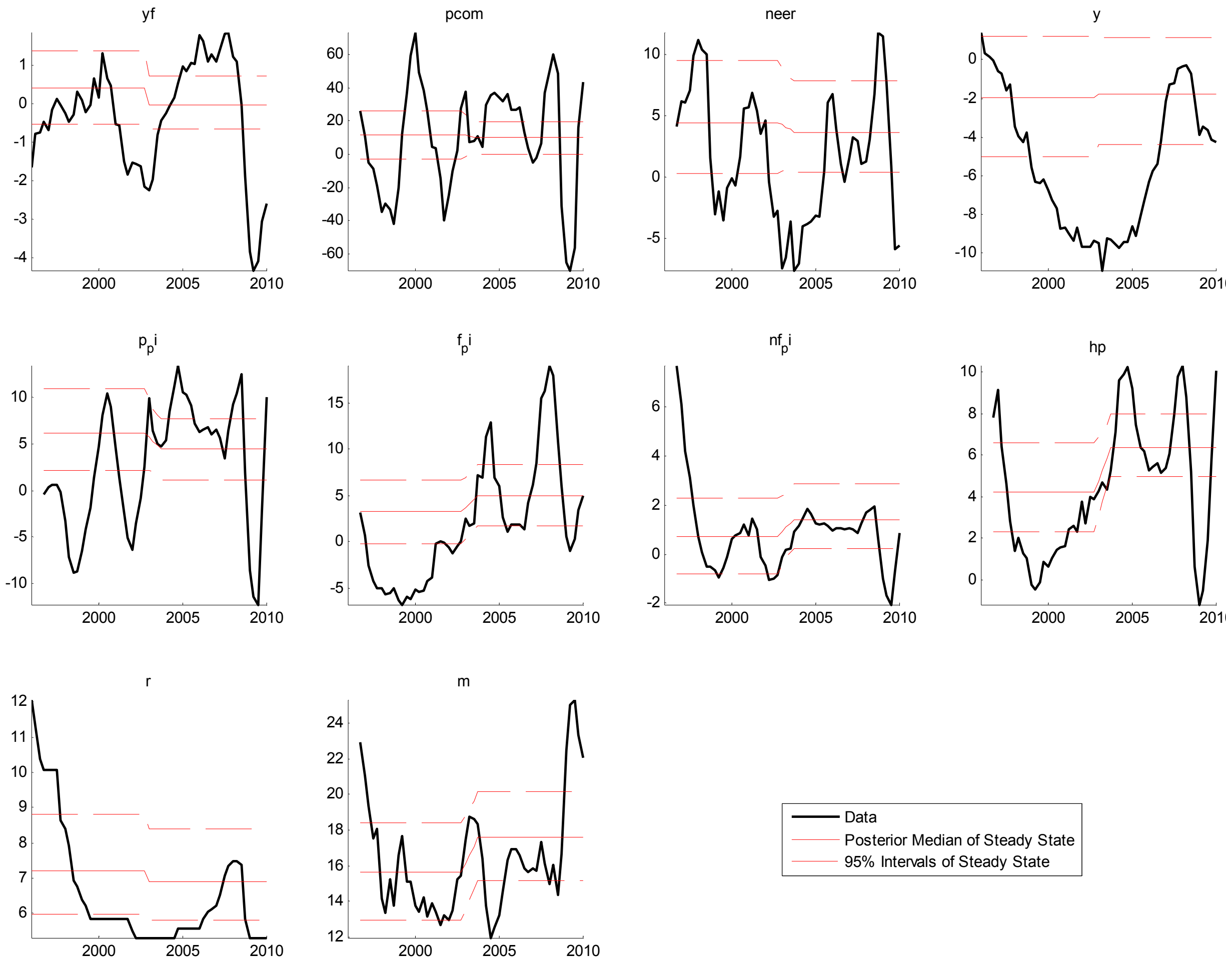


Figure A2. Estimated Steady State Distributions



References

Aziz, Jahangir, 2008, "Real and Financial Sector Linkages in China and India," IMF Working Paper 08/95 (International Monetary Fund: Washington, DC).

Bosworth, Barry, and Susan Collins, 2008, "Accounting for Growth: Comparing China and India, Journal of Economic Perspectives, pp. 45-66.

Gali, Jordi and Mark Gertler, 1999, "Inflation Dynamics: A Structural Econometric Analysis," Journal of Monetary Economics, Vol 44, pp. 195-222, (Elsevier: Amsterdam)

Gali, Jordi, and J. David Lopez-Salido, 2001, "A New Phillips Curve for Spain," BIS Paper No. 3.

Holz, Carsten, 2005, "The Quality and Quantity of Labor in china1978-2000-2025," Working Paper, (Hong Kong University of Science and Technology: Hong Kong).

Koivu, Tuuli, Aaron Mehrotra, and Riikka Nuutilainen, 2008, "McCallum Rule and Chinese Monetary Policy," BOFIT Discussion Paper 15/2008 (Bank of Finland: Helsinki).

Litterman, Robert B., 1986. "Forecasting with Bayesian Vector Autoregressions-Five Years of Experience," Journal of Business & Economic Statistics, Vol. 4, pp. 25-38.

Rotenberg and Woodford (1997) "An optimisation-based econometric framework for the evaluation of monetary policy",in *NBER Macroeconomic Annual* 1997, Ben Bernanke and Julio Rotemberg, eds, pp 297-346, (MIT Press: Cambrige, MA)

Rumler, Fabio, 2005, "Estimates of the Open Economy New Keynsian Phillips Curve for Euro Area Countires," ECB Working Paper No. 496 (ECB: Frankfurt).

Villani, Mattias, 2005, "Inference in Vector Autoregressive Models with an Informative Prior on the Steady State," Working Paper No. 181, (Sveriges Riksbank: Stockholm).

Yiping, Huang, Wang Xun, and Hua Xiuping, 2010, "What Determine China's Inflation?" China Center for Economic Research Working Paper 2010-2.

Zhang, Jinghai, Angang Hu, and Arne Bigsten, 2009, "Potential Output in a Rapidly Developing Economy: The Case of China and a Comparison with the United States amd the European Union," Federal Reserve Bank and St. Louis Review, pp. 317-42.

Zhang, Wenlang, and Daniel Law, "What Drives China's Food Price Inflation and How Does it Affect Aggregate Inflation?" HKMA Working Paper 06/2010 (HKMA: Hong Kong SAR).