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The Diffusion and Dynamics of Producer Prices, Deflationary Pressure across Asian Countries, and the Role of China

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Abstract

Persistent producer price deflation in China and other Asian economies has become a genuine concern for policymakers. In August 2016, China's producer prices were down 12.4 percent from their peak in 2011, following a 54-month stretch of consecutive negative producer price readings (March 2012 to August 2016). Given problems with overcapacity and heavy corporate debt burdens, the incessant decline in producer prices has eroded corporate profitability, dampened fixed investment and depressed growth overall. This paper analyzes the determinants of producer price declines across eleven Asian economies, finding that the recent synchronous and protracted producer price deflation has been driven by weak production and export growth, low commodity prices, spillover effects from China, and exchange rate pass-through. With China at the heart of the region's producer price deflation challenge, we consider the structural adjustments needed in China to cope with the decline and head off deflationary threats.

Keywords: Producer prices, international spillovers, deflation, Asia, structural adjustments, China
JEL-Classification: C23, C32, E31

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1. Introduction

The unrelenting downward trajectory of producer prices across Asia has become a serious macro concern for economic policymakers in the region. Weak aggregate demand has resulted in a feedback loop that exacerbates deflationary pressures and risks triggering a deflationary spiral. The graph below (Figure 1) shows significant heterogeneity across Asia's eleven largest countries, with the aggregate producer price indices at their lowest average point in six years. South Korea, Taiwan and Singapore succumbed to deflationary pressures about three years ago, and today only Indonesia still exhibits producer price inflation. China, of course, lies at the heart of the region's deflation challenge, notching up 54 consecutive months of falling factory-gate prices between March 2012 and August 2016.

China's current persistent deflationary trend and Japan's similar performance in the 1990s are rare in modern history. As of August 2016, China's producer prices were down a cumulative 12.4 percent from their peak in 2011. The recent acceleration in the rate of deflation is its own cause for alarm. As recently as September 2014, the producer price index (PPI) showed a mere 1.8 percent drop. In December 2015, the decline was 5.9 percent. Even India, with an otherwise robust economy, slipped into producer price deflation in 2015.

As it is unclear whether the recent synchronous and protracted of producer price deflation in Asian economies reflects spillover within the region or common factors and similar development of local factors, we apply the spillover index proposed by Diebold and Yilmaz (2009) to measure the spillover among the Asian economies, and investigate possible determinants of the Asian producer price deflation using a dynamic panel model.

Under our pessimistic deflationary scenario, falling producer prices in Asia reduce corporate profits, employment and consumer demand. As the drag on global demand intensifies, tepid economic growth in Europe and Japan is further depressed and the US recovery cools. Today we can already see some aspects of this scenario baked in: China's cost-insensitive state-owned enterprises (SOEs) continue to conduct business as usual in the face of low prices and excess demand. This behavior crowds efficient private firms from the market, so falling producer prices effectively prevent the needed rebalancing of market share to allow productivity gains.

A corollary issue here is that producer price deflation eventually filters down to affect the consumer price index (CPI), which, at the time of writing was still in positive territory (even if it had reached a five-year low). The high correlation between changes in the PPI and CPI has been identified in the long-term historical data (Eichengreen et al., 2016; ADO, 2016). Although Borio et al. (2015), using CPI data, find evidence that contradicts the traditional view of the adverse impact of deflation on growth, Eichengreen et al. (2016) provide fairly strong empirical evidence confirming the negative spiral between PPI deflation and growth. In any case, producer price deflation is a critical policy issue with significant regional and global implications. Tackling the deflationary threat is a central challenge for monetary policymakers.[1]

The remainder of the paper is organized as follows. Section 2 presents some stylized facts. Section 3 considers how Asia's PPI decline is likely transmitted across countries. Section 4 covers the estimation results for our PPI model, identifying possible reasons for the PPI decline. Given the centrality of China in addressing the region's PPI deflation challenge, Section 5 reviews China's policy options for coping with the PPI decline. Section 6 concludes.

2. PPI inflation in Asian economies

To identify the main characteristics of PPI inflation in Asian economies, we consider a sample of PPI inflation in eleven Asian economies from January 2000 (after the Asian Financial Crisis) to December 2015. Monthly PPI year-on-year inflation readings in the sample period show similar trends for these Asian economies (Figure 1).

PPI inflation in all Asian economies shows a time-varying trend. The year-on-year PPI changes remain in positive territory up to the Global Financial Crisis (GFC), when there is a sharp drop. We see a structural

[1] For a summary description of the problem, see Asian Development Bank (2016), pp. 22-29.

break in 2012 that signals the arrival of the current period of prolonged weakness. While the sharp PPI deflation during late 2008 to 2009 is readily explained by the GFC, the reasons for the recent unusually synchronous and protracted decline are harder to fathom.[2]

Table 1 shows fairly high (over 0.5) correlations of PPI inflation for most of our sample economies. The exceptions are correlations between the Philippines and Indonesia and the other Asian economies. While the volatilities of PPI inflation in the Philippines and Indonesia are higher than in other economies, the trend for PPI inflation is similar to that of other Asian economies. The high correlations among Asian economies support our initial observation that the PPI inflation of Asian economies show a common trend. They also suggest that the common trend, particularly the recent PPI deflation in Asian economies, may be driven by common factors. The correlations between China and other Asian economies are very high ranging around 0.7 to 0.9 (again, with the exceptions of the Philippines and Indonesia, which are still relatively high at 0.37 and 0.55, respectively). Thus, we might also posit PPI inflation in other Asian economies is affected by spillover effects from China. We consider common factors and spillover effects in our econometric analysis in Section 4, but first we explore the extent to which producer prices reflect idiosyncratic behavior linked to individual countries and the extent to which producer price dynamics reflect spillovers across countries.

3. Measuring international producer price spillovers

In this section, we describe our spillover methodology and empirical findings. The approach of Diebold and Yilmaz (2009) measures the intensity of interdependence across countries that allows for decomposition of spillover effects by source and recipient.[3] Diebold-Yilmaz indexing builds on the well-

[2] To put this in perspective, the average monthly year-on-year changes in PPI were -2.5% for the US and -2.9% for the Euro Area during September 2008 to December 2009. In the same period, the average monthly year-on-year change in PPI for our eleven Asian economies was only -0.8%. In contrast, the average monthly year-on-year change PPI deflation in our eleven Asian economies during January 2012 to December 2015 was -1.4%, while the figures for the US and Euro Area were -0.4% and -0.2%, respectively.

[3] Among the first applications of the methodology proposed by Diebold & Yilmaz (2009), we find McMillan and Speight (2010) who analyze market co-movements across the USD/EUR and other euro exchange rates. Bubák, Kocenda & Žikeš (2011) employ the Diebold-Yilmaz approach for studying volatility spillovers among several central European currencies and the EUR/USD exchange rate. Diebold and Yilmaz (2011) measure spillovers in equity returns and equity return volatilities in the Americas. The issue of Asian financial markets is discussed in Fujiware and Takahashi (2012), who use the spillover method to assess the interlinkages across Asian financial markets. In the same vein, Zhou et al. (2012) analyze volatility spillovers between the Chinese and select world equity markets between 1996 and 2009. Measured in terms of volatility spillovers, they find an increasing influence of the

known notion of forecast error variance decompositions. It allows an assessment of the contributions of shocks to variables to the forecast error variances of both the respective and the other variables in the system. The starting point for the analysis is the following *p*-order, *N*-variable VAR:

$$x_t = \sum_{i=1}^{p} \theta_i x_{t-1} + \varepsilon_t \,, \tag{1}$$

where x_t is an $N \times 1$ verctor of *N* endogenous variables, θ_i are $N \times N$ parameter matrices and $\varepsilon_t \sim N(0, \Sigma)$ is an $N \times 1$ vector of iid disturbances. Assuming covariance stationarity, the VAR can be transformed into the $\mathrm{MA}(\infty)$ representation

$$x_t = \sum_{j=0}^{\infty} A_j \varepsilon_{t-j} \,, \tag{2}$$

where the $N \times N$ coefficient matrices A_j are recursively defined as

$$A_j = \theta_1 A_{j-1} + \theta_2 A_{j-2} + \cdots + \theta_p A_{j-p} \,, \tag{3}$$

where A_0 is the $N \times N$ identity matrix and $A_j = 0$ for $j < 0$.

In defining our spillover measures, we are interested in the *H*-step-ahead forecast at time *t*. The associated variance decompositions then allow the fraction of the *H*-step-ahead forecast error variance x_i owing to shocks in x_j , $\forall j \neq i$, for each *i* to be measured. Diebold and Yilmaz (2009) employ Cholesky decompositions, which yield variance decompositions depending on the ordering of the variables. To resolve the dependency on ordering, Diebold and Yilmaz (2012) extend the approach with the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), in which variance decompositions are invariant to the ordering of the variables. The calculation of robust spillover measures is accomplished by averaging the results over all possible permutations of the system.[4]

Chinese stock market on other stock markets since about 2005. Antonakakis et al. (2014) use the methodology to examine the dynamic relationship between changes in oil prices and the economic policy uncertainty index for a sample of net oil-exporting and net oil-importing countries.

[4] We refer the reader to Diebold and Yilmaz (2009, 2012) for a detailed exposition of the algorithm. For further reading, we suggest Gaspar (2012), who gives a good overview on the spillover literature.

The variance decompositions yield an $N \times N$ matrix $\phi(H) = [\phi_{ij}(H)]_{i,j=1,\cdots N}$, where each entry gives the contribution of variable *j* to the forecast error variance of variable *i*. The main diagonal elements contain the (own) contributions of shocks to the variable *i* to its own forecast error variance, while the off-diagonal elements show the (cross) contributions of the other variables *j* to the forecast error variance of variable *i*. When employing the generalized impulse response functions, the own- and cross-variable variance contribution shares do not sum to one, i.e. $\sum_{j=1}^{N} \phi_{ij}(H) \neq 1$. Thus, for each entry of the variance decomposition matrix $\tilde{\phi}_{ij}(H) = \phi_{ij}(H) / \sum_{j=1}^{N} \phi_{ij}(H)$ with $\sum_{j=1}^{N} \tilde{\phi}_{ij}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H) = N$ by construction. These assumptions allow us to summarize the information on various spillovers as a single number, i.e. the total spillover index:

$$(4) \qquad TS(H) = 100 \times \frac{\sum_{i,j=1, i \neq j}^{N} \tilde{\phi}_{ij}(H)}{N}$$

The index $TS(H)$ gives the average contribution of spillovers from shocks to all other variables to the total forecast error variance in percent. The index is invariant to rescaling of the variables. This approach also allows us to obtain a more differentiated picture by calculating directional spillovers. Specifically, the directional spillovers from all other variables *j* to variable *i* are measured as

$$(5) \qquad DS_{i \leftarrow j}(H) = 100 \times \frac{\sum_{j=1, i \neq j}^{N} \tilde{\phi}_{ij}(H)}{N}.$$

Likewise, the directional spillovers from variable *i* to all other variables *j* to variable *i* are calculated as

$$(6) \qquad DS_{i \rightarrow j}(H) = 100 \times \frac{\sum_{j=1, i \neq j}^{N} \tilde{\phi}_{ji}(H)}{N}.$$

In a nutshell, the set of directional spillovers provides a decomposition of total spillovers into those coming from (or to) a particular variable.

The spillover table may be interpreted as follows. The *ij*$^{\text{th}}$ entry is the estimated contribution to the forecast error variance of country *i*'s PPI year-on-year growth rates resulting from innovations to country *j*. Hence, the off-diagonal column sums (labeled “To others”) or row sums (“From others”), when totaled across countries, give the numerator of the spillover index. Similarly, the column sums or row sums (including diagonals), when totaled across countries, give the denominator of the spillover index. In other words, the spillover table provides an input-output decomposition of the spillover index. We learn from Table 1, for example, that innovations to China's PPI year-on-year growth rates are responsible for 29.9% and 25.9%, respectively, of the error variance in forecasting Singapore's and Taiwan's PPI growth rates six months ahead, but only 7.8% of the error variance in forecasting Hong Kong's PPI growth rates six months ahead. One observation that stands out is that spillovers from Malaysia are higher than spillovers from other countries. Also worth highlighting are the facts that spillovers from Hong Kong to all other countries are tiny and that the deflationary producer price spillovers from Japan are generally negligible. Distilling the various cross-country spillovers into a single spillover index, the main take-away from Table 2 appears in the lower right-hand corner of the table – 52.2% of forecast error variance comes from spillovers. The aforementioned findings imply moderate spillovers on average. To scrutinize our findings, we extended the forecast horizon to twelve periods in Table 2. As expected, comparison of the results in Table 2 and Table 3 shows that spillovers increase in magnitude for h = 12.

Overall, our results underline the importance of a fine-grained approach in studying the dynamics of producer prices. Such an approach is the research objective in the next section of the study.

4. Econometric model, data and estimation results

As shown in Figure 1, the recent declines in Asian PPI appear in 2012, with a sharp drop beginning in the second half of 2014. Notably PPI deflation occurs during 2015 in all Asian economies, except Indonesia. Unlike the PPI deflation episode of late 2008 to 2009, which was mainly driven by the impact of GFC, recent PPI deflation in Asian economies is long-lived. As noted in the first section, the synchronous nature of the PPI decline suggests common factors or spillover effects may be involved. This section aims to discuss the key drivers of the decline and set the stage of the policy options discussion in the next section.

Model setup

We now consider how the mechanisms through which aggregate producer prices in our eleven Asian economies are affected by demand and supply shocks. In principle, firms adjust their producer prices (i) in response to exchange rate movements, (ii) because of changes in marginal cost, and/or (iii) because of markup adjustments (firms may adjust their markup to keep the foreign currency export price stable when they are pricing in the foreign currency). Turning to the econometric specification, we combine these elements in the following baseline pass-through panel model:

$$(7) \quad \Delta P_{i,t} = \beta_0 + \beta_1 \Delta P_{i,t-1} + \beta_2 \Delta E_{i,t-1} + \sum_j \beta_3^j \Delta E_{i,t-1} D_{i,t-1}^j + \beta_4 \Delta Y_{i,t-1} + \beta_5 \Delta P_{i,t-1}^{Input}$$

$$+ \sum_j \beta_6^j \Delta P_{i,t-1}^{Input} D_{i,t-1}^j + \beta_7 \Delta Export_{i,t-1} + \beta_8 U_{t-1}^{China} Exp_{i,t-1}^{China} + \beta_9 \Delta S_{i,t-1}$$

$$+ \beta_{10} \Delta E_{i,t-1}^{Debt} + \beta_{11} GFC_t + \varepsilon_{i,t} \ ,$$

where $\Delta P_{i,t}$ is the year-on-year growth rate of PPI in country *i* at time *t*, $\Delta E_{i,t}$ is the year-on-year growth rate of the nominal effective exchange rate, $D_{i,t}^j$ are dummy variables of country-specific exchange rate regimes. Equation (7) provides a closer look at the determinants of Asian producer prices. The interaction of $D_{i,t}^j$ and $\Delta E_{i,t}$ enable us to explore structural differences across countries arising from country-specific exchange rate regimes. $\Delta Y_{i,t}$ is the year-on-year growth rate of production in country *i*, and is included to control for fluctuations in factor demand.[5] $\Delta Export_{i,t}$ is the year-on-year growth rate of export index of country *i*, which is included for capturing the impact of external demand. One feature of equation (7) is that import price shocks are not restricted to those resulting from exchange rate movements, but include commodity price shocks. The variable $\Delta P_{i,t}^{Input}$ is the year-on-year growth rate of an input price index (proxied by the global commodity price index multiplied by exchange rate of country *i*). Notably, we single out the interaction of $D_{i,t}^j$ and $\Delta P_{i,t}^{Input}$. This enables us to explore the different impact of input prices among different exchange rate regimes across countries. $U_t^{China} Exp_{i,t}^{China}$ measures spillovers of China's policy uncertainty, which leads into the long-standing debate on the role of globalization in imposing

[5] The degree of exchange rate pass-through is a key determinant of an optimal exchange rate policy regime. See e.g. Devereux and Engel (2003, 2007).

subdued inflation patterns even in countries enjoying buoyant economic growth. $\Delta S_{i,t}$ is the year-on-year growth rate of representative stock index of country *i*. $\Delta E_{i,t}^{Debt}$ is the year-on-year changes of effective debt-weighted exchange rate index, which proxies the impact of exchange change through the financial channel, instead of the real channel (see Kearns and Patel, 2016). GFC_t is the dummy variable for global financial crisis (September 2008 to March 2009). ε_{it} is an i.i.d. error term. Moreover, all the regressions include fixed effects. All regressors are included with a one-period lag to reduce potential simultaneity bias.

Contrary to the much-studied exchange rate pass-through literature analyzing the transmission of exchange rate shocks to import prices and CPI (Gagnon and Ihrig, 2004), we investigate the degree to which currency changes are transmitted to domestic producer prices. This assumes exchange rates transmit or absorb the external inflation pressure to domestic producer prices. Given that exchange rates first pass through to import prices, which in turn affect producer prices, we gauge the ultimate pass-through of exchange rates to producer prices, taking observed changes in import prices as given. This exchange rate pass-through approach allows for broad interpretation as import price shocks include those resulting from exchange rate movements and commodity price shocks.

The PPI has two main drivers: input cost and production cost. Input cost is determined by global commodity prices. For instance, the recent PPI deflation in all Asian economies may share decline in global commodity prices as a common factor. Global commodity prices showed small increases or decline after 2012, but then plunged in the second half of 2014. The low point in 2015, which was around 30 percent below the 2012 average, reflected low oil prices. The similar development in global commodity prices and PPI inflation bolsters the view that this commodity price shock has been a determinant of recent PPI deflation. Production is expected to directly affect production cost. High production growth thus indicates high demand for industrial output. Given the demand effects, there should have higher price for production output. Also, the higher external demand effect, proxied by the export growth should have an impact causing higher product price. As we saw in Section 3, the spillover effects within Asian economies are high. When China sneezes, everybody else catches pneumonia. Thus, this spillover effect from China should be included in the model to capture China’s risk imposed on other Asian economies. Alternatively, the change in stock prices is included in the model as a control for level of risk. Given there is a possibility that the exchange rate pass through via the financial channel may offset the pass through effect via the trade channel, appreciation in effective debt-weight exchange rate index is expected to boost the real economy and the product prices (Kearns and Patel, 2016). Finally, a dummy variable for GFC period is also included to control the impact of GFC. A decrease in stock prices indicates higher risk that might lead to lower PPI inflation.

Data

This paper draws upon monthly data from 2000 to 2015 for eleven Asian countries, and uses the following data definitions and sources. The macroeconomic data, including the data for the producer price index and industrial production are taken from national sources and dated back using data from IMF Data's International Financial Statistics (IFS). The export indexes of countries are using the World Trade Index constructed by CPB Netherlands Bureau for Economic Policy Analysis (CPB).[6] Specifically, the index for Japan is directly using the index created by CPB, while the index for the rest of Asian economies are using the index for Emerging Asian countries multiplied by the share of the export of the economy to all the 10 Asian economies. The Bank for International Settlements (BIS) broad indices for nominal effective exchange rate (NEER)[7] are used in the model for capturing the exchange rate impact on PPI inflation. The dummy variables for exchange rate regime are created based on IMF's four-group classification (hard-peg, soft-peg, floating and residuals) for de facto exchange rate regime. The classification appears in the IMF's annual report on exchange rate arrangements and exchange restrictions. The input price is proxied by the IMF global commodity price index[8] (in US dollars) multiplied by the exchange rate of country *i*, rebased to an index with the same base period (2005=100) as IMF global commodity price index. In other words, the input price is the commodity price in local currency and changes in this variable represent the dynamic combination of the effects of changes in commodity price and exchange rate of local currency. A higher year-on-year change in the input price translates to a higher commodity price in the local currency.

[6] Accessed at http://www.cpb.nl/en/data .
[7] Accessed at http://www.bis.org/statistics/eer.htm.

[8] Accessed at http://www.imf.org/external/np/res/commod/index.aspx.

Specifically, the higher the IMF commodity price index or higher the value of exchange rate per USD (i.e. local currency depreciates), the higher value of commodity price in the local currency.

To examine the spillover effect from China to other Asian economies, the model includes a variable: spillovers of China policy uncertainty. For impact of China's policy uncertainty on each of the Asian economies, the China Policy Uncertainty Index (CPUI) multiplied by the export share to China (proxied the impact of China) is included in the model. The CPUI may be downloaded from the Economic Policy Uncertainty website.[9] It is a news-based index constructed from counting newspaper articles on China's policy-related economic uncertainty.[10] A higher index reading implies greater uncertainty and an expectation that PPI inflation will be lower. The export share to China is calculated by dividing the nominal value of export to China by the total value of export of the individual country. For the export share from China, the figure for China is assumed to 1. The import data are from national sources. The effective debt-weight exchange rate index is constructed by Kearns and Patel (2016). For changes in stock prices, the year-on-year changes of the representative stock indexes from Bloomberg are used.[11]

[9] Accessed at http://www.policyuncertainty.com/china_monthly.html.

[10] The news articles appeared in the *South China Morning Post* (SCMP), Hong Kong's leading English-language newspaper. The method follows our news-based indexes of economic policy uncertainty for the United States and other countries.

[11] Indexes used are as follows: China – Shanghai Composite Index; Hong Kong – Hang Seng Index; Indonesia – Jakarta Composite Index (JCI); India – Sensex Index; Japan – Nikkei Index; Korea – Korea Composite Stock Price Index (KOSPI); Malaysia – Kuala Lumpur Composite Index (KLCI); Philippines – Philippine Stock Exchange (PSE) Composite Index; Singapore – Straits Times Index (STI); Thailand – Stock Exchange of Thailand (SET) Index; Taiwan – Taiwan Stock Exchange Weighted Index.

Estimation results

Our panel model, a dynamic panel with fixed effects, uses the Kiviet method (Kiviet,1995; Bun and Kiviet, 2001). The Kiviet method is a least squares dummy variable (fixed effects) estimator (LSDV) that corrects for bias in the estimation of dynamic panel model. Bun and Kiviet (2001) suggest that the corrected LSDV method is an asymptotic consistent estimator and yields a lower mean squared error than with IV or GMM methods.[12]

Table 4 reports the estimation results. Model 1 is the basic model, including the explanatory variables for lagged PPI inflation, change in NEER, industrial production growth and change in commodity price in local currency only. In this model, lagged PPI inflation and changes in industrial production and commodity price are significant, but the change in NEER is insignificant. Model 2 adds the year-on-year growth of export index, which the variable and change in NEER are statistically significant. Model 3 adds a new explanatory variable, spillover of China policy uncertainty, with the new variable significant. Model 4 further includes the change in stock price, our risk indicator. In Model 4, the change in stock price is significant, but the spillover of China policy uncertainty becomes insignificant. Model 5 includes the variable of year-on-year growth of effective debt-weighted exchange rate index, and the variable is significant. Model 6 includes the dummy for GFC, on top of Model 5. The dummy for GFC is significant, but industrial production becomes insignificant. Model 2a to Model 6a add the interactive dummy variables of exchange rate regime multiplied by the change in commodity price to Model 2 to Model 6. The results are similar between both sets of models when the interactive dummy variables are added (except the commodity price growth). Summarizing the results from different models, lagged PPI is significant in every model and show high coefficients ranging between 0.91–0.94. This result confirms the use of the dynamic panel model as the PPI inflation can be explained by its lagged term.

The exchange rate sensitivity is rather low but usually significant (except Model 1). The results confirm that the higher the change in NEER, the lower the PPI inflation. Exchange rate sensitivity

[12] Making use of the asymptotic bias derived by Nickell, Kiviet (1995) proposes a direct bias correction method. His innovation is to approximate the unknown bias with a two-stage procedure. Empirical estimates are derived in the first round, and an empirical estimate of the bias is derived in the second. The motivation for the procedure lies in the well-known fact that the LSDV estimator is biased, but has a much smaller variance compared to instrumental variables estimators. Alternatively, GMM estimators may be used. The asymptotic properties of GMM are well established in the econometric literature. However, these are asymptotic results that do not necessarily hold for a small sample as shown by Guggenberger (2008). Furthermore, the efficiency of the GMM estimator relies heavily upon a fixed T and N going to infinity. Such conditions do not apply to our sample.

depends on whether the exchange rate regime uses a floating, a hard peg or a soft peg. These results confirm that the decline of producer prices in recent year may be interpreted as an "internal devaluation', particularly in a situation of a fixed nominal exchange rate. The interaction term NEER*Dummy (hard peg) turn out negatively significant in models 2a to 4a. This may be interpreted such that the PPI decline is stronger in countries with a hard peg. The meaning of internal devaluation is to carry out real effective exchange rate depreciation without nominal devaluation. This can be done by several means—direct cuts of wages and prices but also manifold structural reforms that render the economy more efficient. In other words, an internal devaluation seeks to restore competitiveness by replicating the outcomes of an external devaluation.[13]

Low exchange rate sensitivity may be explained by slow trade growth. Since 2010, growth in global trade has slowed significantly. Given that many Asian countries are highly open economies, the slowdown in world trade has weighed heavily on their exports (this is also confirmed by the significant and positive in the variable of growth in export index in the models). The post-GFC trade slowdown may be attributed to anemic advanced economy growth. It may also be attributed to the maturation of global value chains reducing the elasticity of trade flows to world GDP. During the 1990s, trade liberalization and a decline in shipping times and cost and encouraged rapid fragmentation of production across countries. With maturing supply chains, this trade growth has lost momentum.[14] As a result, trade has become less sensitive to world GDP and effective exchange rate changes.

Some recent studies have sought to test the proposition of Taylor (2000) that global competition reduces the extent to which exporting firms can pass through exchange rate movements into the domestic currency prices charged to importers. This proposition since has found considerable empirical support (see e.g. Olivei, 2002; Gagnon and Ihrig, 2004). This decline seems to be due to both a shift of imports away from commodities to manufacturing goods, which tends to have lower

[13] An environment of persistent low inflation across the Asian countries makes the relative price adjustment between countries more difficult. Moreover given nominal rigidities, a persistent low inflation might also be a hurdle to the necessary adjustments in real wages, which has important consequences for the required pace of internal devaluation.

[14] Some supply chains may even have begun to shorten again as higher-value added activity moved to emerging markets. World trade data can be found at http://www.cpb.nl/en/data. The study by Auer and Mehrotra (2015) also demonstrates that real integration through the supply chain matters for domestic price dynamics in the Asia-Pacific region.

pass-through rates, and a general decline in the exchange rate pass-through across all product categories.[15]

Our industrial production growth variable, which is positive and significant in some models, indicates that higher production growth pushes up PPI inflation. Accordingly, the recent PPI deflation is in line with the decline in industrial production among Asian economies. However, this variable is insignificant if the stock price, effective debt-weighted exchange rate and the dummy for GFC are included in the models. For the external demand, the growth in export index shows are positive and significant in all cases, indicating higher external demand will push up the product prices. The significant GFC effects may capture most of the significance of industrial production growth. As expected, the dummy for GFC is significant and negative, reaffirming other evidence that PPI inflation suffered a significant negative impact from the global turmoil financial and economic conditions during the GFC period.

The change in input prices, proxied by commodity price in local currency, is significant in the most of the models. The positive relationship between PPI inflation and change in input prices is confirmed by the estimation results. This result also confirms that recent PPI deflation has been driven by the sharp decline in commodity prices. Adding the interactive dummy variables for exchange rate regime multiplied by commodity price change, the commodity price becomes insignificant, which the difference under different exchange rate regime is also insignificant.

The changes in effective debt-weighted exchange rate is positive and significant, which indicates that the appreciation of exchange rate weighted by the debt level, to proxy the financial channel of the exchange rate pass through effect will boost the producer prices. This confirms the finding by Kearns and Patel (2016).

The spillover of China policy uncertainty is also significant, confirming that PPI deflation in Asian economies may be partly explained by the risk spillover from China. However, this effect is insignificant when the change in local stock prices is included in the model. The risk of the individual country is captured by stock price variable and the change in stock price is significant in the model.

[15] This interpretation rests on the assumption that the regressors are weakly exogenous to the system. Testing for weak exogeneity using Wu-Hausman tests indicates that this condition is met. The test entails regressing the explanatory variables on a set of variables that are clearly exogenous and then testing whether the residuals from this regression have any explanatory power in addition to the variables already included in the empirical framework.

The change in local stock price may be a better proxy for the risk of an individual country as it captures both local risks and risk spillover from other countries. In general, the PPI inflation has the positive correlation with changes in stock prices, although there are exceptions for some economies in 2015.

Overall, the recent PPI deflation in Asian economies may be explained by the similar development in local factors such as exchange rate pass-through, production growth, and risk factor (stock price), as well as the common factors such as the sharp drop in commodity prices. The spillover effect from China is also a key determinant of Asian economies. This suggests that economic trends and China's policy responses will be crucial to the development of Asian PPI readings. In the following section, we discuss the prospects for China's PPI deflation and consider the policy options for coping with PPI decline in Asian economies.

5. PPI deflation and the underlying challenges of the Chinese economy

PPI deflation may be a symptom of encouraging underlying developments such as productivity gains that enable the economy to produce more goods and services at lower cost and thereby raise consumers' real incomes. It could also reflect declining global commodity prices. On the other hand, PPI deflation could signal bad times ahead if demand is running chronically below the economy's industrial capacity, causing a negative output gap and reducing profits. In such circumstances, firms may cut prices and wages, weakening demand further. Moreover, debt aggravates the cycle. As prices, profits and incomes fall, the real value of debt rises, forcing borrowers to cut other spending as they pay down debt. Such conditions are fertile ground for a downward economic spiral with ever-gloomier economic expectations. The Chinese economy's three biggest problems at the moment are declining corporate profits, overcapacity, and excessive debt. These three problems are interconnected, self-reinforcing, and particularly severe in the case of SOEs.

Figure 2 shows that corporate profit growth and PPI inflation are positively correlated, i.e. declining producer prices lead to declining profitability.[16] With slowing economic growth, profit growth of

[16] Some uncoupling is visible since 2011. Since 2012, lower costs have allowed companies to stabilize profits at a low level, even as producer prices continued to fall. In other words, firms have acclimatized to some extent to declining producer prices.

corporations, regardless of ownership structure, declines. For SOEs, profit growth on average turns negative and many SOEs encounter losses (Figure 3).

Lower capacity utilization rates have eroded producer prices, thereby compounding the effects of higher debt levels. The recent rapid accumulation of debt in the Chinese economy has become a major concern for policymakers. BIS estimates put China's total non-financial debt at about 255% of GDP in 2015 (BIS, 2016). Most of it has accumulated after 2008, when the Chinese government loosened policy and began pumping credit through the economy to fight off the effects of the global financial crisis. Most of the new credit went to SOEs. Figure 5 shows that SOE debt-to-asset ratios soared after 2008, while those of private enterprises declined. According to the IMF, SOEs in 2015 accounted for about 55 percent of corporate debt, but only about 22 percent of total output (Lipton, 2016). This is much smaller than their share of total corporate debt. Thus, SOEs are far less profitable than private enterprises. History suggests that the imminent process of deleveraging will be painful. In China's case, the rapid build-up of debt is a relatively recent phenomenon. The rapid pace of SOE credit growth also makes a benign outcome ever less likely. Looking at the economy as a whole, the incremental capital output ratio has skyrocketed in recent years, which means that new investment is much less efficient in producing additional output. The leverage level of zombie firms reaches as high as 71.6 percent (Wang et al., 2016).

With declining corporate profits, overcapacity, high debt levels and high corporate leverage, the Chinese economy faces strong headwinds and risks drifting into a debt-deflation spiral. Therefore, the central issues in supply-side reform are reducing overcapacity, improving efficiency, and raising SOE profitability. Other aspect of supply-side reform involves finding ways for the government to reduce distortions in e.g. prices, taxes, and credit supply in order to create proper incentives for private sector investment, particularly R&D investment that allows firms to climb the technology ladder. Measures here include reducing corporate taxes and encouraging bank lending to the real sector of the economy.[17]

[17] The above assessment largely comports with PBoC commentary. See, for example, People's Bank of China (2014), *Q4 2014 Monetary Policy Report*, p. 55, and People's Bank of China (2015), *Q3 2015 Monetary Policy Report*, p. 57.

6. Conclusions

The recent PPI deflation episode in Asian economies has been synchronous and protracted since 2012. Synchronous PPI growth is partly confirmed by the spillover index of Diebold and Yilmaz (2009, 2012), with the empirical results showing fairly high spillover readings (between 53% and 64%) of PPI growth among the Asian economies.

The empirical results from our dynamic panel model suggest that the recent PPI deflation in Asian economies can also be explained by similar developments of local factors. A similar development in production growth, export growth and stock prices (used here to capture risk), as well as common factors such as the sharp drop commodity prices and the spillover effect from China are the key determinants of recent Asian PPI deflation. The empirical results confirm that China lies at the heart of the region's PPI deflation challenge. The slowdown in Chinese economic growth calls for comprehensive supply-side policies, as well as a new round of SOE reforms. In particular, China's three fundamental economic issues – declining corporate profits, overcapacity, and debt – have to be addressed.

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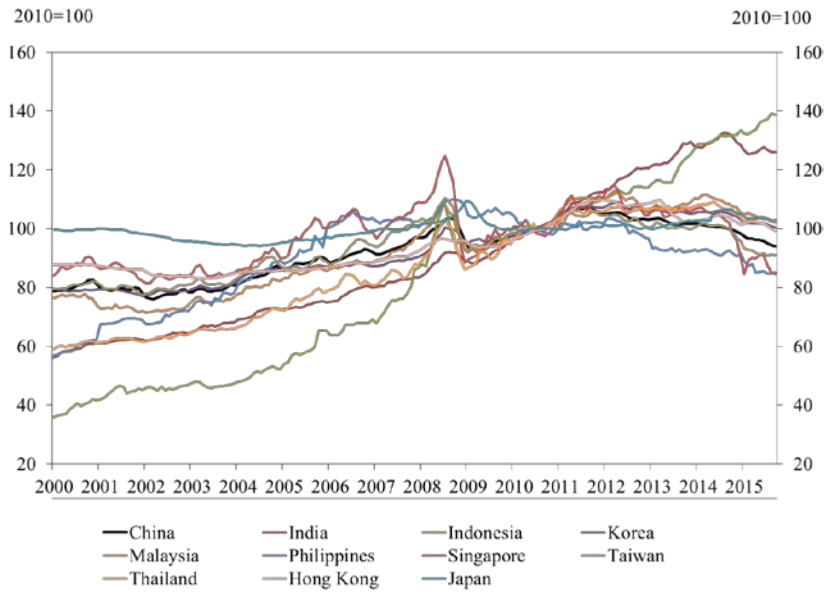
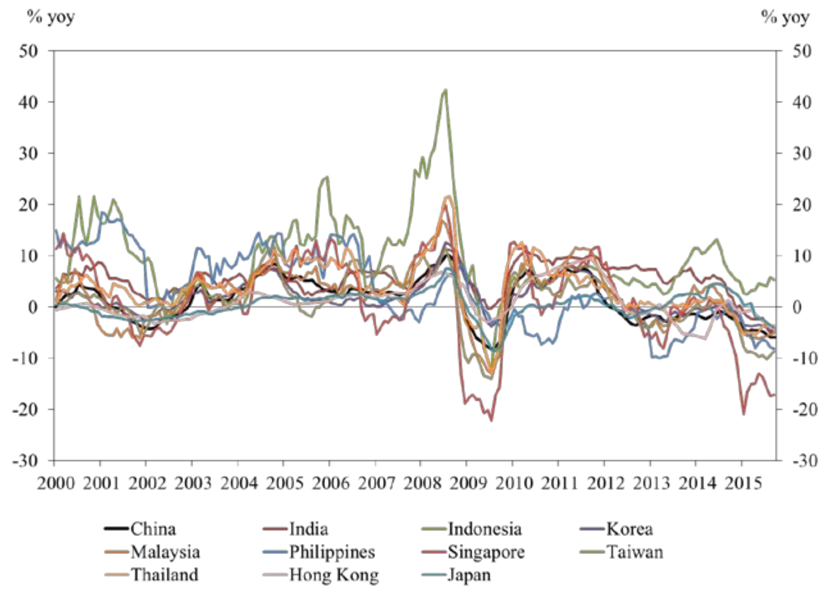
Figure 1. PPI inflation in Asian economies

(A) PPI level



(B) Year-on-year PPI growth rates



Note: The charts show the monthly PPI index (2010=100) and PPI inflation (year-on-year basis) of Asian countries from January 2000 to December 2015. For Hong Kong's PPI inflation, we perform linear interpolation using quarterly PPI inflation.

Sources: Various national sources, IMF Data (IFS).

Table 1. Correlations of PPI inflation among Asian economies

	CN	HK	ID	IN	JP	KR	MY	PH	SG	TH	TW
CN	1	0.75	0.55	0.70	0.66	0.84	0.89	0.37	0.81	0.86	0.85
HK	0.75	1	0.33	0.62	0.47	0.77	0.68	0.05	0.49	0.57	0.58
ID	0.55	0.33	1	0.30	0.64	0.45	0.54	0.34	0.59	0.67	0.50
IN	0.70	0.62	0.30	1	0.48	0.71	0.61	0.18	0.63	0.62	0.67
JP	0.66	0.47	0.64	0.48	1	0.57	0.71	0.12	0.56	0.60	0.61
KR	0.84	0.77	0.45	0.71	0.57	1	0.78	0.31	0.62	0.72	0.66
MY	0.89	0.68	0.54	0.61	0.71	0.78	1	0.18	0.82	0.81	0.83
PH	0.37	0.05	0.34	0.18	0.12	0.31	0.18	1	0.44	0.36	0.33
SG	0.81	0.49	0.59	0.63	0.56	0.62	0.82	0.44	1	0.85	0.80
TH	0.86	0.57	0.67	0.62	0.60	0.72	0.81	0.36	0.85	1	0.79
TW	0.85	0.58	0.50	0.67	0.61	0.66	0.83	0.33	0.80	0.79	1

Note: Correlations are calculated using monthly PPI inflation (on year-on-year basis) within the sample period of 2000–2015.

Sources: Authors' calculations based on various national sources.

Table 2. Producer price spillovers across countries based on 6-step-ahead forecasts

		From											
		CN	IN	ID	KR	MY	PH	SG	TW	TH	HK	JP	From others
To	CN	67.2	0.2	2.0	0.7	22.2	1.0	0.8	0.7	2.3	2.1	0.7	33
	IN	17.1	59.2	2.7	0.7	10.8	1.9	2.1	1.2	2.5	1.7	0.1	41
	ID	17.6	2.8	65.8	2.0	6.3	0.1	0.2	2.2	2.9	0.1	0.1	34
	KR	27.5	5.6	7.7	30.4	20.0	2.2	2.9	1.6	1.4	0.7	0.0	70
	MY	24.2	0.8	3.3	1.4	64.4	3.0	0.1	0.6	0.8	0.2	1.2	36
	PH	19.1	0.6	1.8	9.9	1.3	59.3	2.4	0.3	1.7	1.1	2.5	41
	SG	29.9	0.7	6.9	1.3	37.1	0.8	17.7	1.3	3.9	0.0	0.4	82
	TW	25.8	4.7	3.2	1.3	28.9	0.3	3.2	28.3	1.7	1.9	0.8	72
	TH	26.1	0.1	18.7	2.4	21.9	2.6	2.4	0.8	24.2	0.2	0.8	76
	HK	7.8	1.3	1.1	0.9	4.6	1.3	1.9	1.7	0.7	77.9	1.8	22
	JP	19.3	3.4	8.6	2.0	29.7	2.5	2.0	0.1	4.3	0.1	28.0	72
	To others	214	20	56	22	183	16	18	11	22	8	8	TS = 52.5%

Notes: The dataset covers the period from 2000M1 through 2015M12. The quarterly data for HK have been interpolated using the CPI index. The spillover index has been calculated for the PPI year-on-year growth rate. The optimal VAR lag length $p = 2$ has been determined using the AIC and BIC information criteria. Vietnam was not been included because the sample period only starts in 2006.

Table 3. Producer price spillovers across countries based on 12-step-ahead forecasts

		From											
		CN	**IN**	**ID**	**KR**	**MY**	**PH**	**SG**	**TW**	**TH**	**HK**	**JP**	**From others**
To	**CN**	59.5	5.5	5.4	1.6	17.5	1.1	1.0	2.5	1.6	4.0	0.5	41
	IN	20.5	45.3	3.6	2.1	12.2	2.7	1.6	0.9	4.3	4.4	2.5	55
	ID	25.0	6.5	44.8	7.4	4.9	0.2	1.2	3.4	5.2	0.6	0.7	55
	KR	34.4	4.6	6.1	19.8	19.5	3.2	5.9	2.4	0.9	3.1	0.1	80
	MY	23.4	6.5	8.1	2.2	48.7	3.0	0.4	3.3	1.8	1.7	0.9	51
	PH	35.2	0.8	1.6	8.1	1.4	41.2	1.4	1.5	4.8	1.7	2.2	59
	SG	27.3	9.3	8.6	4.1	25.3	0.6	11.4	2.0	9.8	0.6	0.9	89
	TW	24.4	4.9	10.3	3.9	22.6	1.3	2.2	22.5	3.6	3.6	0.6	77
	TH	29.1	9.1	14.8	5.2	16.0	1.9	1.8	1.1	18.3	0.8	1.9	82
	HK	10.1	9.6	2.1	1.9	4.2	2.2	3.1	5.1	0.9	59.9	0.7	40
	JP	23.6	2.7	6.4	6.5	30.5	3.6	1.9	0.2	2.7	0.2	21.8	78
	To others	253	59	67	43	154	20	21	23	36	21	11	TS = 64.3%

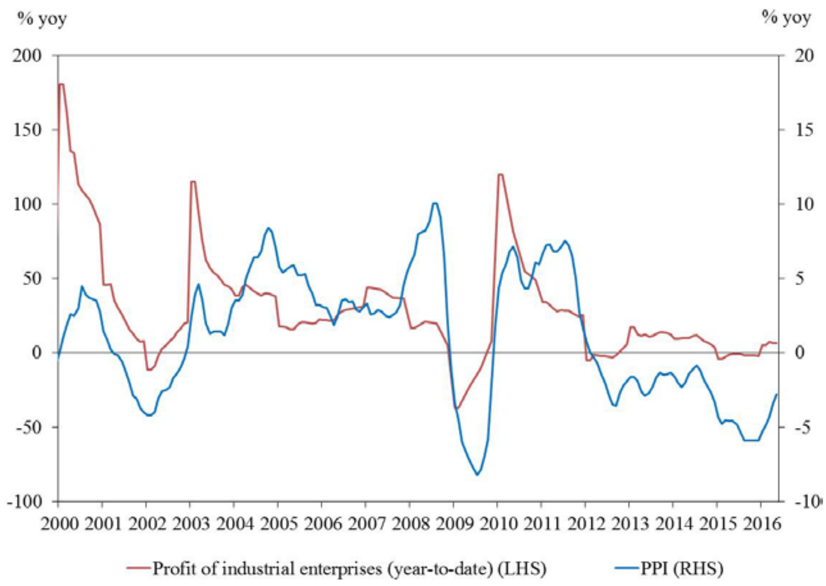
Notes: See Table 2.

Table 4. Dynamic panel regression of year-on-year PPI growth, Jan 2000–Dec 2015

Model	1	2	3	4	5	6	2a	3a	4a	5a	6a
PPI_{t-1}	0.923***	0.919***	0.920***	0.927***	0.922***	0.932***	0.918***	0.919***	0.926***	0.922***	0.932***
	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.009)	(0.007)
$NEER_{t-1}$	-0.032	-0.033*	-0.033*	-0.038**	-0.069***	-0.072***	-0.036***	-0.036***	-0.039***	-0.069***	-0.069***
	(0.024)	(0.020)	(0.020)	(0.016)	(0.013)	(0.009)	(0.006)	(0.006)	(0.003)	(0.012)	(0.022)
$NEER_{t-1}$*Dummy(Hard $Pegs_{t-1}$)	0.004	-0.002	-0.001	0.010	0.027**	0.023***	-0.019***	-0.021***	-0.008*	0.013	0.008
	(0.024)	(0.018)	(0.018)	(0.015)	(0.011)	(0.005)	(0.007)	(0.007)	(0.005)	(0.008)	(0.020)
$NEER_{t-1}$*Dummy(Soft $Pegs_{t-1}$)	-0.025	-0.022	-0.017	-0.023*	-0.008	-0.004	-0.025*	-0.022*	-0.029**	-0.015	-0.008
	(0.023)	(0.018)	(0.019)	(0.012)	(0.008)	(0.008)	(0.013)	(0.013)	(0.014)	(0.011)	(0.018)
$NEER_{t-1}$*Dummy($Floating_{t-1}$)	0.028	0.024	0.024	0.019	0.024	0.013	0.027***	0.028***	0.021*	0.025**	0.010
	(0.025)	(0.020)	(0.019)	(0.017)	(0.017)	(0.013)	(0.008)	(0.008)	(0.012)	(0.011)	(0.022)
IP_{t-1}	0.015***	0.009*	0.010*	0.005	0.006	0.001	0.009*	0.009*	0.005	0.005	0.001
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)	(0.005)	(0.005)	(0.006)	(0.006)	(0.007)
Commodity $Price_{t-1}$	0.018***	0.015***	0.014***	0.008***	0.006**	0.002	0.017	0.017	0.009	0.007	0.000
	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.012)	(0.012)	(0.014)	(0.013)	(0.015)
Commodity $Price_{t-1}$*Dummy(Hard $Pegs_{t-1}$)							-0.009	-0.012	-0.009	-0.007	-0.003
							(0.011)	(0.011)	(0.013)	(0.012)	(0.013)
Commodity $Price_{t-1}$*Dummy(Soft $Pegs_{t-1}$)							-0.005	-0.008	-0.006	-0.006	0.001
							(0.013)	(0.013)	(0.014)	(0.013)	(0.016)
Commodity $Price_{t-1}$*Dummy($Floating_{t-1}$)							-0.001	-0.002	0.000	0.000	0.002
							(0.011)	(0.011)	(0.012)	(0.012)	(0.014)
Export $Index_{t-1}$		0.012**	0.012**	0.010**	0.010**	0.008**	0.012**	0.011**	0.010**	0.009**	0.008**
		(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
China Policy Uncertainty $Index_{t-1}$*Export share to $China_{t-1}$			-1.8E-05**	-1.1E-05	-1.5E-05	-1.1E-05		-2.3E-05***	-1.6E-05*	-1.9E-05*	-1.3E-05
			(0.000)	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)
Stock $Price_{t-1}$				0.010***	0.010***	0.007**			0.010***	0.009***	0.007**
				(0.003)	(0.003)	(0.003)			(0.003)	(0.003)	(0.003)
Debt-weighted exchange rate $index_{t-1}$					0.028**	0.039***				0.028**	0.039***
					(0.013)	(0.012)				(0.013)	(0.012)
Dummy for GFC_t						-0.019***					-0.019***
						(0.004)					(0.004)
No. of Countries	11	11	11	11	11	11	11	11	11	11	11
No. of Observations	2,112	2,112	2,112	2,112	2,112	2,112	2,112	2,112	2,112	2,112	2,112

Notes: The dynamic panel regression is estimated by LSDV using the Kiviet K1 method. ***, **, and * respectively indicate significance at the 1%, 5%, and 10% levels. Standard errors are given in the parenthesis underneath coefficient estimates. All variables are in year-on-year growth, except China Policy Uncertainty Index, export share to China, and Dummy for GFC. For the export share to China, the figure for China is 1. The China Policy Uncertainty Index is in level. Dummy for GFC: Dummy=1 if during September 2008 to March 2009, 0 otherwise.

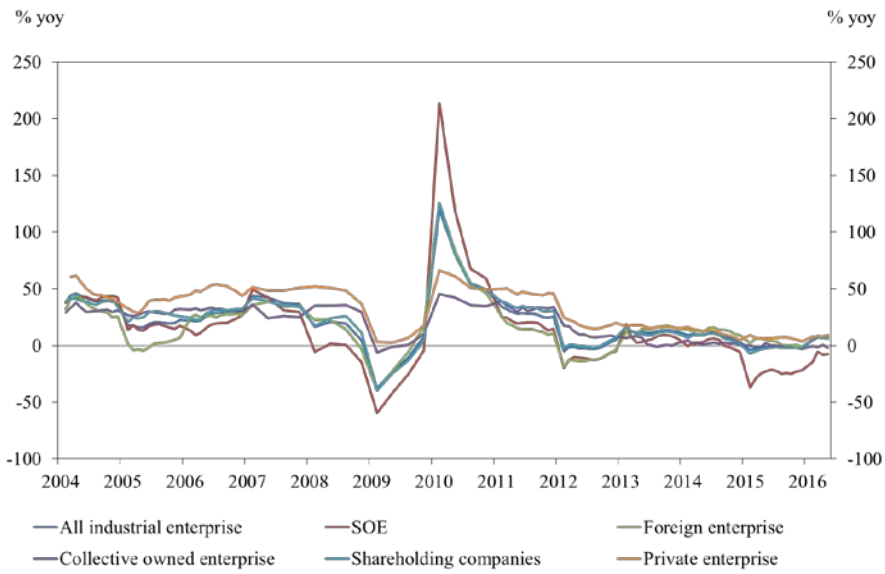
Figure 2. PPI dynamics and profitability of Chinese firms, Jan 2000 – May 2016



Notes: Total profit refers to the operation results in a certain accounting period. It is the balance of various incomes minus various spending in the course of operation, reflecting total profits and losses of enterprises in a reporting period (year-to-date figures in monthly basis). The enterprises included in the sample vary over time. From 2011, enterprises with revenues of more than RMB 20 million a year from their main operating activities are included in the sample. Before 2011, the revenue floor was RMB 5 million.

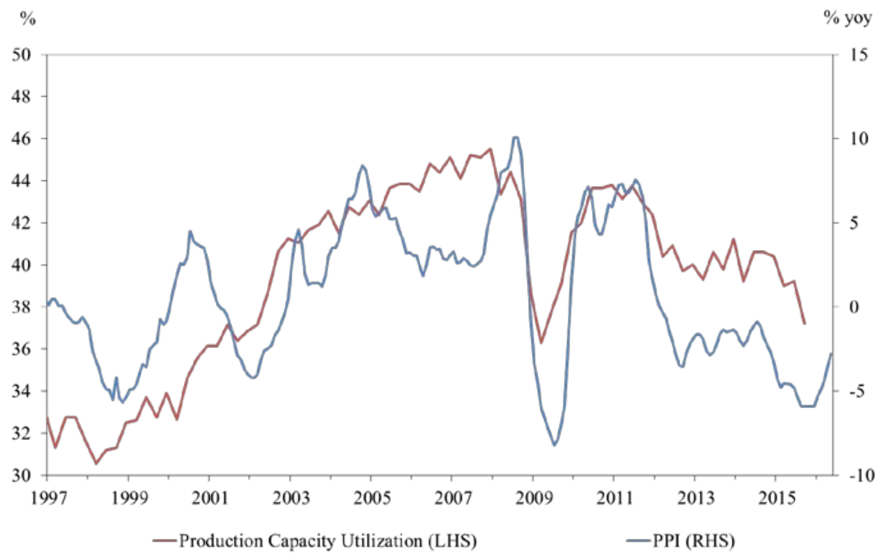
Source: National Bureau of Statistics of China.

Figure 3. Profitability of Chinese firms by ownership, Jan 2004 – May 2016



Note: Profit figures are year-to-date figures on a monthly basis. Source: National Bureau of Statistics of China.

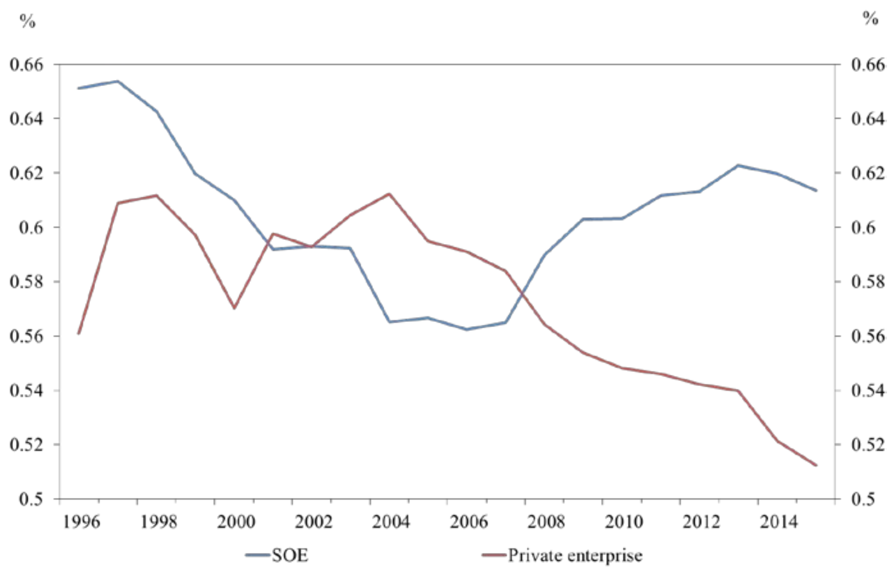
Figure 4. Production capacity utilization and PPI, Jan 1996 – May 2016



Note: Production capacity utilization is the diffusion index in 5000 Industrial Enterprises Survey conducted on a quarterly basis by the People's Bank of China. The latest available figures for production capacity utilization are from September 2015.

Sources: National Bureau of Statistics of China and People's Bank of China.

Figure 5. SOE and private enterprise debt-to-asset ratios, 1996 – 2015



Sources: National Bureau of Statistics of China and People's Bank of China.