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Xiaowen Jin

Munich Graduate School of Economics, Ludwig Maximilians University Munich, Germany

✉ Xiaowen.Jin@campus.lmu.de

An Empirical Study of Exchange Rate Pass-Through in China

Summary: This paper seeks to estimate exchange rate pass-through in China and investigate its relationship with monetary policy. Linear and VAR models are applied to analyze robustness. The linear model shows that, over the long run, a 1% appreciation of NEER causes a decline in the CPI inflation rate of 0.132% and PPI inflation rate of 0.495%. The VAR model supports the results of the linear model, suggesting a fairly low CPI pass-through and relatively higher PPI pass-through. Furthermore, this paper finds that, with the fixed exchange rate regime, CPI pass-through remains higher. The exchange rate regimes influence on CPI pass through, combined with the fact that appreciation diminishes inflation, suggests that the Chinese government could pursue a more flexible exchange rate policy. In addition, reasons for low exchange rate pass-through for CPI are analyzed. The analysis considers price control, basket and weight of Chinese price indices, distribution cost, and imported and non-tradable share of inputs.

Key words: Pass-through, Exchange rate, Consumer price, Producer price, Monetary policy.

JEL: E31, E42, F31, F41.

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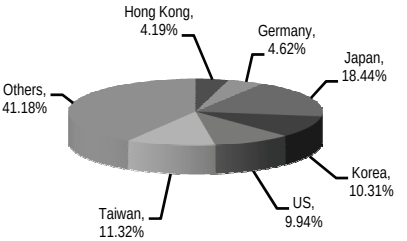
The debate about revaluation of the Chinese Yuan has been a hot topic for a long time. Although the Chinese Yuan appreciated almost 20% from 2005 to 2008, the degree of appreciation is not considered sufficient by the international community. The exchange rate war has reemerged with the easing of the subprime crisis. Krugman's impossible trinity pointed out, in the framework of an open economy, that exchange rate stability, domestic monetary policy independence, and free capital movement could not be obtained simultaneously. It was clear that China would open its capital market gradually; therefore rendering reform of exchange rate policy inevitable. However, when and how the reform would be realized remains a major issue for China's central bank. After all, the central bank does not want to sacrifice economic growth, or to suffer from high unemployment or inflation.

The transmission mechanism from exchange rate to price level, namely exchange rate pass-through (ERPT), serves as one of the concerns. In the new open economy macroeconomics, the degree of ERPT is crucial for appropriate monetary policy. A low ERPT implies that government need not worry about price instability or inflation when adjusting exchange rate policy. Therefore, a low ERPT is believed to provide greater freedom for pursuing independent monetary policy. In this paper, the movement from exchange rate to domestic price is examined, potentially assisting the Chinese government in considering revaluation of the Chinese Yuan. Furthermore, the impact that three years of appreciation of the Chinese Yuan has had on ERPT is considered.

Measuring ERPT for the Chinese Yuan remains problematic as the Chinese Yuan has been pegged to the US dollar. Figure 1 illustrates the major importing countries and regions for China, suggesting that the exchange rate should not only be discussed in terms of the US dollar. Rather, the nominal effective exchange rate (NEER), which continually fluctuates, is universally used as it takes all of the main trading partners' currencies into account.

In the empirical literature, three approaches are employed to measure ERPT: Single Equation Method, Vector Autoregressive (VAR) Model and Cointegration Model. However, few studies have calculated China's EPRT. Notable exceptions include Michele Ca' Zorzi, Elke Hahn, and Marcelo Sanchez (2007) which analyzed numerous emerging countries' ERPT, including China. Additionally Liubo Chen and Houjun Liu (2007), Chang Shu and Xiaojing Su (2009) and Jinbin Wang and Nan Li (2009) have calculated China's ERPT for a batch of price indices.



Source: International Monetary Fund (IMF), International Financial Statistics (IFS) Data and author's calculation.

Figure 1 Main Importer for China in 2000

One innovation of this paper is to employ both single equation and VAR methods. While each method has its own drawback, the systematic estimation of ERPT by two methods allows the estimation arrived at in this paper to overcome the deficiency of utilizing a single approach. The second intriguing innovation is that this study facilitates a comprehensive understanding of the association between the exchange rate regime and ERPT. Although Wang and Li (2009) mentioned the increase of ERPT during the appreciation period by a simple division of the sample, this method is not convincing as a result of the limited availability of data. This paper improves their methods through the addition of dummy variables in the single equation method as well as by including the more reliable VAR model. Finally, this paper investigates the cause of pass-through discrepancy for various price indices; while previous works stated the existence of a discrepancy the causes were not considered.

To assess the degree of pass-through for CPI and PPI, we begin by adopting the ordinary least square model (OLS). The results demonstrate that the appreciation of the Chinese Yuan could decrease the CPI inflation rate; however, the degree is statistically insignificant. The effect of PPI is more significant than CPI in the long run. Nevertheless, the deficiency of single equation regression is that it neglects the impact of inflation on the exchange rate. As a result, VAR analysis with Cholesky

decomposition could strengthen the robustness of previous OLS measures through the endogenous treatment of variables. The impulse response function illustrates a limited impact of NEER on CPI and a relatively more significant response in the case of PPI. This finding is consistent with OLS estimation.

In the following paragraph the factors which influence pass-through are discussed. The linear regression results show that the exchange rate regime indeed impacts CPI pass-through, with CPI pass-through remaining higher in the fixed the exchange rate regime. Inspired by Ariel T. Bustein, Joao C. Neves, and Sergio Rebelo (2003) and Manuel J. Campa and Linda S. Goldberg (2006) we supply evidence which interprets the discrepancy between CPI and PPI pass-through. The evidence covers the divergent composition of price indices, the share of imported inputs and non-tradable goods, and distribution costs.

This paper is organized as follows. Section 1 illustrates the stylized facts of the post 90's Chinese economy. Section 2 presents two analytical frameworks, namely OLS and a VAR model, as well as reporting the results of ERPT measurement for CPI and PPI. Section 3 further discusses the pass-through topic, including the relation between the exchange rate regime and ERPT and the reason for a fairly low CPI pass-through. Section 4 concludes.

1. Stylized Fact on Post – 1990's China

Due to the particularities of the Chinese economy, either exchange rate or inflation rate is influenced by specific policy regulation. In this Section, the evolution of China's policy regulations after 1990 is briefly summarized[1].

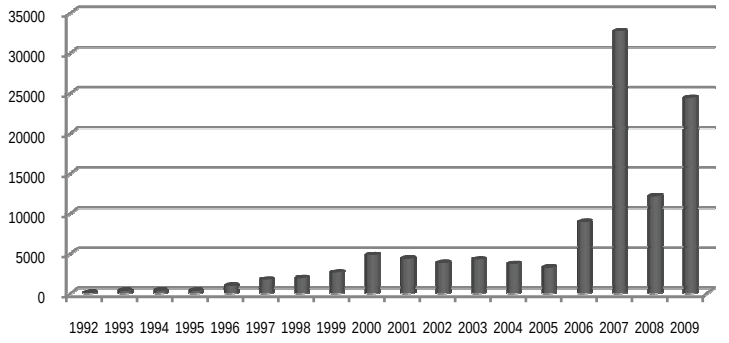
1.1 Capital Market Deregulation

Heavy control is the principal characteristic of China's capital market. As a result of the reform and open-door policy, foreign direct investment (FDI) was liberalized in the mid 90's. However, remaining restrictions on other inflows and outflows are still fairly strict nowadays. For local financial institutions and those aboard, the Chinese government introduced a program of qualified foreign institutional investors (QFII) and qualified domestic institutional investors (QDII) in 2003. The institutions must satisfy the requirements on the scale of registered capital, financial status, etc, before the special investment quota will be authorized. With gradual deregulation, the number of QFII and QDII reached 98 and 93 respectively. Non-QDII institutions and individuals are forbidden to invest in the foreign capital market. Yet strict government control in the capital market has come at the cost of diminished efficiency. Large amounts of hot money continuously flow into China, especially around 2007.

Moreover, the domestic capital market is incomplete. The stock market serves as the primary capital market in China. In 1990, the Shenzhen and Shanghai stock exchanges were set up successively. Following the establishment of the China Securities Regulatory Commission in Oct 1992, the period between 1993 and 1998 is re-

[1] See Reuven Glick and Michael M. Hutschison (2004), Duo Qin (2005), Jens Forssbeck and Lars Oxelheim (2007) and Ge Wu (2009) for a nice overview of China's policy.

garded as the forming and initial developing stage. Along with the promulgation of Securities Law in 1998, the evolution of the stock market entered into the regularization stage. The reform of non-tradable shares is another milestone of this stage. At the end of 2009, there were 1718 listed companies with total market value reaching 24.40 trillion (see Figure 2). Accordingly, stocks have become one of the most important financial assets of households.



Source: IMF, IFS Data.

Figure 2 Total Market Value of Stock

The bond market has lagged behind the development of the stock market. This lagging development is evidenced by treasury bills existing as the only issued bond for a long time. In 2003 and 2004, commercial paper and certificates of deposit were introduced. Meanwhile, the corporate bond market has remained insignificant.

1.2 Monetary Policy

The major monetary policy instruments of the PBC are interest rates, bank required reserve ratios, and money supply. Compared to the market-based interest rates of other countries, strict control of the PBC has led to a deterioration of efficiency. The situation has improved with interest rate liberalization beginning in 1996. The PBC reforms, starting in the money and bond markets, facilitated greater influence of the market in determining the interbank market rate, the bond market rate including financial bonds utilized in monetary policy. Similarly, the lending rate and the large deposit rate for foreign currencies were liberalized in 2000, followed by commercial banks freedom to determine the small deposit rate of major foreign currencies. In the two years after 1998, the PBC has expanded the floating band of commercial lending rates three times and attempted liberalization of the long-run large deposit rate. Accompanying the launch of the Shanghai Interbank Offered Rate, the PBC's commitment of pursuing market-based interest rates has been fulfilled gradually.

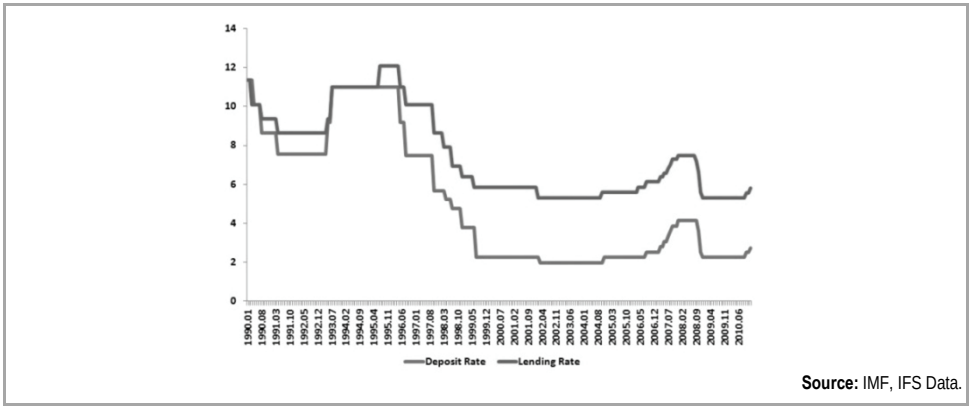


Figure 3 Interest Rate (1 Year Rate)

Required reserve ratios exerts much more influence than that of interest rate instruments. The original aim of reserve ratios was to maintain the liquidity and ensure the stability of banks in case of large withdrawals. Later, reserve ratios have been widely employed as an instrument of liquidity management, facilitating control of credit growth and to indirectly affect the money supply. The first significant reserve ratio change occurred in 1998. After that, the PBC adjusted the reverse ratio 30 times from 2006 to 2008. Since Sep 25, 1998, the adjustment started to classify small and large financial institutions, in the sense that large institutions required a higher reserve ratio. Meanwhile, excess reserve ratios for commercial banks also serve a subsidiary function.

The control of the base money supply is implemented through the open market as well as currency and bill issuance. As China's normal anchor, money supply is crucial for the execution of loosened or tightened monetary policy. An intriguing phenomenon is the close correlation between the inflation rate and M2 growth (see Figure 5), implying that M2 played a key role in price stability.

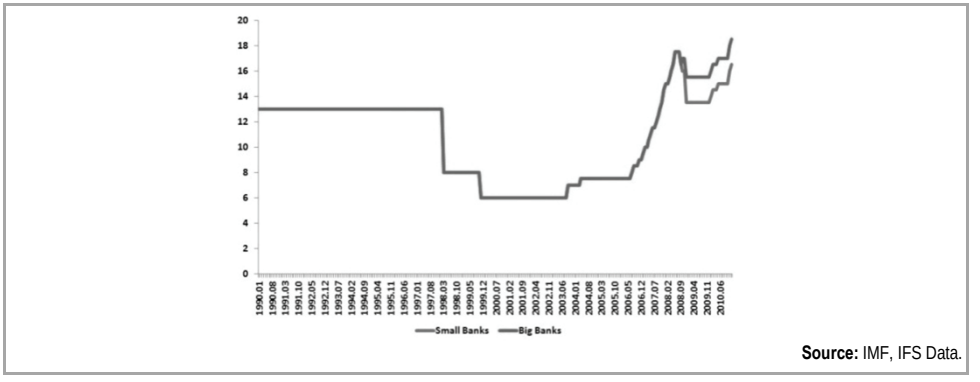
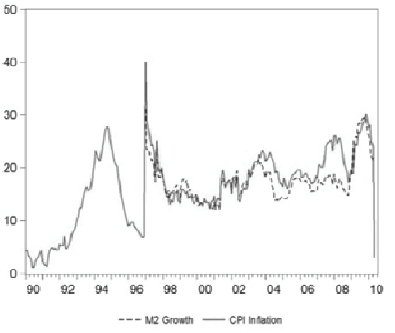


Figure 4 Reserve Ratio

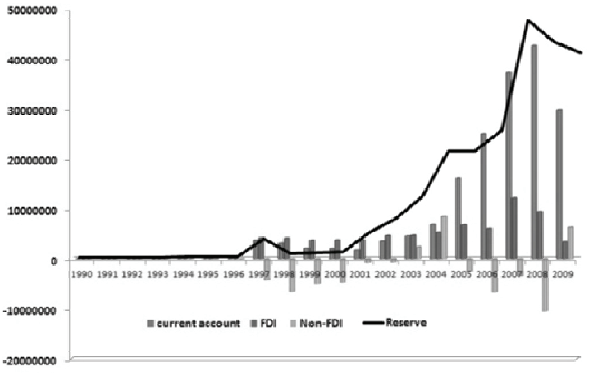


Source: IMF, IFS Data.

Figure 5 Money Growth and Inflation (12 Months Change)

1.3 Foreign Reserve and Exchange Rate Policy

In the 21st century, attributed to the growing current account surplus and FDI inflows, reserve accumulations have increased rapidly. The current account surplus was growing especially fast from 2005 onward due to the trade surplus. For the first time since 2000, the current account surplus declined in 2009. Furthermore, the growth of FDI has remained relatively smooth.

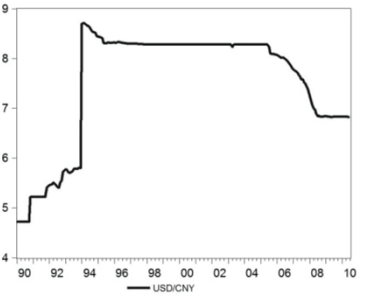


Source: IMF, IFS Data.

Figure 6 Reserves and Component (Million Dollars)

Large foreign reserves cause controversy about exchange rate policy, consequently precipitating policy reform. The reform is propelled step by step. Before 1994, there were two different exchange rates: the official rate and the swap market rate. On Jan 1994, the government merged the two exchange rates, implementing a so-called market-based single and managed floating exchange rate system. However, it was still a pure US Dollar pegging system, but the nominal USD/CNY rate was adjusted suddenly from 5.8 to 8.7.

Since the sudden adjustment until 2005, the nominal value of USD/CNY fluctuated in a rather narrow range around 8.28, even during the Asian financial crisis. Due to the imbalance of international payments, the challenge of independent monetary policy, overheating concern and pressure from western countries, China adopted a new manageable floating exchange rate policy on July 21, 2005. This new policy was based on market supply and demand and is referenced to a basket of currencies. The referenced currencies consisted of the US Dollar, Euro, Japanese Yen, and Korean Won, but the operation remained opaque. In the subsequent 3 years, the nominal USD/CNY rate decreased from 8.28 to 6.84, which implies that the CNY appreciated nearly 20%. Following the breakout of the subprime crisis, the appreciation ceased and the nominal USD/CNY rate continued at this level until 2010.



Source: IMF, IFS Data.

Figure 7 Exchange Rate vis-a-vis the U.S.Dollar

1.4 Inflation and Exchange Rate

Since the Asian financial crisis, China experienced a period of deflation. The deflation was mild but lasted until 2002. After that, China's inflation rate was relatively low and stable except in 2007, when the asset price bubble was serious. For PPI inflation, the general trend remains analogous to that of CPI's, merely with more significant fluctuation.

We have mentioned the importance of NEER in the Introduction and Figure 8 describes the co-movement between domestic price (CPI, PPI) and the NEER. The trend of the CPI and PPI is similar. In comparison with NEER, they move in the same direction during 1995-1997 and 2005-2010, while they varied in opposite direction during 1998 and 2004.

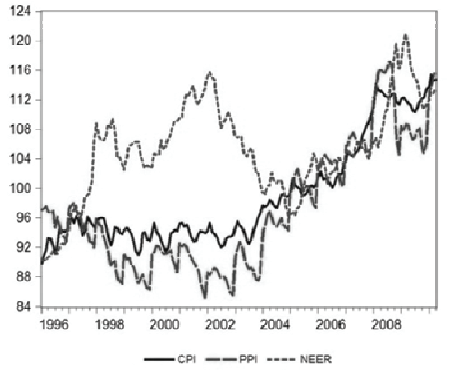
2. Empirical Analysis

2.1 Single Equation Analysis

2.1.1 Framework

Much of the literatures employs single equation to regress the domestic price as a function of the exchange rate, foreign price, and control variables such as output gap,

see e.g. Jeannine Bailliu and Eiji Fujii (2004), Campa and Goldeberg (2005), Jane E. Ihrig, Mario Marazzi, and Alexander D. Rothenberg (2006).



Source: IMF, IFS Data.

Figure 8 CPI, PPI and NEER (2005=100, Base Year)

Following Michael B. Devereux and James Yetman (2009), we suppose a large number of import firms, which purchase differentiated consumer goods from foreign countries and sell it to domestic consumers. Demand function for firm *i* is as follows:

$$C_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\lambda} C_t, \tag{1}$$

where $C_t(i)$ is the demand of firm i, C_t is the total demand, $P_t(i)$ is the price of firm i, $\mathrm{P_t}$ is the composite price index for imported goods, and λ is the elasticity of substitution.

The profit function for firm *i* is defined as:

$$\Pi_t(\mathrm{i}) = \mathrm{P_t(i)C_t(i)} - \frac{\mathrm{P_t^*}}{\mathrm{S_t}}\Theta_t \mathrm{C_t(i)}, \tag{2}$$

where S_t is the exchange rate foreign currency per unit of domestic currency, P_t^* is the all differentiated imported goods' foreign currency price, Θ_t is the per unit distribution cost. The firm it's import price setting is defined as:

$$P_t(i) = \frac{\lambda - 1}{\lambda}\Theta_t \frac{\mathrm{P_t^*}}{\mathrm{S_t}}. \tag{3}$$

Assuming all import firms are identical, $P_t(i) = P_t$. The logarithm version of this equation can be written as:

$$p_t = \zeta_t + \theta_t + p_t^* - s_t. \tag{4}$$

where $\zeta_t = ln(\frac{\lambda-1}{\lambda})$, the small letters represent natural logarithm.

As a result, the import price could be expressed as a function of the markup, distribution cost, exchange rate, and foreign price. In order to control for monetary policy's influence on domestic price, a monetary policy instrument is introduced.

2.1.2 Data Description and Econometric Specification

We access two ERPTs respectively for consumer price index (CPI) and producer price index (PPI). The import price index is ruled out due to limited data length. The NEER is used as the exchange rate index. Taking advantage of the definition of NEER and the real effective exchange rate (REER), the foreign price index (FPI) is calculated by FPI = NEER*CPI/REER. Through applying the Hodrick-Prescott filter to gross industrial production data, we get an approximation of the output gap. The monthly average Baltic Exchange Dry Index (BDI) is utilized to represent distribution cost (mainly transportation cost). The monetary policy variable adopts broad money supply (M2)[2].

Considering price stickiness, the lagged variables for p_t, p^*_t, s_t are involved. In what follows, the ERPT could be estimated by the following Autoregressive Distributed Lag Model. Denoting the short-run ERPT by β_0, then the long-run ERPT can be written as:

$$\frac{\Sigma_{i=0}^{5}\beta_i}{1-\Sigma_{i=1}^{5}\alpha_i}.$$

$$\Delta lncpi_t = \sum_{i=1}^{5}\alpha_i \Delta lncpi_{t-i} + \sum_{i=0}^{5}\beta_i \Delta lnneer_{t-i} + \sum_{i=0}^{5}\gamma_i \Delta lnfpi_{t-i} + \zeta outputgap + \eta \Delta lnbdi + \delta \Delta lnm2 \quad (5)$$

$$\Delta lnppi_t = \sum_{i=1}^{5}\alpha_i \Delta lnppi_{t-i} + \sum_{i=0}^{5}\beta_i \Delta lnneer_{t-i} + \sum_{i=0}^{5}\gamma_i \Delta lnfpi_{t-i} + \zeta outputgap + \eta \Delta lnbdi + \delta \Delta lnm2 \quad (6)$$

We adopt monthly data from Jan 1996 to April 2010, taking 2005 as the base year (index equal to 100 in 2005), and the entire data series is seasonally adjusted by X12-ARIMA. According to the Augmented Dickey-Fuller and Phillips-Perron Test, most of the variables, except output gap, are integrated by order 1. Therefore, in the OLS estimation, all of the variables, except output gap, take logarithm-difference form.

2.1.3 Results

From Table 1, we observe that the lagged CPI inflation has a positive influence on current inflation. The coefficients $lnneer_{t-1}$ and $lnneer_{t-5}$ are significant at the 10% level, this implies that the movement from NEER to inflation is not immediate but involves a delay of several months. For FPI, it seems that both the current and lagged FPI influence the CPI inflation rate. The short and long-run CPI pass-through is 0.016 and -0.132 respectively. It suggests that 1 percent increase in NEER (1% appreciation) leads to 0.016% increase of the CPI inflation rate in the first month and

[2] Detail description of data sees Appendix A.

0.132% decline in the long run. The hypothesis test suggests neither short nor long-run ERPT is significantly different from 0 at the significance level of 5%.

To keep the comparability of outcomes, the same regression is applied on PPI. R^2 improved significantly compared to the same regression for CPI. According to the significance of coefficients, the PPI inflation rate is affected by the previous PPI inflation rate, previous NEER change, and both current and prior FPI variation. The short and long-run PPI pass-through is 0.012 and -0.495 respectively, so initially the PPI response to NEER is weaker than CPI, but over the long run, PPI pass-through is almost fourfold that of CPI's. The long-run ERPT is significantly different from 0, while the short-run ERPT is not.

The measured ERPT from the single equation regression suggests that appreciation of domestic currency has a negative impact on the inflation rate, which is especially significant in the case of PPI. The negative correlation between exchange rate and inflation is consistent with theory. In principal, the appreciation of domestic currency reduces the price of import goods directly and partially diminishes the CPI and PPI, which is proportional with the percentage of import goods in these indices. The composition of the price index is one of the main reasons for the difference between CPI and PPI ERPT. This will be discussed concretely in Section 3.2.

Table 1 Pass-Through by OLS Estimation

CPI	Short-run	0.016≤	Long-run ERPT		-0.132≤
Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
$\Delta lncpi_{t-1}$	0.104(.082)	$\Delta lnneer_t$	0.016(.027)	$\Delta lnfpi_t$	0.613***(.199)
$\Delta lncpi_{t-2}$	0.116(.082)	$\Delta lneer_{t-1}$	-0.058*(.029)	$\Delta lnfpi_t$	0.035(.206)
$\Delta lncpi_{t-3}$	0.070(.079)	$\Delta lnneer_{t-2}$	0.041(.029)	$\Delta lnfpi_t$	-0.392*(.203)
$\Delta lncpi_{t-4}$	0.108(.078)	$\Delta lnneer_{t-3}$	-0.036(.029)	$\Delta lnfpi_t$	0.260(.204)
$\Delta lncpi_{t-5}$	0.138*(.080)	$\Delta lnneer_{t-4}$	0.026(.028)	$\Delta lnfpi_t$	-0.022(.214)
$output\ gap$	0.000(.000)	$\Delta lnneer_{t-5}$	-0.050*(.027)	$\Delta lnfpi_t$	-0.527**(.194)
$\Delta lnbdi$	-0.003(.002)	$\Delta lnm2_t$	0.015(.034)	R^2	0.284

PPI	Short-run	0.012≤	Long-run ERPT		-0.495≥
Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
$\Delta lnppi_{t-1}$	0.311***(.081)	$\Delta lnneer_t$	0.012(.028)	$\Delta lnfpi_t$	0.999***(.212)
$\Delta lnppi_{t-2}$	0.147*(.085)	$\Delta lneer_{t-1}$	-0.058*(.031)	$\Delta lnfpi_t$	0.523(.233)
$\Delta lnppi_{t-3}$	0.015(.088)	$\Delta lnneer_{t-2}$	0.069**(.030)	$\Delta lnfpi_t$	-0.112(.224)
$\Delta lnppi_{t-4}$	0.120(.086)	$\Delta lnneer_{t-3}$	-0.011(.031)	$\Delta lnfpi_t$	-0.150(.222)
$\Delta lnppi_{t-5}$	0.051(.076)	$\Delta lnneer_{t-4}$	0.031(.030)	$\Delta lnfpi_t$	-0.125(.229)
$output\ gap$	0.000(.000)	$\Delta lnneer_{t-5}$	-0.019(.030)	$\Delta lnfpi_t$	-0.578**(.215)
$\Delta lnbdi$	-0.002(.002)	$\Delta lnm2_t$	0.052(.036)	R^2	0.647

Note: The figures in parentheses are standard errors. * denotes significance at the 10% levels, ** significance at the 5% levels, *** significance at the 1% levels. ≤(≥)implies an ERPT elasticity is significantly different from 0(1) at the 5% level. For the hypothesis test of long-run EPRT, delta method is utilized to compute the mean and variance, and establish statistic based on normal distribution.

Source: Author's calculation.

In comparison with the estimations for industrial countries', the estimation of China's CPI pass-through in this paper is a bit higher. A potential explanation is the divergence of the economic structure. Considering other measurements for China's data, the long-run CPI pass-through is a little lower in our analysis, but the significant gap between CPI and PPI is a widespread phenomenon.

2.2 Vector Autoregressive Model

The single equation regression neglects the fact that the inflation rate could impact the exchange rate. Thereby, the VAR model with Cholesky decomposition is applied to measure ERPT. This approach treats all variables endogenously and thus strengthens the robustness of the previous OLS measurement (see Jonathan McCarthy 2000; Elke Hahn 2003; Harim Faruqee 2006; Takatoshi Ito and Kiyotaka Sato 2008). The variables for the VAR model include CPI and PPI, NEER, output gap (control supply shock), foreign price index (FPI), and broad money supply (M2). All variables adopt the same form as OLS estimation. The baseline VAR model treats CPI and PPI separately and contains five variables. Under this framework, the results can be compared with the former OLS measurement.

The order of indicators determines which shocks are not allowed to contemporaneously affect which variables. Hence, selecting the appropriate order of the endogenous variables through economic interpretation is crucial. Foreign price index is ordered first because its residual is hardly influenced by any other shocks. Afterwards, we order the output gap, which is only affected by foreign price index and affects all other shocks except foreign price index. Assuming that monetary policy does not react to current inflation and NEER change, but to expected inflation, M2 is settled prior to NEER. NEER is ordered before domestic price, because strands of empirical literature claim that the NEER granger causes price, but that the opposite is not true. To sum up, the vector for the VAR model is $(\Delta lnfpi_t, outputgap_t, \Delta lnm_t, \Delta lnneer_t, \Delta lnp_t)$, where lnp_t could be lncpi or lnppi. The number of lags is determined by Akaike Information Criterion. Both CPI and PPI models are VAR (7).

The left two plots in Figure 9 depict the influence of a NEER shock to CPI and PPI, with the data spanning from Jan 1996 to April 2010. The vertical axis in Figure 9 is the accumulative percentage change in domestic prices responding to a 1% shock. The dotted line denotes 2 standard-error 95% confidence bands of the estimates. It is computed by the Monte Carlo method.

The response of CPI to a NEER shock is initially positive, but after a slight fluctuation it remains around -0.040%. This means that an appreciation of NEER will reduce CPI inflation in the long run. In addition, the response is statistically insignificant, as two standard error confidence bands surround the zero line almost symmetrically.

In contrast, PPI response is much larger and lasts for a longer horizon, approximately 13 months. The initial impact of a NEER shock to PPI is similar to that of CPI. The difference appears after one year, the response of PPI reaches -0.786%, which is 18 times larger than the one of CPI[3].

[3] The order of variables is crucial for impulse response analysis. For robustness consideration, we apply different orders. The results suggest there is little difference.

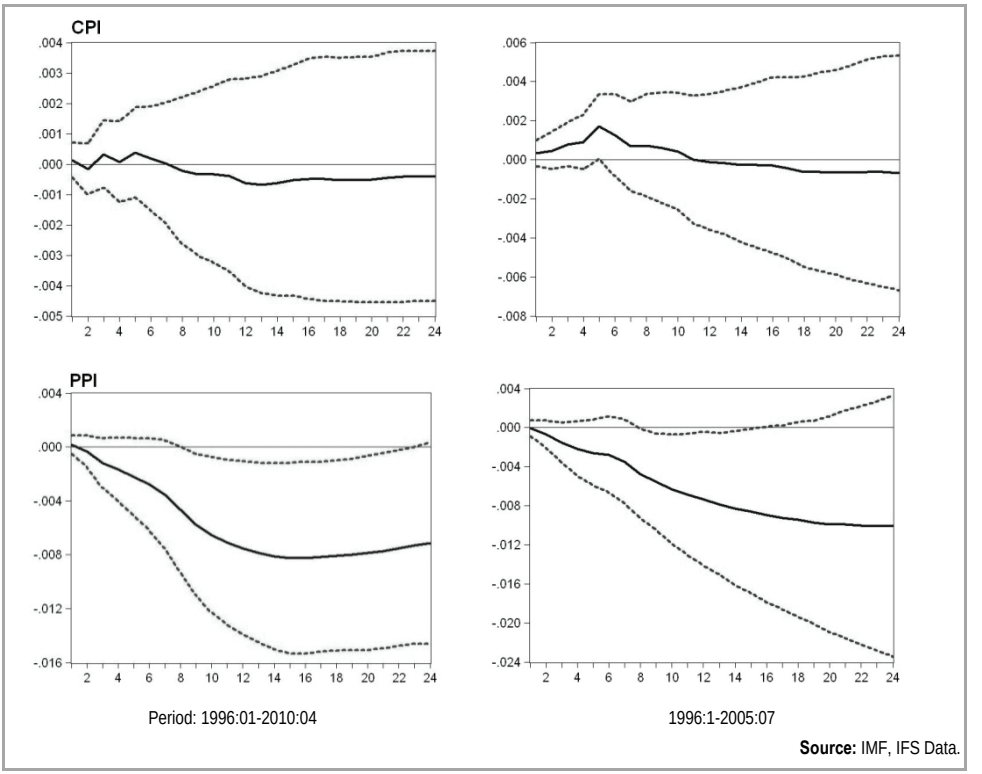


Figure 9 Impulse Response to NEER Shocks

3. Discussion

3.1 Exchange Rate Regime and Pass Through

Previous studies, including Fabrizio Coricelli, Bostjan Jazbec, and Igor Masten (2006) and John Beirne and Martin Bijsterbosch (2009), have established that a fixed exchange rate regime is associated with higher ERPT. To investigate the relation between ERPT and the exchange rate regime in China, we still start with the single equation framework. The stability Chow test provides an intuitive method to judge whether exchange rate policy reform causes structural change. Regarding July 2005 as the potential breakpoint, the linear regression of CPI rejects the null hypothesis of no breaks at the 10% significance level, while the regression of PPI accepts the above hypothesis.

Table 2 Chow Test for Structural Break

CPI			
F-statistic	1.538	Prob. F(21,124)	0.077
Log likelihood ratio	38.426	Prob. Chi2(21)	0.012
Wald statistic	32.298	Prob. Chi2(21)	0.055
PPI			
F-statistic	0.584	Prob. F(21,124)	0.923
Log likelihood ratio	15.645	Prob. Chi2(21)	0.789
Wald statistic	12.255	Prob. Chi2(21)	0.933

Note: The null hypothesis is there is no break in 2005M7 in the OLS regression.

Source: Author's estimations.

With the preliminary evidence from the Chow test, a new econometric equation (eq. 9) is set up for examining the connection between the exchange rate regime and ERPT (see Sebastian Edwards 2006; Weera Prasertnukul, Donghun Kim, and Makoto Kakinaka 2010). The dummy variable EX is added to the original single equation for this distinction. EX equals to 1 during the nominal appreciating period of July 2005 to July 2008, otherwise 0. The ERPT is calculated as in Table 3.

$$\begin{aligned}\Delta lncpi(lnppi)_t = &\sum_{i=1}^{5}\alpha_i\Delta lncpi(lnppi)_{t-i} + \sum_{i=0}^{5}\beta_i\,\Delta lnneer_{t-i} + \sum_{i=0}^{5}\gamma_i\Delta lnfpi_{t-i} \\ &+ \zeta outputgap + \eta\Delta lnbdi \\ &+ \sum_{i=1}^{5}\varphi_i\Delta lncpi(lnppi)_{t-i}\,EX + \sum_{i=0}^{5}\chi_i\,\Delta lnneer_{t-i}\,EX\end{aligned} \tag{9}$$

Table 3 Long Run ERPT and Exchange Rate Regime

Period	Expression	CPI	PPI
Whole		-0.132	-0.495
Fixed	$\frac{\sum_{i=0}^{5}\beta_i}{1-\sum_{i=1}^{5}\alpha_i}$	-0.140	-0.502
Flexible	$\frac{\sum_{i=0}^{5}\beta_i+\sum_{i=0}^{5}\chi_i}{1-\sum_{i=1}^{5}\alpha_i-\sum_{i=1}^{5}\varphi_i}$	-0.031	-0.524

Source: Author's estimations.

The detail of the regression results is presented in Appendix B. Table 3 lists the long-run ERPT estimation for different periods. There are two pieces of evidence which support the claim that the shift of exchange rate regimes affects CPI pass-through, but not the PPI pass-through. First, there is an obvious distinction of ERPT between two exchange rate regimes. In the fixed exchange rate regime, long-run CPI pass-through is -0.140, while it is -0.031 in the flexible exchange rate regime. Second, in Appendix B we can see that some coefficients for the interaction term (φ_i,χ_i) are significant. In terms of PPI, the ERPT among the divergent regime is consistent (-0.502 vs -0.524 respectively) and none of the interaction coefficient terms are significant. The conclusion of higher CPI pass-through in the fixed exchange rate regime is consistent with Karim Barhoumi (2005) and Beirne and Bijsterbosch (2009).

Analogously, the VAR model is implemented within the reduced datasets from Jan 1996 to June 2005. See the right hand side of Figure 9, the impulse response displays a slight distinction with full period analysis as demonstrated graphically on the right hand side of Figure 9. Nevertheless, relatively significant responses of both price indices, within the fixed exchange rate regime, are found in the long run. By the end of two years, the responses of CPI and PPI before exchange rate reform are -0.068% and -1.00%, compared with -0.040% and -0.713% for the whole period. The VAR analysis partially supports the evidence from the single equation, but failed to prove the divergent influence of exchange rate regime for two price indices. One explanation could be that the impulse response function only considers the response of price indices to NEER, while the computation of ERPT in the linear model also considers the response of NEER to itself.

The revaluation period between 2005 and 2008 is extraordinary for China's economy. A series of policies are implemented in response to the challenge. Figure 2-6 in Section 1 reflects the special volatility of policy and economic status from 2005 to 2008. Attributed to intense appreciation expectations in 2005, capital inflows increased rapidly regardless of strict capital controls. These inflows increased the base money supply, producing a bubble in stock and real estate markets and stimulating inflation. In order to control the money supply and liquidity, the PBC increased interest rates and bank reserve ratios vigorously. However, an enlarged interest difference combined with anticipated appreciation caused hot money to enter even more fiercely. As a result of the failure to control inflows, inflation remained fairly high between 2006 and 2008. Maintaining efficient monetary policy is not only challenging but involves severe repercussions. With the chain reaction following the appreciation, it becomes apparent that inflation depends on the efficiency of monetary policy in controlling excess liquidity risk especially in the early phases of the appreciation period.

3.2 Explanation for Pass-Through Difference

This section concentrates on explanting the ERPT difference from various aspects. One explanation of the gap between CPI and PPI pass-through might be the different definitions and composition of price indices. PPI reflects the price change when industrial products go into circulation for the first time, while CPI traces the price of consumer goods and services for the final consumers. In regard to the composition of price indices, different baskets and weights of price indices could be the reason. However, the Chinese government does not publish the detailed construction of price indices. The general construction for CPI is as follows, food 33.2%, tobacco and alcohol 3.9%, clothes 9.1%, household equipment and maintenance services 6.0%, medical care and personal products 10.0%, transportation and communications 10.4%, entertainment, education and culture 14.2%, and residence 13.2%. Means of production, such as raw materials and machinery, electronics, chemical, and textile products, compose the majority of the PPI. The weight of the means of subsistence for domestic final consumption is less than 30%. Hence, the cross term is that CPI contains 50% of industrial consumer goods, while PPI includes 30% of the means of subsistence.

Furthermore, Burstein, Neves, and Rebelo (2003), Campa and Goldberg (2006) and Ihrig, Marazzi, and Rothenberg (2006) explained this puzzle by considering imported inputs, the existence of non-tradable goods, and distribution costs through the information from the OECD input-output table. This paper follows this work and provides evidence from China.

3.2.1 Imported Inputs and Non-Tradable Sector

In Campa and Goldberg (2006) and Ihrig, Marazzi, and Rothenberg (2006), the calibration of ERPT into CPI demonstrates that imported inputs can improve CPI pass-through as higher imported inputs contribute to the price of non-tradable goods and home produced tradable products. The imported inputs ratio refers to the ratio of the total value of imported intermediate inputs to the value of the total intermediate inputs. In Table 4, the third column reports the share of imported inputs for several countries. The ratio of imported inputs for China rises gradually from 0.087 in 1995 to 0.109 in 2002 due to the heightening degree of openness. Compared with the other countries of the table, the share of imported inputs in China is only slightly lower.

There is a large consensus in the literature that exchange rates only influence the price of tradable goods. Campa and Goldberg (2006) and Ihrig, Marazzi, and Rothenberg (2006) point out that the price of non-tradable goods can also affect exchange rates through imported inputs, although pass-through for non-tradable goods is still much lower than for tradable goods. Therefore, the larger the scale of the non-tradable sector, the lower CPI pass-through is; this result derives from CPI's inclusion of the price for both tradable and non-tradable goods. In contrast, PPI is regarded as a proxy for the domestic price index of tradable goods. Hence, it cannot be affected by the scale of the non-tradable sector.

Following the method from Campa and Goldberg (2006) and Ihrig, Marazzi, and Rothenberg (2006), we compute the share of tradable goods in consumption as the ratio of the value of consumption by households in tradable products relative to the value of total consumption by households. The tradable goods are selected from the OECD input-output table (category 1 to 25), while the remaining categories are considered non-tradable goods. The fourth column of Table 4 indicates the share of non-tradable consumption in China, which increased from 0.26 in 1995 to 0.468 in 2002. Particularly in the year 2000, the ratio is nearly half that of the US, France, and Japan's. Meanwhile India and Indonesia have a similar composition of consumption, implying that the degree of development in a country is proportional to the share of non-tradable goods.

Table 4 Share of Imported Input, Non-Tradable

Country	Year	Imported input	Non-tradable to consumption
China	1995	0.087	0.260
	2000	0.095	0.304
	2002	0.109	0.468
US	2000		0.797
France	2000	0.144	0.676
Japan	2000	0.070	0.779
UK	2000	0.160	0.682
Germany	2000	0.201	0.689
Indonesia	2000	0.210	0.432
Korea	2000	0.235	0.698
India	1998`	0.117	0.396

Note: Some data is identical to Campa and Goldberg (2006) and Ihrig, Marazzi, and Rothenberg (2006), due to the identical calculation method.

Source: Author's calculation.

3.2.2 Distribution Cost

The concept of distribution cost comes from Burstein, Neves, and Rebelo (2003). They consider distribution cost as the cost of distributing tradable goods, such as transportation, wholesale, and retail. Moreover, they defined distribution margin as the ratio of the difference between retail price and producer price over retail price.

It is obvious that high distribution cost leads to low ERPT. In addition, distribution cost could also partially explain why PPI pass-through is higher than CPI. The definition of CPI involves more intermediate distribution links, which lead to higher distribution cost.

However, there is no suitable data to calculate such a type of margin. Therefore, we use the input-output table to calculate the distribution margin for three final demand sections: final consumption expenditure by households, gross fixed capital formation, and exports. The distribution costs for service and non-tradable goods are assumed to be zero, such that the whole cost is allocated to tradable goods[4].

The distribution margin for tradable goods is calculated as final demand divided by the total inputs of tradable goods. Table 5 reports the distribution margin for three sectors. In all of the countries, the distribution margin for final consumption expenditure by households is larger than those of the export and gross fixed capital formation sections. For the final household consumption section, China's distribution service consists of 10.2%, 10.3% and 16.5% of final consumer price in the year 1995, 2000 and 2002 respectively. In comparison with other countries, the distribution sector is not an important element for tradable consumption, since the ratio of industrial countries is above 60% in 2000. This difference probably comes from the distinct structure between developed and developing countries. As we observe in Table 5, the distribution margins for Indonesia, Korea and India are also small.

To summarize, the low imported inputs and considerable scale of non-tradable and distribution sectors for China could partially explain the low CPI pass-through in China. However, the impact from distribution and non-tradable sectors is much smaller than that in industrial countries. Hence, there must be additional reasons, such as price regulation.

[4] The distribution sectors are category 31, 33-35.

Table 5 Distribution Margins

Country	Year	Final consumption expenditure by household	Gross fixed capital formation	Export
China	1995	0.102	0.051	0.032
	2000	0.103	0.046	0.094
	2002	0.165	0.083	0.174
US	2000	0.904	0.189	0.263
France	2000	0.593	0.120	0.111
Japan	2000	1.052	0.332	0.181
UK	2000	0.616	0.221	0.278
Germany	2000	0.600	0.103	0.094
Indonesia	2000	0.253	0.240	0.134
Korea	2000	0.377	0.120	0.144
India	1998`	0.279	0.140	0.280

Source: Author's calculation.

The Chinese government utilizes price controls mainly in the fields of energy, agricultural commodities, land, and resources. Particular areas within the energy industry are seriously administrated, including retail prices of petrol, diesel oil, and electricity. Taking oil as an example, the corresponding policy is that the price of domestically produced oil is delimited, while the average price of crude petroleum in the international market fluctuated more than 4% in 22 consecutive working days. This policy implies that the oil price in China lacks elasticity and is hysteretic to international oil price fluctuation. Concerning the electricity industry, coal price is determined by market demand and supply, whereas the price of electricity is not. Prices for agricultural commodities are also regulated, especially grain prices; when compared with other agricultural commodities, such as pork and vegetables, the variation of grain prices is always the lowest.

4. Conclusion

In this paper, ERPT for China's CPI and PPI is estimated by employing single equation regression and VAR models. The OLS model finds that a 1% devaluation of the exchange rate leads to 0.016% CPI deflation in the short run and 0.132% CPI inflation over the long run. The ERPT for PPI amounts to 0.495 in the long run, which is much higher and is consistent with the prediction. The VAR model supports the results obtained with the linear model: a fairly low CPI pass-through and relatively higher PPI pass-through. The negative correlation between exchange rate variation and long-run inflation implies that appreciation could reduce the inflation rate.

Next, the relation between the exchange rate regime and pass-through is considered. The exchange rate regime indeed impacts the pass-through to CPI, but not to PPI. In the long run, the periods under the fixed exchange rate regime have higher CPI pass-through.

Different definitions, baskets and weights of price indices could be a reason for the difference of CPI and PPI pass-through. Furthermore, low imported inputs, as well as the considerable magnitude of non-tradable and distribution sectors could partially explain the low ERPT. Other potential reasons are left for the future research.

The estimation results suggest that the government could pursue a more flexible exchange rate policy and maintain the independence of monetary policy. The unfavorable impact of exchange rate fluctuation on price stability is not a problem.

However, this conclusion is not absolute. The variation of pass through should be considered, as ERPT may vary according to different macro factors such as inflation performance (John B. Taylor 2000) and monetary policy regime (Devereux and Yetman 2009). An even more extreme explanation for the variation of pass through is that ERPT might be endogenous in the open economy macroeconomic framework (Devereux, Charles Engle, and Peter E. Storgaard 2004).

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Appendix

A1 Date Resource and Special Treatment

CPI/PPI: China's CPI and PPI data published in international database are mainly based on CPPY=100 (current period previous year=100). Ideal data for our estimation is based on one specific year, afterwards the monthly growth could be obtained easily. In order to adjust these indices to base on 2005=100, which is consistent with other index data, we use CPI's chain index data and CPI data based on CPPY=100 for CPI adjustment, and use PPI data based on CPPY=100 and producer goods' chain price index data for PPI adjustment.

Foreign Price Index: Without doubt, the most ideal index which presents the importing cost would be the weighted average of the export price index; however, there is not enough data to support the calculation of this index. Some literature directly replace the export price index by CPI, yet, in order to keep the consistency of weights within NEER, we adopt Campa and Goldberg (2005)'s treatment. According to IMF's methodology, $REER_i = \prod_{j \neq i} (\frac{CPI_i R_i}{CPI_j R_j})^{W_{ij}}$, where j is an index that runs over country i's trade partners, $W_{ij}$is the competitiveness weight put by country i on country j, R_i, R_j is the nominal exchange rate of country i and j's currencies in US dollars. $NEER_i = \prod_{j \neq i} (\frac{R_i}{R_j})^{W_{ij}}$. Therefore,$FPI_i = \frac{NEER_i CPI_i}{REER_i} = \prod_{j \neq i} (CPI_j)^{W_{ij}}$, FPI is regards as an appropriate weighted average of foreign countries CPI.

Per unit distribution cost: Per unit distribution cost is difficult to measure. Baltic Exchange Dry Index is a daily average of prices to ship raw material. It represents the cost paid by an end customer to have a shipping company transport raw materials across seas on the Baltic Exchange, which is the global marketplace for brokering shipping contracts. It actually measures the transportation cost).

Data resource: CPI, PPI (CPPY=100), NEER, REER, Industrial Production, and M2 collect from IMF IFS, downloaded through Data Stream. While Baltic Exchange Dry Index make monthly sum of the daily data from Baltic Exchange, downloaded also from Data Stream. CPI and producer goods chain price index are from WIND info (authoritative database in China).

Table A1 ERPT by OLS Estimation with Dummy Variable EX

CPI		PPI	
Variable	**Coefficient**	**Variable**	**Coefficient**
$\Delta lncpi_{t-1}$	0.045(.097)	$\Delta lnppi_{t-1}$	0.296* * * (.086)
$\Delta lncpi_{t-2}$	0.020 (0.095)	$\Delta lnppi_{t-2}$	0.151*(.091)
$\Delta lncpi_{t-3}$	0.004 (0.092)	$\Delta lnppi_{t-3}$	0.003(.095)
$\Delta lncpi_{t-4}$	0.108 (0.091)	$\Delta lnppi_{t-4}$	0.084(.092)
$\Delta lncpi_{t-5}$	0.170* (0.093)	$\Delta lnppi_{t-5}$	0.094(.082)
$\Delta lnfpi_t$	0.614*** (0.206)	$\Delta lnfpi_t$	0.976***(.220)
$\Delta lnfpi_{t-1}$	0.013 (0.214)	$\Delta lnfpi_{t-1}$	0.486* (0.248)
$\Delta lnfpi_{t-2}$	-0.247 (0.206)	$\Delta lnfpi_{t-2}$	-0.113(.0235)
$\Delta lnfpi_{t-3}$	0.188 (0.205)	$\Delta lnfpi_{t-3}$	-0.106(.232)
$\Delta lnfpi_{t-4}$	-0.058 (0.218)	$\Delta lnfpi_{t-4}$	-0.241(.243)
$\Delta lnfpi_{t-5}$	-0.523*** (0.194)	$\Delta lnfpi_{t-5}$	-0.673**(.230)
$\Delta lnneer_t$	0.009 (0.028)	$\Delta lnneer_t$	0.014 (.032)
$\Delta lneer_{t-1}$	-0.055* (0.031)	$\Delta lneer_{t-1}$	-0.054(.034)
$\Delta lnneer_{t-2}$	0.013 (0.030)	$\Delta lnneer_{t-2}$	-0.068**(.033)
$\Delta lnneer_{t-3}$	-0.036 (0.031)	$\Delta lnneer_{t-3}$	-0.034 (0.034)
$\Delta lnneer_{t-4}$	0.039 (0.030)	$\Delta lnneer_{t-4}$	-0.028 (0.034)
$\Delta lnneer_{t-5}$	-0.062** (0.028)	$\Delta lnneer_{t-5}$	-0.015 (0.033)
$\Delta lncpi_{t-1}$ EX	0.146 (0.194)	$\Delta lnppi_{t-1}$ EX	-0.005 (0.236)
$\Delta lncpi_{t-2}$ EX	0.477** (0.188)	$\Delta lnppi_{t-2}$ EX	0.057 (0.266)
$\Delta lncpi_{t-3}$ EX	0.222 (0.183)	$\Delta lnppi_{t-3}$ EX	0.119 (0.257)
$\Delta lncpi_{t-4}$ EX	-0.241 (0.186)	$\Delta lnppi_{t-4}$ EX	0.282 (0.268)
$\Delta lncpi_{t-5}$ EX	-0.306* (0.183)	$\Delta lnppi_{t-5}$ EX	-0.290 (0.237)
$\Delta lnneer_t$ EX	0.125 (0.083)	$\Delta lnneer_t$ EX	-0.050 (0.093)
$\Delta lneer_{t-1}$ EX	-0.061 (0.082)	$\Delta lneer_{t-1}$ EX	-0.037 (0.093)
$\Delta lnneer_{t-2}$ EX	0.152** (0.076)	$\Delta lnneer_{t-2}$ EX	0.017 (0.084)
$\Delta lnneer_{t-3}$ EX	-0.013 (0.083)	$\Delta lnneer_{t-3}$ EX	0.120 (0.084)
$\Delta lnneer_{t-4}$ EX	-0.199** (0.089)	$\Delta lnneer_{t-4}$ EX	0.038 (0.096)
$\Delta lnneer_{t-5}$ EX	0.077 (0.090)	$\Delta lnneer_{t-5}$ EX	-0.011 (0.099)
$\Delta lnm2_t$	0.008 (0.034)	$\Delta lnm2_t$	0.021 (0.035)
output gap	0.000 (0.000)	output gap	0.000 (0.000)
$\Delta lnbdi_t$	-0.004* (0.002)	$\Delta lnbdi_t$	-0.002 (0.002)
R^2	0.367	R^2	0.666

Note: The figures in parentheses are standard errors. * -significance at the 10% levels, **-significance at the 5% levels, ***-significance at the 1% levels.

Source: Author's estimations.