Domestic Financial Instability and Foreign Reserve Accumulation in China

Lirong Wang¹ and C. James Hueng², ³, * (ORCID: 0000-0002-9135-532X)

1 Department of Economics and the Key Laboratory of Applied Statistics of MOE, Northeast Normal University, Changchun, Jilin, China.
2 Department of Economics, Western Michigan University, Kalamazoo, Michigan, U.S.A.
3 School of Economics, Zhongnan University of Economics and Law, Wuhan, Hubei, China

*Corresponding author.  C. James Hueng, Department of Economics, Western Michigan University, Kalamazoo, MI 49008-5330, Phone: 269-387-5558, Email: James.Hueng@wmich.edu

Acknowledgements

Wang acknowledges the financial support from the China Social Science Foundation under Grant No. 15CGJ020.  Hueng acknowledges supports from the 2016-17 U.S. Scholar Fulbright Program. We thank the PRC Macro Advisors (PRC Macro Limited Ltd) for providing the data.
Domestic Financial Instability and Foreign Reserve Accumulation in China

Abstract
In a time series analysis, this paper argues that domestic financial instability, which increases the potential for resident-based capital flight from the domestic currency, provides an incentive for China to hold more foreign reserves in the short run. To measure its domestic financial conditions, we construct a monthly Chinese financial stress index, which is used to proxy for the possibility of capital flight. The empirical results show that this index is a significant determinant of the movements of China’s foreign reserve around its trend, and that using M2 to proxy for domestic financial instability as suggested by previous studies is not a valid strategy for China. It is suggested that greater attention should be given to the role of domestic financial conditions in explaining China’s short-run demand for foreign reserves.

JEL classification: E44; F31; F32

Keywords: Capital flight; Chinese foreign reserves; Financial stress; Precautionary demand for reserves
I. Introduction

This paper contributes to the explanations of China’s foreign reserve in a time series analysis. We argue that domestic financial instability, which increases the potential for resident-based capital flight from the domestic currency, provides an incentive for China to hold more foreign reserves in the short run. To measure the financial conditions in China, this paper uses a principle component model to construct a monthly Chinese financial stress index (CFSI). The variables used to construct the index are carefully selected, including several Chinese market interest rates and their spreads, and more importantly, the actual or expected behaviors of financial asset prices that we estimate. The empirical results show that this index is a significant determinant of the movements of China’s foreign reserve around its trend. Therefore, greater attention should be given to the role of domestic financial instability in explaining China’s short-run demand for reserves.

In its Report to Congress on International Economic and Exchange Rate Policies in April 2015, the U.S. Department of the Treasury claimed that the level of foreign reserves held by China was “well beyond established benchmarks of reserve adequacy.” Yet these “benchmarks of reserve adequacy” are not specifically defined in the report nor in the research cited by the report. Indeed, there is still no consensus on a universally applicable measure of reserve adequacy in the literature.

Empirical research often uses panel regressions for a group of developing economies and singles out the finding that China’s excessive accumulation of foreign reserves cannot be fully explained by variables that work well for other countries [e.g., Edison (2003), Gosselin and Parent (2005), Obstfeld et al. (2010), and Ghosh et al. (2014)]. As pointed out by Aizenman (2008), China’s unique growth path and absence of significant currency crises suggest that it is not proper to apply the experiences of other countries to China regarding its optimal reserve levels. Therefore, before assessing China’s reserve adequacy, it is necessary to study its motives for accumulating foreign reserves. This paper is uniquely devoted to this purpose in a time series analysis.
Specifically, we investigate the impact of domestic financial stress on China’s demand for foreign reserves.

We follow the literature suggesting that international reserves are held at least partly to prevent or mitigate domestic capital flight. Obstfeld (2011) argues that domestic financial instability increases the potential for resident-based capital flight from domestic currency. Therefore, central banks would hold a higher level of reserves when facing domestic financial stress. Particularly for China, Aizenman (2008) suggests that the massive hoarding of foreign reserves by China may be used to deal with the growing fragility of its banking system flooded with excessive money supply and nonperforming loans led by enormous economic growth. That is, exposure to latent domestic instability provides the incentive for the Chinese authority to aggressively accumulate foreign reserves.

This latent domestic instability, however, imposes a challenge to the empirical test of this precautionary motive. Edison (2003) suggest that broad money is an indicator of capital account vulnerability in the event of financial crisis, because it measures the size of domestic financial liabilities that could potentially be converted into foreign currencies. Obstfeld et al. (2010) present a model in which, when there is a negative shock to the home economy and the authority tries to stabilize the exchange rate, the demand for reserve rises proportionally with the size of the domestic banking system’s liabilities. Therefore, reserve adequacy should be judged relative to a broad measure of money like M2.

This paper argues that using a single monetary aggregate alone to proxy for the possibility of a capital flight is problematic. First, McKinnon and Schnabl (2009) argue that the high growth in M2 was largely a natural result of China’s very high savings rate when bank deposits are the principal financial asset open to Chinese savers. Therefore, financial instability is not the only nor a main determinant of Chinese M2 over time. Secondly, Aizenman and Lee (2007) show that regardless of the level of financial instability, bank deposits and foreign reserves are complements
in that liquidity shocks will increase optimal demand for both reserves and deposits. Finally, the causal effect may be the other way around. Taguchi (2011) states that foreign reserves accumulated by the monetary authority’s unsterilized intervention in the foreign exchange market may lead to an increase in the money supply. Specifically, Ouyang et al. (2010) argues that the People’s Bank of China does not try to fully neutralize the domestic monetary effects of the increasing reserves under the government direction, even though there are net marginal benefits to sterilization [Prasad and Wei (2007)]. Therefore, using M2 to proxy for domestic financial instability that gives the Chinese authority the incentive to accumulate reserve is not very convincing.

This paper proposes a direct measure of the domestic financial instability to serve as a predictor of China’s foreign reserve holding. Our financial stress index CFSI is constructed from a wide range of financial variables by using the principal components analysis. Each of these variables is supposed to capture some aspect of financial stress. In particular, different from most of the existing FSIs constructed from various interest rates and yield spreads, we reply more on constructing variables that capture the behaviors of asset prices. This is because most of the interest rates and bond yields in China are in some ways managed by the authority and lack of movements reflecting the financial market dynamics.

The empirical results show that the CFSI is a significant determinant of the movements of China’s foreign reserve around its trend. This confirms the prediction that exposure to the latent domestic instability provides the incentive for the Chinese administrators to aggressively accumulate foreign reserves. The positive effect of M2 on the foreign reserve disappears once the CFSI is included in the model. This confirms the argument that the high growth in M2 is a result of China’s high growth and high savings rate, and is not a good proxy for the latent financial instability. We conclude that the path of Chinese foreign reserve around the trend can partly be explained by the precautionary motive of dealing with domestic financial stress.

II. Chinese Financial Stress Index (CFSI)
The monthly Chinese Financial Stress Index (CFSI) measures the degree of stress in the Chinese financial markets. Similar to the Kansas City Fed’s Financial Stress Index (KCFSI) and the St. Louis Fed’s Financial Stress Index (STLFSI), our CFSI is constructed using the Principal Components Analysis model, which extracts factors responsible for the comovement of a group of financial variables. Each of these variables is supposed to capture some aspect of financial stress and quickly reflect changes in financial conditions. According to Hakkio and Keeton (2009), the key features of financial stress include increased uncertainty about fundamental value of assets, increased uncertainty about behavior of other investors, increased asymmetry of information, decreased willingness to hold risky assets (flight to quality), and decreased willingness to hold illiquid assets (flight to liquidity).

Variables used by the KCFSI include yield spreads of financial assets and sample volatilities of asset prices. The STLFSI adds various interest rates and several published indices that measure financial asset behaviors. In general, the variables fall into three categories: market interest rates, yield spreads, and asset price behaviors. Unlike the U.S. treasury yields, however, almost all the Chinese government bond and some corporate bond interest rates are managed by the authority. Therefore, we only include a limited number of market interest rates and their spreads, and rely more on the actual or expected behaviors of asset prices that we construct by ourselves.

For market interest rates, as argued by Bai et al. (2013), the markets of Chinese government bonds are not efficient at processing market information. Simple plots of these rates show little movements of the series. Therefore, we avoid the government bond rates. Instead, we select (i) two short-term rates: the three-month AAA commercial papers & notes rate and the three-month HIBOR (Hong Kong Interbank Offered Rate); (ii) two intermediate-term rates: the two-year and five-year Interest Rate Swaps, which are used to proxy for the two-year and five-year market interest rates, respectively; and (iii) two long-term rates: the ten-year AA+ and BBB+ corporate bonds rates.
For yield spreads, we use (i) two spreads reflecting the term structure: the average five-year/three-year spread of the private corporate AAA and AA+ bonds and notes, and the five-year/two-year Interest Rate Swaps spread; and (ii) three spreads reflecting the risk structure: the ten-year corporate AA+/BBB spread, the average AAA/AA+ spread of the five-year and three-year private corporate bonds and notes, and the three-month HIBOR/CGB spread [mirroring the LIBOR/T-bill (TED) spread].

The third group of the variables includes eleven indicators reflecting the behaviors, mostly the higher moments, of asset prices from the bond market, the foreign exchange market, the securitization market, and the equity market. The first indicator is the value-weighted Corporate Vulnerability Index (CVI) of China produced by the Risk Management Institute at the National University of Singapore. It tries to proxy for the aggregate credit risk in China. The probabilities of default of all individual listed firms in China are calculated based on “historical equity market defaults and financial statements data of the firms,” where default is defined as “bankruptcy filing, a missed or delayed payment of interest and/or principal, and debt restructuring/distressed.” See http://rmicri.org/cvi/view_cvi/.

In the bond markets, we collect the one-year and five-year sovereign zero yield volatilities to proxy for the pressure on the national economy and the state of government finances. In the foreign exchange market, we select the CNY three-month and one-year Option Implied Volatilities to proxy for exchange rate risk. Financial crises are often associated with unusual exchange rate uncertainty and spikes in risk aversion. Both are reflected in the volatilities implied by the prices of currency options. Therefore, the CNY Option Implied Volatility can be used as a measure of the cost to hedge CNY weakness.

In the securitization market, the Credit-Default Swap (CDS) on the five-year sovereign debt is included. Credit derivatives are seen as a gauge of risk, among which the CDS has become the most widely traded instrument for transferring credit risk [Ammer and Cai (2007)]. Especially
for emerging economies, sovereign risk is an important indicator to foreign investors in assessing risks of their foreign direct investment and portfolio investments [Eyssell et al. (2013)]. Therefore, we use the Credit-Default Swap on sovereign debt to proxy for global investors’ sentiment toward China.

In addition to the above published indices from the derivative markets, we construct five more variables from the equity market. Following the KCFSI, we calculate the stock market volatility, the cross-section dispersion of bank stock returns, and the idiosyncratic volatility of the banking industry. The monthly stock market return volatility is measured by the standard deviation of the daily returns of the Shanghai Composite Index (SHCOMP). The cross-section dispersion of bank stock returns is the standard deviation across the monthly returns of the 16 commercial banks listed under the WIND database. The idiosyncratic volatility of the banking industry is calculated in three steps. The first step is to estimate a CAPM regression of the daily return on the bank stock index (SHCOMP-Bank) against the daily return on the SHCOMP, using the data from the previous month. The second step is to use the estimated beta from the CAPM regression and the daily returns on the SHCOMP to calculate the residual (idiosyncratic) return on the SHCOMP-Bank index for each day of the month. The last step is to calculate the standard deviation of the daily idiosyncratic returns for the month.

Hong and Stein (2003) and Hueng and McDonald (2005) argue that stock trading volumes or turnover ratios represent the differences of opinions on the stock prices, which reflect the uncertainty in the stock market. Therefore, we add two turnover ratios (trading volume divided by free float market cap) to the calculation of the CFSI: overall stock market (Shanghai Stock Exchange plus Shenzhen Stock Exchange) and the banking stocks (CSI300 Banks) turnover ratios.

The financial stress is assumed to be the most important factor (the first principal component) in explaining the comovement of those 22 financial variables mentioned above. Since most of the financial variables used to construct the CFSI are only available from 2005, our sample
period is from January 2005 to December 2017. Since not all variables are available from 2005, as a preliminary step, the missing values of the dataset are first imputed by a multiple imputation using a Bayesian PCA model [Audigier et al. (2016)]. Then the variables are converted to the same units by subtracting the sample mean and dividing by the standard deviation. Next, we use the non-linear iterative partial least squares method of principal components to calculate the loadings on the variables. Finally, the estimated loadings on the variables that yield the first principle component are scaled so that the standard deviation of the index equals one.

Figure 1 plots our financial stress index for China, which has zero-mean and unit-variance. The high financial stress in the early sample period is likely a result of a relatively fixed exchange rate together with China’s capital account liberalization, which exposes its weak banking system to great risks. After the Asian financial crisis the excessive credit expansion substantially heats up the real estate market, raising concerns about the quality of bank loans. Given the high non-performing loan ratios, the banking system is vulnerable to liquidity problems.

After 2005 China moves towards a more flexible (managed float) exchange rate, allowing it to cope with the external shocks by an independent monetary policy. At the same time, the nonperforming loans and their rates keep decreasing in 2006 and 2007. China’s financial market performs well and tends to attract capital inflow before the full burst of the global financial crisis.

The index successfully picks up the spillover financial stress from the global financial crisis. Then after an extended period of low financial stress, the index starts to shoot up in 2014, reflecting the liquidity shortage in the interbank market and the appreciation of RMB during the latter half of 2013 and the first quarter in 2014. The stress level keeps rising as the rapidly inflating bubble in the stock market drives share prices to dizzying heights while the economy is cooling off dramatically, and finally bursts in June 2015. The CFSI stays higher than average in 2016 and comes down only mildly in 2017.

III. Empirical Models and Results
Measures for assessing the adequacy of reserves are traditionally facilitated by a cost-benefit analysis. That is, the level of reserves depends on the opportunity cost of holding reserves and the adjustment cost of restocking reserves. After the Asian currency crisis in the late 1990s, the increasing frequency and intensity of financial crises, along with the increasing cross-border capital mobility, draw significant attention to the precautionary motives for holding reserves in the developing economies. Risks associated with a country’s external debt position and the volatility of its capital flows become the focal points when analyzing the precautionary accumulation of reserves. Researchers believe that foreign reserves, as an important asset of central banks, have been used as a tool to manage vulnerability to external instability and internal drains.

Therefore, empirical research in general groups the determinants of the foreign reserve holdings into five categories: (i) economic size (e.g., real GDP per capita, population); (ii) opportunity cost (e.g., the difference between the yields on reserves and alternative investments); (iii) exchange rate flexibility (e.g., exchange rate regimes and the volatility of exchange rate); (iv) current account vulnerability (e.g., trade openness and imports); and (v) capital account vulnerability (e.g., financial openness and domestic capital flight).

Different from previous research using panel data from a group of countries, this paper is a time series analysis of an individual country. Therefore, while trying to tie our empirical model as closely as possible to that in Obstfeld et al. (2010), we only consider determinants that affect the foreign reserves over time during our sample period. For example, measures of financial openness, such as the Chinn-Ito index [Chinn and Ito (2006)], stay constant in our sample period and therefore, are not considered in this paper. Short-term external debt is not included, either, because it is only available quarterly and the level is very low compared to the reserves.

As to the opportunity cost of holding reserve, Grimes (1993) argues that central banks are not income maximizers and tend to ignore interest rate movements in favor of accumulating reserve balances to avoid a reserve shortfall. In addition, Aizenman and Marion (2004) and Hauner (2006)
argue that the opportunity cost is hard to measure and the proxies are often found not significant. Therefore, we do not consider opportunity cost in the empirical model. Finally, another popular variable in panel research “sudden stops” is not suitable because, as shown by Jeanne and Rancière (2011) and Bianchi et al. (2013), China has never experienced sudden stops in the recent history.

Our goal is to see whether the domestic financial stress is an indicator of the capital account vulnerability to domestic capital flight. To control the effects of the other variables, we include in the control variables some popular determinants in the literature that vary over time and capture the exchange rate flexibility and current account vulnerability.

To control for economic size over time, we use the index of real value-added industrial production, which we manually derive by using the reported year-over-year growth rates. The second control variable is the volatility of exchange rates, measured by the standard deviation of the daily RMB/USD exchange rates within a month. Reserve acquisition is motivated by a desire to dampen exchange rate movements to provide a stable economic environment for foreign investment and domestic economic activity [Dominguez (2012)]. A country with truly floating exchange rates should never need foreign exchange reserves. As argued by Ghosh et al. (2017), de facto willingness to tolerate greater exchange rate volatility should be associated with a lower demand for reserves.

Import of goods and services is used to proxy for current account vulnerability. It is expected to be associated with a higher precautionary demand of reserves. That is, more reserves will be required to finance large nominal imports [Aizenman and Marion (2003), Gosselin and Parent (2005), and Ghosh et al. (2017)].

While vulnerability to current account shocks was relatively important in the 1980s, factors related to the magnitude of potential capital outflows have drawn most attentions in recent research as emerging markets have become more financially integrated. Specifically, we believe that exposure to latent domestic instability provides an incentive for Chinese administration to
aggressively accumulate foreign reserves. Edison (2003) and Obstfeld et al. (2010) suggest that a broad measure of money like M2 represents the size of domestic liabilities that could potentially be converted into foreign currency and therefore, is a good proxy for capital account vulnerability.

Using the domestic liabilities convertible to foreign currency as a measure of potential capital flight does not address the reason why the liabilities would be converted. This paper instead suggests directly measuring domestic financial stress that increases the potential for resident-based capital flight from the domestic currency. In the empirical analysis, we wish to see whether our CFSI contributes to explaining China’s holding of foreign reserves.

In sum, the dependent variable is the total foreign reserves (excluding gold, SDR holding and reserve position in the Fund) in RMB. The explanatory variables include output measured by real industrial production, total imports in RMB, exchange rate volatility measured by the standard deviation of the daily RMB/USD exchange rates, M2, and our financial stress index CFSI. The Chinese macro data are obtained from the National Bureau of Statistics of China and the State Administration of Foreign Exchange websites.

It is well known that Chinese macro data are often distorted by the Chinese New Year, whose timing varies from year to year on the Gregorian calendar. Especially, the January and February figures of reserve, output, imports, and money supply are clearly affected by this effect. Therefore, we use the United States Census Bureau X-13ARIMA-SEATS procedure to adjust the Chinese New Year effects for these four variables. The Chinese New Year holiday is set to start from the New Year Eve and lasts for seven days. Following Lin and Liu (2003) and Findley and Soukup (2000), we also adjust the pre- and post-holiday effects, with the lengths of the pre- and post-holiday periods chosen by minimizing the AIC corrected for finite sample sizes, i.e., the AICc of Hurvich and Tsai (1989).

Figures 2-5 plot the natural log of these four adjusted time series and Figure 6 plots the RMB/USD exchange rate volatility. Judging from the plots of the data series, apparently we do not
expect the CFSI to account for the upward trend of the Chinese foreign reserve. Rather, we focus on the CFSI’s role in explaining the movements of reserve around its trend.

To detrend the variables, we use the Augmented Dickey-Fuller (ADF) tests, which have the null hypothesis of a unit root against the alternatives of stationarity, and the generalized KPSS tests, which have the null hypothesis of stationarity against the alternatives of nonstationarity, to determine whether the upward trends in Figures 2-5 are deterministic or stochastic. Both tests clearly indicate that the logs of reserves, output, imports, and M2 are best modelled as I(1) variables, and the exchange rate volatility is better modelled as an I(0) variable. The tests on the CFSI, on the other hand, is ambiguous. The ADF-\(\rho\) test rejects the null of a unit root while the ADF-Z\(\tau\) test fails to reject the null at the 5% significance level. Since it is well known that the ADF tests have low power against stationary alternatives, we turn to the generalized KPSS-tests, which clearly (at the traditional significance levels) indicate that the CFSI is better modelled as a mean-stationary process.

Therefore, our empirical model takes the following form:

\[
\Delta \ln(R_t) = \beta_0 + \beta_1 \cdot \Delta \ln(Y_t) + \beta_2 \cdot \Delta \ln(IM_t) + \beta_3 \cdot h_t + \beta_4 \cdot \Delta \ln(M_t) + \beta_5 \cdot CFSI_t + \varepsilon_t, \quad (1)
\]

where \(R_t\) is reserve, \(Y_t\) is real industrial production, \(IM_t\) is imports, and \(M_t\) is M2, \(h_t\) is the volatility of exchange rates, and \(CFSI_t\) is our financial stress index for China. The OLS results are shown in Panel (I) of Table 1. Columns A and B show the results with and without the CFSI, respectively.

In Columns A, the estimated coefficients on output, imports, and exchange rate volatility all have the right signs, but are statistically insignificant. The insignificant effect of output indicates that once the long-run stochastic trends are removed, output does not have significant short-run effects on reserve. The insignificant effect of imports confirms that the vulnerability to current account shocks is relatively unimportant after emerging markets become more financially
integrated. On the other hand, the insignificant effect of exchange rate volatility is due to the fact that the standard deviations shown in Figure 6 are mostly less than RMB0.05/$, which is relatively small compared to the exchange rates ranging from RMB7.19/$ to RMB6.11/$.

The only significant factor in Column A of Panel (I) is M2, confirming, in a time series setting, Obstfeld et al.’s (2010) arguments. However, after we add the CFSI as an additional explanatory variable in Column B, the estimated coefficient on M2 declines and becomes marginally significant at the 5.2% level. More importantly for our purpose, the CFSI has a significantly positive effect on reserve. Including the CFSI increases the adjusted R-squared from 0.078 to 0.204.

As argued in the Introduction, inclusion of money supply in the regressions may suffer from an endogeneity problem in that foreign reserves accumulated by unsterilized intervention may lead to an increase in the money supply. To take care of this issue, we run the Instrumental Variables (IV) estimation, using lagged M2 and the current and lagged exogenous variables in the model as the instruments for M2. The results with and without the CFSI are shown in Columns A and B of Panel (II), respectively. After correcting for endogeneity, the positive effect of M2 on reserve is completely replaced by the CFSI when the CFSI is included in the regression. Therefore, our CFSI is a better proxy than M2 for potential capital flight that increase the precautionary motives for accumulating foreign reserves.

Recall that our CFSI is constructed by three categories of variables: market interest rates, yield spreads, and asset price behaviors. It is interesting to see the effects of the financial stress represented by each of these three categories on foreign reserves. We use the corresponding loadings that yield the first principle component in the PCA model to construct the weighted average of the variables in each category. The results are shown in Columns C-E of Panel (II). The financial stress represented by each of the three categories yields the same conclusion: once a
direct measure of financial stress is included as an explanatory variable, the effects of M2 on precautionary demand for reserve completely disappear.

**IV. Conclusions and Discussions**

Cross-sectional research often finds that China’s excessive accumulation of foreign reserves cannot be fully explained by the traditional models based on a cost-benefit analysis. When considering financial conditions, however, Aizenman and Lee (2007) and Obstfeld et al. (2010) find that China is not an obvious outlier. This implies the importance of financial stability in explaining China’s demand for reserves. Since financial market conditions change frequently and rapidly, active reserve managements become increasingly important [e.g., Edison and Warnock (2003) measure the monthly intensity of capital controls].

Especially, China is facing pressures to speed up its capital account liberalization, but still struggling to strengthening its domestic financial structure. Even though the Chinese government has been using capital control policies to maintain a stable economic environment, Ma and McCauley (2008) and Cheung and Herrala (2014) show that it still cannot eliminate illicit capital flows, which impose significant risk of capital flight in the short run. Therefore, monitoring the financial conditions in the short run before a massive capital flight is out of control is as important as the long-term policies.

This motivates us to investigate the relationship between the financial conditions and foreign reserves in a time series setting for China. Current cross-sectional research only focuses on the long-term policy effects and cannot capture the short-run dynamics. With the construction of the monthly Chinese Financial Stress Index, we are able to investigate this short-run active reserve managements. Our discussion suggests that domestic financial stress increases the PBOC’s willingness to hold more foreign reserves to avoid the potential resident-based capital flight from domestic currency.\(^8\)
We suggest that greater attention should be given to the role of domestic financial instability in explaining the demand for reserves and the functioning of buffer stocks in China. As the Chinese government is promoting the internationalization of RMB, it is necessary to tackle the problems resulting from the transitional stage of financial developments. All the possible financial reforms, such as the marketization of interest rates and the soon-to-be convertible capital account, will lead to changes in China’s financial conditions. Therefore, China’s reserve demands will change accordingly to all the future financial developments.

Due to the globalization of the world financial markets, especially the rapid development in the emerging economies, possible future research includes the analysis on the role of domestic financial instability in determining the demand for reserves in other developing countries. Once more financial market data are available in those developing economies, this research will further advance our understanding of central banks’ precautionary motives to accumulate foreign reserves when facing turmoil in the domestic financial markets in general.
References


<table>
<thead>
<tr>
<th>Variables</th>
<th>Models</th>
<th>(I) OLS</th>
<th>(II) Instrumental Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Output</td>
<td>0.065 (0.427)</td>
<td>0.010 (0.899)</td>
<td>0.040 (0.671)</td>
</tr>
<tr>
<td>Import</td>
<td>0.030 (0.221)</td>
<td>0.024 (0.292)</td>
<td>0.008 (0.791)</td>
</tr>
<tr>
<td>Exchange Rate Volatility</td>
<td>-0.060 (0.477)</td>
<td>0.005 (0.948)</td>
<td>0.053 (0.614)</td>
</tr>
<tr>
<td>Money</td>
<td>0.564 (0.002)</td>
<td>0.344 (0.052)</td>
<td>1.490 (0.003)</td>
</tr>
<tr>
<td>CFSI</td>
<td></td>
<td>0.603 (0.000)</td>
<td></td>
</tr>
<tr>
<td>CFSI – Interest Rates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFSI – Yield Spreads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFSI – Asset Behaviors</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \Delta \ln(R_t) = \beta_0 + \beta_1 \cdot \Delta \ln(Y_t) + \beta_2 \cdot \Delta \ln(IM_t) + \beta_3 \cdot \Delta \ln(M_t) + \beta_4 \cdot \Delta \ln(h_{et}) + \beta_5 \cdot CFSI_t + \varepsilon_t, \]

where $R_t$ is reserve, $Y_t$ is output, $IM_t$ is imports, $h_{et}$ is exchange rate volatility, $M_t$ is M2, and $CFSI_t$ is the financial stress index.

‡ CFSI – Interest Rates: the portion of the CFSI that is explained by the six market interest rates.

‡ CFSI – Yield Spreads: the portion of the CFSI that is explained by the five yield spreads.

‡ CFSI – Asset Behaviors: the portion of the CFSI that is explained by the eleven measures of asset prices behaviors.

† The numbers in parentheses are p-values. A p-value of 0.000 indicates that the p-value is nonzero, but smaller than 0.0005.
Endnotes

1 Another short-term interest rate SHIBOR (Shanghai Interbank Offered Rate) is generally seen as a market-sensitive benchmark since it is based on quoted rates from large financial institutions [Fan and Johnson (2010)]. However, as claimed by Chong and Liu (2016), it is introduced by the central bank to build the benchmark rate, not driven by market demand like the LIBOR.

2 These are the fixed rates that are paid on interest rate swaps to receive payments based on the interbank seven-day fixing repo rate.

3 Even though enterprise bonds are a much larger sector of the Chinese bond market compared to corporate bonds, they are issued to fund projects vital to national well-being and therefore, face more restrictions. Corporate bonds, on the other hand, are issued to fund own business operational needs. There is no restriction on the issuers of corporate bonds and the approval process is quicker, easier, and more market-driven compared to enterprise bonds.

4 Cheung et al. (2016) construct a measure of China’s capital flight by using trade misinvoicing. They find that money was moving out of China from 1998 to 2006, a period during which China had a substantial current account surplus and net capital inflows. This implies that the perceived risk of illicit capital flight was high, consistent with our high CFSI level in the early sample.

5 Another support for the high CFSI level in the early sample is from the observation of the corporate vulnerability index (CVI), which is a narrower measure of financial instability and can be dated back to 2000. The CVI also has its highest level prior to 2005, and shows a declining trend from 2000 to 2007, similar to what we observe in the early period of the CFSI.

6 We first use a cubic spline interpolation to convert the quarter data in 1995 to monthly data. Then the year-over-year growth rates are used to grow the index.

7 We recognize that multicollinearity may exist in our regressions because the CFSI also include proxy variables of exchange rate risk. However, since our purpose is to test the significance of the
effect of the CFSI on reserves, and the results show that the effect is highly significant, the multicollinearity issue is not a problem in this study and does not alter our conclusions.

8 The People’s Bank of China can change the reserve level in the short term by borrowing/lending through capital account, buying/selling foreign assets in the exchange market, and temporary capital flow managements.