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Mercantilism and China's Hunger for
International Reserves

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Marcel Schröder [*]

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Abstract

This paper is motivated by the popular view that the surge in China's foreign exchange reserves is due to a distortionary exchange rate policy aimed at keeping the real exchange rate undervalued to support export-led growth. It undertakes an in-depth empirical investigation to quantify how much "mercantilist" and "precautionary" motives have contributed to the reserve build-up in China during 1998Q4-2011Q4. A substantial problem is that theory is consistent with employing two vastly differing approaches to defining and estimating the role of mercantilist reserve accumulation. *A priori*, either method could generate misleading results. The study shows, however, that the distinction between the two approaches is immaterial in China's case. The results suggest that mercantilism accounts for less than 10 percent of reserve accumulation. Precautionary motives and other factors seem to be the dominant determinants of the surge in China's international reserves.

Keywords: International reserves, Precautionary demand, Mercantilism, China

JEL codes: E58, F31, F36

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1 Introduction

Over the past two decades, China has accumulated foreign exchange reserves at an unprecedented rate and is now by far the world's largest holder of international reserves. While still moderate at 8 percent of GDP (about US$ 30 billion) in 1990, reserve holdings since then have almost sextupled to 44 percent of GDP (about US$ 3.2 trillion) in 2011 (see Figure 1). In an increasingly integrated world characterized by volatile capital flows, it is prudent for emerging economies to stockpile reserves as self-insurance against Sudden Stops (Aizenman and Marion, 2003).[1] Yet the general perception is that China's reserve holdings are too large to be justified by precautionary motives. In light of the record trade surpluses and a fixed exchange rate regime, an often stated suspicion is that China accumulates reserves as part of mercantilist policies, which aim at keeping the real exchange rate (RER) undervalued in order to support export-led growth (Dooley et al., 2004). Paul Krugman (2010), for instance, accused China of "the most distortionary exchange rate policy any major nation has ever followed".[2]

The purpose of this study is to examine whether this view about China's exchange rate policy has any merit. A number of empirical papers estimate a reserve demand model for a large group of emerging economies in order to analyze the relative significance of precautionary and mercantilist motives in explaining the reserve build-up in those countries (Aizenman and Lee, 2007; Delatte and Fouquau, 2012; Ghosh et al., 2012, 2014). Such cross-country studies are useful for testing the determinants of the surge in average reserve levels in emerging countries or assessing reserve adequacy of an individual economy relative to the average country experience. Howver, this approach is of dubious value for investigating how a particular factor such as mercantilism explains reserve hoarding in a peculiar country such as China, which substantially differs from the average emerging economy in terms of economic size, export performance, and the extent of reserve accumulation. This motivates an in-depth case study of China's surge in reserves.

Analyzing the importance of mercantilist motives as a determinant of reserve hoarding is greatly complicated by the fact that, theoretically, reserve accumulation in combination with RER undervaluation is consistent with both precautionary and mercantilist motives. There are two ways to deal with this problem. The first is to define arbitrarily any reserve accumulation associated with RER undervaluation as mercantilist. Previous studies unanimously use this approach. However, entirely ruling out precautionary motives of reserve accumulation in the context of real undervaluation would naturally tend to substantially overstate the relevance of mercantilism as a determinant of the surge in China's

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[1] Sudden Stop refers to the situation of a sudden downturn in capital inflows (Calvo, 1998).

[2] Paul Krugman (14 March, 2010), "Taking on China", *New York Times*, http://www.nytimes.com/2010/03/15/opinion/15krugman.html, April 29.

Figure 1: Stock of foreign exchange reserves, 1990-2011.
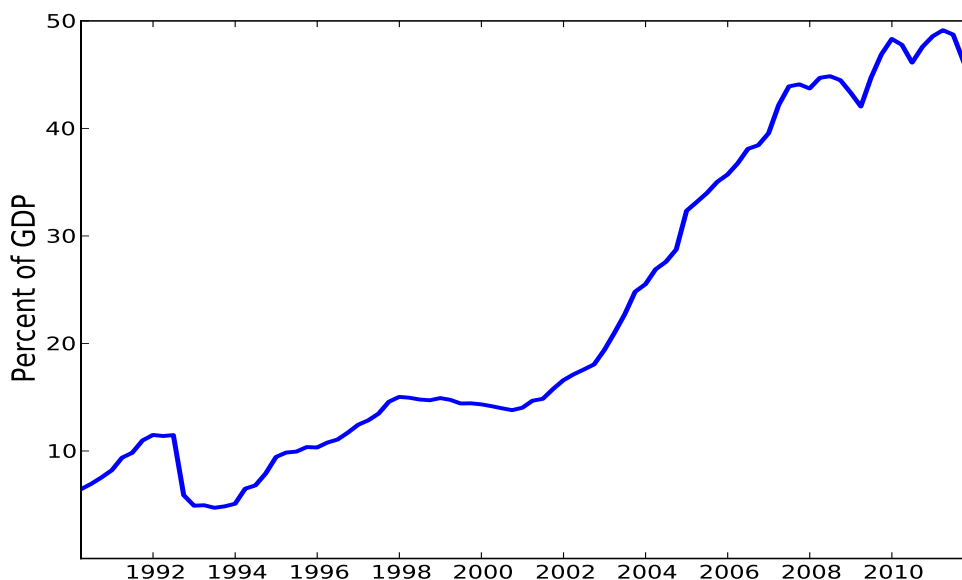
foreign exchange reserves, especially in light of the general perception that China has undergone a long period of sustained real undervaluation.

The second option is to follow a two-stage approach: the first step assesses China's level of reserves needed for precautionary purposes. The second calculates the cumulative contribution of mercantilism to the hoarding of reserves by defining reserve accumulation in relation to RER undervaluation as mercantilist only if reserve holdings are in excess of precautionary needs. A caveat of this method is the implicit assumption that precautionary and mercantilist motives do not overlap, which could lead to overemphasizing the former over the latter. Since there is no obvious advantage between the two approaches I adopt both with the objective of testing the sensitivity of the estimation results of favoring one definition of mercantilist reserve accumulation over the other.

I initially follow the two-stage procedure. I determine China's level of reserves needed for precautionary purposes on the basis of the IMF's (2011) new reserve adequacy measure, which specifies optimal reserve holdings to depend on the stocks of external short-term debt (12 months maturity or less), portfolio equity liabilities, broad money (M2), and exports of goods and services. Since it is broader in scope the, IMF (2011) measure is preferable to the existing "traditional" ones such as the 3-months import cover rule, 5-20 percent of broad money (M2), or the "Guidotti-Greenspan" rule.[3] The IMF con-

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[3]The Guidotti-Greenspan rule recommends that reserve holdings should be the equivalent to the stock of external short-term debt, where short-term refers to a maturity of 12 months or less.

siders reserve holdings in the range of 100-150 percent of its reserve adequacy measure to be adequate. In this paper, I use both bounds as cut-off points in determining reserve excessiveness for two reasons. The first is to take into account the uncertainty in assessing optimal precautionary reserve levels. The second and more important one is to minimize the danger of underestimating the mercantilist motive as a determinant of China's reserve build-up by selecting too generous a threshold of precautionary reserve needs. The analysis focuses on the period after the Asian Financial Crisis using quarterly data covering 1998Q4-2011Q4. The IMF (2011) measure suggests that reserves crossed the 100 and 150 percent limit in 2002Q4 and 2005Q1, respectively.

This study uses two approaches to calculate the cumulative contribution of RER undervaluation to reserve hoarding: (1) "Back-of-the-envelope" calculations based on the available estimates of the price elasticity of import and export demand and (2) estimating a reserve demand model which explicitly takes into account the effect of real undervaluation on reserve accumulation. Both methods yield virtually the same results. To estimate RER misalignment I use the single-equation methodology (Edwards, 1989; Elbadawi, 1994; Baffes et al., 1999), which, after carefully weighing the relative merits of various approaches to measuring equilibrium real exchange rates (ERERs), I argue to be the most preferable one. My estimates suggest that China's RER underwent an undervaluation episode from 2002Q2-2008Q2, which almost perfectly coincides with the period during which reserve accumulation was the fastest (see Figure 1). In addition, the start date of the real undervaluation episode is only two quarters before reserves cross the IMF (2011) measure's 100 percent benchmark in 2002Q4. This suggests that the distinction between the two above approaches to measuring the quantitative importance of mercantilist policies is immaterial in the particular case of China. Finally, my RER misalignment estimates are similar to previous ones such as those of Qin and He (2011) or Gan et al. (2013) and more generally consistent with the broad consensus that the renminbi has been undervalued during most of the 2000s (Cline and Williamson, 2007).

The main results suggest that mercantilist motives contributed between US$ 200-300 billion (or less than 10 percent) to reserve accumulation in China. The exact number depends on whether reserves are deemed excessive from 2002Q4 or 2005Q1 onwards. Even when taking into account the uncertainty surrounding the estimation of the reserve demand model, the upper bound estimate still does not significantly exceed US$ 500 billion. My estimates translate into 3-7 percent of GDP and are therefore similar to the 4.5 percent of GDP figure of Ghosh et al. (2014), which further corroborates that for China, both approaches to estimating mercantilism's contribution to reserve accumulation generate similar results.[4] Nonetheless, while the above numbers are large, the central message of this paper is that they are too small to fully account for China's hoarding of reserves. The IMF's (2011) reserve adequacy measure would still indicate excessiveness, even in the absence of mercantilist motives. This means that precautionary motives and other factors seem to be the dominant determinants of the surge in China's foreign exchange reserves.

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[4]The study of Ghosh et al. (2014) is the only preivous one that provides a China-specific estimate of mercantilism's importance in the surge in foreign exchange reserves.

The rest of the paper is organized as follows. Section 2 reviews the precautionary and mercantilist motives for reserve demand and how both are related to the real exchange rate. Section 3 assesses China's reserve adequacy levels for precautionary purposes, estimates RER misalignment, and then proceeds to undertake the "back-of-the-envelope" calculations. Section 4 estimates a reserve demand model for China on the basis of which I compute the cumulative contribution of mercantilism to reserve accumulation. The last section concludes.

2   Reserve accumulation and the real exchange rate

This section discusses the interplay between the current account, the real exchange rate (RER), and international reserves accumulation. It reviews the mercantilist and the precautionary motive of reserve hoarding and shows that both are consistent with RER undervaluation.

In a series of influential papers, Dooley et al. (2004, 2005) argue that the governments of East Asian countries, and China in particular, have the objective of absorbing unskilled surplus labor in the modern manufacturing sector, while simultaneously building the domestic capital stock along the way. To achieve those goals these countries follow mercantilist policies in that they deliberately undervalue their RERs to support export-led growth.

In this international system, which Dooley et al. (2004) refer to as "Bretton Woods II", the authorities fix the nominal exchange rate to the US dollar such that the RER is undervalued relative to its equilibrium value. In the absence of intervention, the usual adjustment process would be that the excess supply of foreign exchange, (triggered not only by the increase in exports but potentially also by additional net capital inflows), generates appreciation pressure on the nominal exchange rate. Yet the authorities can interfere with the latter process through reserve accumulation and by imposing capital controls, thereby resisting appreciation of the nominal exchange rate. In addition, since international reserves add to the monetary base, the resulting inflationary effect needs to be sterilized by selling bonds domestically. Therefore, another important ingredient of the policy mix is financial repression, which keeps the fiscal costs of sterilization manageable. As a result, China displays large current account surpluses, rapid international reserve accumulation, and an undervalued RER.

However, reserve accumulation need not necessarily be the outcome of mercantilist policies. A country may increase the stock of international reserves as a precautionary measure to face a sudden exodus of volatile capital triggered by various external shocks such as a currency crisis. Indeed, the string of financial crises in the 1990s has brought the issue of costly sudden exodus into the spotlight (Radelet and Sachs, 1998; Calvo, 1998). Indonesia's output for instance contracted by 15 percent of GDP during the Asian Financial Crisis of 1997/98. There is empirical evidence that emerging countries, especially those in East Asia, have begun to stockpile international reserves based on the bitter lessons of the 1997/98 financial crisis to insure themselves against both current and capital account shocks (Aizenman and Marion, 2003; Aizenman and Lee, 2007; Obstfeld et al., 2010; Ghosh et al., 2012, 2014).

If a country decides to accumulate international reserves for precautionary purposes, undervalu-

ation in the RER could well be an unintended side effect. In theory, an improvement in the net foreign asset position, brought about by foreign reserve purchases, usually appreciates the equilibrium real exchange rate (ERER). Reserve accumulation is thus associated with real undervaluation. Durdu et al. (2009) formalize the latter notion in their model in which emerging economies go through sustained episodes of reserve accumulation in the face of financial globalization and Sudden Stop risk. In their framework, these periods are characterized by persistent current account surpluses and real undervaluation. The authors note that:

"[T]he current account surplus and undervalued real exchange rate are by-products of the buildup of precautionary savings in the aftermath of Sudden Stops, or following financial globalization. They do not require intentional exchange rate management by central banks." (Durdu et al., 2009, p.207).

Reserve accumulation in combination with RER undervaluation is not mercantilist in this case since the authorities' underlying objective is not to boost exports via the RER.[5] In addition, mercantilist policies are defined as the deliberate undervaluing of the RER. In contrast, real undervaluation in the context of precautionary reserve accumulation is an unintended consequence of which the authorities may or may not be aware.

A number of studies attempt to analyze empirically whether reserve accumulation in emerging economies is dominated by the precautionary or mercantilist motive (Aizenman and Lee, 2007; Delatte and Fouquau, 2012; Ghosh et al., 2012, 2014). The approach of these papers is to estimate reserve demand for a large number of countries as a function of indicators of current and capital account shocks. The demand function also includes some estimate of RER undervaluation as a measure for mercantilist motives. If there is a positive association between reserve accumulation and the extent of real undervaluation, then this is taken as suggestive evidence of deliberate foreign exchange market intervention to keep the RER undervalued as part of a mercantilist growth strategy (Aizenman and Lee, 2007; Delatte and Fouquau, 2012; Ghosh et al., 2012, 2014). Yet the latter inference is only correct if we are willing to assume that reserve accumulation in combination with an undervalued RER is always mercantilist and never precautionary. This is an overly restrictive assumption, which may bias the results towards giving mercantilism as a determinant of the surge in China's foreign exchange reserves too much importance. This concern is especially relevant in China's case, given the widespread view that the country's RER has been persistently undervalued.

Another approach to analyzing the role of mercantilism in China's reserve build-up is to follow a two-stage procedure: the first step assesses China's level of reserves needed for precautionary purposes. The second calculates the cumulative contribution of mercantilist motives by defining reserve accumulation in relation to RER undervaluation as mercantilist only if reserve holdings are in excess of precautionary needs. A major problem with this method is the implicit assumption that precautionary and mercantilist motives are never simultaneously at play. This does not seem to be realistic and may result in overemphasizing the precautionary motive.

Without knowing the Chinese authorities' true motivations for accumulating reserves, neither of

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[5]Ghosh et al. (2014) note that this might be a possibility but they do not further investigate the issue.

the two approaches dominates the other.[6] For lack of a better choice, in this paper I use both approaches with the intention to examine the sensitivity of the estimation results to choosing one definition of mercantilism over the other. I first follow the two-stage procedure.

3   Reserve adequacy

This section assesses China's level of reserves needed for precautionary motives. There are several measures of reserve adequacy. A widely used rule-of-thumb for optimal reserve holdings says that the latter should be equivalent to the value of three months of imports. However, this metric does not incorporate a country's exposure to volatile capital flows and seems therefore inappropriate for assessing reserve adequacy during an era of financial globalization (Athukorala and Warr, 2002).[7]

The "Guidotti-Greenspan" rule (GGR) recommends that reserves should not fall below the amount of external short-term debt, where short-term debt is defined as all obligations maturing within 12 months. The idea behind this is that emerging countries should hold enough reserve coverage to withstand a Sudden Stop of short-term capital. In light of its focus on Sudden Stop risk, GGR seems a more appropriate measure of reserve adequacy than the three-months import cover rule. Nonetheless, since China is becoming ever more financially integrated with the rest of the world, an important caveat of GGR is that in its assessment it leaves out other "mobile capital" such as portfolio equity liabilities (Athukorala and Warr, 2002). [8] Finally, the IMF (2011) notes that the 12 month benchmark of GGR is *ad hoc* since the duration of a crisis or a Sudden Stop of short-term capital may both last significantly longer or less than 12 months. In any case, notice that reserves in China have historically surpassed the short-term debt stock several-fold, even in the 1980s (Figure not shown). This suggests that Chinese authorities have not given short-term debt holdings much emphasis in assessing reserve adequacy.

The reserve adequacy measures discussed so far ignore the possibility that during a crisis foreigners who had invested in financial assets in the country, along with domestic deposit holders who look for a "safe haven", are putting pressure on foreign exchange reserves (Obstfeld et al., 2010). The third conventional measure builds on this latter idea by recommending to central banks that they should hold reserves to the equivalent of 5-20 percent of broad money (M2).

The major shortcomings of the reserve adequacy measures is that they are arbitrary and based on only one particular source of balance of payment pressure. This motivated the IMF (2011) to develop a new measure of reserve adequacy that is based on previous experiences of emerging countries during crisis episodes. It identifes four factors that capture various sources of risk for balance of payments

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[6]From a Chinese point of view, the concerns associated with nominal exchange rate revaluation are a significant loss in employment in export-linked industries and an increase in speculative capital flows (Gang, 2008). Notice that these concerns do not directly imply a mercantilist motive of reserve accumulation. Pursuing export-led growth and employment creation in the tradable sector does not require an undervaluation in the RER, as highlighted by Williamson (1990).

[7]The import coverage rule dates back to the time of Bretton Woods when a loss of trade credit for three-months was perceived to be the worst possible current account shock (Athukorala, 2014).

[8]Similarly when it comes to the rule-of-thumb that reserve holdings should be equivalent to three months worth of imports.

pressures, which are a combination of the ones discussed above: (1) a loss in export earnings due to an adverse terms of trade shock, (2) short-term debt (12 months maturity), (3) medium and long-term debt and portfolio equity liabilities, and (4) broad money (M2). For countries with a fixed exchange rate regime such as China, the IMF (2011) proposes the following rule-of-thumb metric for adequate international reserve holdings at time t:

$$R_t^* = 0.3\,STD_t + 0.15PDL_t + 0.1M2_t + 0.1X_t. \tag{1}$$

In this equation, the weights are based on the 10th percentile of respective outflows during balance of payment pressure events (IMF, 2011). The definitions of the variables are as follows:

- R*: adequate stock of foreign exchange reserves by the precautionary motive,

- STD: the stock of short-term debt (12 months maturity or less),

- PDL: gross portfolio equity liabilities, and

- X: exports of goods and services (over 12 months).

Based on the above measure, I construct a reserve adequacy index (RAI). The RAI is defined as as the ratio of actual reserves (R) to the adequate stock of reserves needed for precautionary reasons (R*):

$$RAI_t = \frac{R_t}{R_t^*}100\%. \tag{2}$$

To assess the level of reserves needed for precautionary purposes, my analysis relies solely on the RAI rather than the other discussed reserve adequacy measures.

Since R* is a "round number" there is considerable scope when assessing reserve adequacy. The IMF (2011) considers values for the RAI_t within the range 100-150 percent as optimal. In this paper I consider both bounds as reserve adequacy thresholds, to take into account the uncertainty in determining the optimal level of reserve holdings needed for precautionary purposes. More importantly, the practice of also using the lower limit of 100 percent substantially reduces the probability of underestimating mercantilism's contribution to reserve accumulation. This will therefore result in an upper and lower bound estimate of mercantilism's contribution to reserve accumulation.

3.1 Data

The data on international reserve holdings, broad money (M2), and the value of both imports and exports come from the IMF's International Financial Statistics (IFS) data base. Each of these time series is measured at quarterly frequency. I source the data on portfolio equity liability from the External Wealth of Nations mark II (EWNII) database developed by Lane and Milesi-Ferretti (2007). Observations on the stock of short-term external debt (12 months maturity or less) come from the World Bank's

Figure 2: Reserve adequacy index (RAI), 1998Q4-2011Q4.
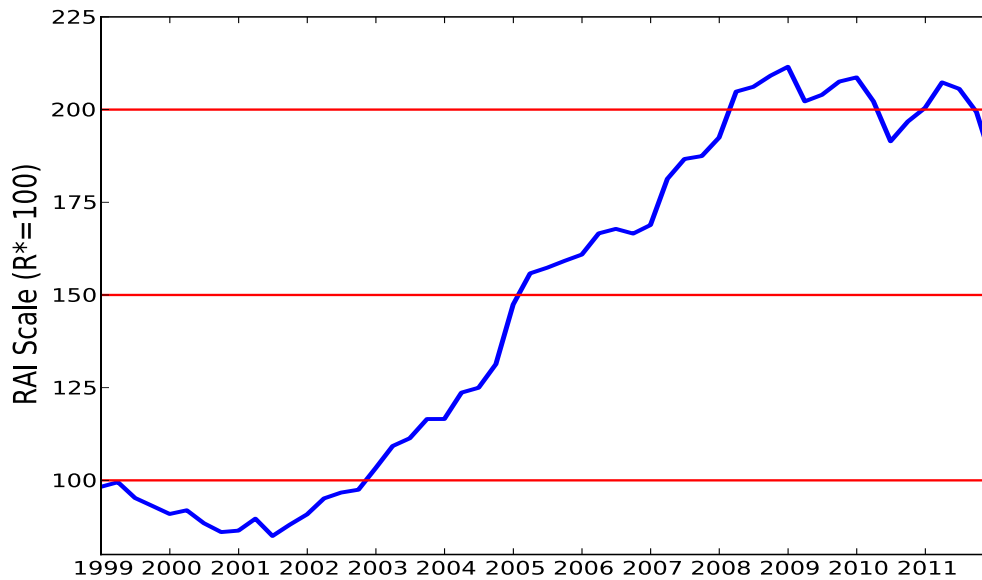
International Debt Statistics databank. To transform the data series of short-term debt and portfolio equity liabilities from annual to quarterly frequency I use the cubic spline interpolation method.

Each of the above series are measured in current US dollars, except M2, which is expressed in renminbi (RMB). Therefore, M2 is converted into US dollars using the period-average (at quarterly frequency) nominal exchange rate (RMB per US dollar), which is also sourced from the IFS. Finally, all the time series are normalized by GDP. The latter is also sourced from the IFS and only available at annual frequency, and therefore the GDP series also needed to be interpolated before normalizing.

The sample period is dictated by data availability of M2 at quarterly frequency, which only starts in 1998Q4. This is not a caveat, however, since the focus of this paper is on China's reserve build-up post the Asian Financial Crisis in 1997. Since the EWNII database ends in 2011 the end of the sample period is 2011Q4.

3.2 Evolution of the reserve adequacy index

Figure 2 plots the RAI over the sample period (1998Q4-2011Q4). An RAI of below 100 percent indicates a reserve inadequacy based on precautionary needs, adequacy within the range 100-150 percent, and excessiveness beyond this range (IMF, 2011). To better highlight these cut-off points, Figure 2 adds horizontal lines at 100, 150, and 200 percent.

In the period after the Asian Financial Crisis, the index has never been significantly below 100 percent, with the sole exception of when it was 85 percent in 2001Q2. From then, the RAI increased sharply between 2002 and 2008, the years when Chinese reserve accumulation was the fastest (see Figure 1). Reserve levels exceeded the 100 percent mark in 2002Q4 and the 150 percent threshold in the first quarter of 2005. Between 2008Q1 and 2011Q4 the index stabilized at around 200 percent, despite the accumulation of a staggering US\$ 1.5 trillion in reserves during that period. Thus, solely using the RAI conceals the astounding magnitudes involved in this analysis. For instance, in 2011Q4, the RAI at 100 and 150 percent translates into US\$ 1.7 and US\$ 2.6 trillion, respectively.

In terms of assessing reserve adequacy, the RAI suggests that China's reserves were slightly below the level needed for precautionary purposes up until the end of 2002. Reserves were then within the "adequacy range" between 2002Q4 and 2004Q4. They became excessive by 2005Q1 at the latest.[9] Consequently, the cut-off dates for indicating reserve excessiveness are both 2002Q4 and 2005Q1.

3.3 Estimating RER misalignment

The next step in assessing the importance of the mercantilist motive is to quantify how much real undervaluation has contributed to reserve accumulation during the quarters in which reserves are judged excessive by the RAI.[10] Since RER undervaluation is unobserved it needs to be estimated. However, obtaining reliable RER misalignment estimates is a nontrivial task in the process.

There is a large variety of methods for estimating RER distortions: purchasing power parity adjusted for the Balassa-Samuelson effect (PPP-A); the single equation approach (SEA) using individual-country or panel data; and the macroeconomic balance (MB) methodology. Cline and Williamson (2007) review 18 recent papers that estimate the ERER for China and conclude that the RER misalignment results are highly sensitive to the method used.

None of the approaches is strictly preferable over the other. Each method has its advantages and disadvantages, but for some the latter dominate. The problem with the PPP-A and MB approaches is that they often do not generate consistent misalignment estimates across different papers. Cheung (2012), for instance, shows that PPP-A distortion estimates are sensitive to revisions in China's output and national price level data to the extent that, when also controlling for serial correlation, the previously 2004 undervaluation estimate of 53 percent turns into a 13 percent overvaluation.

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[9] Figure A.1 in the Appendix plots the Guidotti-Greenspan rule and 20 percent of M2 (20M2) together with the stock of international reserves (each expressed as GDP ratios). From the figure it is immediately noticeable that Chinese reserve holdings grossly exceed the stock of short-term external debt by several multiples, as mentioned earlier. 20M2 consistently exceeded the stock of international reserves up until the end of 2004. Reserve holdings surpass 20M2 in 2005Q1, which is the same date when RAI exceeds the 150 percent mark. This thus suggests that the chosen cut-off dates are not sensitive to using the RAI.

[10] Notice that it would not be appropriate to define the quantity of foreign exchange market intervention as the difference between actual and adequate reserve holdings (R-R*) and interpret the resulting number as indicative of the mercantilist motive. Even though the authorities keep the RMB-value to the US dollar fixed through foreign exchange market interventions, this does not necessarily imply that the RER is undervalued (cf. Corden (2009) in a different but similar context). There are other factors, mostly exogenous to the policy makers' influence, which contribute to reserve accumulation.

In addition, the misalignment literature typically follows Nurkse (1945) and defines the ERER as the value of the RER, which leads to external and internal balances, given all relevant variables at their sustainable values. Consequently, Cline and Williamson (2007) question the usefulness of the PPP-A approach as an equilibrium exchange rate concept since a number of historical examples show that RER deviations from the PPP-A equilibrium may coincide with external and internal balances.

The greatest strength of the MB methodology is how well it incorporates the concepts of internal and external equilibriums. But on balance, the MB framework is very limited due to its sensitivity.[11] The MB approach uses a two step procedure to determine the ERER. The first step specifies a current account "norm", either in an *ad hoc* fashion, or empirically estimated as a function of a set of macroeconomic fundamentals. The second step uses trade elasticities to calculate RER misalignment as the depreciation or revaluation required to close the gap between the actual and "norm" current account. The fundamental problem of the MB approach, especially in the context of China, is that there is no consensus on either the current account norm or the trade elasticities. Schnatz (2011) shows that even small changes in either the current account norm or trade elasticities can substantially affect the RER distortion estimates.

The single-equation methodology also includes the cornerstones of external and internal balances but, unlike the MB approach, does not require intermediate estimation steps, and this decreases the sensitivity of the misalignment results substantially. Indeed, Qin and He (2011), Peng et al. (2008), and Gan et al. (2013) estimate RER misalignment for China and their results are similar, despite differences in data sources, estimation methods, and sample periods. However, the single-equation approach is flawed when pooled panel regressions are used to estimate ERERs because by doing so the implicit assumption is homogeneity in cross-country long-run RER behavior, and this is incompatible with the theory of RER misalignment (Schröder, 2013). Therefore, in what follows, I estimate the ERER for China individually.[12] I discuss potential caveats along the way.

The starting point of the single-equation approach is Nurkse's (1945) definition, which suggests that the ERER is determined by a set of macroeconomic fundamentals. Following Edwards (1989), Montiel (1999), and Faruqee (1995) the ERER depends on the following variables:

$$ERER = ERER(\underset{(+/-)}{TOT}, \underset{(+)}{\phi}, \underset{(-)}{\zeta}, \underset{(-)}{G_N}, \underset{(+)}{G_T}, \underset{(+/-)}{I}, \underset{(+/-)}{NFA}), \tag{3}$$

where TOT refers to the terms of trade, ϕ is a measure of trade policy, ζ captures productivity differentials (Balassa-Samuelson-effect), G_N and G_T are government consumption on nontradables and tradables, I refers to investment, and NFA to the net foreign asset position. The signs of the partial derivatives appear below.

According to the single equation approach, in a first step, the long-run equilibrium relationship between the ERER and its fundamentals is estimated using the empirical equivalent of the equation

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[11] For a detailed discussion about the limitations of the MB approach, see Schnatz (2011).
[12] The estimation procedure is very similar to the one in Schröder (2013).

above:

$$ln\, RER_t = \beta' F_t + \nu_t, \qquad (4)$$

where F is the vector of the set of fundamentals, β describes the long-run relationship between RER and the fundamentals, and ν_t is a stationary mean zero error term.

The second step requires the computation of sustainable values of those fundamentals that form a long-run relationship with the actual RER in order to calculate the ERER:

$$ln\, ERER_t = \beta' F_t^S, \qquad (5)$$

where superscript S indicate the fundamentals at their sustainable values.

In a third and final step the degree of misalignment (mis_t) is calculated:

$$mis_t = \frac{RER_t - ERER_t}{RER_t}, \qquad (6)$$

where positive values of mis_t indicates overvaluation in RER.

Data   Observations on RER come from the IFS. The IMF measures the RER as $RER = P_N / E\, P_T$, where P_N, P_T, and E refer to the price of nontradables, tradables, and the nominal exchange rate, respectively. This means that appreciation is associated with an increase in RER. Due to data constraints, the ERER needs to be estimated using annual data so that cubic spline interpolation methods are required to obtain observations of the ERER at quarterly frequency. Quarterly data on RER are, however, available in the IFS database.

The sample period is entirely determined by Lane and Milesi-Ferretti's (2007) EWNII database. Observations on China's net foreign asset position are available over the thirty year period 1981-2011. Investment (as a ratio to GDP) and the terms of trade I source from the World Development Indicators (WDI). There are no observations on the other fundamentals so proxies have to be used. Trade openness I proxy by the ratio of total trade (exports plus imports) to GDP, all sourced from the WDI. The Balassa-Samuelson-effect I proxy with the ratio of China's GDP per capita to the OECD average GDP per capita. Finally, I use total government consumption as a proxy for G_N in Eq. 3 under the assumption that government expenditures disproportionately fall on nontradable goods (Edwards, 1989).

Estimation method   Most macroeconomic series are nonstationary in levels and require at least one differencing operation to produce a stationary process, i.e. they are integrated of order d (I(d), $d > 0$). The possible presence of I(d) variables on both sides may introduce the problem of a spurious regression (Granger and Newbold, 1974). Therefore, I first determine the order of integration of the RER and the fundamentals using Augmented Dickey-Fuller (ADF) tests. The test results for the variables in levels and first difference are reported in Table 1. For each of the fundamentals, the null hypothesis that the series contains a unit root can never be rejected at conventional levels. The RER is also treated

Table 1: RER fundamentals: Unit root tests.

Panel A: Variables in levels			
	Test Eq. Includes	Test Statistic	P-Value
Real Exchange Rate (RER)	Constant	-2.8	0.07
Terms of Trade (TOT)	None	-1.6	0.10
Trade Openness (OPEN)	Constant & Trend	-3.1	0.13
Productivity of Tradable Production (PROD)	Constant	5.7	1.00
Government Consumption (GEXP)	Constant	-2.2	0.22
Net Foreign Asset Position (NFA)	Constant	0.0	0.68
Investment (INV)	None	1.2	0.94

Panel B: Variables in first differences			
	Test Eq. Includes	Test Statistic	P-Value
Real Exchange Rate (RER)	None	-4.1	0.00
Terms of Trade (TOT)	None	-5.1	0.00
Trade Openness (OPEN)	None	-4.0	0.00
Productivity of Tradable Production (PROD)	None	2.6	1.00
Government Consumption (GEXP)	None	-4.6	0.00
Net Foreign Asset Position (NFA)	None	-3.8	0.00
Investment (INV)	None	-4.6	0.00

Notes: This table reports the ADF-test statistic under the null hypothesis that the series is nonstationary. Sample period: 1981-2011.

as nonstationary, even though the null can be rejected at the 10 percent level. The first differences of all variables are stationary, except for the proxy for productivity growth of tradable production (PROD, measured as the ratio of China's GDP per capita to the OECD average GDP per capita). Therefore, PROD is treated as I(2). I use first differences of this proxy in a regression setting.

The next task is to estimate β, the parameters describing the long-run relationship between the RER and fundamentals. My preferred estimation method is the dynamic OLS (DOLS) estimator (Phillips and Loretan, 1991; Saikkonen, 1991; Stock and Watson, 1993), which is an augmentation of the static OLS estimator with leads and lags of first differenced independent nonstationary variables. The optimal number of leads and lags are best chosen such that the information criteria are minimized (Kejriwal and Perron, 2008). In the estimation of the cointegrating regression there is no asymptotic bias arising from simultaneous equations or measurement error (Phillips and Durlauf, 1986). Another important feature is that DOLS performs well in small samples (Stock and Watson, 1993; Montalvo, 1995).

Augmenting Eq. 4 with m_1 leads and m_2 yields:

$$ln\,RER_t = \beta' F_t + \sum_{s=-m_2}^{s=m_1} \gamma_s' \Delta F_{t+s} + \nu_t, \qquad (7)$$

where vector F contains the fundamentals.

Finally, I test for cointegration and stability of the estimated long-run parameters using the ADF-

cointegration test for the former and the L_c-test as developed by Hansen (1992) for the latter. A substantial problem when it comes to estimating the ERER is that it is not unusual to find various subsets of fundamentals explaining long-run RER behavior. Since theory offers little guidance on this issue, for lack of better alternatives, I use a selection algorithm that is similar to those used in Montiel's(2007) and Schröder's(2013) studies. In particular, I choose the specification which includes the largest number of fundamentals. Additional requirements are that the variables are cointegrated, the estimated parameters stable, and the signs of the coefficients attached to the fundamentals should be consistent with theory as shown in Eq. 3.

Following this procedure, the estimated long-run equilibrium relationship is:

$$ln\,RER_t = \underset{(0.005)}{0.05}\,NFA + \underset{(0.01)}{0.40}\,GEXP - \underset{(0.003)}{0.03}\,OPEN, \tag{8}$$

$$\text{Observations: } 30 \quad \text{ADF (p-value): } 0.00 \quad L_c : 0.55.$$

An improvement in the NFA is associated with ERER appreciation, consistent with Eq. 3 and the discussion in Section 2. The other fundamentals that matter for ERER determination over the long run in the Chinese case are government consumption and trade openness. An increase in government consumption appreciates the ERER, whereas greater trade openness (proxied as total trade over GDP) leads to ERER depreciation; this is consistent with the underlying theory of ERER determination. Finally, ADF and L_c tests suggest that the requirements of cointegration and parameter stability are satisfied.

To derive sustainable values of the fundamentals I use the Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1997), setting the smoothing parameter at $\lambda = 100$. The HP-filter decomposes a series into trend and cyclical components. Since the three fundamentals (NFA, GEXP, and OPEN) that describe China's long-run RER movements are nonstationary, movements in their respective trend components are permanent and therefore used to calculate the ERER given by $\hat{\beta}' F_t^S$.

Results   Figure 3 plots the RER misalignment estimates over the sample period 1998Q4-2011Q4. In the late 1990s the RER was overvalued by about 10 percent, and subsequently hovered around its equilibrium value until the beginning of 2002, before entering a long episode of undervaluation in 2002Q2. The degree of undervaluation was increasing at first and culminated in the first quarter of 2005 at 16.5 percent. From then onwards the RER slowly reverted back to equilibrium. 2008Q2 marks the end of the undervaluation episode, which suggests that mercantilist motives of reserve hoarding only played a role until then. Interestingly, my estimates suggest that the start and end dates of the RER undervaluation and reserve accumulation episodes coincide almost perfectly (cf. Figures 1 and 2).

Of great importance for this study is the finding that the real undervaluation episode only starts two quarters before the RAI crosses the 100 percent threshold in 2002Q4. This suggests that the two earlier discussed approaches to measuring the contribution of mercantilist motives to reserve accumulation generate very similar results in China's particular case.[13] This finding therefore alleviates the concern

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[13]For convenience, in the following analysis I disregard any effect on reserve accumulation that stems from RER underval-

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Figure 3: RER misalignment, 1998Q4-2011Q4.
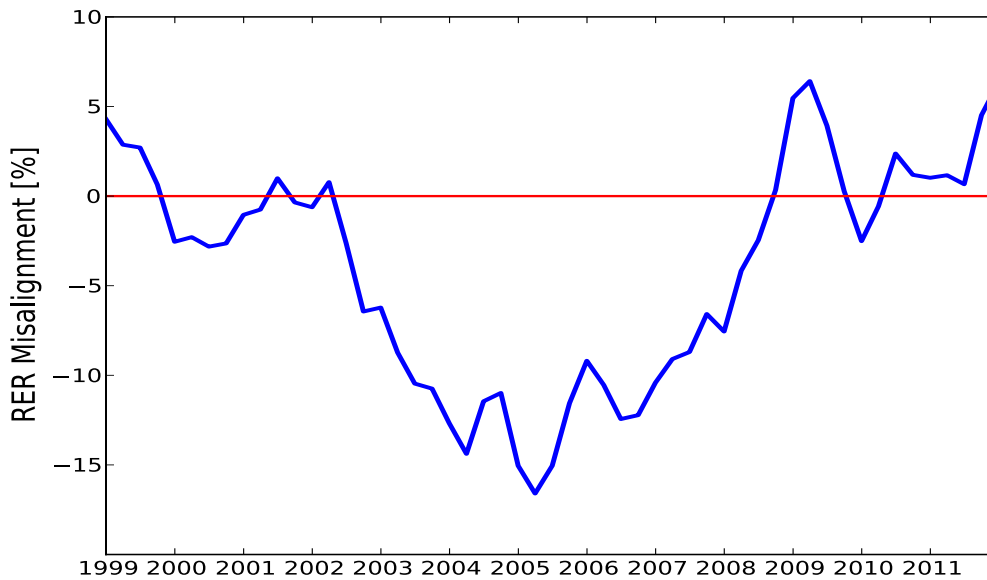
Note: Positive (negative) values refer to RER overvaluation (undervaluation).

that favoring one approach over the other may result in misleading inferences regarding the relative importance of mercantilist versus precautionary motives of reserve accumulation.

It is worthwhile investigating the driving forces behind the misalignment estimates. Figure 4 plots the ERER together with the actual RER at quarterly frequency over 1990-2011. The ERER appreciated slowly from the mid 1990s until 2000, but has remained virtually unchanged since then. Figure 5 plots the ERER fundamentals: NFA, government consumption, and trade openness at sustainable values. Since the mid 1990s there has been a steady improvement in the NFA. Since 2000, the associated ERER appreciation with the latter development is, however, entirely counteracted by China's move towards greater trade openness and the decline in government consumption. It is thus highly misleading to infer a large RMB undervaluation on the basis of China's rapid accumulation of foreign assets alone. The undervaluation episode was thus the result of the RER depreciation between 2002 and 2005, which was due to the US dollar losing its value relative to the currencies of China's trading partners, in particular the Euro. Between 2005 and 2009, China's RER appreciated by 28 percent due to a combination of RMB appreciation vis-à-vis the US dollar and a surge in the inflation rate, which eventually brought the real undervaluation episode to an end.

Finally, these estimates of RER misalignment are similar to those reported in a number of other

uation during the two quarters before 2002Q4. This decision does, however, not affect any of the results in this paper since the RER was only marginally undervalued at the beginning of the episode.

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Figure 4: RER and ERER, 1990Q1-2011Q4.
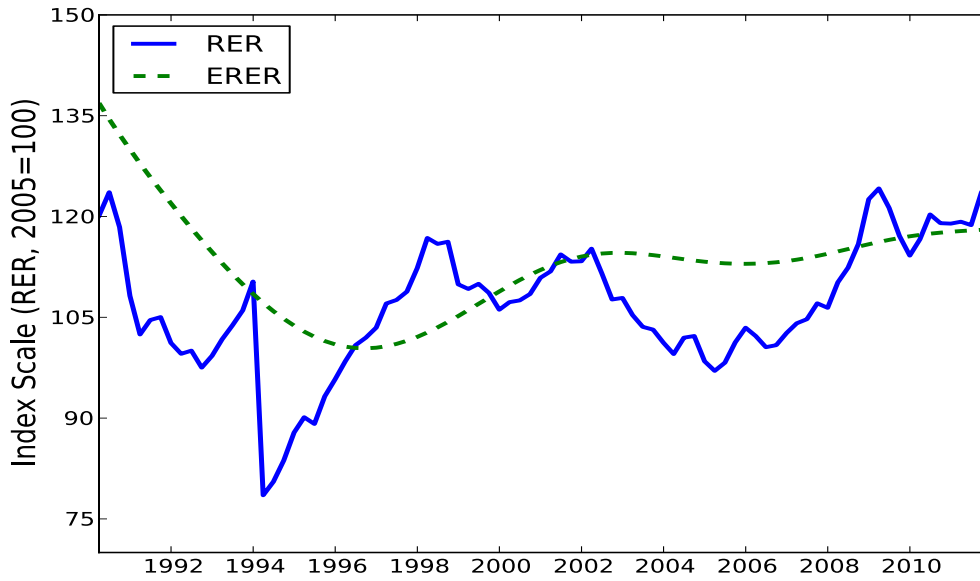
Note: An increase in RER and ERER indicates appreciation. Therefore, ERER>RER denotes real undervaluation.

studies based on the single-equation approach (Gan et al., 2013; Peng et al., 2008; Qin and He, 2011; Schröder, 2013).[14]

Discussion   The ERER estimates reported here are open to criticism. For instance, Cline and Williamson (2007) raise the important point that continuous policy interventions might bias the single-country misalignment estimates. If there is foreign exchange market intervention to prevent the nominal exchange rate from appreciating, as suspected in China's case, the theorized effect of the resulting accumulation in reserves is RER undervaluation. However, a regression of the actual RER on the net foreign asset position would not properly pick up the latter described mechanism. The concern thus is that the RER misalignment estimates are biased towards the equilibrium level during undervaluation episodes.

How serious is this problem in the present case? Notice that the coefficient attached to the net foreign asset position is significant, and of the expected sign in the sense that an improvement in China's external position appreciates the ERER (cf. Eq. 8). This suggests that China has not intervened over the entire sample period. But the question remains whether the coefficient on the net foreign asset position is significantly smaller in magnitude than it should be. Even though knowing the counterfactual is impossible, we can still compare the reaction of China's RER to an improvement in the net external position to the average cross-country experience.

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[14]The sample periods of those studies do not go beyond 2007.

Figure 5: ERER fundamentals (sustainable values), 1990-2011.
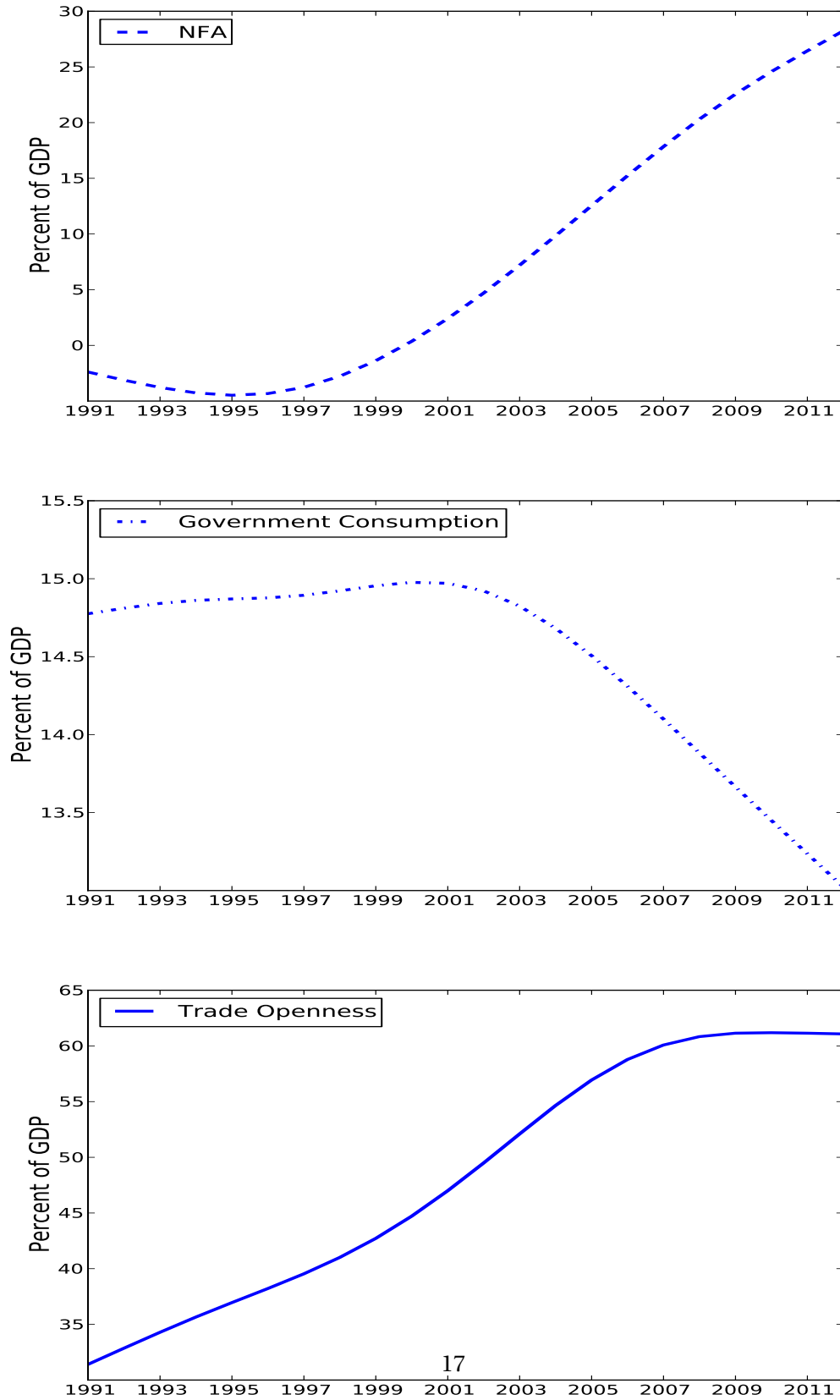
Note: The sustainable values of the fundamentals are derived using the Hodrick and Prescott (1997) (HP) filter.

Schröder (2013) estimates RER distortions for 63 developing countries on a country-by-country basis. Surprisingly, the results of his study suggest that the appreciating effect of an improvement in net external indebtedness is strongest in China. Finally, the misalignment estimates of Gan et al. (2013) are similar to those in the present study even though the authors exclude the net external position from the set of ERER fundamentals.[15] In conclusion, the impact of the net foreign asset position on China's RER does not appear to be systematically underestimated here. Of course, the possibility of biased estimates cannot be ruled out entirely.

3.4 Back-of-the-envelope calculations

To examine the role of mercantilism in China's reserve build-up, as a first approximation, I undertake some simple back-of-the-envelope calculations. To keep the exercise as tractable as possible I impose the simplifying assumption that the RER influences reserve accumulation through the trade balance but not the capital account. As mentioned, there is no consensus on the exact trade elasticites for China. For this reason, I experiment with a variety of different export and import elasticities. In particular I consider the values in the set {0.3,0.5,0.7,1.0}, which are "conventional" ones for China (Cline and Williamson, 2007; Schnatz, 2011; Thorbecke, 2013; Xing, 2012). For convenience, I set the same value for the elasticity of exports and imports, respectively.[16] In addition, I follow Cline and Williamson (2007) and assume that half of China's imports are composed of re-exportable parts and components. For instance, assuming elasticities of 0.7, a 1 percent real appreciation reduces exports by 0.7 percent. The US dollar-value of final good imports increases by 0.7 percent, which is offset by a 0.7 percent reduction in the US dollar value of parts and components imports. Thus the net effect on the trade balance is the loss in exports.

As an example consider the first quarter of 2005, when total exports amounted to 7.8 percent of GDP, or US\$ 156 billion. The RER at that time was undervalued by 16.5 percent.[17] Assuming a revaluation of the same magnitude and trade elasticities of 0.7, exports in this case would fall by 0.9 percent of GDP. This translates into a reduction of about US\$ 22 billion in the trade balance or the accumulation of reserves. In the following, I consider trade elasticities in the set {0.3,0.5,0.7,1.0} and redo the illustrated calculation for every quarter during the RER undervaluation episode in which reserve holdings are deemed excessive on the basis of the RAI. Summing the obtained estimates then yields first approximations of how much mercantilism contributed to the reserve build-up in China.

Starting with the lower bound estimates, the first quarter for which the RAI suggests that reserves are excessive is Q1 in 2005. The last quarter of the undervaluation episode is Q2 in 2008, so 14 quarters

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[15]That is, Gan et al. (2013) condition on the steady-state value of the net external position. Thus their ERER estimate is for a longer time horizon than the one in this study (Montiel, 2007). This makes the similarity between the two misalignment estimates even more remarkable.

[16]Considering non-overlapping trade elasticities would generate little additional insight. Generally, the estimates are increasing in the magnitude of the export and import elasticities.

[17]Since an increase in RER denotes appreciation, "percent of undervaluation" equals "percent of revaluation" required to close the gap to the ERER.

in total. The estimate of mercantilism's contribution to reserve accumulation (as per the above calculations) is increasing in the value of the trade elasticities. For instance, for export and import elasticities of 0.3, the stock of reserves would be US\$ 119 billion lower in the hypothetical case of no RER undervaluation during 2005Q1-2008Q2. The estimate increases substantially to about US\$ 400 billion if, instead, we assume unitary trade elasticities. The results for the upper bound estimate are similar, even though in this case reserve excessiveness already began in 2002Q4. The cumulative trade surplus over the 23-quarter period that is attributable to RER undervaluation sums up to US\$ 156 billion and about US\$ 500 billion for trade elasticities of 0.3 and 1.0, respectively.[18]

These are big numbers by any standard, yet too small to account for China's rapid reserve accumulation. In fact, reserve holdings would still be deemed excessive by a large margin according to the RAI, even in the absence of mercantilist policies. To illustrate this point, Figure 6 plots the actual RAI and the respective hypothetical RAI in the absence of RER undervaluation since 2005Q1 for the various export and import elasticities. The dashed vertical line indicates the end of the real undervaluation episode in 2008Q2. Overall, Figure 6 suggests that mercantilism alone appears to be a poor candidate to explain China's rapid reserve accumulation during the 2000s. Irrespective of the particular trade elasticities assumed, the gap between the hypothetical RAIs and the reserve adequacy benchmark of 150 percent remains substantial, both in 2008Q2 and at the end of the sample period.

Figure 7 plots the actual RAI and the indexes that would prevail in the hypothetical case of no RER undervaluation since 2002Q4. The hypothetical RAIs never stay close to the 100 percent benchmark and also surpass the reserve adequacy threshold of 150 percent by the end of the sample period in 2011Q4, although reserves are not far off the adequacy range when assuming unitary export and import elasticities. Therefore, even in the extreme case of regarding all reserve accumulation in combination with real undervaluation as mercantilist, the point still stands that the surge in China's foreign exchange reserves cannot be explained by distortionary foreign exchange market interventions alone, unless the elasticities of exports and imports are well above 1.0.

While suggestive, there are a number of caveats associated with the back-of-the-envelope calculations in this section. It may well be that real undervaluation spurs reserve accumulation through the capital account and not just the current account. Indeed, Prasad and Wei (2007), for example, argue that much of China's reserve hoarding in the early 2000s can be traced back to "hot money" inflows, as opposed to improvements in the trade balance. In addition, the results are also sensitive with respect to the assumption that the price elasticities do not exceed unity.[19] The next section attempts to address these issues by estimating China's reserve demand as a function of real undervaluation and other factors, precautionary ones in particular.

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[18]As mentioned earlier, disregarding RER undervaluation's contribution to reserve accumulation during the two quarters before 2002Q4 does not significantly affect the above results. At most, only about US\$ 2 billion would be added to the US\$ 500 billion figure.
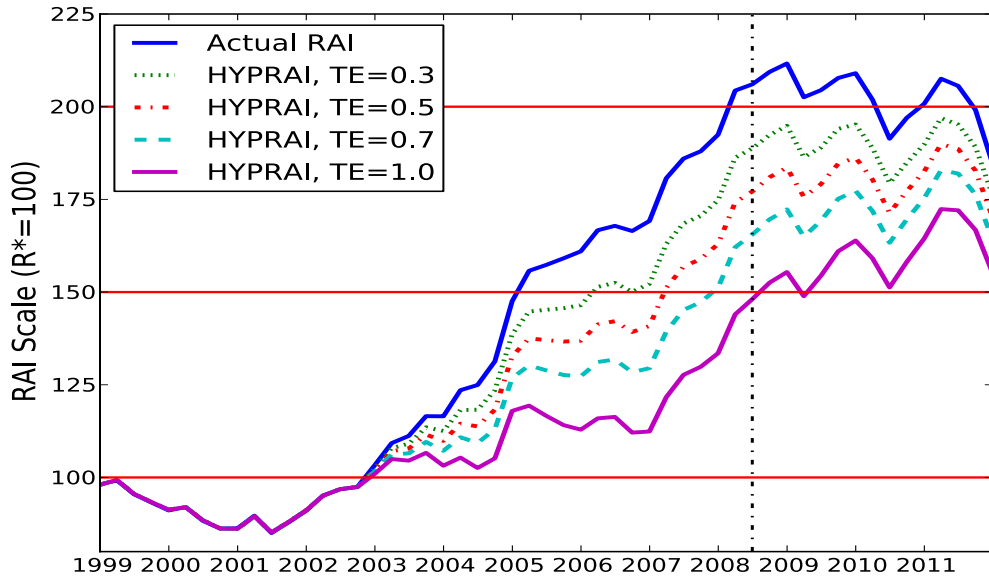
[19]Ahmed (2009), for example, reports export price elasticities that are greater than unity.

Figure 6: Back-of-the-envelope calculations, RAI and hypothetical RAIs, 2005Q1.
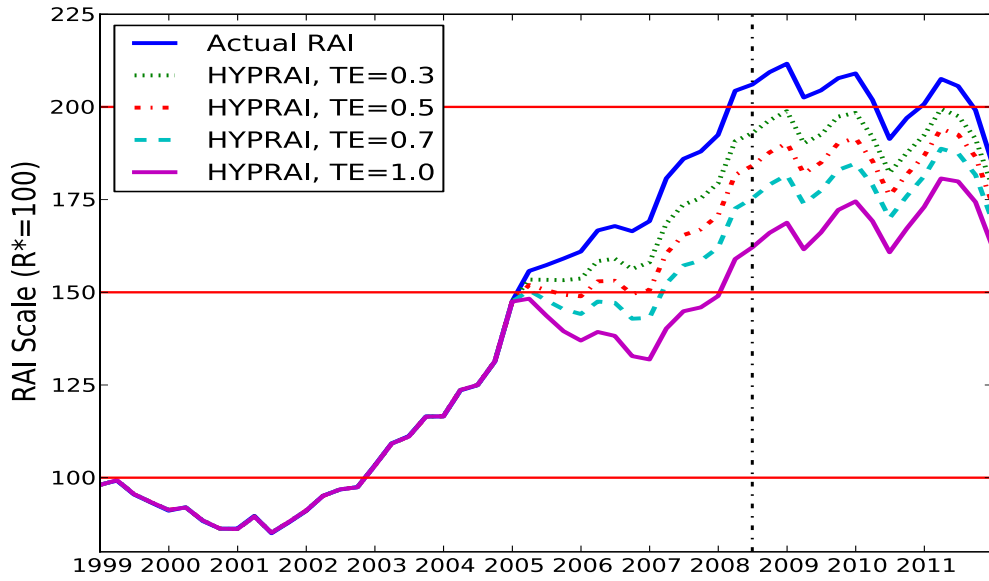
Figure 7: Back-of-the-envelope calculations, RAI and hypothetical RAIs, 2002Q4.

4 Determinants of reserve demand

In this section I estimate China's demand function for international reserves. The main purpose is to obtain an estimate of the impact of RER undervaluation on reserve accumulation while controlling for other factors driving reserve demand. The advantage of this approach is that it is free of imposing *ad hoc* assumptions, as has been done for the back-of-the-envelope calculations in the last section. In addition, estimating a reserve demand function also allows an analysis of the role played by precautionary and other "traditional" factors in China's reserve hoarding.

The reserve demand model takes the form:

$$ln(\text{reserves/GDP})_t = \beta' X_t + \varepsilon_t, \tag{9}$$

where the dependent variable, $ln(\text{reserves/GDP})_t$, is the logarithm of the reserves to GDP ratio .Vector X_t contains the determinants of reserve demand discussed below. The error term ε_t is stationary and mean-zero.

I follow Aizenman and Marion (2003), Aizenman and Lee (2007), Ghosh et al. (2012), Ghosh et al. (2014), and Obstfeld et al. (2010) by including the following explanatory variables, where, unless indicated otherwise, the same data sources and definitions apply as laid out in Section 3.1:

- the logarithm of the total trade (exports plus imports) to GDP ratio [+],

- the log of the ratio M2 to GDP [+],

- the logarithm of the fraction of portfolio equity liabilities over GDP [+],

- the log of the ratio of short-term debt over GDP [+],

- the logarithm of GDP per capita (WDI, interpolated) [+], and

- RER misalignment as defined in Eq. 6 [+/−].

The signs in square brackets represent the partial derivatives. Most of these variables represent precautionary reserve demand to insure against not only a wide range of potential capital account shocks (M2, portfolio equity liabilities, and short-term debt) but also against current account shocks. To proxy the latter, I use total trade to capture both the extent of loss in export earnings and the propensity to import. Other options to control for current account shocks would be to use the log ratio of imports or exports to GDP. Either way, the particular choice of proxy has no material impact on the results.

Since reserve holdings should increase with the exposure to current and capital account shocks, the association between the former and the variables that capture the latter should be positive. The model also includes GDP per capita as a "scale" variable to capture that reserve demand is potentially "non-homogenous" in the size of the economy (Ghosh et al., 2012).

Finally, the model includes RER misalignment in order to estimate the impact of real undervaluation on reserve accumulation. Since undervaluation (overvaluation) in the RER boosts (discourages) exports and may attract (distract) capital inflows, the sign attached to the coefficient on RER misalignment is expected to be negative. Recall, however, that additional reserve accumulation induced by real undervaluation is not necessarily due to the mercantilist motive. As discussed in Section 2, RER undervaluation is also fully consistent with precautionary reserve hoarding. Nonetheless, notice that it is also possible for a country to accumulate foreign exchange reserves at times of RER overvaluation, in which case the association between RER misalignment and reserve accumulation would be positive (Aizenman and Lee, 2007). Yet in China's case this is not an expected outcome since there is a strong overlap between both RER undervaluation and fast reserve accumulation episodes. Nonetheless, *a priori* the sign of the coefficient on RER misalignment is ambiguous.

4.1 Method

Before turning to the estimation of the reserve demand model, I examine the time series properties of the variables. To this end, I employ ADF tests. The test results are reported in Table 2. They suggest that all variables are I(1), except GDP per capita and RER misalignment. The former is I(2) and the latter I(0) by construction. I then difference the GDP per capita variable so that it enters the reserve demand equation as an I(1) variable.

For estimating the reserve demand equation I use the DOLS estimator. The DOLS-versions of the equations are of the following form:

$$ln(\text{reserves/GDP})_t = \alpha \, \text{mis}_t + \beta' X_t + \sum_{s=-l_2}^{s=l_1} \gamma_s' \Delta X_{t+s} + \varepsilon_t, \tag{10}$$

where mis_t refers to RER misalignment and vector X_t contains the other regressors. The DOLS regression also includes l_1 leads and l_2 lags of the first-differenced X_t variables.

4.2 Results

I initially estimate the "traditional" reserve demand model that, in addition to RER misalignment, includes total trade and the scale variable, GDP per capita. The result for this specification is reported in Table 3 Column 1. The expected positive long-run relationship between trade and reserves seems to hold. The coefficient on RER misalignment is positive and significant, which suggests that China accumulates international reserves at times of real overvaluation. As discussed, this estimation result was not expected. However, the results for the "traditional" reserve demand do not control for precautionary capital account variables and may therefore generate spurious results.

The reserve demand equation after adding M2, portfolio equity liabilities, and short-term debt is reported in Table 3 Column 2. Since GDP per capita does not form a long-run relationship with reserve

Table 2: Unit root tests.

Panel A: Variables in levels

	Test Eq. Includes	Test Statistic	P-Value
Reserves	None	-1.2	0.21
Trade (Imports plus Exports)	None	-1.4	0.16
GDP per capita	Constant & Trend	-3.4	0.07
M2	Constant	-1.7	0.43
Portfolio Liabilities	Constant & Trend	-1.9	0.64
Short-Term Debt	Constant	-1.8	0.38

Panel B: Variables in first differences

	Test Eq. Includes	Test Statistic	P-Value
Reserves	None	-3.0	0.00
Trade (Imports plus Exports)	None	-3.4	0.00
GDP per capita	None	-0.0	0.67
M2	Constant	-3.9	0.00
Portfolio Liabilities	None	-3.8	0.00
Short-Term Debt	None	-3.4	0.00

Notes: This table reports the ADF-test statistic under the null hypothesis that the series is nonstationary. Sample period: 1998Q4-2011Q4.

Table 3: Reserve demand.

Independent variable	(1)	(2)	(3)	(4)	(5)
Δ GDP per capita	2.97 (6.86)				
Trade	2.99 (0.59)***	0.13 (0.15)			
M2		1.58 (0.19)***	1.61 (0.14)***	1.62 (0.14)***	1.64 (0.16) ***
Portfolio Equity Liabilities		0.38 (0.03)***	0.38 (0.02)***	0.38 (0.02)***	0.38 (0.02) ***
Short-Term Debt		-0.02 (0.05)			
RER Misalignment	6.87 (1.26)***	-0.46 (0.30)	-0.31 (0.24)		
RER Undervaluation				-0.33 (0.24)	
RER Overvaluation				0.25 (0.22)	
Cumulative Undervaluation					0.00 (0.002)
Observations	53	53	53	53	53
[leads, lags]	[2, 0]	[1, 2]	[2, 2]	[2, 2]	[2, 2]

Notes: The dependent variable is the log of the reserves to GDP ratio. ***, **, * denote the level of statistical significance at 1, 5, and 10 percent. Standard errors in parentheses. GDP per capita is expressed in logs. The other variables are measured in logs as a ratio of GDP (except RER misalignment).

holdings, it is dropped from the model. Once precautionary capital account variables are controlled for, the long-run relationship between reserves and RER misalignment turns insignificantly negative, suggesting that there is, at best, weak evidence of distortions in the RER affecting reserve accumulation in China. Additionally, the coefficient on trade substantially shrinks in size and loses its statistical significance. The stocks of broad money and portfolio equity liabilities seem to be the sole variables that form a statistically significant long-run relationship with reserve holdings. Finally, consistent with the discussion in Section 3, short-term debt does not seem to matter for reserve accumulation in China. In fact, the negative, albeit insignificant point estimate of short-term debt suggests that, if anything, there is a weak pattern of declining reserves as the stock of short-term debt increases.

The estimates reported in Column 3 help in checking whether the lack of association between RER misalignment and reserves is a result of too much noise stemming from the other insignificant variables in the regression. Consequently, trade and short-term debt are dropped from the reserve demand equation. However, RER misalignment remains an insignificant determinant of reserve demand. Column 4 explores the possibility that reserve hoarding is asymmetric in real over- and undervaluation. To this end, I split RER misalignment into two variables: The first takes the negative values of mis_t when the RER is undervalued, and zero otherwise. The other equals mis_t for positive values, and zero whenever the exchange rate is undervalued. This procedure does not significantly change the results. While both RER over-and undervaluation enter the regression with the expected signs, they are not significant drivers of long-run reserve accumulation.

The estimation results discussed so far may have failed to pick up the relationship between real undervaluation and reserve holdings due to misspecification. The issue is that the dependent variable is the stock of international reserves (as a ratio of GDP). While precautionary demand of reserves is linked to the holding of a particular stock, RER misalignment only affects reserve accumulation in a given period and hence refers to the flow rather than the stock. Ghosh et al. (2012) also recognize this point. To address this issue, I follow their approach and construct the variable CUMUVAL, which takes the value of the cumulative number of quarters that the RER is undervalued.[20] The logic behind using CUMUVAL is to better capture the gradual impact of RER misalignment on the stock of international reserves. Column 5 therefore includes CUMUVAL as a regressor, but there is no significant association between reserve holdings and the duration of real undervaluation episodes.

A fundamental weakness of CUMUVAL is that it leaves out important information relating to the degree of undervaluation. Unfortunately there are no better alternatives under the "stock setup". Therefore, in what follows, I re-specify the reserve demand model into a "flow equation" by using first differences of the dependent and explanatory variables, except RER over- and undervaluation.[21] As a starting exercise, I employ OLS to estimate the trivariate relationship between reserves, real overvaluation, and real undervaluation. The first Column of Table 4 reports the result. The magnitude of the

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[20]Once a real undervaluation episode ends, $CUMUVAL$ is reset to zero.

[21]Since the variables are expressed as ratios of GDP and measured in (natural) logarithms, first differences represent growth rates in the GDP ratios.

Table 4: Reserve demand (flow).

Independent variable	(1)	(2)	(3)	(4)
	OLS	OLS	2SLS	2SLS
ΔM2		0.55 (0.20)***		0.46 (0.22)**
RER Undervaluation	-0.21 (0.09)**	-0.23 (0.09)**	-0.24 (0.10)**	-0.22 (0.09)**
RER Overvaluation	-0.81 (0.26)***	-1.02 (0.26)***	-0.30 (0.51)	-0.70 (0.52)
Observations	52	52	51	51
R^2	0.36	0.46	0.36	0.42
Sargan (p-value)			0.55	0.55

Notes: The dependent variable is the change in reserve holdings. ***, **, * denote the level of statistical significance at 1, 5, and 10 percent. Robust standard errors in parentheses.

coefficient attached to RER undervaluation (-0.22) suggests that every percentage point of RER undervaluation leads to a 0.22 percent increase in the reserve to GDP ratio. RER overvaluation on the other hand seems to significantly slow down the pace of reserve accumulation. The relevant coefficient is -0.81, which suggests that a five percentage point increase in overvaluation reduces the reserve to GDP ratio by about four percent. In Column 2 I add first differenced M2 to the regression as this variable was previously found to be one of the most important determinants of reserve demand (cf. Table 3). Doing so, however, does not substantially change the magnitude of the coefficient attached to RER undervaluation (-0.23).

An issue with the OLS estimates is that they do not take into account reverse causality. Reserve accumulation also directly affects RER undervaluation, as suggested by the theory of ERER determination.[22] Moreover, reserve accumulation may lead to growth in the monetary base (M0) under imperfect sterilization, in which case the direction of causation between reserves and M2 would be reversed (Obstfeld et al., 2010). However, in China's instance this is not a concern since M0 (as a ratio of GDP) has been falling steadily during the 2000s, despite the rapid reserve build-up. Therefore, I instrument real over-, and undervaluation using their first two lagged values, whereas I treat M2 as exogenous.[23]

Column 3 in Table 4 reports the two stage least-squares (2SLS) results for the trivariate specification. Compared to the OLS results, the point estimates of both RER over- and undervaluation change considerably. In the case of real overvaluation, the magnitude of the coefficient shrinks to about one third of its previous size (from -0.81 to -0.30). The change in the point estimate of real undervaluation is less pronounced, but still a nontrivial 14 percent increase (in absolute value). My preferred specification reported in Column 4 additionally controls for first differenced M2, which leaves the point estimate of RER undervaluation virtually unchanged (-0.22). The size of the coefficient attached to RER overvaluation increases substantially, but loses its significance.[24] Finally, notice that the validity of the

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[22]See the discussions in Sections 2 and 3.3.

[23]Assuming that M2 is exogenous does not significantly affect the results.

[24]I have also experimented with including the other potential determinants of reserve demand in the flow equation. While other potential specifications exist the point estimate of real undervaluation remains virtually unchanged compared to Column 4. The only exception is when I include the first difference of portfolio equity liabilities, which causes all other variables to lose their explanatory power. The results of those alternative specifications are available upon request.

instruments used in Columns 3 and 4 cannot be rejected on the basis of a Sargan test of overidentifying restrictions.

4.3   Reserve accumulation due to mercantilism

This section computes the cumulative contribution of mercantilism to China's reserve build-up on the basis of the consistent 2SLS point estimate of RER undervaluation, as reported in Column 4 of Table 4. The task is to calculate the amount of additional reserves accumulated in each quarter during the RER undervaluation episode in which reserves are judged excessive according to the RAI. I consider the same cut-off points of reserve excessiveness as for the back-of-the-envelope calculations: Q4 in 2002 and Q1 in 2005.

The results of these calculations are reported in Table 5. The Table comprises two panels: Panel A with 2005Q1 and Panel B with 2002Q4 as the starting date. The first two Columns list actual RAI reserve holdings (in US$ billions) and the RAI. Columns 3 and 4 report the hypothetical RAI (HYPRAI) and stock of international reserves (HYPRES) had there been no RER undervaluation. The fifth Column shows the amount of accumulated reserves (CONTRUVAL) that is due to real undervaluation in a given quarter, with the cumulative sum reported at the bottom of the panel.

Table 5: Reserves without mercantilism.

Panel A: Start 2005Q1

	Actual RAI	Actual (bn)	HYPRAI (% GDP)	HYPRES (bn)	CONTRUVAL (bn)	-2 s.d. RAI	-2.s.d. (bn)	CONTRUVAL -2 s.d.	+2.s.d. RAI	+2 s.d. (bn)	CONTRUVAL +2 s.d
2005Q1	155.8	663.3	145.2	618.2	23.0	153.0	651.3	4.5	137.7	586.0	40.5
2005Q2	157.4	715.2	142.7	648.3	21.7	153.7	698.7	4.4	132.2	600.7	37.1
2005Q3	159.2	772.4	141.8	688.2	17.4	155.1	752.3	3.6	129.6	628.8	29.2
2005Q4	160.9	821.5	141.5	722.6	14.6	156.4	798.3	3.1	128.0	653.7	24.2
2006Q1	166.6	877.7	144.5	761.3	17.5	161.5	850.8	3.7	129.3	681.2	28.7
2006Q2	167.8	943.8	143.3	805.6	21.8	162.2	912.2	4.7	126.6	712.1	35.2
2006Q3	166.6	990.5	139.5	829.6	22.7	160.4	953.9	5.0	121.5	722.5	36.3
2006Q4	168.9	1068.0	140.2	887.0	20.1	162.4	1027.0	4.5	121.5	768.4	31.6
2007Q1	181.3	1203.9	151.2	1004.0	18.9	174.5	1158.6	4.2	131.7	874.7	29.6
2007Q2	186.7	1334.9	155.8	1114.3	20.6	179.7	1285.0	4.6	136.1	973.2	32.5
2007Q3	187.5	1436.0	156.4	1198.0	17.4	180.4	1382.2	3.9	136.7	1046.8	27.5
2007Q4	192.5	1530.0	159.8	1270.5	21.6	185.1	1471.5	4.8	139.2	1106.8	34.1
2008Q1	204.9	1684.1	171.7	1411.9	12.6	197.4	1622.7	2.8	151.0	1241.0	19.9
2008Q2	206.1	1810.9	174.2	1530.4	8.3	198.9	1747.7	1.8	154.2	1354.7	13.1
2011Q4	184.6	3203.0	167.6	2908.3	0.0	180.8	3136.7	0.0	157.0	2723.3	0.0
Σ					258.2			55.7			419.3

Notes: RAI refers to the reserve adequacy index, which is based on the IMF's (2011) measure. HYPRAI and HYPRES is the hypothetical RAI and stock of international reserves in the absence of RER undervaluation episode, respectively. CONTRUVAL indicates the amount of accumulated reserves that is due to real undervaluation in a given quarter. The last six columns show HYPRAI, HYPRES, and CONTRUVAL when 2 standard errors are added or subracted to the point estimate of RER undervaluation (column 4 of Table 4).

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Table 5: Reserves without mercantilism (ctd.).

Panel B: Start 2003Q1

	Actual RAI	Actual (bn)	HYPRAI (% GDP)	HYPRES (bn)	CONTRUVAL (bn)	- 2 s.d. RAI	- 2 s.d. (bn)	CONTRUVAL - 2 s.d.	+ 2 s.d. RAI	+ 2 s.d. (bn)	CONTRUVAL + 2 s.d
2002Q4	103.3	291.1	100.7	283.7	3.7	102.8	289.6	0.7	98.6	277.8	6.6
2003Q1	109.3	321.0	104.8	308.0	5.6	108.4	318.4	1.1	101.4	297.8	9.9
2003Q2	111.4	351.5	104.9	331.2	7.2	110.1	347.4	1.4	100.0	315.6	12.6
2003Q3	116.5	389.0	108.1	360.8	8.0	114.8	383.3	1.6	101.7	339.4	13.8
2003Q4	116.5	408.2	105.5	369.6	10.4	114.3	400.4	2.1	97.4	341.0	17.6
2004Q1	123.7	444.4	109.5	393.6	12.2	120.8	434.1	2.5	99.3	356.9	20.3
2004Q2	125.0	475.2	108.9	413.9	10.4	121.7	462.6	2.2	97.5	370.6	17.1
2004Q3	131.3	519.1	113.2	447.3	10.6	127.6	504.2	2.3	100.6	397.4	17.1
2004Q4	147.4	614.5	126.4	527.0	15.7	143.0	596.2	3.4	112.2	467.6	25.2
2005Q1	155.8	663.3	130.5	555.4	20.4	150.5	640.6	4.5	113.6	483.7	32.8
2005Q2	157.4	715.2	129.3	587.8	19.5	151.4	688.1	4.3	111.1	504.9	30.7
2005Q3	159.2	772.4	129.7	629.2	15.8	152.9	741.7	3.6	110.8	537.6	24.5
2005Q4	160.9	821.5	130.2	664.9	13.4	154.3	787.8	3.0	110.9	566.1	20.7
2006Q1	166.6	877.7	133.8	705.0	16.1	159.5	840.3	3.7	113.4	597.4	24.8
2006Q2	167.8	943.8	133.5	750.9	20.2	160.3	901.7	4.6	112.5	632.6	30.9
2006Q3	166.6	990.5	130.6	776.5	21.2	158.7	943.6	4.9	108.8	647.1	32.2
2006Q4	168.9	1068.0	132.0	835.2	18.8	160.7	1016.6	4.4	110.1	696.3	28.3
2007Q1	181.3	1203.9	143.6	953.2	17.8	173.0	1148.3	4.2	121.3	805.4	26.8
2007Q2	186.7	1334.9	148.9	1064.6	19.6	178.3	1274.8	4.6	126.8	906.5	29.9
2007Q3	187.5	1436.0	150.0	1149.1	16.6	179.1	1372.0	3.8	128.2	981.9	25.6
2007Q4	192.5	1530.0	153.8	1222.4	20.7	183.8	1461.3	4.8	131.3	1044.0	32.0
2008Q1	204.9	1684.1	166.0	1364.4	12.2	196.1	1612.6	2.8	143.5	1179.4	18.8
2008Q2	206.1	1810.9	168.8	1483.2	8.0	197.8	1737.5	1.8	147.3	1293.7	12.5
2011Q4	184.6	3203.0	164.9	2861.4	0.0	180.2	3126.6	0.0	153.5	2663.1	0.0
Σ					324.0			72.6			510.5

Notes: RAI refers to the reserve adequacy index, which is based on the IMF's (2011) measure. HYPRAI and HYPRES is the hypothetical RAI and stock of international reserves in the absence of RER undervaluation episode, respectively. CONTRUVAL indicates the amount of accumulated reserves that is due to real undervaluation in a given quarter. The last six columns show HYPRAI, HYPRES, and CONTRUVAL when 2 standard errors are added or subtracted to the point estimate of RER undervaluation (column 4 of Table 4).

The estimated cumulative contribution of mercantilism over the period 2005Q1 to 2008Q2 is about US$ 260 billion or 8 percent of the total stock of international reserves. In 2008Q2, a hypothetical reduction of US$ 260 billion in foreign exchange means that the stock of reserves would have amounted to US$ 1.53 trillion instead of the actual US$ 1.8 trillion. The RAI would have declined from 206 percent to 174 percent. So reserves would still be considered excessive according to the RAI, which suggests that mercantilist and precautionary motives alone cannot explain China's hoarding of foreign exchange reserves.

To provide a "confidence interval" for the impact of mercantilism, I add and subtract, respectively, 2 standard errors to the point estimate of RER undervaluation and repeat the above calculations. The last six Columns of Table 5 report the results. The "upper confidence bound" of mercantilism's contribution is US$ 420 billion. HYPRAI would stand at 154 percent, still slightly above the 150 percent benchmark. In other words, the null hypothesis that mercantilism explains China's excessive reserve hoarding would be rejected at the 5 percent level.

Panel B reports reserve hoarding due to mercantilism when reserves are deemed excessive from 2002Q4 onwards. Since in this case all quarters of real undervaluation count towards the mercantilist motive, the resulting numbers are somewhat larger. The cumulative sum of CONTRUVAL is US$ 324 billion (10 percent of actual reserve holdings). At the end of the undervaluation episode in 2008Q2, the hypothetical RAI in the absence of mercantilist motives would still be at 169 percent, which is well above the 150 percent threshold. The observation thus still stands that mercantilism alone cannot explain China's excessive reserve hoarding. The absolute upper bound estimate of mercantilism that results from adding two standard errors to the point estimate of RER undervaluation is about US$ 500 billion. But even then the HYPRAI would still be near, albeit marginally below, 150 percent in 2008Q2.

Overall, these numbers are strikingly similar to the ones obtained from the back-of-the-envelope calculations in Section 3.4, further corroborating the inference that mercantilism has contributed substantially, but not totally, to the exorbitant reserve build-up in China. In addition, the estimates of the contribution to China's build-up in foreign exchange reserves in this study range between US$ 240 and US$ 500 billion, which translates into 3-7 percent of GDP (or about 10 percent of total reserve accumulation). Ghosh et al. (2014) provide a similar estimate at 4.5 percent of GDP. Their approach is to define any reserve accumulation associated with RER undervaluation as mercantilist. This comparability in estimation results thus underlines the earlier formulated view that the results are not sensitive to which particular method of measuring mercantilism's importance is chosen in the case of China.

5 Conclusion

The purpose of this paper has been to test empirically whether the prevalent view holds that China engages in distortionary exchange rate policies which aim at maintaining an undervalued real exchange rate to support export-led growth. If this were so, these mercantilist policies would explain much of China's foreign exchange reserves stock, which is above of US$ 3 trillion as of 2011. This paper's goal

has been to quantify how much precautionary and mercantilist motives have contributed to the reserve build-up in China. The study has highlighted how theory is consistent with employing two vastly differing approaches with respect to defining and estimating the role of mercantilism, either of which could generate misleading results. The study has, however, shown that the latter is not a concern in China's particular case since both approaches yield similar results.

The main results of this paper suggest that while the period rapid of the reserve build-up does coincide with a prolonged episode of RER undervaluation, distortionary foreign exchange market interventions during that time have only contributed between US$ 200-300 billion (less than 10 percent of total reserve accumulation). Indeed, even in the absence of mercantilist motives, reserves would still be considered to be in excess of what is needed for precautionary purposes based on the RAI. This paper's results thus cast doubt on the widely-held view that mercantilism is an important factor in explaining China's unprecedented reserve hoarding, and more generally on the Bretton Woods II-view as formulated by Dooley et al. (2004).

The question then is: which factors beyond precautionary and mercantilist motives can account for China's extraordinary reserve demand? One possibility is that the accumulation of foreign exchange reserves includes the precautionary savings of the private sector as well. According to Caballero et al. (2008) and Mendoza et al. (2009) for example, agents in emerging countries such as China demand assets to insure themselves against idiosyncratic income shocks, however, financial market underdevelopment in emerging economies inhibits the supply of quality assets that allow hedging against those shocks. This supply-demand mismatch induces residents of emerging economies to acquire assets in countries with advanced financial markets, typically the US, to fill the void in insurance. In the particular case of China, the absence of adequate social insurance (Carroll and Jeanne, 2009; Chamon et al., 2013) may additionally explain an exceptionally high precautionary saving motive. Moreover, Wei and Zhang (2011) argue that the growing gender imbalances in China incentivize parents to raise their savings to increase their son's attractiveness in the marriage market. These studies offer plausible explanations as to why China operates under current account surpluses and accumulates foreign assets. However, as pointed out by Gourinchas and Jeanne (2013), specifically accounting for the hoarding of international reserves requires the additional assumption that the government accumulates the latter on behalf of the private sector.

Another plausible explanation for the surge in reserves that deserves more attention is China's joining of the World Trade Organization (WTO) in 2002. Athukorala (2009a) argues that this event significantly reduced China's perceived country risk, which triggered substantial inflows of foreign direct investment (FDI) in export-linked industries. China's integration into global production networks was thus a significant contributor to the record trade surpluses, which might have been, by and large, independent of the RER. China has become the premier assembly center within global production networks within vertically integrated dynamic industries, in particular electronics and electrical goods (Athukorala, 2009b). There is evidence that the RER is only one among the many other variables which determine Chain's attractiveness as a final assembly center (Cline and Williamson, 2007; Schnatz, 2011;

Thorbecke, 2013; Xing, 2012). These other variables include: low labor cost relative to that in the US and other home countries of multinational enterprises (MNEs) involved in these industries[25]; ample availability of labor (including supervisory manpower) required for mass assembly operations (Rawski, 2011); high-quality trade-related infrastructure; and political stability. These factors are perhaps far more important for the expansion of these industries than the exchange rate.

China's emergence as an assembly center has therefore resulted in a surge in exports, which generated extra savings. The extraordinary demand for foreign exchange reserves may be explained that inefficiencies in the Chinese capital market and banking system (Riedel et al., 2007) make it rational for savers to temporarily "park" their funds abroad until the domestic investment climate improves (Corden, 2007, 2009).

Appendix

Figure A.1: Traditional measures of reserve adequacy, 1998Q4-2011Q4.

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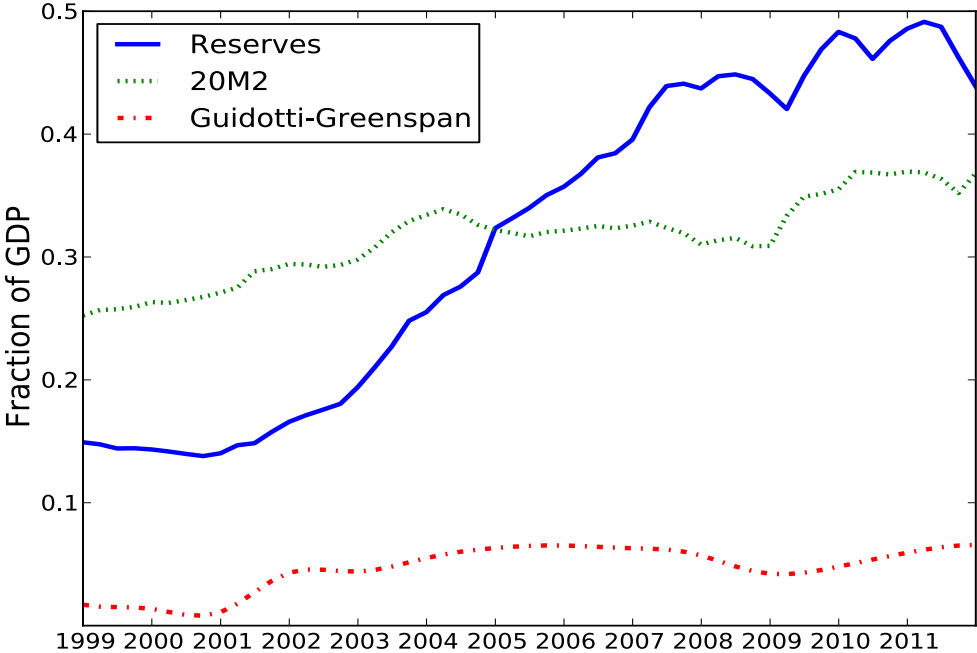
[25]The labor cost in China has increased significantly over the past decade or so, but still, the average hourly wage of a factory worker amounts to less than 5 percent of the US equivalent in 2009 (Banister, 2013).

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