The compensation thesis, as exemplified by the case of the Chinese central bank

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This paper follows discussions about ‘endogenous sterilization’ and the Chinese economy that one of the authors had with Wynne Godley. We are also indebted to Gabriel Rodriguez, who did some preliminary empirical work and is now working at the central bank of Peru, as well as to Xue Yan, who wrote her MA major paper on a related topic in August 2004.
ABSTRACT  The present paper extends the theory of demand-led money supply endogeneity to the case of an open economy with a fixed exchange rate. This case was first explored by French central bankers in the 1970s, and was called the compensation thesis. This approach can be contrasted to the Mundell-Fleming model, where interest rates are endogenous variables and where monetary policy is assessed by the money supply level. In the compensation approach, central banks are able to set interest rates, even in a fixed exchange rate regime, either because there are automatic market mechanisms that will induce the private sector to act in such a way that changes in foreign reserves will be compensated by opposite changes in central bank claims over the domestic economy, or because the central bank will engage in endogenous sterilization operations in its efforts to keep the benchmark interest rate at the level that it sees fit. We take the case of China, with its quasi fixed exchange rate and large acquisitions of foreign reserves to provide some empirical evidence of the compensation thesis. Analyzing the balance sheet of the Chinese central bank and China's macroeconomic performance in recent years, we find that the large rise in foreign reserves on the asset side is compensated by large positive changes in items of the liability side that are unrelated to the monetary base, in particular bonds issued by the central bank. We also find that foreign reserves are not cointegrated with the money base, meaning that there is no long-run relationship between foreign reserves and the supply of base money. We also find no long-run relation between foreign reserves and the consumer price index.

KEY WORDS: Foreign reserves, Sterilization, Fixed exchange rates, Endogenous money, Central banking, Post-Keynesian theory, China.
Introduction

While open economy macroeconomics is in a state of disarray, with a multitude of different models trying to explain international financial relations and exchange rates, the Mundell-Fleming model is still ‘the workhorse of international monetary economics all over the world’ (Claassen 1996, p. 135). The model is well-known for its symmetry when discussing the possibility of economic policy under the two main exchange regimes. With perfect capital mobility and perfect asset substitution, fiscal policy is only effective in the fixed exchange regime, while monetary policy is only effective in the flexible exchange regime. As is well known, in the fixed exchange rate regime, any balance of payments surplus leads to an increase in the foreign reserves of the central bank. As a result, Mundell and the utilizers of his model claim that any balance of payments surplus position is associated with an endogenous increase in the monetary base and hence in the money supply. This should lead to reduced real interest rates and rising prices, and hence, eventually, the external surplus position ought to be eliminated. This is an indirect version of the old price-specie flow mechanism. Indeed the mechanism described by Mundell and his followers corresponds to the Rules of the Game. As Ethier (1988, p. 341) among others describes them, ‘A balanced of payments deficit should be fully reflected in a reduction in the supply of money, and a surplus should be fully reflected in an increased money supply’. While more sophisticated open economy models have since been discussed in the literature, such as the portfolio approach, the positive link between balance of payments surpluses and increases in the monetary base and the money supply is held by all to be an adequate representation of this portion of the story.

The purpose of the paper is to present an alternative, the so-called ‘compensation’ thesis, and to present some empirical evidence sustaining this approach. The compensation approach is the open-economy version of the reflux principle, put forth by Thomas Tooke and the Banking School, as it applies to the central bank. The modern version of the Banking School can be found in the works of post-Keynesians, where it is known under the theory of endogenous money. The compensation thesis asserts that fluctuations in a central bank foreign exchange reserves will be compensated by opposite movements in other elements of the balance sheet of the central bank. These compensating movements are the normal response of the financial system to the external
disequilibrium (Lavoie, 2001). They will be either induced by the private sector on its own, or they will be initiated by the monetary authorities as part of their day-to-day operations designed to achieve the target interest rate.

In the first section of the paper, we show how the notions of compensation and sterilization link up, and we discuss the different meanings of money endogeneity. In the second section, we briefly explain how compensation can operate, and we recall the arguments of previous economists who have taken note of the compensation principle. In the third section we present the case of the Chinese economy, as it applies to the People’s Bank of China. China is an excellent possible example of the compensation thesis, since it has had a fixed exchange rate for a long time, with large balance of payments surpluses. In the fourth section, we present the results of cointegration analysis.

The Rules of the Game and sterilization

On a number of occasions, Mundell (1963) has underlined the relationship between the balance of payments surplus or deficit position on the one hand and the foreign exchange reserves and the monetary base on the other. Here are some quotes:

…To prevent the exchange rate from falling the central bank intervenes in the market, selling foreign exchange and buying domestic money….[] Forcing the central bank to intervene by buying foreign reserves and increasing the money supply…. When the central bank buys or sells foreign exchange the money supply increases or decreases (Mundell, 1963, p. 479).

A very similar opinion is to be found in the modern literature:

But the main point is that, in behaving in this way, the central bank loses control over the home country’s money stock. This is because each exchange by the central bank of dollars for foreign currency has the effect of changing the home country’s stock of ‘high-powered money’ (alternatively referred to as ‘base
money’ or the ‘monetary base’). And as most readers will know from their study of money and banking, changes in high-powered money tend strongly to induce changes – approximately equal percentage changes – in the stock of money ....

Let us conclude this section by reiterating its central and fundamental message: in order to maintain a fixed exchange rate, a central bank must engage in foreign exchange transactions that prevent it from managing the monetary base so as to achieve other macroeconomic objectives. If monetary policy is dedicated to pegging the exchange rate, it is then unavailable (except on a highly temporary basis) for application to other goals (McCallum, 1996, pp. 137, 139-140).

Students are sometimes told that such a situation need not occurred, however, if the impact of the deficit on official foreign reserves is being neutralized or sterilized. In the case of the balance of payments deficit, this would imply that monetary authorities retain control over the monetary base by engaging into counter-balancing open market operations, by purchasing government securities on the open market. These sterilization operations allow central banks to keep their assets at a constant level, thus halting any endogenous decrease in the money supply.

Similar mechanisms operate when a country finds itself in a balance of payments surplus position. In this case, the central bank is said to accumulate foreign reserves, thus leading to an increase in its assets. As a result, the monetary base expands, and so does the money supply. Once again, students are sometimes told that the central bank may then engage into operations of sterilization, selling government bonds, and thus reducing its domestic assets in line with its increase in foreign assets, and thus retaining control over the monetary base and the money supply.

It is usually argued that sterilization cannot be pursued for very long or is ineffective. For Claassen (1996, p. 51) for instance, ‘in the context of “perfect capital mobility” ... sterilized intervention policies are doomed to be ineffective’. In our opinion, such statements confuse perfect capital mobility with perfect asset substitutability. Capital mobility refers to whether or not there are restrictions to capital flows. It may be that capital is perfectly mobile, while asset-holders do not consider assets to be perfectly substitutable. In this case, rates of return need not be equal. This implies that domestic interest rates need not be equal to world rates, or that
uncovered interest parity need not hold. Thus in the case of perfect capital mobility accompanied
by imperfect asset substitutability, as is recognized by Claassen (1996, p. 80), sterilized
intervention will have some effect. But the more frequent view is the one offered in the long
exert below, taken from a well-known neoclassical writer:

Thus we see that any exchange by a central bank of home country for foreign
country will have the effect of changing the stock of high-powered or base money
in the home country. Such changes can admittedly be offset by the central bank by
means of ‘open-market’ exchanges of domestic money for other domestic assets
such as government securities. The effect on the stock of base money of a
purchase of foreign currency could be undone, for example, by a sale by the
central bank of government bonds. Such an action is termed a sterilization of the
foreign exchange purchase, which becomes a sterilized intervention’. It is the
case, then, that central bank interventions in the foreign exchange market may not
affect the home country money stock if they are sterilized. Most research on this
issue has indicated, however, that the effects on exchange rates of sterilized
market interventions are both weak and short-lived. Thus a central bank can keep
its nation’s exchange rate fixed only by engaging in non-sterilized interventions
(McCallum, 1996, p. 138)

It should be noted that McCallum, in the above quote, does not make any distinction
between a balance of payments surplus or deficit position. It is understandable that an economy
in an external deficit position and a fixed exchange regime will eventually run out of reserves.
Although the external deficit position can last for a long time if foreign reserves are substantial
and the deficit is meagre, it will not be sustainable forever, and hence at some point, something
will need to break: the currency will be devaluated, interest rates will be pushed up, government
will have expenditures cut-backs, or quotas or financial controls will need to be imposed. On the
other hand, it is hard to see what limits there are when an economy is into an external surplus
position. Why should there be any limits to the amount of foreign reserves being held by the
central bank of an economy with a recurrent balance of payments surplus? Is there any such limit
in the case of the Chinese economy, which has been piling up huge surpluses over the last decade?

With regards to China, some people argue that sterilization in countries with external surpluses cannot go on forever because rates of interest on the liabilities of the central bank are bound to be higher than rates of interest on US T-bills; this, it is argued, would lead to operating losses (or opportunity costs) to the sterilizing central bank. For instance, in the context of Latin American countries, Frenkel (2006, p. 587) writes that sterilization operations “consist in the selling of public-sector or central bank papers with the objective of money absorption. They imply a financial cost to the treasury or the central bank, proportional to the difference between the interest rate of those papers and the interest rate earned by the central bank’s international reserves”. This argument certainly does not apply to countries such as China, where interest rates are administered, and can be set at levels lower than in the United States or Europe. Also, why would interest rates in surplus countries be any higher than interest rates in countries facing current account deficits and trying to avoid devaluation? One would have thought that countries faced with external deficits would be the countries induced to set high or rising interest rates! In any case, one thing is certain: if the central bank lets its exchange rate rise, it will experience capital losses on the value of its foreign reserves. The financial argument thus seems to be a moot point.¹

The compensation thesis

The compensation thesis has a long tradition, despite being ignored in textbooks. The compensation thesis is also sometimes called the Banque de France view, because in its modern incarnation it was endorsed by Pierre Berger, who was the general director of research at the Banque de France. Berger (1972a, p. 94, 1972b, p. 171), points out that the compensation phenomenon that can be observed in modern economies could already be observed in the 19th century. Statistics show that when France had large external surpluses, and hence was

¹ In a latter paper, Frenkel (2008) reconsiders this issue, and recognizes that sterilization of excess foreign currency can be sustainable under some conditions even if home interest rates are higher than the rate of return obtained on foreign reserves.
accumulating gold reserves, the peaks in the gold reserves of the Banque de France were accompanied by throughs in credits to the domestic economy. As a result, despite the wide fluctuations in gold reserves, the variations in the monetary base and the money supply were quite limited.²

This analysis is confirmed by studies on the gold standard period, between 1880-1913 and 1922-1938. Bloomfield (1959, p. 49) shows that when looking at year-to-year changes in the period before the First World War – the heyday of the gold standard – the foreign assets and the domestic assets of central banks moved in opposite directions 60% of the time. Foreign assets and domestic assets moved in the same direction only 34% of the time for the eleven central banks under consideration. The prevalence of a negative correlation thus shows that the so-called Rules of the Game were violated more often than not, even during the heyday of the gold standard. Indeed, ‘in the case of every central bank the year-to-year changes in international and domestic assets were more often in the opposite than in the same direction’ (Bloomfield, 1959, pp. 49-50).

Almost identical results were obtained in the case of the 1922-1938 period. Ragnar Nurkse (1944, p. 69) shows that the foreign assets and the domestic assets of twenty-six central banks moved in opposite direction in 60% of the years under consideration, and that they moved in the same direction only 32% of the time. Studying the various episodes of inflows or outflows of gold and exchange reserves, Nurkse (1944, p. 88) concludes that ‘neutralization was the rule rather than the exception’. Without saying so, Nurkse adopts the compensation principle as the phenomenon ruling central banks in an open economy. The rules of the game as they were to be endorsed in the modern IS/LM/BP models of Mundell are an erroneous depiction of reality.

² Denizet (1969: 203-204) notes a specific instance of the lack of a relationship between the flows of gold and the money supply. When France had to transfer one billion francs worth of gold to Germany in 1870, as a form of war reparation, everyone expected France to fall into a recession as a result of the diminished liquidity, but the reverse occurred. France entered a period of prosperity, while the Banque de France compensated the outflow of gold with a substantial amount of advances to banks.
There is nothing automatic about the mechanism envisaged in the “rules of the game”. We have seen that automatic forces, on the contrary, may make for neutralization. Accordingly, if central banks were to intensify the effect of changes in their international assets instead of offsetting them or allowing them to be offset by inverse changes in their domestic assets, this would require not only deliberate management but possibly even management in opposition to automatic tendencies. (Nurkse, 1944, p. 88)

Nurkse’s account of the negative correlation between foreign and domestic assets of central banks in various dramatic instances is particularly interesting because he rejects the standard interpretation in terms of a ‘sterilization’ operation initiated by the central bank. Nurkse considers that it would be ‘quite wrong to interpret [the inverse correlation] as a deliberate act of neutralization’ on the part of the central bank. On the opposite, Nurkse considers that the neutralization of shifts in foreign reserves is caused by ‘normal’ or ‘automatic’ factors, and that the compensation principle operates both in overdraft financial systems and in the asset-based ones, as we shall define them in the next section. In the overdraft system, Nurkse (1944, p. 70) notes that ‘an inflow of gold, for instance, tends to result in increased liquidity on the domestic money market, which in turn may naturally lead the market to repay some of its indebtedness to the central bank’.

But Nurkse also observed compensating phenomena that were consistent with the operation of an asset-based financial system. In the case of an inflow of gold and foreign exchange, foreign investors (or the banks where their deposits would be held) would purchase new government securities. This would allow Government to reduce its debt to the central bank, as would be the case in an open-market operation. However, as Nurkse (1944, p. 77) points out,

3 Keynes (1930, ch. 32) was also keenly aware of the compensation phenomenon. He points out that year after year the Bank of England would gain £10,000,000 of gold in the spring and lose a similar amount in the autumn. This should have caused concern to all, but it did not, because these inflows and outflows were compensated by corresponding seasonal outflows and inflows arising from the Treasury. In the spring, with the receipts of income tax, the Treasury
in contrast to the usual open-market operation, the manoeuvre ‘did not come about at the Bank’s initiative’. Alternatively, Nurkse (1944, p. 76) points out, gold inflows could also be neutralized by an increase in government deposits held at the central bank, as the Bank of Canada used to do.

Some well-known specialists of central banks have also recently endorsed the compensation principle.\(^4\) When speaking of the various determinants of the monetary base, Charles Goodhart (1984, p. 192) points out that there is ‘some tendency towards negative covariation in these flows, i.e., they seem to interact in a way that produces some partial compensation, which alleviates some of the difficulties facing the authorities. A large foreign exchange inflow usually encourages sales of gilts and also reduces company demand for bank credit’. That Goodhart is aware of the possibility of compensation is not surprising since Goodhart (1989) has also endorsed the notion of demand-led endogenous money, which is closely associated with the compensation thesis.

Neoclassical economists are usually keen to say that, whereas otherwise it is exogenous, the money supply process is endogenous in the case of an open economy with fixed exchange rates. It should be clear that such an instance of endogeneity of the money supply has nothing to do with the endogenous money supply process that is usually underlined by post-Keynesian authors. In this neoclassical instance of the endogenous money supply, the endogeneity process is \textit{supply-led}, whereas in the post-Keynesian approach, the money supply is endogenous because it is \textit{demand-led}. In the post-Keynesian case, the money supply grows because more of it is being demanded by the various agents of the economy. For instance, as more loans are being demanded by firms, new banking deposits are being created. Similarly, when agents desire more banknotes, the central bank provides these banknotes to the users of the monetary system. In the open economy case underlined by neoclassical authors, the money supply increases endogenously, but independently of the demand for money expressed by the economic agents.

\(^4\) It must be pointed out that Mundell (1961, p. 153) himself was aware that the automaticity of the \textit{Rules of the Game} relied on a specific behaviour of the central bank. Indeed he lamented over the fact that modern central banks were following the \textit{banking principle} instead
Changes in interest rates then adapt the endogenous, but autonomous, increase in the money supply to the unchanging money demand schedule. This sort of endogeneity of the money supply is thus totally at odds with the type of endogeneity underlined by post-Keynesian authors (Lavoie, 1992, p. 189). Indeed, this is precisely the point made by Arestis & Eichner (1988, p. 1015): ‘So long as it is recognized that money supply is credit-driven and demand-determined, the exchange rate regime is of absolutely no consequence in the determination of money and credit’. In other words, a recurrent balance of payments surplus will not lead to an excessive amount of money in the economy.

**The compensation mechanism**

Neoclassical textbooks usually make the claim that central banks have only four significant items in their balance sheets, two on each side, as indicated in Table 1:

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign reserves</td>
<td>Currency in circulation</td>
</tr>
<tr>
<td>Domestic government securities</td>
<td>Bank reserves</td>
</tr>
</tbody>
</table>

Under this representation, since bank reserves plus currency in circulation equate the monetary base, there has to be a one-to-one relation between the size of the assets of the central bank and the monetary base (currency plus bank reserves), unless sterilization, represented by open market operations over domestic government bonds, compensates for the movements in foreign reserves. This representation is biassed. While it may represent, to some extent, the characteristics of Anglo-Saxon monetary systems, which we call *asset-based* financial systems, of the *bullionist principle*, and hence adjusting ‘the domestic supply of notes to accord with the needs of trade’.
it certainly oversimplifies the majority of the monetary systems that can be found in the world. It thus yields a misleading comprehension of the functioning of most monetary systems. The correct balance sheet of most central banks looks more like the following one, as shown in Table 2.

Table 2: A more realistic balance sheet of the central bank

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign reserves (claims on non-residents)</td>
<td>Currency in circulation</td>
</tr>
<tr>
<td>Claims on domestic government</td>
<td>Bank reserves</td>
</tr>
<tr>
<td>Claims on domestic banks</td>
<td>Government deposits</td>
</tr>
<tr>
<td></td>
<td>Central bank bonds</td>
</tr>
<tr>
<td></td>
<td>Capital (own funds)</td>
</tr>
</tbody>
</table>

On the asset side, claims on domestic private banks are the crucial addition. In most monetary systems, central banks lend to private banks. These commercial banks are structurally in debt vis-à-vis the central bank, and will thus attempt to reduce this debt whenever they can. These monetary systems are often called overdraft systems, because private banks can make use of a kind of overdraft, by pulling on a line of credit at the central bank, provided they show the appropriate collateral requirements. This overdraft system is symmetric to the one in use between non-financial economic agents, such as firms, and their private bankers.

On the liability side of the central bank balance sheet, three additional items have been included. Besides the capital of the central bank, there are central bank bonds and government deposits. A central bank can move government deposits around, at its choice, between its own central bank account and the accounts that government agencies hold at the various private banks. Also, in several countries, central banks issue their own securities, called central bank bills or central bank bonds, since these securities are often perceived as carrying less risk than government securities.
An increase in foreign reserves can thus be sterilized – compensated – either by a reduction in advances to domestic banks or by an increase in government deposits and in securities issued by the central bank. These additional entries in the central bank balance sheet disrupt the straightforward relation between the size of the assets of the central bank and the monetary base. The main argument of the compensation approach is that, in the external surplus case, when commercial banks wind up with additional reserves, having sold their newly acquired stocks of foreign currency to their central bank, they will do their best to get rid of these additional reserves. Banks have already granted all the loans that they could make to credit-worthy borrowers, and hence they will usually comply in getting rid of these excess reserves (that usually carry no interest) either by reducing the advances that they have taken from the central bank, or by purchasing risk-free assets, such as government securities or central bank bonds.

In some other countries, such as Canada, where the overnight rate is clearly under the control of the central bank, it will initiate the sterilization process by transferring government deposits, removing the excess liquidity through the clearing and settlement system. In one of its background papers, the Bank of Canada (2003) explains that when it conducts exchange rate operations to slow down the appreciation of the dollar, thus selling Canadian dollars on the exchange markets and acquiring foreign currency, ‘to prevent downward pressure on Canadian interest rates ... the same amount of Canadian-dollar balances are withdrawn from the financial system’. This is done by removing government deposits at commercial banks and redepositing them on the books of the central bank. Thus sterilization is not a matter of choice, it is a necessity as long as the central bank wants to keep the interest rate at its target level.

Godley (1999) and Godley & Lavoie (2005-06) have built a series of formal models that replicate the mechanism of the compensation approach. In these models, the central bank is setting interest rates, as central banks now claim they do. The supply of money in these models is endogenous and demand-led. When a country on a fixed exchange rate regime, say China, has an external surplus, this will be compatible in a quasi-steady state with a constant monetary base despite rising foreign exchange reserves. The central bank holdings of domestic securities, by contrast, will be dwindling. Mainstream authors would say that the central bank of the surplus country is sterilizing foreign reserves, by selling domestic government securities on the open
market. But this is not the result of any intentional policy, where central bankers are actively intervening in financial markets. The central bank of the surplus country, just like the other central banks, is simply attempting to keep its base interest rate constant. Bills are provided to those who demand them at the target rate of interest. This can clearly go on for a very long time without any negative implication for the (Chinese) economy.

While these models show that theories with endogenous money and the compensation thesis can be formalized within a coherent stock-flow framework, one may wonder whether there exists any further empirical analysis sustaining the compensation principle. Jacques David (1971, p. 51), Éric Arnoult (1977) and Nicholas Kaldor (1980, p. 309) have provided some econometric evidence in support of the principle. The most interesting and recent empirical study is that of Marselli (1993). He shows that changes in foreign reserves are not cointegrated with additional bank loans. This supports the claim that banks do not need to await free reserves to grant new loans. Marselli also shows that changes in central bank foreign reserves and changes in the government securities held by private banks are cointegrated, with a positive sign. This is consistent with the claim that when private banks wind up with free reserves, they usually do not use them to grant new loans. Rather, they will use these excess reserves to acquire risk-free government securities. (The latter, of course, is also consistent with systematic sterilization operations made at the initiative of the central bank). Our intent here is to provide a clear example of the compensation principle, that of the Chinese economy over the last decade or so.

The case of the Chinese central bank

The People's Bank of China (PBC) was established in 1948. In 1983 it was decided that this bank would act as a central bank. The central bank status of the PBC was confirmed in 1995 and its roles strengthened in 2003. As (almost) all central banks, the People’s Bank of China must formulate and implement monetary policy, act as the State fiscal agent, issue domestic currency (the Renminbi or yuan), ensure the normal operation of the payment and settlement systems, regulate financial markets including the foreign exchange market, hold and manage foreign reserves, and maintain the external value of its currency at its proper level. ‘The objective of monetary policy is to maintain the stability of the Renminbi and thereby promote economic
growth’ (PBC 2006). Thus in contrast to the mandate of newly independent central banks, the main objective of the PBC is not to target inflation, but rather to target the exchange rate. Thus in law, and in fact until very recently, the Chinese economy is a clear-cut case of a fixed exchange rate economy. We may now say that it has a kind of crawling peg, or a highly managed floating rate.

As is well known, and as Americans have been complaining for some time now, the Chinese economy had an official exchange rate that remained constant for more than ten years, until the renminbi was appreciated by a little over 2% in July 2005. The fluctuations of the renminbi/US dollar rate are only permitted within a narrow band. As a result, the Chinese central bank – the People’s Bank of China – must intervene on foreign exchange markets. As a result of large current account or capital account surpluses, there has been a blistering growing pace in foreign exchange reserves in recent years. While foreign exchange reserves were next to zero in 1989, they grew to 1388 billions of renminbi in 1999, 5143 billions in March 2005, and reached 16 254 billions in December 2008, as can be read from Table 3. China thus looks like an interesting case to test the validity of the compensation thesis versus the standard fixed exchange rate Mundell-Fleming predictions.

As can be seen from the asset side, central bank advances to commercial banks and other financial institutions constitute an entry with substantial amounts. By contrast, claims on domestic government are relatively small. In other words, one may easily deduce that China is an overdraft economy. On the liability side, besides the standard currency and bank reserves entry, there are some large special entries, including a large capital item. There are also government deposits at the central bank, as well as central bank bonds which are issued by the PBC as part of the compensation or endogenous sterilization process.

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5 It slowly drifted up with respect to the US dollar ever since.
Table 3: People’s Bank of China balance sheet, in billions of renminbi

<table>
<thead>
<tr>
<th></th>
<th>June 1999</th>
<th>December 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign assets</td>
<td>1388</td>
<td>16 254</td>
</tr>
<tr>
<td>Claims on central government</td>
<td>158</td>
<td>1619</td>
</tr>
<tr>
<td>Claims on banks and other financial institutions</td>
<td>1501</td>
<td>2032</td>
</tr>
<tr>
<td><strong>Liabilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currency and bank reserves</td>
<td>3020</td>
<td>12 922</td>
</tr>
<tr>
<td>Central government deposits</td>
<td>31</td>
<td>1696</td>
</tr>
<tr>
<td>Central bank bonds</td>
<td>12</td>
<td>4577</td>
</tr>
<tr>
<td>Foreign liabilities</td>
<td>33</td>
<td>73</td>
</tr>
<tr>
<td>Capital accounts and other items</td>
<td>-49</td>
<td>637</td>
</tr>
</tbody>
</table>

*Source: International Monetary Fund (IMF) – International financial statistics online service.*

Looking at the balance sheet, we see that there are six entries of particular interest: the monetary base entry (currency plus bank reserves), central government deposits, and central bank bonds on the liability side; and foreign exchange reserves, government securities, and advances to financial institutions on the asset side. Because we believe that China is more an overdraft economy than an asset-based economy, and because they are the smallest items in the balance sheet of the PBC in 2005, we have decided to neglect government deposits and government securities in our empirical analysis. In any case, we cannot use all the entries of the balance sheet, for otherwise we would be studying an identity!

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6 Prasad et al. (2005, p. 12) claim that central bank bills and bonds are the ‘main sterilization instrument’ of the People’s Bank of China.
We now turn to the empirical part of this paper, where we examine whether endogenous sterilization is compatible with the Chinese economy. We check whether there is a long-run relationship between foreign reserves and the monetary base on the one hand, and between foreign reserves, credits to the domestic economy, and central bank bills on the other hand. According to the Mundell-Fleming model, there should be a relationship between foreign reserves and the monetary base under a fixed exchange regime, with the change in the monetary base being caused by the change in foreign assets. According to the compensation thesis, there should be a long-run relationship between foreign reserves and central bank bonds as well as advances to the domestic economy.

We use a cointegration test with bootstrapping to study these relationships. First of all, we test for the presence of a unit root for each variable. Secondly, we figure out the cointegration rank, i.e., how many stationary cointegration relationships there are in our system. Thirdly, we identify cointegrating vectors in each relationship, putting some restrictions on cointegrating vectors by testing hypotheses on the long-run coefficients. Our purpose is to provide evidence that if endogenous sterilization holds, there is at least one cointegration relationship in our system, with the monetary base being excluded from the relationship, while foreign reserves have a negative effect on advances to domestic financial institutions and a positive one on central bank bonds.

**Empirical Tests**

*Data*

All tests are applied to five monthly data series obtained from balance sheets of the People's Bank of China. These five series are foreign assets (foreign reserves), base money, total claims of the central bank on the domestic economy, bonds issued by the central bank, and government deposits at the central bank, going from December 1999 to November 2007. Base money is what we have called the monetary base: it includes currency held outside the financial system and the reserve deposits of banking and non-banking financial institutions. Total claims on the domestic economy are comprised of four elements: claims on government, claims on deposit money banks, claims on specific depository institutions, and claims on other financial institutions. On the liability side, apart from base money, central bank bonds and government deposits are taken
into consideration, while foreign liabilities and own capital are excluded from our tests because of their small amounts in the balance sheet. For the sake of simplicity, all five variables – foreign reserves, base money, total claims on the domestic economy, central bank bonds, and government deposits – are expressed as FR, MB, Claim, Bond and GD respectively and they are transformed into logarithmic form.

Obviously, for a time-series analysis, the sample size of each series is not overly large: it has only 96 observations since Chinese official statistics were not clear and reliable until the end of the 1990s and thus data from the official website of the Chinese central bank are all starting from 1999. Furthermore, the data series of central bank bonds is incomplete, with missing values from March 2000 to August 2002. To make the model operate properly, we extrapolate the missing values with the help of SAS, computing the average point over each month.

In addition, as already pointed out, China left its pure fixed fixed exchange rate regime with the US dollar in July 2005. The data after that date thus suffers from some contamination if foreign reserves in the balance sheet are in RMB, and so the data of foreign assets are collected from in US dollar units. Although China started to increase the proportion of other currencies such as Euros and Yens in its foreign exchange reserves, according to unofficial sources about 80% of Chinese foreign reserves are still invested in US dollars. As a result, we decided to ignore the impact of the fluctuations in the exchange rates of other currencies. All five data series used in the test are shown in Figure 1.

\[ \Delta FR = \Delta US*EX + US*\Delta EX, \]
where FR, US and EX represent foreign reserves in RMB, foreign reserves in US dollars and the value of RMB in dollars (the exchange rate) respectively. Changes in foreign reserves in RMB (ΔFR) reflect partially a capital loss, when the dollar depreciates. Ideally, the foreign reserves data should be adapted to remove the capital loss, because what counts is the value of the flow change in reserves, not the change in the value of the stock of reserves. To avoid this kind of contamination, we use the first part of the right hand side of the equation (ΔUS*EX) in our tests.

\[ \text{In our tests, } FR (\square) = \Delta US \ast EX, \]
where the data of ΔUS are obtained from the Chinese central bank.

Unit Root Tests

Different unit root tests are used and the lag length is selected by the Modified AIC. In Table 5, Panel A presents the result of the most popular Augmented Dicky and Fuller unit root test. Panel B extends the GLS detrending procedure of Elliott, Rothenberg and Stock (1996) to the ADF test and Panel C calculates two unit root statistics using GLS detrended data for each variable introduced by Ng and Perron (2001). The reason for which we added the latter two tests is that many studies have shown they improve the finite sample performance with better size and power properties. Table 4 suggests that there is a unit root in each variable, meaning that all five data series are nonstationary. Therefore, we can proceed to the next step and test the cointegration relationships.

Table 4: Unit root tests
### Panel A: ADF Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Lag Length</th>
<th>Test Statistics</th>
<th>Critical Value (95%)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Reserves</td>
<td>1</td>
<td>1.223360</td>
<td>-2.892536</td>
<td>0.9981</td>
</tr>
<tr>
<td>Reserve Money</td>
<td>1</td>
<td>1.122147</td>
<td>-2.896346</td>
<td>0.9974</td>
</tr>
<tr>
<td>Total Claims</td>
<td>0</td>
<td>-1.800810</td>
<td>-3.457808</td>
<td>0.6968</td>
</tr>
<tr>
<td>Government Deposits</td>
<td>11</td>
<td>1.122147</td>
<td>-2.896346</td>
<td>0.9974</td>
</tr>
<tr>
<td>Bond issues</td>
<td>1</td>
<td>-1.352644</td>
<td>-2.892536</td>
<td>0.6021</td>
</tr>
</tbody>
</table>

### Panel B: Dicky-Fuller GLS Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Lag Length</th>
<th>Test Statistics</th>
<th>Critical Value (95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Reserves</td>
<td>1</td>
<td>-1.113653</td>
<td>-3.049200</td>
</tr>
<tr>
<td>Reserve Money</td>
<td>10</td>
<td>-0.326013</td>
<td>-3.078000</td>
</tr>
<tr>
<td>Total Claims</td>
<td>0</td>
<td>-1.784086</td>
<td>-3.046000</td>
</tr>
<tr>
<td>Government Deposits</td>
<td>11</td>
<td>-1.506591</td>
<td>-3.081200</td>
</tr>
<tr>
<td>Bond issues</td>
<td>1</td>
<td>-1.702304</td>
<td>-3.062000</td>
</tr>
</tbody>
</table>

### Panel C: Ng-Perron Test

<table>
<thead>
<tr>
<th>Variables</th>
<th>Lag Length</th>
<th>MZ$_\alpha$ Test Statistics</th>
<th>MZ$_\tau$ Test Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Reserves</td>
<td>1</td>
<td>-2.23484</td>
<td>-1.03668</td>
</tr>
<tr>
<td>Reserve</td>
<td>0</td>
<td>-12.9540</td>
<td>-2.30717</td>
</tr>
</tbody>
</table>

10 The null hypothesis is that the variable has a unit root.
11 The null hypothesis is that the variable has a unit root.
12 The null hypothesis is that the variable has a unit root and critical values for the corresponding MZ$_\alpha$ and MZ$_\tau$ statistics obtained from Ng-Perron are -17.3 and -2.91 respectively.
### Money

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Claims</td>
<td>0</td>
<td>-6.01340</td>
</tr>
<tr>
<td>Government</td>
<td>11</td>
<td>-0.52141</td>
</tr>
<tr>
<td>Deposits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bond issues</td>
<td>0</td>
<td>-6.52629</td>
</tr>
</tbody>
</table>

**Correcting for the small sample size**

In this paper, we select the likelihood ratio (LR) test of cointegration rank (Johansen, 1988) to test for cointegration, as this test has been much used in recent studies because of its relative simplicity to calculate LR statistics by reduced rank regression. The 5-dimensional vector autoregressive (VAR) model is considered to analyze the multivariate nonstationary data. We use the model that includes a constant and a trend term.

However, as pointed out before, we rely on a small sample size – less than 100 observations for each variable of our data set. Many economists believe that this sample size is insufficient to provide reliable empirical results since the maximum likelihood cointegration procedure relies on asymptotic considerations. A number of simulation tests have shown that there is much difference in the cointegration trace test between the small sample and asymptotic properties. As noted by Li and Maddala (1997, p. 299), ‘It is now widely recognized that inference based on asymptotic distributions has two major drawbacks: (a) The estimators, though consistent (and often super consistent) have substantial small sample biases and (b) The tests of significance based on the asymptotic distributions have substantial size distortions’.

Johansen (2002, p. 1929) has also pointed out that ‘the limit distribution of the test is often a poor approximation to the finite sample distribution and it is therefore relevant to derive an approximation to the expectation of the likelihood ratio test for cointegration in the vector autoregressive model in order to improve the finite sample properties’. Basically, the problem can be regarded as a lack of coherence between the test statistics and its corresponding distribution. Two methods have been considered to alleviate the distortion. One either corrects the reference distribution, for a given test statistics, or one modifies the test statistics for a given reference distribution (Gredenhoff and Jacobson, 2001). The latter correction can be implemented...
by the Bartlett factor, which is proposed by Johansen (2002), suggesting that by computing the expectation of the LR statistics over the small sample distribution, we can correct this statistics, keeping the same sample mean.

Alternatively, the bootstrap approach could be considered as a feasible way to correct the small sample distribution of the statistics. This method generates a number of pseudo-observations and trace statistics of interest using the OLS estimators and residuals to approximate a new asymptotic distribution and critical values that are used to replace those of the limit distribution, as in Swensen’s (2006) bootstrap algorithms for a VAR model.

There are two basic approaches, parametric and non-parametric, to bootstrap data. Parametric bootstrapping draws the new innovations from a multivariate standard normal distribution and then calculates the covariance matrix from the original estimated residuals to transform the new innovations into bootstrapped residuals. Non-parametric bootstrapping, such as block bootstrap, is more common and closely related to the method proposed by Swensen (2006). Non-parametric bootstrapping means that one draws pseudo-residuals independently from a population of estimated residuals without making assumptions about the form of the population. Both approaches have been claimed to be effective to improve the performance of the asymptotic distribution of test statistics. Davidson (2002) used parametric bootstrapping to test the existence of the cointegration relationship between UK consumption and disposable income, concluding that the test is consistent with both stationary and nonstationary cointegrating residuals and performs better than standard tests. Applying bootstrap procedures to the case of US consumption, income and wealth, Davidson (2006) showed that these tests function reasonably well in a small sample even if they are not asymptotically pivotal.

Cointegration results

We now turn to the empirical evidence of this paper. Cointegration of rank r is carried out using the regular Johansen cointegration test first. According to Figure 1, there is a significant intercept and trend for each variable, thus, only the case of a constant and restricted linear trend is
examined. Centered seasonal dummies are also taken into account because of the significant seasonal adjustment shown in the dataset. The number of the lag length is 1 which is optimally selected by AIC, FPE, HQC and SC. The parametric bootstrap approach is utilized and the number of replications is 1999. Table 5 presents inference about the conventional cointegration test.

Table 5: Conventional Cointegration Analysis

<table>
<thead>
<tr>
<th>$H_0$</th>
<th>LR trace statistics</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>r=0</td>
<td>103.8756</td>
<td>0.0027</td>
</tr>
<tr>
<td>r≤1</td>
<td>58.2383</td>
<td>0.1361</td>
</tr>
<tr>
<td>r≤2</td>
<td>27.3508</td>
<td>0.6607</td>
</tr>
<tr>
<td>r≤3</td>
<td>10.9310</td>
<td>0.8791</td>
</tr>
<tr>
<td>r≤4</td>
<td>3.7486</td>
<td>0.7781</td>
</tr>
</tbody>
</table>

The conventional cointegration test suggests $r = 1$. However, as argued previously, the inference might be distorted by poor approximations in a small-sample distribution. Using the Bartlett correction, we get the cointegration results of Table 6.

Table 6: Bartlett Corrected Cointegration Analysis

<table>
<thead>
<tr>
<th>$H_0$</th>
<th>LR trace statistics (Corrected)</th>
<th>90%</th>
<th>95%</th>
<th>99%</th>
<th>Bartlett Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>r=0</td>
<td>95.5538</td>
<td>84.380</td>
<td>88.800</td>
<td>97.600</td>
<td>1.087089</td>
</tr>
<tr>
<td>r≤1</td>
<td>49.8888</td>
<td>60.090</td>
<td>63.880</td>
<td>71.470</td>
<td>1.167362</td>
</tr>
<tr>
<td>r≤2</td>
<td>18.1405</td>
<td>39.750</td>
<td>42.910</td>
<td>49.360</td>
<td>1.507718</td>
</tr>
<tr>
<td>r≤3</td>
<td>8.7188</td>
<td>23.340</td>
<td>25.870</td>
<td>31.160</td>
<td>1.253734</td>
</tr>
<tr>
<td>r≤4</td>
<td>2.7034</td>
<td>10.670</td>
<td>12.520</td>
<td>16.550</td>
<td>1.386616</td>
</tr>
</tbody>
</table>

13 All tests are done by the Matlab based software SVAR developed by a time series econometrician Warne, who is working at the European Central Bank. http://texlips.hypermart.net/warne/index.html
14 Lag length = number of lagged difference terms
Table 6 indicates improved empirical results with asymptotically critical values. Using a standard 5% significant size, we can find that the cointegration rank is 1 again. The implementation of the correction factor leads to some changes in the trace statistics, but the corrected procedure still favours the conclusion that \( r = 1 \). Thus there is one cointegration relationship.

We now examine what happens when the correction is done through the bootstrapping procedure, to simulate the corrected reference distribution.\(^{15}\) Table 7 shows the new critical values of the simulated reference distribution for different quintiles. In Panel A-E of Table 7, the 90%, 95% and 99% percentiles are compared with the corresponding asymptotic critical values. Bold numbers represent critical values of the simulated empirical distribution when the null hypothesis is true. Note that almost all critical values from the empirical distributions are smaller than the asymptotic ones, i.e., the empirical distributions are skewed to the left of the asymptotic ones, which means when we use the asymptotic critical values, there is a higher probability of underrejecting nulls.

\(^{15}\) Note that when we bootstrap the new trace statistics \( Q \), we also use the Bartlett correction factor.
Table 7: Simulated Critical Values with Corresponding Quantiles

<table>
<thead>
<tr>
<th></th>
<th>Panel A</th>
<th>Panel B</th>
<th>Panel C</th>
<th>Panel D</th>
<th>Panel E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₀: r=0 against Hₐ: r≥ 1</td>
<td>H₀: r=1 against Hₐ: r≥ 2</td>
<td>H₀: r=2 against Hₐ: r≥ 3</td>
<td>H₀: r=3 against Hₐ: r≥ 4</td>
<td>H₀: r=4 against Hₐ: r≥ 5</td>
</tr>
<tr>
<td>Quantiles</td>
<td>0.9</td>
<td>0.95</td>
<td>0.99</td>
<td>0.9</td>
<td>0.95</td>
</tr>
<tr>
<td>Critical values</td>
<td>84.38</td>
<td>88.8</td>
<td>97.6</td>
<td>60.09</td>
<td>63.88</td>
</tr>
<tr>
<td>DGP rank</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>82.82</td>
<td>87.29</td>
<td>98.78</td>
<td>121.27</td>
</tr>
<tr>
<td>1</td>
<td>48.41</td>
<td>51.34</td>
<td>59.41</td>
<td>57.38</td>
<td>60.04</td>
</tr>
<tr>
<td>2</td>
<td>26.33</td>
<td>28.77</td>
<td>33.53</td>
<td>30.2</td>
<td>32.52</td>
</tr>
<tr>
<td>3</td>
<td>12.28</td>
<td>13.45</td>
<td>16.12</td>
<td>14.15</td>
<td>15.38</td>
</tr>
<tr>
<td>4</td>
<td>4.05</td>
<td>4.6</td>
<td>5.53</td>
<td>4.58</td>
<td>5.24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Panel D</th>
<th>Panel E</th>
<th>Panel D</th>
<th>Panel E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₀: r=3 against Hₐ: r≥ 4</td>
<td>H₀: r=4 against Hₐ: r≥ 5</td>
<td>H₀: r=3 against Hₐ: r≥ 4</td>
<td>H₀: r=4 against Hₐ: r≥ 5</td>
</tr>
<tr>
<td>Quantiles</td>
<td>0.9</td>
<td>0.95</td>
<td>0.99</td>
<td>0.9</td>
</tr>
<tr>
<td>Critical values</td>
<td>23.34</td>
<td>25.87</td>
<td>31.16</td>
<td>10.67</td>
</tr>
<tr>
<td>DGP rank</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>157.38</td>
<td>164.78</td>
<td>175.37</td>
</tr>
<tr>
<td>1</td>
<td>88.2</td>
<td>93.21</td>
<td>102.07</td>
<td>89.93</td>
</tr>
<tr>
<td>2</td>
<td>42.93</td>
<td>46.53</td>
<td>51.91</td>
<td>45.28</td>
</tr>
<tr>
<td>3</td>
<td>20.25</td>
<td>22.06</td>
<td>25.69</td>
<td>22.46</td>
</tr>
<tr>
<td>4</td>
<td>6.53</td>
<td>7.4</td>
<td>8.95</td>
<td>7.91</td>
</tr>
</tbody>
</table>
To identify the cointegration relationship among the different variables, we test the long-run linear restrictions on $\beta$. By several trials of different null hypothesis, there is one null hypothesis, shown below, that cannot be rejected, with $LR(2)=8.8017$ and the corresponding p-value at 0.1461, which means the variable MB is long-run excluded.

\[
\beta = \begin{bmatrix}
FR \\
Claim \\
Bond \\
t
\end{bmatrix} = \begin{bmatrix}
1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 1
\end{bmatrix} \begin{bmatrix}
FR \\
MB \\
Claim \\
GD \\
Bond \\
t
\end{bmatrix}
\]

Therefore, the equilibrium relation (standard error in parenthesis) is given by:

\[
FR_t + 1.6891Claim_t = 0.0849Bond_t + 0.0136t \tag{1}
\]

\[
(0.393) \quad (0.0801) \quad (0.0027)
\]

where the cointegrating coefficient of $FR_t$ is normalized as 1. According to this equation, the signs seem correct. The terms on the asset side of the balance sheet of the Chinese central bank on the left hand side equal the terms on the liability side of the balance sheet on the right hand side.

To make it straightforward to interpret the cointegrating relationship in terms of an error correction mechanism measuring the sterilization effect, we use two other expressions to show the marginal effect, with the first of which being normalized on $Claim_t$, while the second is normalized on $Bond_t$:

\[
Claim_t \sim -0.6FR_t \\
Bond_t \sim 11.7FR_t
\]

If foreign reserves FR increase by 1%, total claims on the domestic economy will tend to decrease by 0.5%, or central bank issues will increase by 11.7%. Thus, as one would expect with
the compensation thesis, the increased foreign reserves FR on Claims and Bonds yield effects of opposite signs, and FR seems to influence Bond much more than Claim.

We can now sum up the results so far by saying that in the case of the Chinese central bank with a fixed or highly managed exchange regime, the increasing foreign reserves impact the amount of total claims on the domestic economy as well as the amount of central bank bonds. The independence of the money base relative to foreign reserves falsifies the Mundell-Fleming argument that the money supply is endogenously driven by foreign reserves. In addition, the tested relationship suggests that there is an opposite movement between foreign reserves and total domestic credits whereas there is a comovement between foreign reserves and central bank bonds. The relatively large cointegrating coefficient of Bond shows the significant role of bond issues in the sterilization process presently used by the Chinese central bank. Because no one can force Chinese financial institutions to purchase the bonds issued by the central bank, it seems quite appropriate to speak of compensation or endogenous sterilization.

*Some robustness tests*

Many studies have shown that applying cointegration tests to bivariate systems is a good check of the overall plausibility and consistency of the results. Cointegration tests may have relatively lower power when applying higher dimensional system (Lutkepohl and Kratzig, 2004). Thus, I put MB and FR into an error correction model. Table 8 shows that there is no cointegration between the two variables, supporting our previous result of the multivariate system that changes in base money are not determined by changes in foreign reserves.
Table 8: Cointegration analysis of the bivariate system

<table>
<thead>
<tr>
<th>Rank</th>
<th>LR</th>
<th>LR (Corrected)</th>
<th>Different Percentiles for Empirical Distributions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>90%</td>
</tr>
<tr>
<td>r = 0</td>
<td>21.6352</td>
<td>20.3685</td>
<td>22.6073</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>2.8098</td>
<td>2.0248</td>
<td>8.7029</td>
</tr>
</tbody>
</table>

Another test to verify the robustness of our empirical results is to redo all tests using samples that start in September 2002, getting rid of the missing values of the bond series. However, the sample size would be smaller and the bootstrap and Bartlett factors seem to be more important in this case. As shown in Table 9, the LR statistics are also corrected by the Bartlett factor, distributions are improved by bootstrap, and we still get a single cointegration relationship (r = 1).

Table 9: Cointegration analysis with sample starting only in September 2002

<table>
<thead>
<tr>
<th>H₀</th>
<th>LR trace statistics (Corrected)</th>
<th>Different Percentiles for Empirical Distributions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H₀</td>
<td>90%</td>
</tr>
<tr>
<td>r=0</td>
<td>87.7615</td>
<td>81.4259</td>
</tr>
<tr>
<td>r≤1</td>
<td>53.4697</td>
<td>58.2169</td>
</tr>
<tr>
<td>r≤2</td>
<td>22.6086</td>
<td>36.9011</td>
</tr>
<tr>
<td>r≤3</td>
<td>10.5445</td>
<td>20.3710</td>
</tr>
<tr>
<td>r≤4</td>
<td>2.7003</td>
<td>8.3472</td>
</tr>
</tbody>
</table>

Moreover, the exclusion test shows only MB – the money base – is excluded from the system by testing various hypotheses. The identified cointegration vector is:

---

16 The lag number of 1 is automatically selected.
To make it straightforward, this relation can be expressed by:

\[
\begin{align*}
\text{Claim}_t &\sim 0.3\text{FR}_t & \text{if normalizing on Claim}_t \\
\text{GD}_t &\sim 0.2\text{FR}_t & \text{if normalizing on GD}_t \\
\text{Bond}_t &\sim 3.7\text{FR}_t & \text{if normalizing on Bond}_t
\end{align*}
\]

When foreign reserves increase by 1%, total claims on the domestic economy, government deposits and central bank bills tend to rise by 0.3%, 0.2% and 3.7% respectively.

Equation (2) yields a few different implications relative to the results given by equation (1). Government deposits are cointegrated in the case of equation (2), a result which is in line with the compensation thesis. This effect is perhaps most obvious when only the most recent data is being considered because the numerical importance of government deposits has only arisen over the last few years. Indeed, some Chinese economists have pointed out that government deposits have recently gained some significance in the sterilization process (Li and Peng, 2007; Chinese Financial Development Report, 2006). It can also be noted that the effect of foreign reserves on central bank bonds is smaller in equation (2) than it was in equation (1), although the bond issue is still the most important instrument of sterilization.

Most obviously, there is now a comovement of foreign reserves and domestic claims. While this seems to be more consistent with the visual aspect of the data, as seen in Figure 1, it appears to be inconsistent with the compensation thesis. The sign of Claim\(_t\) is reversed in equation (2), which seems inconsistent with the ‘compensation thesis’. There might be two reasons for this to happen. One is that the Chinese domestic market has been growing rapidly these years, with a large appetite for credits provided by the central bank. The Chinese central bank finds it more difficult to rely solely on reducing total claims to implement sterilization, although most Chinese economists argued that the reduction of advances to commercial banks

---

17 The number of restriction is 1 and LR(1)=0.6192 and p-value=0.4314
had played a dominant role in sterilization before 2001. The other reason is that the proportion of claims to total assets has diminished substantially after 2003 due to the previous sterilization process. Meanwhile, foreign reserves are increasing at a faster pace. There is thus less space to continue sterilization through a single instrument – domestic claims. As a matter of fact, since 2003, the Chinese central bank has been more inclined to issue bonds than to use other instruments. This might explain why the coefficient of Claim is consistent with the “compensation thesis” when incorporating all observations starting from 1999, while it has the wrong sign when dealing with the subsample starting from September 2002.

Mundell’s views about the growth of the money base causing inflation, which he inherited from Irving Fisher’s quantity theory of money, claiming that an increase in foreign reserves will lead to an increase in the money supply and thereby a rise in prices, is still widely accepted by most Chinese economists. The following ultimate test is to investigate the relationship between the amount of foreign reserves and the consumer price index (CPI), in order to check whether Mundell’s statement is valid or not in the case of the Chinese economy. Empirical evidence, as given by Table 10, shows there is no relationship between the two variables and Mundell’s causality of inflation is thus invalid. Fears about the inflationary consequences of rising foreign exchange reserves seem unwarranted, as the behaviour of the consumer price index seems to be independent of that of foreign reserves.

Table 10: Cointegration analysis between the amount of foreign reserves and the CPI

<table>
<thead>
<tr>
<th>Rank</th>
<th>LR</th>
<th>LR (Corrected)</th>
<th>90%</th>
<th>95%</th>
<th>99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>r = 0</td>
<td>25.036</td>
<td>21.7575</td>
<td>23.34</td>
<td>25.87</td>
<td>31.16</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>3.5097</td>
<td>3.4125</td>
<td>10.67</td>
<td>12.52</td>
<td>16.55</td>
</tr>
</tbody>
</table>

18 China Financial and Economic News, April, 2007
19 The number of lags is 2.
Conclusion

The present paper extends the theory of demand-led money supply endogeneity to the case of an open economy with a fixed exchange rate. This case was first explored by French central bankers in the 1970s, and was called the compensation thesis. This approach can be contrasted to the Mundell-Fleming model, where interest rates are endogenous variables and where monetary policy is assessed by the money supply level, which is assumed to be under the control of the central bank, except precisely in the case of a fixed exchange rate regime. By contrast, the compensation approach claims that central banks are able to set interest rates, even in a fixed exchange rate regime, either because there are automatic market mechanisms that will induce the private sector to act in such a way that changes in foreign reserves will be compensated by opposite changes in central bank claims over the domestic economy, or because the central bank will engage in endogenous sterilization operations in its efforts to keep the benchmark interest rate at the level that it sees fit.

We have taken China as an example of the compensation approach. Despite huge increases in its foreign reserves since 1999, the rate of inflation in China remained below 1% until 2003, and even fell below 0% for a couple of years. After some burst in 2004 and early 2005, the rate of inflation was back to around 1 or 2% until 2007 when it went over 4%. Soaring food and commodity prices, a world-wide phenomenon, however was responsible for this inflationary boost, and it could be observed as well in countries with a flexible exchange rate. Indeed, the Chinese inflation rate remained high for only about a year, and it started to fall in July 2008, as a result of the world-wide slowdown and falling commodity prices. Still, during that time, the growth in foreign reserves continued unabated.

The lack of any empirical relationship between price inflation and the accumulation of foreign assets by the central bank can be explained, among other things, by the systematic use of sterilization procedures. Sterilization seems to have occurred initially through some endogenous process, whereby the increase in foreign reserves was compensated by a decrease in the size of advances made by the central bank to the domestic economy. More recently, at least since 2002, sterilization has occurred more on the liability side of the balance sheet of the People’s Bank of China – the central bank of China. Increase in foreign reserves have been compensated, at least
in part, by increases in the amount of outstanding bonds issued by the central bank, as well as increases in the size of government deposits at the central bank, thus insulating the monetary base from changes in foreign reserves. Cointegration analysis, with appropriate corrections to take into account the small size of the sample, has given support to the compensation thesis, showing that there was no long-term relationship between foreign reserves and the monetary base, whereas there did exist in all cases a clear long-term relationship between foreign reserves and the amount of bonds issued by the Chinese central bank. Depending on the period under study, claims to the domestic economy and government deposits also played a role in the sterilization process.
References


Prasad, E., Rumbaugh T., & Qang, Q. (2005) Putting the cart before the horse? Capital account liberalization and exchange rate flexibility in China, IMF Policy Discussion Paper 05/1, IMF.