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

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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. 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 take the case of China, with its fixed exchange rate and large acquisitions of foreign reserves to provide some empirical evidence of the compensation thesis. The central bank of China uses issues of central bank bonds in lieu of open market operations as the main tool to sterilize changes in foreign reserves. Cointegration analysis offers some support to the compensation thesis, showing, at least in two of the three cases examined, that there is no long-term relationship between foreign reserves and the monetary base, whereas there does exist a long-term relationship between foreign reserves and the amount of bonds issued by the Chinese central bank.

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 automatic: they are the normal response of the financial system to the external disequilibrium (Lavoie, 2001).

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 now, with large balance of payments surpluses. In the fourth section, we present the results of cointegration analysis. The results are moderately favourable to the compensation thesis.

**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 from the 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 into 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. 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. Also, why would interest rates in surplus countries be any higher than interest rates in countries facing current account deficits and trying hard to avoid devaluation? One would have thought that countries faced with external deficits would be the ones to be tempted by high or rising interest rates!

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 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.¹

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.

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

¹ 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.
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, 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. 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

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2 It must be pointed out that Mundell (1961, p. 153) himself was aware that the automaticity of the 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 banking principle instead of the bullionist principle, and hence adjusting ‘the domestic supply of notes to accord with the needs of trade’.
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 supply-led, whereas in the post-Keynesian approach, the money supply is endogenous because it is 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. 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 biased. While it may represent, to some extent, the characteristics of Anglo-Saxon monetary systems, which we call *asset-based* financial systems, 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</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 bills</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 bills 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, since these securities seem to carry less risk than government securities.

An increase in foreign reserves can thus be wiped out – compensated – either by a reduction in advances to domestic banks or by an increase in government deposits and bills 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 bills.³

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 main 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.

**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, the Chinese economy is a clear-cut case of a fixed exchange rate economy.

As is well known, and as the Bush Administration has been complaining for some time now, the Chinese economy is on a fixed exchange rate regime, and the official exchange rate 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 and 5143 billions in March 2005, as can be read from Table 3, and reached 6343 billions in December 2005. 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 negative 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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4 It slowly drifted up by another percent over the following year.
Table 3: People’s Bank of China balance sheet, in billions of renminbi

<table>
<thead>
<tr>
<th></th>
<th>June 1999</th>
<th>March 2005</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foreign assets</td>
<td>1388</td>
<td>5143</td>
</tr>
<tr>
<td>Claims on central government</td>
<td>158</td>
<td>297</td>
</tr>
<tr>
<td>Claims on banks and other financial institutions</td>
<td>1501</td>
<td>1906</td>
</tr>
<tr>
<td><strong>Liabilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currency and bank reserves</td>
<td>3020</td>
<td>6200</td>
</tr>
<tr>
<td>Central government deposits</td>
<td>31</td>
<td>332</td>
</tr>
<tr>
<td>Central bank bonds</td>
<td>12</td>
<td>1473</td>
</tr>
<tr>
<td>Foreign liabilities</td>
<td>33</td>
<td>62</td>
</tr>
<tr>
<td>Capital accounts and other items</td>
<td>-49</td>
<td>-720</td>
</tr>
</tbody>
</table>

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

Looking at the balance sheet, we see that there are four entries of particular interest: the monetary base entry (currency plus bank reserves) and central bank bonds on the liability side, and foreign exchange reserves 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!

We now move to the empirical part of the paper, where, simply put, we intend to verify whether the compensation thesis is compatible with the data of the Chinese economy. We also examine the standard Mundell-Fleming claim, according to which there is a tight relationship between foreign exchange reserves and the monetary base in a small open economy with a fixed exchange regime, with the foreign reserves ‘causing’ the monetary base. To study this, we use the

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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.
In any case, as explained by Peebles (1992), earlier data is highly unreliable. Subsequent cointegration analysis suggests the potential presence of I(2) variables in the system. However, according to the eigenvalues of the companion matrix, explosive roots may be suspected. It is known that explosive roots mimic the behavior of I(2) processes; see Haldrup and Lildholdt (2002). The analysis of these possibilities is beyond the scope of this paper.

Empirical Results

Cointegrating vectors

Data was obtained from the International Financial Statistics (IFS) of the International Monetary Fund. We have monthly data that spans from June 1999 to March 2005. The IFS provided no data before 1999, and although we had access to data up to December 2005, rather strangely the data for currency and reserves after March 2005 was unavailable. All variables (foreign reserves, the monetary base, claims on financial institutions) are worked in logarithms except the central bank bonds variable. Furthermore, centered seasonal dummies are used. Estimation of unrestricted vector autoregressive (VAR) suggests violation of the null hypothesis of normality of the residuals. The source of the problem appears to be the presence of additive outliers. In consequence, we use dummy variables to capture the influence of these observations.

The Dickey and Fuller statistic using GLS detrended data (Elliott, Rothenberg and Stock, 1996) has been used. The lag length has been calculated using the Modified AIC (MAIC), as suggested by Ng and Perron (2001). The results, not shown in order to save space, suggest that the unit root hypothesis cannot be rejected. Therefore, the subsequent steps of the methodology may be summarized as follows. In a first step, we test for cointegration using the methodology of Johansen (1988, 1995). According to the number of selected cointegrating vectors, the second step consists in testing for restrictions in order to identify the cointegrating vectors.

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6 In any case, as explained by Peebles (1992), earlier data is highly unreliable.

7 Subsequent cointegration analysis suggests the potential presence of I(2) variables in the system. However, according to the eigenvalues of the companion matrix, explosive roots may be suspected. It is known that explosive roots mimic the behavior of I(2) processes; see Haldrup and Lildholdt (2002). The analysis of these possibilities is beyond the scope of this paper.
Since there were many instances where the central bank did not have any bond outstanding, mainly at the beginning of the sample, we could not use the logarithmic value of bonds. The number of lags used in testing for cointegration is 2, which has been selected according to the AIC. There are three issues that deserve mention here. First, the selection of the rank of cointegration depends on the assumption established with respect to the deterministic components. For example, the use of an unrestricted constant means that the levels of the time series contain linear trends. The use of a restricted trend means that the levels of the time series have linear trends and the trend is restricted to the space of cointegration. The use of an unrestricted trend means that the levels of the time series contain quadratic trends. This last case is not used in most empirical applications, but visual examination of the series led us to believe that quadratic trends were not an unreasonable possibility within the time span of the data.

The second issue that deserves mention is the fact that asymptotic critical values may be inadequate for most of the finite samples used in empirical applications. Consequently, in the present case we follow Reimers (1992) and correct the obtained values by the factor \((T-nk)/T\), where \(T\) is the sample size, \(n\) is the number of variables and \(k\) is the number of lags used in the system. The third issue is the fact that additive outliers are present in the time series. Even when dummy variables are used to control for these observations, the limiting distributions (and consequently the critical values) may be inadequate. Therefore, the obtained results should be considered with caution.

Table 4 presents results of cointegration testing for the system

\[ y_t = \{l_{\text{foreign}}, l_{\text{base}}, l_{\text{claims}}, bonds\} \]

where:

- \(l_{\text{foreign}}\) = logarithmic value of foreign reserves
- \(l_{\text{base}}\) = logarithmic value of the monetary base (currency plus bank reserves)
- \(l_{\text{claims}}\) = logarithmic value of the claims on domestic financial institutions
- \(bonds\) = value of bonds or bills issued by the central bank

Results from Table 4 suggest \(rank=1, 2, \) and \(1\) according to the three cases mentioned above (unrestricted constant, restricted trend, unrestricted trend), respectively. Now, we proceed with the identification of the corresponding vectors. In the first case (of Table 4), we have \(r=1\). The restrictions imposed are the long-run exclusion of the variables \(l_{\text{base}}\) and \(l_{\text{claims}}\). Furthermore, we test for strong exogeneity of the same variables. The result is a \(\chi^2(4) = 4.157\) which correspond to a p-value of 0.385. Therefore the cointegrating vector (standard errors in parenthesis) is:

\[ l_{\text{foreign}} = 0.000596 \text{ bonds,} \quad (1) \]

\(^8\) Since there were many instances where the central bank did not have any bond outstanding, mainly at the beginning of the sample, we could not use the logarithmic value of bonds.
In the second case of Table 4 we have \( r=2 \). For the first cointegrating vector, we test for long-run exclusion of the variables \( l\text{base} \), \( l\text{claims} \), and \( \text{trend} \). In the second vector, the long-run excluded variables are \( l\text{claims} \) and \( l\text{foreign} \). Furthermore, strong exogeneity is imposed for \( l\text{claims} \) and \( l\text{base} \) (first vector) and \( \text{bonds} \) (second vector). These restrictions allow to obtain a \( \chi^2(6) = 8.542 \) with a p-value of 0.201. Therefore, the two identified cointegrating vectors are:

\[
\begin{align*}
l\text{foreign} &= 0.000670 \text{ bonds}, \\
         &= 0.000670 \\
        \text{(0.0000709)} & \\
\end{align*}
\]

\[
\begin{align*}
l\text{base} &= 0.00010 \text{ bonds} + 0.0088 \text{ trend}, \\
         &= 0.00010 + 0.0088 \\
        \text{(0.000227)} & + \text{(0.00034)} \\
\end{align*}
\]

The third case of Table 4 suggested \( r=1 \). In this case, the long-run exclusion of the variable \( l\text{base} \) is strongly rejected. However, the long-run exclusion of the variables \( l\text{claims} \) and \( \text{bonds} \) is not rejected. Strong exogeneity of \( l\text{claims} \) is also not rejected. All restrictions allow to obtain a \( \chi^2(3) = 2.268 \) which corresponds to a p-value of 0.518. The identified cointegrating vector is:

\[
l\text{foreign} = 49.448 \ l\text{base}, \\
   (9.691)
\]

**Interpretation of the results**

Equation (1) is simplest to interpret. There is a single cointegrating vector, and this vector only involves foreign reserves and central bank bonds. Since the monetary base variable is excluded, while central bank bonds are part of the cointegrating vector, equation (1) offers support to the compensation thesis, while it leads to the rejection of the Mundell-Fleming approach. The cointegrating vector (1) can be interpreted as representing what we call *endogenous sterilization*, meaning that when the Chinese economy experiences a balance of payments surplus, the increase in foreign reserves are sterilized by selling central bank bonds to the financial institutions. This is a variant of open market operations, whereby the central bank wipes out excess liquidity balances by selling central bank bonds (instead of selling government securities to banks, as is usually assumed).

System (2) of equations is a little more difficult to interpret. Equation (2.1) contains the same variables as equation (1), and its parameter value is nearly identical, so our interpretation in terms of endogenous sterilization remains. Now what about the second cointegrating equation,
given by (2.2)? One possible interpretation would be in terms of some sort of reaction function. When the monetary base is growing too quickly in the eyes of the PBC, the central bank speeds up the issue of central bank bills and bonds.

Finally, we examine the cointegration vector of the third case, that with a non-linear trend, given by equation (3). This equation would seem to support traditional theory, since it indicates a long-term relationship between foreign reserves and the monetary base, as would be deduced from standard macroeconomic textbooks. Equation (3) thus contradicts what could be deduced from equations (1) and (2).

We may thus conclude here that two of the three cases yield support to the compensation thesis, while the third case gives support to traditional theory, that of Mundell-Fleming. We should add however that the assumption of a quadratic trend in the levels of the data, upon which the third case is based, is very rarely used in this kind of empirical work, since this non-linear trend cannot occur indefinitely. We decided to examine this third case because of the apparent non-linearity in some time series.9

The fact that different specifications yield different results indicates that our results are not robust. In a way this is not surprising, since, as was pointed out in the description of the data, normality seemed to be violated due to the presence of many outliers, some of which may be due to changes in definitions used by the PBC. Given the obtained ambiguous results, it would have been interesting to enquire about Granger causality, in an attempt to provide additional evidence regarding the compensation thesis versus the traditional approach, but such an inquiry seems to be meaningless in this case, given that we only have access to monthly data. Indeed, if sterilization or endogenous sterilization is performed, it would be done on a daily basis, or at most on a weekly basis, and hence monthly data will not capture any of this.10

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

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9 However, remember the potential existence of I(2) processes or explosive roots in the system. See footnote 7.

10 In addition, Phillips and Toda (1994) show, based on Monte Carlo simulations, that the validity of the F-statistic is in doubt when sample sizes are small and when three or more variables are used in the system, as precisely would have been the case here!
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 has been back to around 1 or 2%. This can be explained, among other things, by the fact that the increase in foreign reserves has been compensated, at least in part, by an increase in the amount of outstanding bonds issued by the People’s Bank of China – the central bank of China, thus insulating the monetary base from changes in foreign reserves. The issues of central bank bonds thus act in lieu of open market operations as the main tool to sterilize changes in foreign reserves. Cointegration analysis has given some support to the compensation thesis, showing, at least in two of the three cases examined, that there was no long-term relationship between foreign reserves and the monetary base, whereas there did exist a long-term relationship between foreign reserves and the amount of bonds issued by the Chinese central bank.
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.

Table 4: Cointegration tests; system $y_t = \{lforeign, lbase, lclaims, bonds\}$

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<th>Rank</th>
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<th>p-value</th>
<th>$\lambda_{max}$ Test</th>
<th>p-value</th>
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