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Abstract

Due to buoyant capital inflows East Asian central banks with exchange rate targets accumulate foreign reserves and thereby increase surplus liquidity. East Asian central banks with more flexible exchange rate regimes also face surplus liquidity that mainly emanates from past accumulation of foreign reserves. We show based on an augmented Barro-Gordon-type central bank loss function that in both cases surplus liquidity limits monetary policy autonomy. In case of fixed exchange rates East Asian central banks can escape from the impossible trinity and gain monetary policy autonomy by using non-market–based sterilization which leads to financial sector distortions. In a flexible exchange rate regime monetary policy autonomy can be gained without financial sector distortions by using market-based sterilization. As central banks face substantial sterilization costs as well as revaluation losses on foreign reserves, however, monetary policy autonomy is eroded.

JEL-Code: E520, E580, F310.

Keywords: debtor central banks, monetary policy autonomy, sterilization, exchange rate regime, East Asia.

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1 Introduction

In the current environment of cheap and abundant global liquidity emerging market economies and small industrial countries continue to face buoyant capital inflows that have become a major threat to domestic price and financial stability. The sustained appreciation pressure on the currencies of emerging market economies has triggered a controversial discussion concerning the adequate policy response, i.e. either allowing for substantial appreciations (Cline and Williamson 2010), maintaining tight exchange rate pegs (McKinnon and Schnabl 2011) or even introducing capital controls (Ostry et al. 2010).

Beyond this controversial discussion comparatively little research has scrutinized the de facto implications for monetary policy autonomy in flexible exchange rate regimes, when price and financial stability are threatened by surplus liquidity in the domestic financial system. In case of fixed exchange rates given Mundell's impossible trinity central banks can only gain monetary policy autonomy by using non-market–based sterilization as a form of capital control, which – however – increases financial distortions. In contrast, flexible exchange rates allow for more monetary policy autonomy in the first place, but when sterilization costs and revaluation losses on foreign reserves emerge this autonomy can be undermined. In an environment of extremely low international interest rates as they currently prevail these costs can be sizable. If central bank losses lead to fiscal interferences, consequences for monetary policy independence can be substantial.

As East Asia (and in particular China) has become the most important target region of international capital flows we focus our research on this region. East Asia is also an important case study, as a broad variety of exchange rate regimes prevails from a tight peg in Hong Kong, to an upward crawling peg in China, to a (mainly) flexible exchange rate in Korea. After having defined 'surplus liquidity' in section 2 – we use a Barro-Gordon-type model to analyse the degree of monetary policy autonomy in an environment of surplus liquidity for different types of exchange rate regimes in section 3. In section 4 we apply the main results of the model empirically to East Asia. In section 5 we conclude.

2 Surplus Liquidity and Monetary Policy in East Asia

The influx of – what can be called – global liquidity has triggered in many emerging markets around the globe large scale foreign exchange intervention. This has created – what we call – surplus liquidity in the financial systems of emerging market economies, which strongly influences the monetary policy pattern of – what we call – debtor central banks, i.e. central banks, which aim to absorb liquidity from the domestic financial markets to maintain price and financial stability. In the following section we provide a concept of surplus liquidity and trace the origins of surplus liquidity in emerging markets with a focus on East Asia.

2.1 The Concept of Surplus Liquidity

Global liquidity focuses on the cross-border dimension of wider liquidity creation and has both an official and a private component (Committee on the Global Financial System, 2011). Official liquidity can only be created by central banks, while private liquidity is created by financial institutions in various ways and quantitatively dominates official liquidity. Measuring global liquidity precisely is difficult. Assessing *excessive* global liquidity is even more challenging as there is no commonly agreed equilibrium concept, in particular with respect to the question if excessive global liquidity triggers price increases in asset markets rather than in goods markets (Hoffmann and Schnabl 2008).

Central bank liquidity – which is the focus of this article – is related to global liquidity, since the accumulation of foreign reserves triggered by private capital inflows creates reserves of commercial banks[1] at the central bank (central bank liquidity). Commercial banks hold reserves at the central bank for two reasons: (1) To fulfil reserve requirements and (2) as working balances, for example, to service the cash demand and payments of their clients (excess reserves). If excess reserves are in excess of these needs, central banks aim to control the surplus to avoid risks to price and financial stability since overheating could be reflected in increasing consumer or asset prices. Steering the interest rate for central bank liquidity (and not controlling its quantity) is the usual starting point of the monetary policy transmission mechanism, unless central banks have no autonomous monetary policy and directly target exchange rates.

[1] We choose the terms “commercial banks” and “commercial banking sector” to describe money creating sector apart from the central bank itself. The term non-banks describes the money-holding sector, excluding commercial banks and the central bank.

Limiting central bank liquidity quantitatively can provoke frictions in the payment system or a systemic shortage of currency. In this context the concept of the money multiplier should not be mistaken as a policy option. It describes the relationship between central bank money (currency in circulation and central bank liquidity) and a monetary aggregate, which is not necessarily stable and predictable (see Goodhart 1989, Bindseil 2004, Goodhart 2010, Papademos and Stark 2010). Changes of the multiplier may be driven by the payment behavior of nonbanks, central bank decisions on reserve requirements or commercial banks' preferences for holding excess reserves. Even decisions on reserve requirements do not limit commercial bank balance sheet growth directly. Unremunerated reserve requirements rather influence the spread between deposit and lending rates and thereby, function like a tax on commercial banks' business.[2]

Based on a stylized central bank balance sheet as in Figure 1, central bank liquidity can be defined as current account holdings of commercial banks at the central bank (item 4 and 5). Item 4 are excess reserves, which will increase if ceteris paribus items on the asset side increase or items on the liability side – apart of item 4 itself – decrease and vice versa. As monetary policy implementation aims to manage liquidity, excess liquidity is provided by other factors than monetary policy operations. These so called autonomous factors are usually defined as being beyond the direct control of the central bank.[3] We define them more explicitly as reflecting tasks that go beyond the main objective of the central bank to maintain price stability. As the monetary policy implementation is the starting point of the transmission mechanism to the ultimate objective of price stability, autonomous factors are seen as all other items that do not belong to the monetary policy toolkit.

In the stylized central bank balance sheet in Figure 1, open market operations are monetary policy operations with which the central bank steers money market interest rates. They can be liquidity providing (item 2.1) or absorbing (item 6). Required and excess reserves (items 4 and 5) are assumed to be central bank liquidity. Required reserves belong to the monetary policy toolkit. Excess reserves (item 4) represents the remaining item that is to be managed by the monetary policy operational framework.

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[2] Reserve requirements can only control banks' balance sheet growth directly, if central bank money cannot easily be increased. This used to be a relevant case historically when central bank reserve creation had to be backed by gold or it is the case in an orthodox currency board system (see Gray 2011, p. 5).

[3] As defined by the European Central Bank, see http://www.ecb.int/mopo/liq/html/index.en.html

Figure 1: Stylized Central Bank Balance Sheet

Assets	Liabilities
1. (Net) Foreign Assets (NFA)	3. Currency in Circulation (CIC)
	4. Excess Reserves
2. Domestic Assets	5. Required Reserves
2.1 Open Market Operations (OMO)	6. OMO
2.2 Other Credits to Private Sector	7. Capital accounts
2.3 Other Net Credit to Government	

On the asset side, autonomous factors are (net) foreign assets (item 1). They mainly include foreign reserves, which normally originate in foreign exchange interventions.[4] Items 2.2 and 2.3 summarize domestic assets that are held for other purposes than monetary policy operations, e.g. for investment purposes or for financial system restructuring (item 2.2: other credit to the private sector), or for financing the government and/or public entities (item 2.3: other net credit to the government), or simply for fulfilling the fiscal agent function (if item 2.3 is negative, it reflects changes of government deposits at the central bank. In practice, it can be difficult to distinguish between domestic assets that are autonomous factors and that are monetary policy operations. Credit to the government, for instance, can reflect a monetary policy operation and it can reflect monetary financing. Similarly, a claim to a commercial bank can arise from regular monetary policy operations, but also from financial sector bail-out operations.

On the liability side currency in circulation is an autonomous factor (item 3), because servicing the cash needs of the public is a central bank task and should not be used as a monetary policy instrument.[5] Item 7 (capital accounts) represents the own funds of the central bank, which is regarded as an autonomous factor as well.

Based on the identification of autonomous factors we define surplus liquidity as the difference between the sum of autonomous factors on the asset side (items 1, 2.2 and 2.3 in Figure 1) and the sum of autonomous factors on the liability side (item 3 and 7 in Figure 1).[6] A positive sign of this term is equivalent to structural surplus liquidity in the banking system. Autonomous liquidity providing factors are larger than autonomous liquidity absorbing

[4] We assume for parsimony reasons that net foreign assets are exclusively held in form of foreign reserves. Holdings of gold are assumed to be constant.

[5] Otherwise, a restrictive monetary policy stance could trigger a shortage of cash and thereby serious risks for payments and financial stability.

[6] We assume that the level of excess reserves, that is needed as a working balance of the commercial banks, is close to zero.

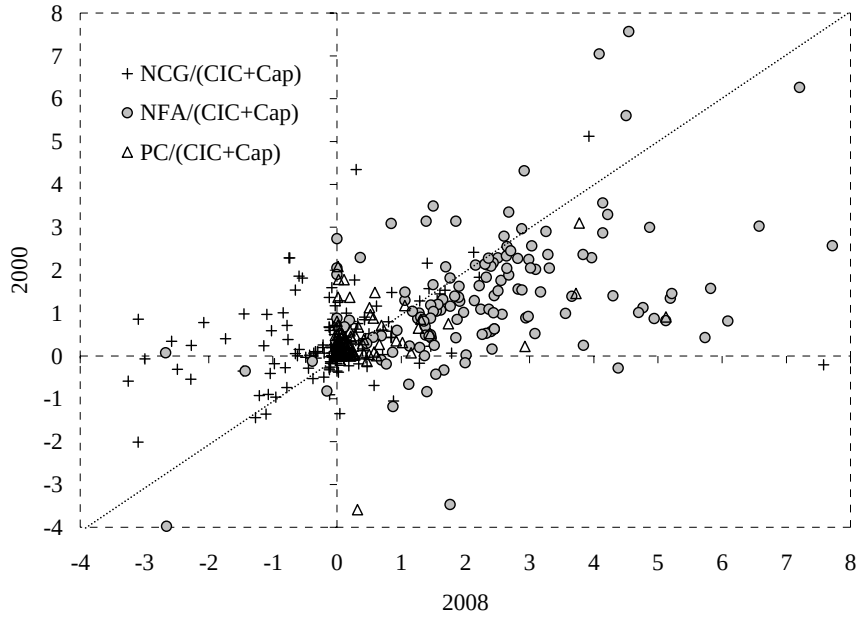
factors. Without liquidity absorbing monetary policy instruments (in Figure 1 items 5 and 6), this would lead to increasing excess reserves, declining interest rates and thereby risks for price (and financial) stability.

For instance, foreign currency purchases of the central bank from commercial banks would lead to higher current account holdings of commercial banks at the central bank that go beyond required reserves and the minimum excess reserves (which we assume to be zero for simplicity). The commercial banks would search for new investment opportunities, which can lead to a lower interest rate, excessive credit growth, asset price booms and/or inflation above target. To maintain its benchmark of consumer and/or asset price stability, the central bank may feel required to manage liquidity via monetary policy operations on the liability side of its balance sheet.

2.2 Origins of Surplus Liquidity and Liquidity Absorption by Debtor Central Banks

If the central bank has other tasks that go beyond maintaining price and financial stability, i.e. exchange rate stabilization, financial system restructuring or government financing, surplus liquidity can be sizable. Figure 2 summarizes possible origins of surplus liquidity for a set of 157 countries.

Figure 2: Origins of Surplus Liquidity



Source: IMF: IFS, national central banks.

We distinguish three liquidity sources: net foreign reserve accumulation (NFA, item 1 in Figure 1), net central bank credit to the government (NCG, item 2.3) and private credit (PC, item 2.1 and 2.2.). While the first is clearly an autonomous factor, the latter two can either be monetary policy operations or autonomous factors depending on the underlying motivation. We put these three central bank balance sheet positions into relationship to the sum of currency in circulation (CIC, item 3) and the capital accounts of the central bank (Cap, item 7), which are the autonomous factors on the liability side of the central bank balance sheets. We introduce a time dimension by plotting the ratios for the three relationships (NFA/(CIC+Cap), NCG/(CIC+Cap), PC/(CIC+Cap),) for the year 2000 on the y-axis and for the year 2008 on the x-axis.

A ratio above zero signals liquidity to be created by the accumulation of the respective liquidity source. A ratio above unity signals surplus liquidity originating from one single factor. A negative ratio stands for net liquidity absorption by one single factor. If, as for instance in the case of many oil exporting countries, government deposits at the central bank are larger than the central bank' holdings of government bonds, the term NCG turns negative, which indicates a liquidity absorbing role of net credit to the government.[7] It is clearly visible from Figure 2 that both in the year 2000 and the year 2008 net foreign reserve accumulation has been the dominating source of liquidity creation in a majority of countries (most circles are above the zero line). For a large number of countries, the circles are located even above one, which indicates surplus liquidity created due to foreign reserve accumulation.

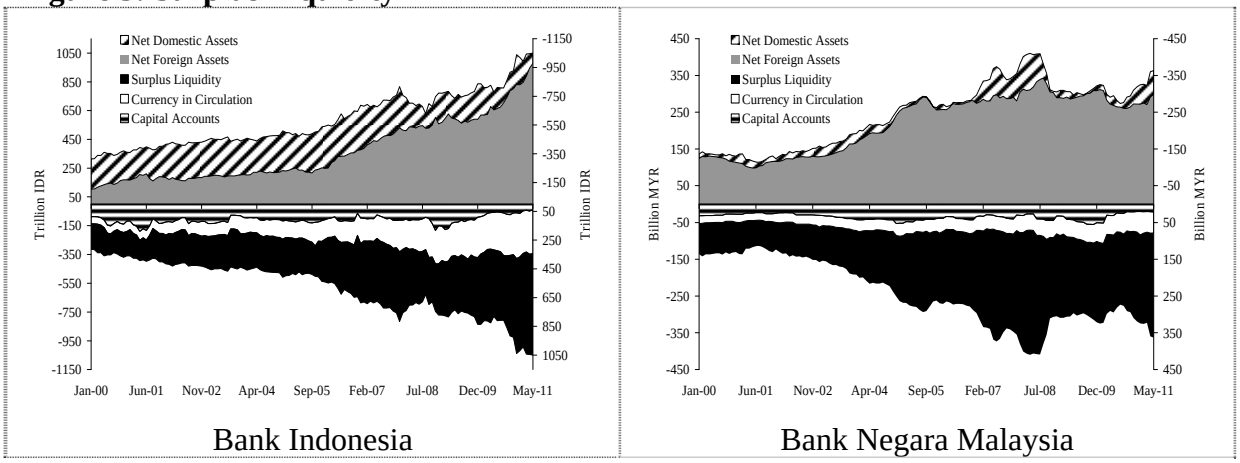
In comparison, for private credit and net credit to the government the impact on the liquidity position is mixed or negligible. For a significant number of countries, a liquidity absorbing role of the net credit to the government position can be observed (crosses below zero). The 45-degree line helps to identify the evolution of the role of reserve accumulation for surplus liquidity creation since the turn of the millennium. The cluster of circles is below the line and in the positive range of the x-axis indicating that the degree of surplus liquidity creation through reserve accumulation has substantially increased between 2000 and 2008.

Figure 3 in detail illustrates the rising role of surplus liquidity originating in reserve accumulation for two East Asian central banks. In 2000 the Bank Indonesia had two main

[7] For more details on liquidity absorption via government deposits at the central bank see Schnabl and Schobert (2009).

sources of liquidity creation: financial restructuring after the Asian crisis[8] and foreign reserve accumulation as shown in the left panel of Figure 3. Since then, the stock of foreign assets and thereby the proxy of surplus liquidity (liquidity providing autonomous factors minus liquidity absorbing autonomous factors as indicated by the black surface) have substantially increased. This was the case despite the official move towards an inflation targeting framework in 2005.

Figure 3: Surplus Liquidity



Bank Indonesia | Bank Negara Malaysia

Source: IMF: IFS.

Bank Negara Malaysia has similarly created surplus liquidity due to foreign exchange accumulation until 2008. Until mid 2005 the Malaysian ringgit was tightly pegged to the US dollar, but even after the move towards more flexible rates the accumulation of foreign reserves and thereby the creation of surplus liquidity persisted. Although reserve accumulation temporarily stopped with the global crisis starting in 2008, the surplus liquidity position as indicated by the black surface in Figure 3 remained in place.[9]

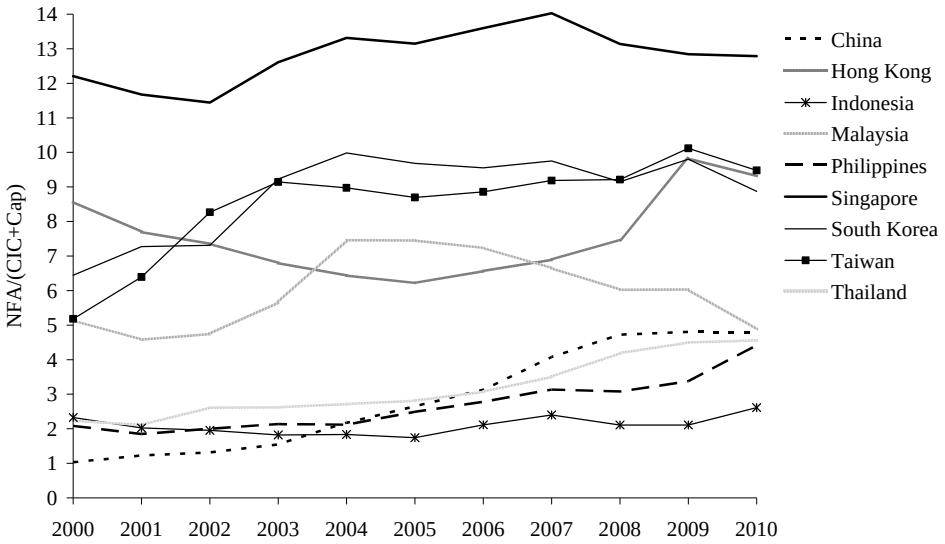
Figure 4 shows the ratio of net foreign assets to currency in circulation from 2000 to 2010 for all East Asian central banks. A ratio of net foreign assets to currency in circulation plus capital greater than unity indicates – based on our measure – surplus liquidity. No later than 2001 all central banks in this region were facing structural surplus liquidity in the banking system due to foreign exchange accumulation. Importantly, this applies for both countries

[8] The Bank Indonesia purchased government bonds that were explicitly issued for financing bank rescue measures and that were remunerated below market rates.

[9] Given that foreign exchange accumulation has stopped the surplus liquidity position continues as long as the stock of foreign reserves is ceteris paribus larger than the liquidity absorbing factors. The central bank can absorb liquidity by selling foreign reserves, but this would tighten monetary conditions and feed into an appreciation of the domestic currency. Thus escaping from the surplus liquidity position would have high opportunity costs.

with a fixed exchange rate regime such as Hong Kong as well as countries with a floating exchange rate regime such as South Korea.

Figure 4: NFA to (CIC+Cap) Ratio in East Asian Central Banks



Source: IMF: IFS, national central banks.

The pattern observed in East Asia is typical for many central banks in emerging markets and developing countries around the globe facing buoyant capital inflows. Exchange rate stabilization triggers liquidity providing foreign exchange interventions.[10] Concerns about domestic price and asset market stability make liquidity absorbing monetary policy operations necessary. As they take place on the liability side of the balance sheets we dub central banks, which structurally engage in liquidity absorbing monetary policy operations as 'debtor central banks'. This pattern of monetary policy making is in sharp contrast to the central banks in the large advanced economies, which perform their monetary policies on the asset side of the balance sheets usually providing liquidity to the financial sector (creditor central banks).[11]

2.3 Management of Surplus Liquidity in East Asia and Risks for the Central Bank

In general, debtor central banks have three options to absorb surplus liquidity. (1) They can absorb surplus liquidity by using market-oriented monetary policy operations, for instance central bank bond sales or reverse repos (item 6). (2) They can use non-market based

[10] There are different explanations for this preference for exchange rate stabilization. See, for example, McKinnon and Schnabl (2004).

[11] For a detailed distinction between debtor and credit central banks see Löffler, Schnabl and Schobert (2010).

measures, for example reserve requirements (item 5) with no or low remuneration or the coercive sale of central bank securities below market rates. (3) The central bank can coordinate its liquidity management with the government. Such fiscal coordination can take two forms. Firstly, the central bank stores foreign exchange on behalf of the government (and agrees to hold the revenues on its account with the central bank). This is most common in case of oil-exporting countries where the government either owns the exported natural resources or heavily taxes the export revenues.[12]

Secondly, if the central bank has purchased foreign exchange from the private sector, the operation will be liquidity providing to the domestic banking system. The fiscal authorities can agree to issue and sell more government securities than necessary to cover the budget deficit. The revenues from the excess issuance of government bonds can be held as government deposits at the central bank. Usually the absorption of liquidity via government deposits at the central bank requires a formal agreement between the central bank and the government to ensure that the government does not use these funds freely thereby creating liquidity that threatens price stability.

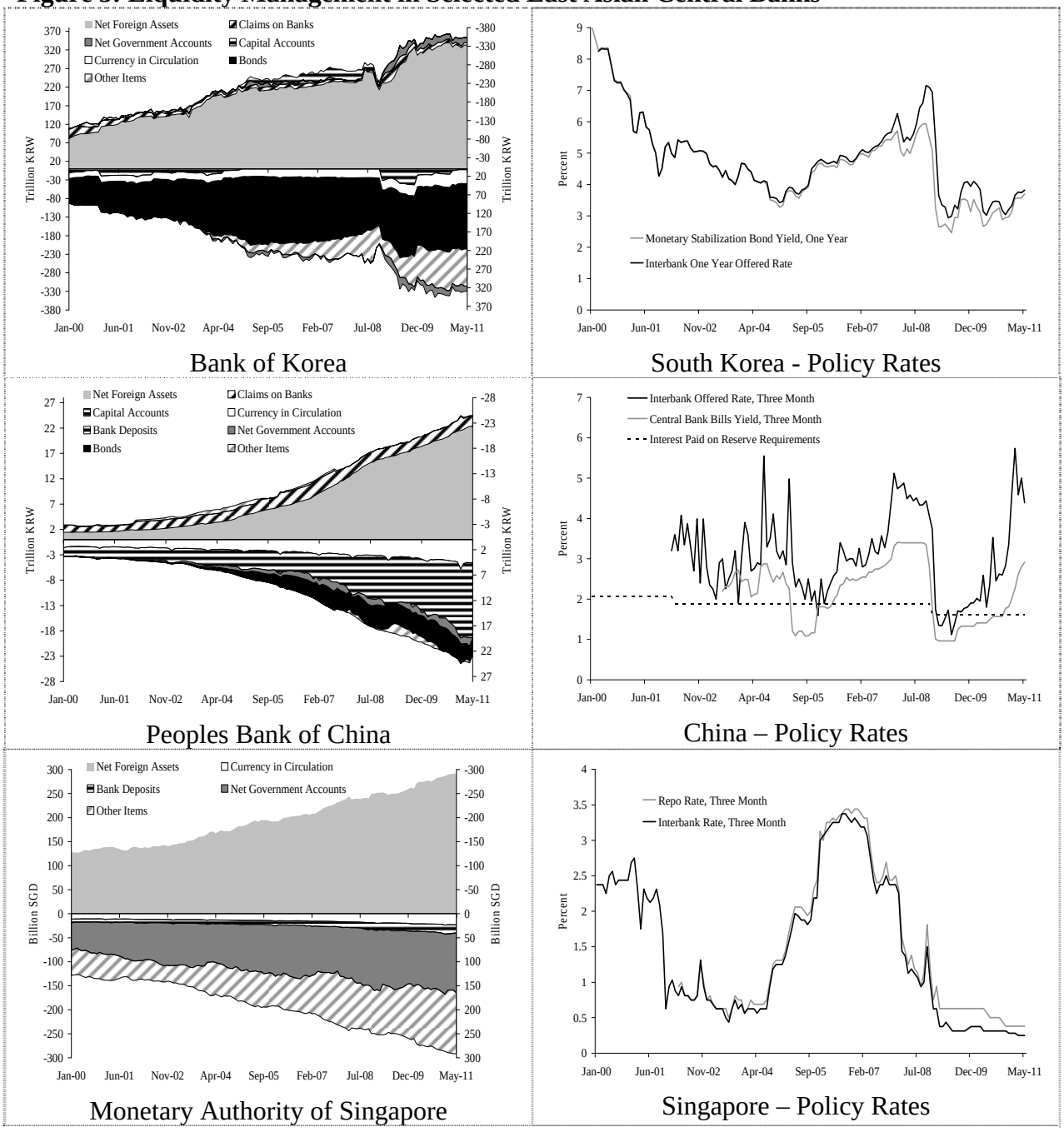
Figure 5 shows the sterilization instruments for three East Asian central banks in the lower parts of the left hand charts. The Bank of Korea (upper left panel) mainly uses sales of central bank bonds (monetary stabilization bonds) to drain liquidity from the markets, which has been created by foreign currency purchases. The yields of these bonds are tightly linked to interbank interest rates (upper right panel), which is an indication for market based sterilization. Since 2007, there is a small spread between the interbank rate and the yield on monetary stabilization bonds. This can be due to higher risk awareness during the crisis, which causes nearly riskless investment at the central bank to carry a lower interest rate as lending in the interbank market.

The Peoples Bank of China (middle left panel of Figure 5) uses a combination of market and non-market based instruments to absorb liquidity. Central bank bills represent in our interpretation market-based sterilization, as their yields are closely following interbank rates. Nevertheless, the fact that these yields remain well below the interbank rate during most of

[12] The government deposits at the central bank will have no liquidity providing effect as long as they are held at the central bank account and not spend in the domestic market. Alternatively the oil revenues are stored directly in a dollar denominated sovereign wealth fund. As foreign reserves are prevented from being converted into domestic currency, a sovereign wealth fund corresponds to „anticipatory sterilization“ as surplus liquidity creation is prevented from the very beginning (McKinnon and Schnabl 2010).

the observation period could be an indication for coercive sales of these liquidity absorbing instruments to the domestic banking sector below market rates (see middle right panel of Figure 5). Reserve requirements represent non-market based sterilization, as the remuneration rate remains widely unchanged and mostly below interbank interest rates. Figure 5 also shows that over time in China the importance of non-market based sterilization has increased relative to (comparatively) market based sterilization.

Figure 5: Liquidity Management in Selected East Asian Central Banks



Source: IMF: IFS, national central banks.

The Monetary Authority of Singapore (lower left panel) sterilizes a large share of its net foreign asset acquisitions via net government deposits at the central bank. As the fiscal agent of the government the Monetary Authority of Singapore manages the issuance of government securities. Given Singapore's persistent budget surpluses the issuance of government securities is not used for government financing but to deepen the financial market and for sterilization purposes. The repo rate on government securities tightly follows the interbank interest rate (lower right panel), which is evidence for a market-based sterilization process.

Depending on the sterilization instruments and individual agreements the costs are shared between the public and the private sector. Under market based liquidity management – as for instance in Korea – the costs are usually born by the central bank and ultimately by the public via lower central bank profit transfers to the government. Non-market based liquidity absorption – as for instance in China – shifts the costs to the commercial banks, which may shift it onwards to their customers. Under fiscal coordination – as for instance in Singapore – the costs can be borne by the government or the central bank, depending on the agreements, and ultimately by the public.

Another cost factor of foreign reserve accumulation cum liquidity absorption are write-downs on the foreign currency positions that emerge when the domestic currency appreciates. Both costs can cause sizable central bank losses. Whether central bank losses are problematic depends on the degree of central bank independence and its success to communicate it appropriately. In practice, however, central bank losses often cause conflicts with the government and therefore, can have a negative impact on the reputation of the central bank and ultimately, on its independence.

3. Limited Monetary Policy Autonomy of Debtor Central Banks

We will show that in an environment of globally abundant liquidity the degree of monetary policy autonomy will be limited, whatever exchange rate regime emerging markets choose. Given fixed exchange rates the scope for monetary policy autonomy is generally low, but non-market based sterilization as a form of capital controls creates some leeway for a diversion of the monetary policy stance from the anchor country. Given flexible exchange rates, an illusion of monetary policy autonomy is created in the first place, which is unlikely

to materialize in the long run, as increasing sterilization costs limit the autonomy from the monetary policy stance of the reserve / anchor currency country.

3.1 Gaining and Losing Monetary Policy Autonomy Given Fixed Exchange Rates

Based on Mundell (1963) and Fleming (1962) a basic postulate of open economy macroeconomics is the incompatibility of pegged exchange rates, international capital mobility and national monetary policy autonomy (impossible trinity). Given fixed exchange rates central banks can only gain monetary policy autonomy if they introduce capital controls. In the context of sterilization policies this corresponds to the use of non-market based liquidity absorption, for instance through unremunerated required reserves. Increasing reserve requirements can have similar results as tightening of capital controls (Reinhart and Reinhart 1999).

Due to the quasi tax effect of unremunerated reserve requirements bank lending rates will increase and/or deposit rates will decrease depending on the availability of substitutes in the credit and deposit market. Whether the widening of the banking system interest rate spread prevents further capital inflows, depends inter alia on the type of capital inflow and the stage of development of the domestic financial market. For instance if the corporate bond market is underdeveloped and the access to foreign lending markets is limited firms will rely more on the domestic credit market and banks can shift the tax burden to the loan market. In addition lower deposit rates will make investment in the domestic banking sector less attractive to non-residents. Under these assumptions a monetary tightening in form of higher reserve requirements would help to forestall additional capital inflows. The widening of the spread of bank interest rates, however, implies distortions in the financial sector. i.e. financial disintermediation.

Assuming that the central bank dislikes financial sector distortions, we analyze the impact of liquidity absorbing operations on monetary policy independence based on an augmented version of a Kydland and Prescott (1977) and Barro and Gordon (1983) type central bank loss function. In contrast to the baseline model it is assumed that the central bank has no output stabilization objective,[13] but trades off inflation against financial sector distortions by deciding on the degree of liquidity absorption in the face of a foreign interest rate shock. Non-

[13] We omit the output stabilization target for parsimony reasons as it is not important for the interpretation of results.

market based sterilization is assumed to be linked to financial sector distortions. In our model, this causes a disutility/ loss for the central bank.

This implies minimizing the following central bank loss function LF[14]:

(1) $LF = 0.5(\pi)^2 + \delta rr$.

The term $(\pi)^2$ refers to the inflation target which is assumed to be zero. An inflation rate below or above zero implies a loss for the central bank. The term δrr models the degree of distortion in the financial system, which is assumed to be linked to the degree of non-market based sterilization reflected in unremunerated reserve requirements per unit of deposits *rr*. Given perfect competition between domestic banks an increase of *rr* reflects a higher distortion. The factor δ is the weight determining the size of disutility of financial distortions in the central bank objective function (with $\delta > 0$).

Inflation is assumed to be based on the inflation of the previous period π_{pre}. Further, we assume a negative impact of the domestic interest rate on loans i_L on inflation dependent on the semi-interest rate elasticity of inflation φ. The term ν is a normal distributed demand shock on inflation with zero mean:

(2) $\pi = \pi_{pre} - \varphi i_L + \nu$

Assuming that the costs of required reserves are (partially) shifted to the domestic interest rate on loans i_L there is a positive correlation λ between the loan rate and reserve requirements *rr*, which is usually smaller than unity ($0 < \lambda \leq 1$). The term λ is assumed to contain all financial market characteristics affecting the transmission of *rr* to i_L, contingent on the transmission of *rr* to deposit interest rates.

(3) $i_L = \lambda rr$

To link the sterilization operations with the interest rate policy in the anchor country, we assume that a declining interest rate in the anchor region (US) leads ceteris paribus to rising capital inflows into the emerging market economies (East Asia). To defend the exchange rate

[14] Time subscripts are omitted for parsimony.

peg the central bank has to buy foreign reserves which necessitate a larger volume of sterilization operations, if it aims at price and financial stability. Thus, there is a positive correlation between the scale factor λ - which affects the transmission of rr to i_L - and the interest rate in the anchor country i_f indicated by the constant β.

(4) $\lambda = \beta i_f$ with $\beta > 0$.

Substituting (4), (3) and (2) into (1) yields the following expected loss function $E(LF)$:

(5) $E(LF) = 0.5(\pi_{pre} - \varphi\beta i_f rr + \nu)^2 + \delta rr$.

Optimizing (5) with respect to optimal inflation π_{opt} yields:

(6) $\pi_{opt} = \frac{\delta}{\varphi i_f \beta}$.

Optimal inflation will be higher, if the central bank has a high preference to avoid financial distortions, indicated by a high δ. If the interest rate transmission to inflation is low[15], indicated by a low φ and if the foreign interest rate is low optimal inflation is high. This implies that a mandate for the central bank to avoid financial distortions $(\delta > 0)$ makes the central bank dependent on the monetary policy stance of the anchor country. If the central bank does not care about financial distortions (δ approximates zero) it would be fully independent from foreign monetary policy decisions and optimal inflation would be in line with the assumed inflation target.

3.2 Scope of Autonomy of Free Floating Countries

If the exchange rate floats freely, no interventions take place and the level of foreign reserves remains unchanged. The impossible trinity would suggest that a central bank has full autonomy in monetary policy making even given free capital flows. The monetary policy strategy could be inflation targeting. In contrast to the fixed exchange rate case a debtor central bank with an inflation target can engage in market based sterilization operations – and therefore can avoid financial distortions – because additional capital inflows attracted by the

[15] The central bank has to create huge distortions as a high lending rate is required to curb inflation. When the central bank dislikes these distortions it will allow for higher inflation.

resulting rise of interest rates do not trigger additional foreign reserve accumulation and monetary expansion.

We will show, however, that a debtor central bank, which conducts an autonomous monetary policy by setting interest rates based on liquidity absorbing monetary policy operations faces limitations in monetary policy autonomy even under principally flexible exchange rates. The reason is that in the face of buoyant capital inflows debtor central banks will run into sterilization costs and revaluation losses on the stock of foreign reserves.[16] These losses erode the capital of the central bank. In our model the central bank needs recapitalization by the government. This will strengthen the government's position in urging the central bank towards (growth enhancing) and cost avoiding interest rate cuts.

To analyze the degree of dependence of the central bank, which allows for a freely floating exchange rate and which is engaged in market based liquidity management the central bank loss function of equation (1) is modified by incorporating losses due to sterilization costs and revaluation of foreign reserves:

$$(7)\ LF = 0.5\pi^2 + DUM\gamma(iSL - (if + \hat{e})NFA)$$

Whereas the first term of equation (7) remains unchanged (inflation target at zero), the second part represents the costs of liquidity management, subdivided in sterilization costs and revaluation losses. With respect to the sterilization costs we assume in contrast to the fixed exchange rate case that sterilization operations will be market based. We further assume that in line with our observation in section 2, liquidity expansion in the past has originated in foreign reserve accumulation. The cost of liquidity absorbing instruments is given by the interest rate paid on the liquidity absorbing instruments i times the outstanding stock of sterilization debt SL which is assumed to be equal to surplus liquidity defined in section 2. Revenues on foreign reserves (i_f * NFA) comprise interest revenues resulting from foreign exchange holdings.

In the face of net capital inflows (outflows) revaluation losses (gains) of an appreciating (depreciating) domestic currency occur. The revaluation losses are proxied by the percentage

[16] For instance during the period from 2004 to 2007 the Bank of Korea accumulated interest rate losses of roughly 0.5 percent of GDP. In the same period the revaluation adjustment account increased to a book loss of 1.7 percent of GDP. The revaluation account records valuation gains and losses accruing during a predefined period until the gains/losses are realized.

exchange rate change $\hat{e}$ times the stock of net foreign assets *NFA* with a negative value of $\hat{e}$ indicating appreciation. The term γ determines the degree of independence of the central bank.

As central banks normally have no objective to maximize profits (in contrast to limit deficits) the second term of equation (7) will be only relevant if the central bank is running losses. Thus the dummy variable DUM takes the value of 0 as long as the central banks' capital (*Cap*) minus central bank losses is above a particular threshold T. In this case the second part of equation (7) cancels out meaning that monetary policy decisions are independent from sterilization costs. If the capital falls below the threshold T the costs will become a relevant factor for monetary policy decisions. Principally the threshold *T* can be assumed to be above, at, or below zero depending on the preference of the central bank or its statutory requirements regarding a specific size of capital holdings.

$$(8)\ DUM(0,1) = \begin{cases} 0 \ \text{ if } \ Cap - (iSL - (if + \hat{e})NFA) \geq T, \\ 1 \ \text{ if } \ Cap - (iSL - (if + \hat{e})NFA) < T. \end{cases}$$

The term γ (with $\gamma > 0$) models the weight of financial losses in the central bank objective function for the case that DUM=1. A large gamma stands for a larger concern of the central bank with regard to a 'conditioned recapitalization' by the government.

Because without distortionary reserve requirements the interest rate transmission from the money market rate to interest (loan) rates set by commercial banks is perfect (in contrast to the fixed exchange rate case (3)) the money market rate is used as determinant of inflation.

$$(9)\ \pi = \pi_{pre} - \varphi i + \nu$$

The money market rate is assumed to be directly linked to the central bank policy rate, which is assumed to be set – at least in the first place – to maintain price stability. The endogenous variable is the exchange rate change, which is assumed to be determined by the relative monetary policy stance of the domestic central bank and the central bank of the large reference country, i.e. the domestic and foreign interest rate spread:

$$(10)\ \hat{e} = \kappa(if - i) + \varepsilon\ .$$

The term κ indicates the sensitivity of the exchange rate on interest rate differentials. With ε=0 and κ = -1 uncovered interest parity, UIP, holds. If kappa is larger than -1, carry trades will be profitable as interest gains will not be eroded by exchange rate losses. The term ε is a normally distributed error term with zero mean.

Substituting (9) and (10) into (7) yields the following expected loss function for the central bank in a freely floating environment:

$$(11)\ E(LF) = 0.5(\pi_{pre} - \varphi i + \nu)^2 + DUM\gamma(i(SL - \kappa NFA) - ifNFA(1+\kappa) - \varepsilon NFA)$$

Based on equation (11) we can derive the optimum interest rate of the debtor central bank contingent on losses generated by sterilization costs and revaluation. In doing so, we distinguish two cases. Firstly, the capital of the central bank remains – despite sterilization and appreciation – above the threshold (*DUM*=0). The second term of the loss function cancels out. Optimizing eq. (11) with respect to the policy instrument *i*, the optimal interest rate is:

$$(12)\ LF_{DUM=0}:\ i_{opt} = \frac{\pi_{pre}}{\varphi}.$$

The interest rate is set with respect to inflation of the previous period and the semi-interest rate elasticity of inflation φ.

Secondly, if the sterilization operations reduce the capital of the central bank below the threshold (*DUM*=1) the central bank will care about sterilization losses and react to it by setting interest rates lower than otherwise. With surplus liquidity (*SL*) being equivalent to *NFA – CIC – Cap* the optimum interest rate is equal to:

$$(13)\ LF_{DUM=1}: i_{opt} = \frac{\pi_{pre}}{\phi} - \gamma\frac{\kappa NFA + SL}{\phi^2}$$

The optimum interest rate will be lower, if surplus liquidity and foreign reserves are high. Equation (12) and (13) represent the corner solutions in which either the central bank is profitable and sets the policy rate according to the inflation target (full monetary policy

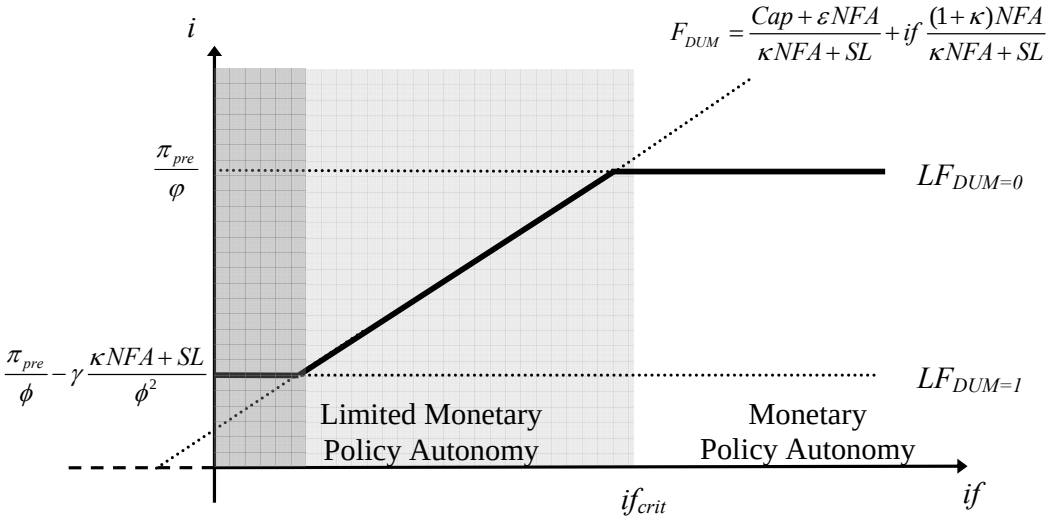
autonomy (12)) or – in the loss environment – trades off inflation performance with profitability (limited monetary policy autonomy (13)).

To decide whether eq. (12) or (13) is valid we use equation (8) to determine the scope of monetary policy autonomy (F_{DUM}). Assuming that the threshold T is zero, the dummy is inactive if

(14) $$LF_{DUM} : i \leq \frac{Cap + \varepsilon NFA}{\kappa NFA + SL} + if \frac{(1+\kappa)NFA + SL}{\kappa NFA + SL}$$

To show the scope of monetary policy autonomy of the debtor central bank using market based measures to absorb surplus liquidity we plot in Figure 6 the two corner solutions for i and the dummy function against *if*.

Figure 6: Monetary Policy Autonomy of Free Floating Debtor Central Banks



The upper part of the function $LF_{DUM=0}$ (upper horizontal line) corresponds to the optimal policy decision if the capital of the central bank is positive above the threshold T (dummy is zero). The interest rate decision is fully independent from the foreign interest rate in the anchor country and is derived according to equation (12). The interest rate is set with respect to previous inflation and the semi-interest rate elasticity of inflation.

The lower part of the function $LF_{DUM=1}$ (lower horizontal line) shows the optimal policy response if the dummy is active, i.e. the central bank generates losses from sterilization

operations, which reduces its capital position below the threshold. The incentive to lower the interest rate compared to $LF_{DUM=0}$ rises contingent on the stock of net foreign assets *NFA*, the semi-interest rate elasticity of exchange rate changes κ, the amount of surplus liquidity *SL* and the weight of central bank losses γ in the loss function. The lower is the weight γ the more independent is the central bank from fiscal interferences and the less it reacts to foreign interest rate decisions. In the extreme case of γ being equal to zero, the second function coincides with the first function. Interest rate decisions in the reserve currency country which affect the financial soundness of the central bank become irrelevant.

The third function F_{DUM} (sloped line) models the scope for monetary policy autonomy dependent on the foreign interest rate. If the foreign interest rates decrease, the central bank will decrease its interest rate to avoid losses. However, in doing so it will violate its inflation target. On average εNFA is zero and can be neglected. Under a given foreign interest rate *if* the higher the capital buffer *Cap*, the lower surplus liquidity *SL* and – depending on κ – the lower the stock of net foreign assets *NFA*, the larger is the scope for monetary policy autonomy as the F_{DUM} schedule shifts upwards (see the first term) and the slope becomes steeper (see the second term).

A high stock of net foreign assets implies high interest income but also high valuation losses in the case of an appreciating exchange rate. Therefore as long as the sensitivity of changes in the interest rate spread on exchange rate changes κ is larger than -1, valuation losses dominate the interest revenue and the central bank is running losses on a net basis. In Figure A1 in the appendix we present evidence, that the term κ rather is positive for the selected East Asian countries during the sample period and that we can neglect the UIP assumption in practice. In Figure A2 of the appendix we will show different scenarios of Figure 6, if currency in circulation, net foreign assets, capital or the relationship between the interest rate spread and exchange rate changes.

Most importantly, there is a critical value for the foreign interest rate if_{crit} that determines the threshold for monetary policy autonomy. If the foreign interest rate *if* shrinks below if_{crit} the central bank adjusts its interest rate on sterilization operations to avoid central bank losses (light gray area in Figure 6). The lower the foreign interest rate, the larger the incentive to cut

domestic interest rates. If if_{crit} is sufficiently low the debtor central bank will not decrease domestic interest rates further as the inflation term dominates the loss term in equation (11).

4. Central Bank Losses and Interest Rate Decisions in East Asia

In section 3 we have shown that a debtor central bank using market based sterilization tools to manage liquidity conditions is dependent on the foreign country's monetary policy stance. The dependence of debtor central banks on the foreign monetary policy stance relates to (1) the degree of structural surplus liquidity, (2) the impact of changes in the interest rate differential on the exchange rate and (3) the capital buffer of the central bank. We test for the impact of central bank losses on interest rate decisions in East Asia contingent on these three factors. This is in particular relevant for debtor central banks with (mostly) freely floating exchange rates and market based sterilization.

4.1 Identifying Market Based Sterilizing Debtor Central Banks in East Asia

Table 1 shows a measure of market based sterilization instruments as a share of total sterilization instruments. It assumes that reserve requirements are non-market based whereas all other liquidity absorbing instruments are market based.[17]

Table 1: Market Based Instruments as a Share of Total Sterilization Instruments

	CN	HK	ID	KO	MY	PH	SG	TH	TW
'00		-	64	89	79	61	94	76	70
'01		-	67	88	84	48	94	92	79
'02	7	-	72	86	85	54	94	94	83
'03	8	-	68	88	88	63	95	95	87
'04	18	-	76	91	92	64	95	95	87
'05	31	-	65	89	92	71	95	96	88
'06	42	-	64	86	91	49	95	96	88
'07	39	-	62	84	91	55	95	97	86
'08	34	-	67	82	92	63	94	97	88
'09	31	-	59	87	99	68	93	98	88
'10	29	-	31	89	97	75	93	98	87

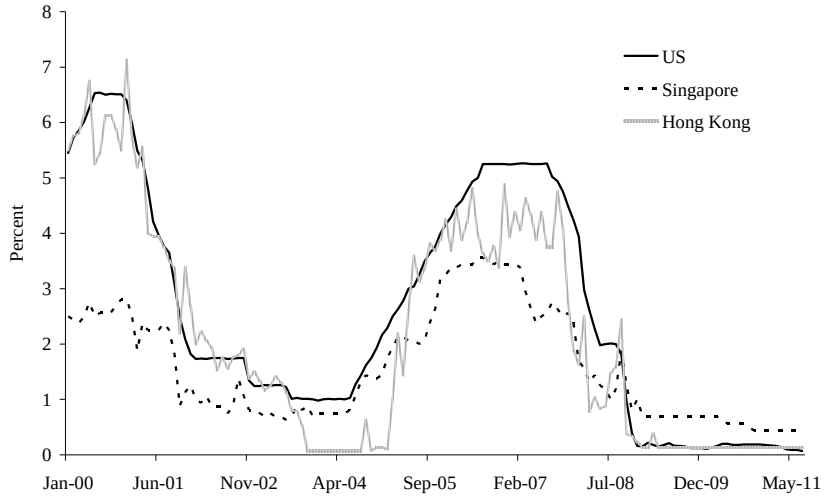
Source: IMF: IFS, national central banks. Shaded cells mark loss making years.

[17] The measure is calculated as $100 - 100 \times (NFA_t - CIC_t - RR_t) / (NFA_t - CIC_t - Cap_t)$. The term *RR* denotes the amount of required reserve balances of commercial banks held at the central bank. The data comes from IMF IFS and national central banks. If central banks have net claims to the government this is seen as indication for monetary financing of the government via the central bank or financial restructuring based on the central bank, which increases the surplus liquidity. Then, these claims are added to the numerator of the fraction leading to $100 - 100 \times (NFA_t + NCG_t - CIC_t - RR_t) / (NFA_t - CIC_t - Cap_t)$.

The central banks of Malaysia, Singapore, South Korea, Taiwan and Thailand primarily sterilize with market-based instruments. Singapore is a special case, market-based sterilization instruments are used under a fixed exchange rate regime.

Singapore and Hong Kong have a very high degree of capital mobility (highest possible score of the Chinn-Ito-Index[18] on capital mobility) and a high degree of exchange rate stability.[19] For these countries, sterilizing surplus liquidity reflects the objective to freeze 'free' liquidity available to banks for macro prudential reasons. They don't follow an autonomous monetary policy as interest rates are set close to those of the anchor currency country as shown in Figure 7. In both countries the policy rates closely follow the US interest rate. In Singapore the moderate divergence from the US policy rate can be explained by the fact that other currencies (euro, yen) are represented in the currency basket.

Figure 7: Money Market Rates in Hong Kong, Singapore and the US



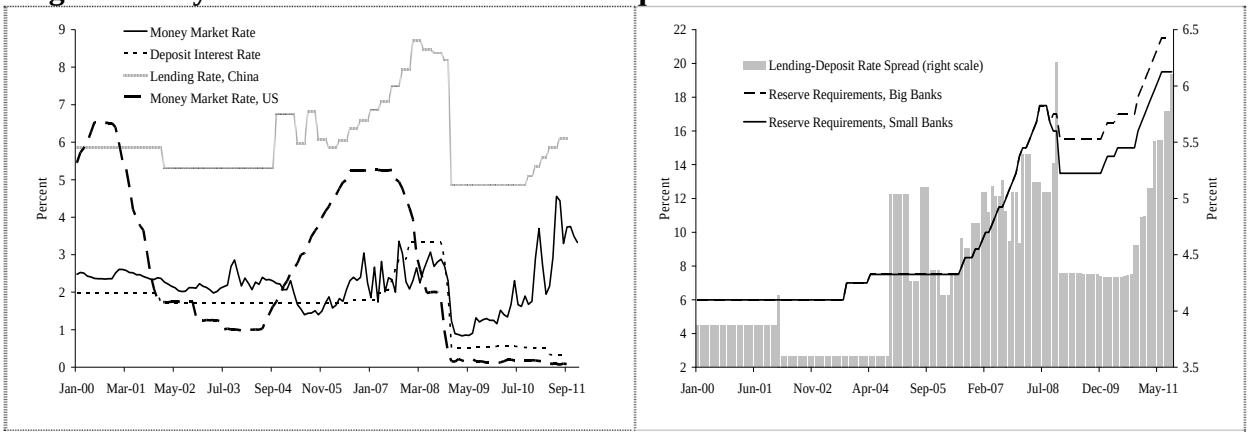
Source: IMF: IFS.

The Peoples Bank of China corresponds to our notion of a central bank operating under a fixed exchange rate regime, which aims to gain monetary policy autonomy through non-market based sterilization. The left panel of Figure 8 shows that despite the tight exchange rate peg to the dollar the Chinese money market rate does not follow the US money market rate, which indicates a certain degree of autonomy in monetary policy making.

[18] For a definition of this index see Chinn and Ito 2008.

[19] Hong Kong has a currency board arrangement with a fixed exchange rate to the USD and Singapore pegs to a basket of currencies.

Figure 8: Key Interest Rates and Reserve Requirements in China



Source: Peoples Bank of China.

The permanent increase of required reserves (right panel of Figure 8) indicates that the policy goal of low inflation outweighs the downsides of financial repression.[20] The high required reserve ratio as well as the spread between banks' lending and deposit rates and their spread versus the money market rate indicates a relatively low preference for avoiding financial distortions of the Peoples Bank of China.

4.2. Market Based Debtor Central Banks

For East Asian countries, which mainly conduct market based sterilization in combination with (managed) floating exchange rates and (widely) autonomous monetary policies (Indonesia, Malaysia, Philippines, South Korea, Taiwan, Thailand) we test the model in two steps. Firstly, we calculate a benchmark target interest rate for "autonomous" interest rate decisions of the freely floating countries in East Asia based on a Taylor rule. Then, we subtract the realized interest rate from the Taylor rule benchmark and normalize it to a scale of -1 (above target) to +1 (below target). The Taylor rule index is calculated as follows.[21]

$$(15)\quad TR-Index_t = \frac{TR_t - i_t}{\max\left|TR\ - i\ \right|},$$

[20] This is congruent to China's growth strategy of supporting exports via an undervalued real exchange rate (McKinnon and Schnabl 2011).

[21] The supscript *t* denotes the time index.

with the Taylor interest rate (*TR*) being derived from the original Taylor (1993) rule.[22] An index value greater (smaller) than zero means that the actual policy rate is too low (high) compared to the Taylor rule benchmark.

Secondly, we calculate a dependency index, which shows based on equation (8) the central bank losses given the assumption that central banks would have set the Taylor interest rate. Again we normalize the index to a spectrum from -1 (large gains) to +1 (large losses):

$$(16)\ Dependency - Index_t = -1 \times \left(\frac{Cap_t - TR_t SL_t - (if_t - \hat{e}_t) NFA_t}{\max \left| Cap - TR\ SL - (if - \hat{e}) NFA \right|} \right)$$

.

If both indices are highly positive, it suggests that the central bank keeps interest rates lower than warranted to avoid losses.

Both indices are calculated for the period from 2000 to end of 2010 based on quarterly data. For Korea (upper left panel in Figure 9) in most periods both indices are positively correlated. Since the end of 2001 the dependency index started to increase together with the negative deviation of the policy rate from its Taylor benchmark indicating limited monetary policy autonomy from the US. An exception is the period from the end of 2004 to 2007 in which the dependency index remained high, but the Taylor rule index decreased.

This corresponds to the time period, when the Bank of Korea has followed an autonomous policy but at the same time has faced massive central bank losses (highlighted area) and respective losses of capital. Equity remained negative until the third quarter of 2008. Then, interest rates declined relative to the Taylor rule benchmark (high index value), which helped to reduce sterilization costs and revaluations losses on foreign reserves. Given the low interest rate environment in the US and the recovery from the crisis in Korea both indices started to rise again since 2010 again associated to a period of low monetary policy autonomy.[23] A similar pattern of periods with different degrees of monetary policy autonomy can be observed for Thailand (middle left panel of Figure 9).

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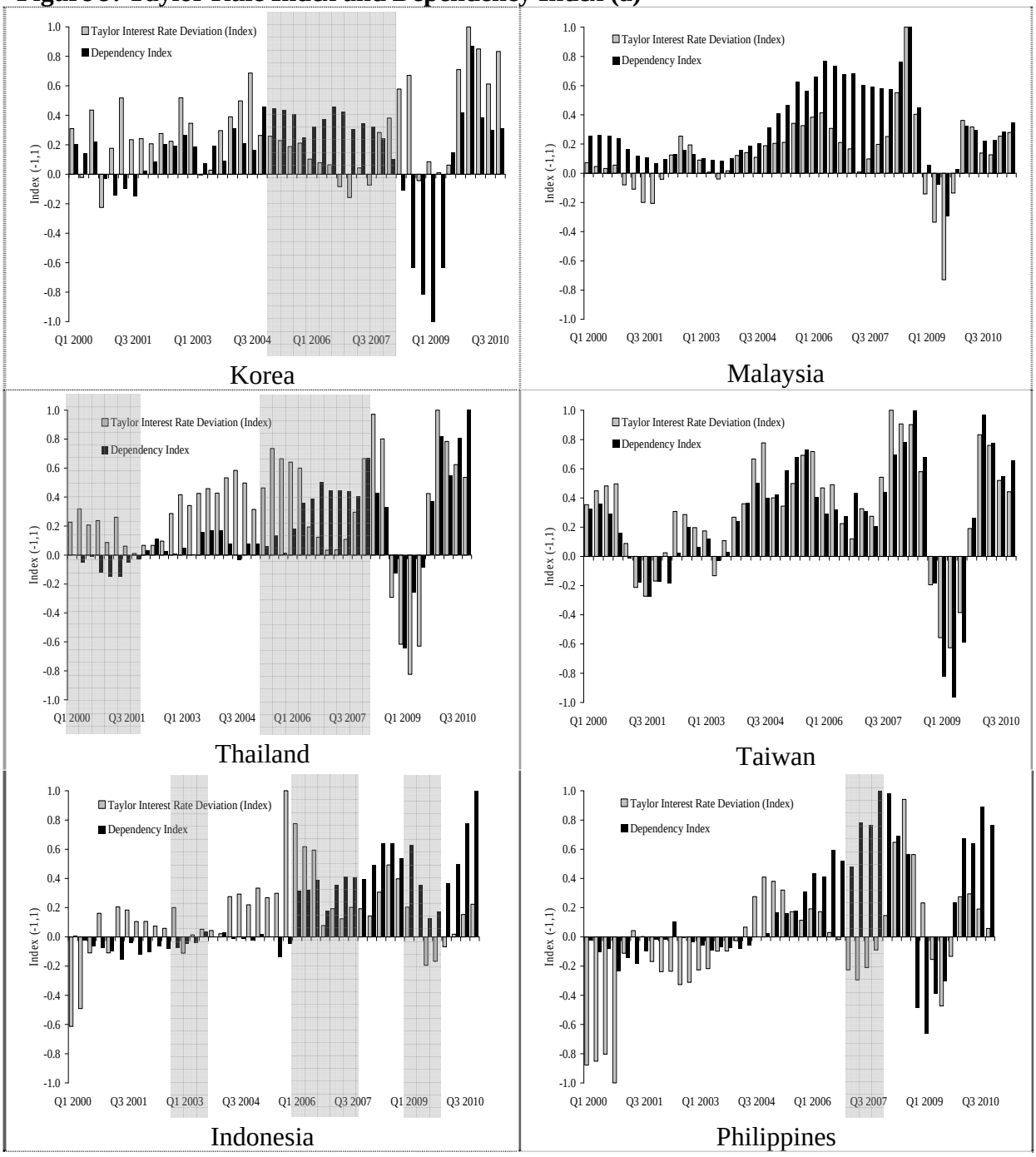
[22] The Taylor rule is given by $TR_t = \pi_t + r^* + 0.5(\pi_t - \pi_t^*) + 0.5(y_t - y_t^*)$ with π_t as the inflation rate, r^* as the implied equilibrium (real) interest rate, π_t^* as the inflation target, y_t as the log real GDP and y_t^* as the log of potential output. We assume a constant equilibrium real interest rate of 2 percent for each country. In case the inflation target is unknown we use a linear trend of actual inflation.

[23] In that period the deviation from the Taylor rule benchmark, however, could be linked to an unconventional monetary policy during the crisis targeting at stabilizing the banking system.

Figure 9: Taylor Rule Index and Dependency Index (a)

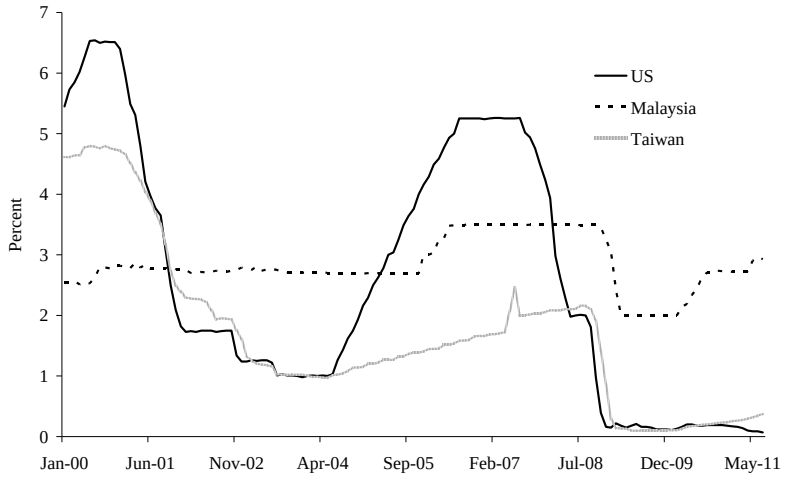


Source: IMF: IFS, national sources, own calculations. Note: shaded areas mark loss making years.

The losses in the beginning of the new millennium originated in interest disbursements paid on external loans which the Bank of Thailand had received during the Asian crisis and in revaluation losses on the stock of net foreign assets as a floating exchange rate regime was introduced in 1997. The sources of losses in the period from 2005 to 2007 were high interest payments on central bank bonds and debt securities as well as valuation losses due to an autonomous monetary policy (low Taylor rule index and high dependency index).

In contrast to the Bank of Korea and Bank of Thailand the central banks of Taiwan and - to a lesser extend – Malaysia have followed the US interest rate policy (see Figure 10) and thereby avoided central bank losses. Accordingly, the Taylor rule and dependency index are highly correlated.

Figure 10: Money Market Rates in Malaysia, Taiwan and US



Source: IMF: IFS, Reuters.

Regarding the central banks of Indonesia and the Philippines (lower Panels of Figure 9) although both central banks have been using a portfolio of market and non-market based measures to absorb surplus liquidity they run losses in particular years reflecting some degree of resistance to losing monetary policy autonomy. The Bank Indonesia suffered losses due to high interest payments on its own debt certificates partly issued for bank restructuring. In 2007 the central bank of the Philippines had a large loss of roughly 1.3 percent of GDP because of high interest payments on central bank securities and revaluation losses on the stock of net foreign assets.

5. Conclusion

In this paper, we define surplus liquidity and relate it to the policy challenges of central banks in East Asia. They face a policy dilemma. High capital inflows put appreciating pressure on their exchange rates. Interventions in the foreign exchange market aim to avoid an appreciation, but lead to an increasing stock of foreign reserves and therefore undue liquidity creation. To control surplus liquidity, central banks can opt for more or less market-oriented sterilization measures. Market based measures lead to increasing interest rates and fuel

additional capital inflows turning sterilization attempts ineffective. Non-market based measures such as unremunerated required reserves can help to escape the impossible trinity, if they successfully restrict capital inflows. The benefit is uncertain as unremunerated reserve requirements lead to distortions of the domestic financial system. This limits monetary policy independence.

Another way to escape the policy dilemma is to let the exchange rate float. We show that debtor central banks then still depend on the past accumulation of foreign reserves. Sterilization costs and valuation losses emerge, if the interest differential to the anchor country is positive and the exchange rate appreciates. Given that the central bank cares about these losses, the degree of dependence of these debtor central banks on the foreign monetary policy stance hinges on the degree of structural surplus liquidity, the impact of changes in the interest rate differential on the exchange rate, and the capital buffer of the central bank.

Thus, flexible exchange rates allow for more monetary policy autonomy in the first place, but when sterilization costs and revaluation losses on foreign reserves emerge, this autonomy is undermined. Reducing the structural surplus liquidity and thus restoring monetary policy autonomy will take place only gradually over time, as it mainly depends on the evolution of the liquidity absorbing factors such as currency in circulation.

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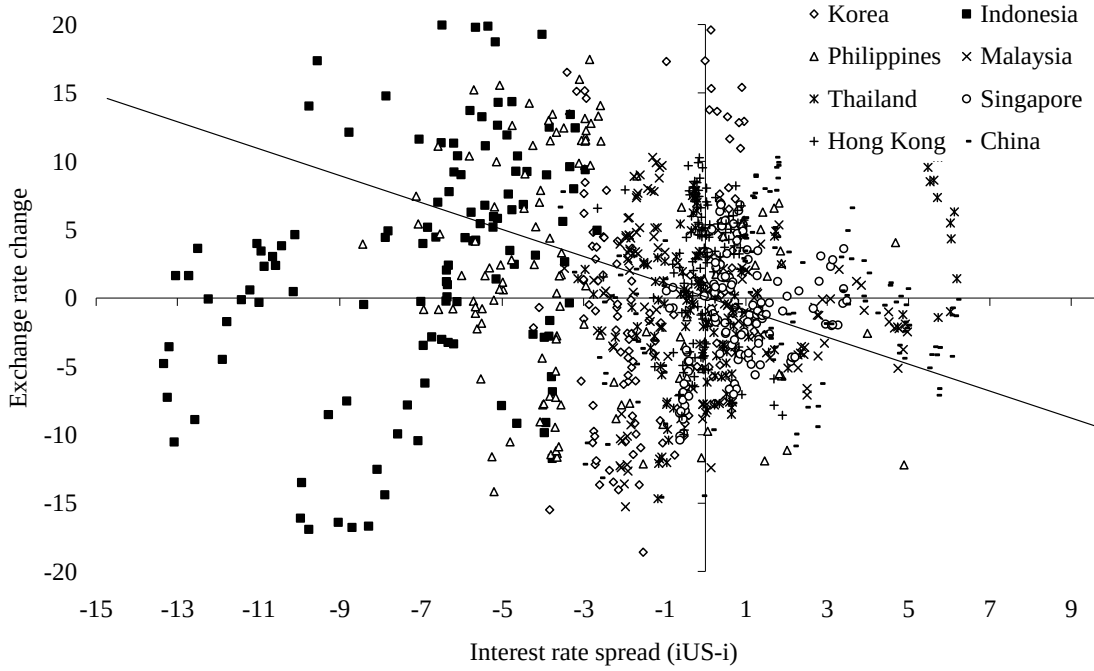
Appendix

Figure A1: Interest Rate Spread and Exchange Rate Changes

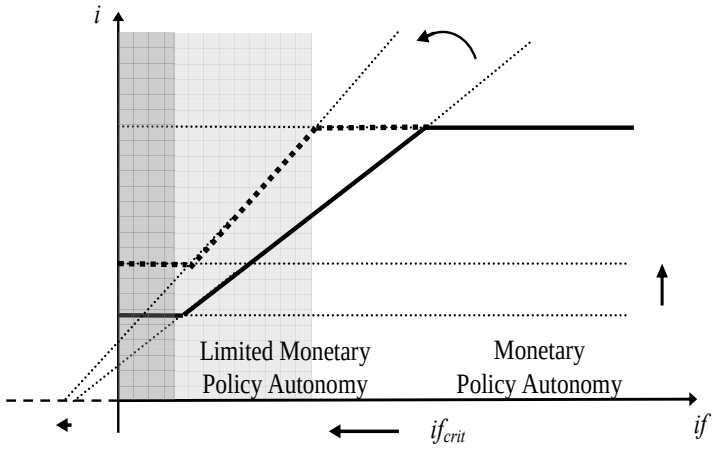


Source: IMF: IFS, national sources.

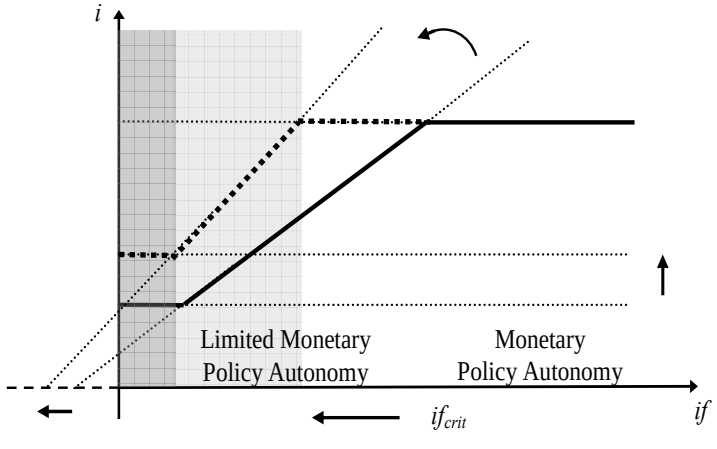
The straight line indicates the theoretical relationship between exchange rate changes (positive means depreciation) and the foreign and domestic interest rate differential if UIP would hold. As obvious the actual realizations are very volatile and the empirical trend of the link between exchange rate changes and the interest rate spread even would suggest a reverse correlation indicating protracted carry trades.

Figure A2 shows different configurations of the impact of a decrease of surplus liquidity on the scope for monetary policy autonomy derived from the theoretical discussion of section 3. As surplus liquidity is defined as NFA-CIC-Cap the upper panels and the lower left panel of Figure A2 distinguishes the change of the scope for autonomy when CIC expands, the capital buffer increases or NFA decreases. Ceteris paribus in all three cases monetary policy autonomy increases, however, with different magnitudes. Improving the capital buffer has the largest impact as the sloped line shifts upwards (more than in the case when CIC increases) and the slope becomes steeper (more than in the case when NFA decreases). The lower right panel shows the increase in the scope for monetary policy autonomy when kappa gets smaller. If kappa approaches minus one (UIP hold) the central bank would be completely autonomous from the foreign monetary policy stance as the net interest expenses on sterilization instruments are compensated by valuation gains on the stock of net foreign assets.

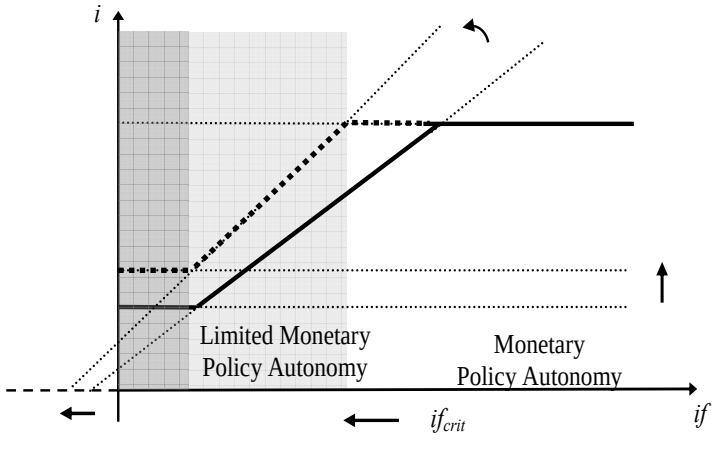
Figure A2: Surplus Liquidity and Monetary Policy Autonomy



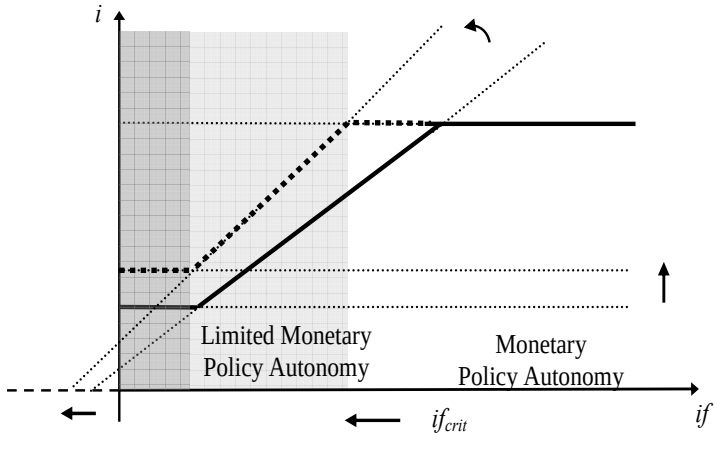
CIC increases



Cap increases



NFA decreases



Kappa decreases