THREE ESSAYS ON MONETARY POLICY IN SMALL OPEN ECONOMIES

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0.1 Acknowledgment

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0.2 Abstract

In this dissertation three different aspects of monetary policy in small open economies (SOEs) are explored. The first chapter investigates Singapore's unique brand of monetary policy and, in particular, how de facto monetary sterilisation works in that country. The second chapter is a theoretical exercise in exchange rate behaviour, testing whether the Dornbusch (1976) overshooting result can be replicated in a richer version of the models of the new open economy macroeconomics genre from the perspective of a small country. Finally, the last chapter looks at the question of whether in a small open developing economy (SODE) with a fixed exchange rate, that the monetary authority retains autonomy in monetary policy, and what role(s), if any, that credit channels may play in its efficacy.

The first chapter studies the role that an obligatory retirement savings plan, known as the Central Provident Fund (CPF), plays in sterilising capital inflows. Using data from 1988 through to 1997, just prior to the Asian crisis, it is shown that the Monetary Authority of Singapore (MAS) mitigated capital inflows associated with an appreciating domestic currency by moving CPF funds between commercial banks and itself.

In the second chapter, a model with nominal wage rigidities is combined with the assumption that all goods are traded in the new open economy framework to derive an outcome where the home country has a strong bias towards its own good. Then it is shown that, under broad assumptions of the parameters of the model, overshooting is a consequence when interest elasticity of money demand is less than unity.

The final chapter investigates the role of credit channels in monetary policy. It

is shown that, even within an SOE with fixed exchange rates, monetary policy can retain its potency and is not completely exogenous to the monetary authority in the presence of capital market imperfections. This efficacy of monetary policy is enhanced by credit channels on the part of credit rationing by banks and depends on a balance-sheet constraint of banks.

Chapter I

Singapore's unique monetary policy: The nexus of monetary, fiscal and exchange rate policies

I.1 Introduction

Asian currencies are taking spotlight once again in the beginning of the twenty-first century. At the closure of the 1990s, a handful of countries in the Asia-Pacific region (APR) were in the news because of the calamitous decline of their currencies.[1] For instance, the Indonesian rupiah, Korean won, Malaysian ringgit and Thai baht all lost over half their value in a space of several months at the peak of the 1997-98 Asian

[1] Many credit Paul Krugman (1994) for first noting the chink in the armour of the rising Asian economies when he pointed out that the Asian "miracle" was just a redistribution of capital rather than actual productivity growth per se.

crisis.[2] This time, however, APR currencies are in the news because of global imbalances:[3] The undersaving of Americans, as expressed through their current account deficit (which registered 7 percent of GDP in 2006), is being financed in large part by Asian central banks, whom have been merrily buying US Treasuries.[4] This, in turn, helps finance America's appetite for foreign goods and at the same time keeps the value of Asian currencies at artificially low (or fixed) levels. America alleges that China is chief among the culprits keeping its currency at unfair and contrived levels. Thus in recent times the American administration has deemed the matter of enough significance to send an envoy – which included the likes of Paul Hankson, the Treasury secretary, and Ben Bernanke, the Federal Reserve chairman – to pressure the Chinese government to revalue the Chinese renminbi (also known as the "yuan"). Although China is vilified by the United States as the principal malefactor (rightly or wrongly),

[2]These four countries were the hardest hit from the crisis. However, the reach of the calamity also ensnared Hong Kong, Singapore, Taiwan and other Asia-Pacific economies, although China was spared. (And many credit the closed nature of China's financial market for saving it from the vagaries of the maelstrom.)

[3]Barry Eichengreen (2004) writes an interesting article comparing the current system of global imbalances with that of the one brought about by the Bretton Woods system (1944-71), calling the current system "Bretton Woods II".

[4]There are many theories as to why Asian central banks have been so keen in acquiring American debt. Three major arguments include: (*i*) A desire to keep robust a key export market; (*ii*) A desire to insulate their foreign reserves from a dollar depreciation (e.g., a 10 percent depreciation of the US dollar would result in a paper loss of about USD 100 billion for China's central bank, which has over USD 1.5 trillion in foreign reserves, with most of that figure held in American Treasury bills); (*iii*) A desire to hold sufficient reserves as a buffer against future financial crises. An interesting perspective on the high accumulation of foreign reserves by Asian central banks is treated in Aizenman & Marion (2003).

much of Asia Pacific retains a fixed or soft-fixed exchange rate regime vis-à-vis the United States. As such, the focus should extend to other currency regimes in the region. Consider the fact that collectively Hong Kong, Japan, Singapore, South Korea and Taiwan hold over $1.88 trillion in foreign reserves, with approximately 70 to 80 percent of that held in American greenbacks, although there is current trend to diversify away from the dollar. When China is added into the equation total foreign reserves jumps to over $3.5 trillion (as at beginning of 2008). From this perspective, Asian exchange rates should form a cornerstone on the debate concerning global imbalances. This time, however, the focus is on whether these currencies need to appreciate relative to the dollar to restore global balances.[5]

Although Singapore's exchange rate has garnered little in the way of attention in the debate about global imbalances – it is, after all, just a small economy[6] – its policy and management offer interesting insights to other central banks and may prove a good model for countries wanting to transition from a fixed rate to a more flexible regime (i.e., managed basket). This is because Singapore has enjoyed much success in the management of its exchange rate (and its foreign reserves), and its current system of a managed float came with a smooth passage from its former days as a currency board. Most importantly, as Singapore's currency is not pegged, its value has not

[5] See, for example, Bergsten & Williamson (2004) about the need for the for Asian currencies to appreciate against the American dollar to eliminate the United State's trade deficit. However, the evidence shows that even a massive appreciation of Asian currencies would not fully correct the huge American currenct account deficit. According to these sources what is truly needed is for Americans to simply tighten their belts and save more.

[6] 2006 GDP (est.) was $141.2bn at purchasing power parity and $122.1bn at market exchange rates, making Singapore's economy slightly larger than Romania's but smaller than Israel's.

been unnaturally misaligned and its stability has allowed the city-state to grow and weather out global macroeconomic shocks such as the financial crisis of 1997-98. (It suffered just a mild recession as a result of contagion from adjacent countries amidst the turmoil of the Asian crisis.)[7]

Singapore's successful exchange rate management, however, has come under the aegis of unorthodox circumstances. The nexus among monetary, fiscal and exchange rate policies provides an interesting study of how nontraditional policies (be they in nature explicit or implicit) can be used to attain macroeconomic stability. Yet the Singapore experience has garnered very little attention amongst academic researchers. This is very surprising given the unique nature of monetary and exchange rate policies in the city-state. Moreover, Singapore provides an ideal case study into the theory and practice of monetary policy in a small open economy (SOE) because of the transparency of its government and institutions. More so, it is a study of monetary policy in an SOE in transition from a developing to mature market, as the 1980s and 1990s were a time when the Singapore economy was still undergoing dynamic stresses of rapid industrialisation.

The Singapore story is also special in that the city-state has successfully managed an intermediate exchange rate regime of the BBC (*b*and, *b*asket and *c*rawl) genre.[8]

[7] The Monetary Authority of Singapore allowed a gradual depreciation of the Singapore dollar amidst the crisis as a means to achieve a soft landing for the economy. Concurrently, compulsory retirement saving contributions were reduced to lower labour costs. The two actions, combined with other government initiatives, resulted in a recession that was very short lived.

[8] The BBC genre of exchange rates is a system of monetary management that is neither pegged nor fixed, but crawling within a range and whose value is based on a basket of currencies (see, e.g., Williamson, 1998).

Indeed, intermediate regimes have come under criticism over the years because of the failure of these systems – notably that they have often led to speculative attacks and collapse. Notwithstanding this, Rogoff et al (2003), among others, have voiced support for regimes beyond those of the corner solutions: "[T]he bipolar view of exchange rates is neither an accurate description of the past, nor a likely scenario for the next decade." Furthermore, the English idiom that "actions speak louder then words" also applies to central banks and so Calvo & Reinhart (2000) have noted that countries often display a disparity between their stated regime and the one that they actually employ, so it is of interest to see which de facto regimes are practiced rather than what is officially expressed. In this regard, Singapore has a history of sound monetary management, even as in earlier times central banking duties were dispersed across distinct institutions. It may be, however, that the unorthodox nature of Singapore's monetary management is at the heart of this success. This idea is explored at greater length in this chapter.

I.1.1 A brief history of monetary policy in Singapore

Modern Singapore was established by the British in 1819 as a trading outpost for the British East India Tea Company. The "Lion City" as it is known, possesses the great asset of being geographically located at a bustling intersection of shipping traffic. In modern times, the Singapore port is the world's busiest port, as measured by TEU, and handles virtually all freight traffic between Europe and East Asia. Over one-quarter of the world's crude passes through the Singapore Straits, where oil multinationals have a significant presence. And it is also said that over one quarter of all traded goods that are marine transported pass through the Singapore port at

one time or another on its journey. (Singapore's port acts as a logistics hub.)

The city-state, whose mascot is the "Merlion" – a creature that is half lion, half mermaid (and completely fabricated by the Singapore Tourism Board) – began its modern history on the silver standard. Surprisingly, even as it was a trading hub for the region there was no common currency of use. Instead the currencies of other regions floated around and it was left to money changers to facilitate the trades of different blocs.

Since its inception as a British outpost, the former British colony has undergone many arrangements with regards to its currency and exchange rate. Notable dates include 1906, when Singapore adopted the gold standard linked to pound sterling (and sterling itself was fixed to gold at the time – these were the heydays of gold standard). After leaving the British sphere of influence post WWII Singapore entered into a federation with Malaysia in 1963, but in light of race riots it gained political independence in 1965.[9] Although politically independent of Malaysia it continued for some time thereafter to remain in a common currency union with its estranged partner known as the Common Currency Board (CCB). It was not until two years after independence, in 1967, that Singapore finally departed from its currency union with Malaysia and established the Board of Commissioners of Currency (BCCS) and issued its own local currency.[10] At that time, Singapore created a currency board

[9] Singapore was, in fact, asked to leave the federation by Malaysia. At the time, the then-prime minister of Singapore was nearly in tears upon announcing the fact that Singapore had been booted from the federation. With no natural resources Singapore seemed doomed to remain a poor country. But 40 years later Singapore has left Malaysia in the dust in the race to economic development. Tensions and rivalry between the two remain to this day over this sensitive matter.

[10] At that time Singapore also established the *Currency Interchangeability Agreement* with Brunei,

linked (once again) to the pound sterling owing to its high dependency on trade and also because of the need of the newly created nation to establish confidence with financial markets. (The rate that was set at the time, however, was based on parity with the Malaysian ringgit. Now, the Singapore dollar is worth more than twice the ringgit.[11])

The Monetary Authority of Singapore (MAS) was formed in 1971 under the *Monetary Authority of Singapore Act* and sanctioned with the power to "regulate all elements of monetary, banking, and financial aspects of Singapore." Nevertheless, currency issue initially remained a preserve of the BCCS, thus limiting the MAS's ability to target certain policy instruments even whilst managing all other financial aspects of Singapore.

In the volatile period of the 1970s Singapore switched its parity from the pound sterling to the US dollar after the British currency was forced to abandon its peg. The United States, however, was itself in a precarious situation, undergoing a period of stagflation (high unemployment coupled with high inflation) as a result of the combination of the Vietnam War and an oil shock. According to the Bretton Woods agreement signed in 1944, the United States dollar was to act as a key currency, with signatories pegging their currencies to the greenback and the United States committed to exchanging the US dollar at the rate of $35 per ounce of gold. But unfavourable macroeconomic conditions led to a massive misalignment of the rate at which the United States was obligated to support the price of gold by the late 1960s.

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so that the currencies of the two countries can be used interchangeably (at par and without charge) in either place. That is, the currencies are "customary tender", although this fact seems to be unknown to most Singaporeans.

[11] The spote rate as at 24 March 2008 shows 1 Singapore dollar buys 2.30 Malaysian ringgit.

The United States abandoned the Bretton Woods arrangement in 1971; Singapore followed shortly thereafter in floating its currency. It was after this last linkage was removed that Singapore formally separated itself from a currency board system.[12]

In its most recent incarnation, exchange rate policy has manifested itself as an intermediate regime that resembles a managed float with BBC characteristics based on undisclosed bands. This policy first took shape in 1981 when the MAS began targeting the exchange rate as a goal of monetary policy,[13] and by the end of the 1980s all effective capital controls from the former British colony were removed.[14] The policy of targeting the exchange rate has served Singapore well and the Singapore dollar (SGD or S$) survived the Asian crisis relatively unscathed in comparison to its southeast Asian neighbours, although it was allowed to depreciate by 20 percent to cushion the economy against a hard landing. Underlying the success of the BBC system in absorbing such macroeconomic shocks has been its flexibility. For instance, it expanded its bands amidst the Asian crisis, thus enabling it to handle the higher volatility of the exchange rate amidst the turmoil (Parrado, 2004). Most recently, the

[12] Some may still argue that Singapore's currency arrangement resembles that of a currency board since its reserves are large and are required, by law, to match the value of currency in circulation. Nevertheless, it does not meet the stated criteria for what is normally defined as a currency board, notably because it does not offer convertibility, among other reasons.

[13] Krugman (1991) is the seminal and pioneering contribution on examining the behaviour of exchange rates under a target zone regime.

[14] However, the MAS does have a policy of "non-internationalisation" of the domestic currency. This means that the MAS discourages foreign institutions from acquiring the Singapore dollar for "non real" (i.e., speculative) purposes. In particular, "financial institutions (in Singapore) may not extend SGD credit facilities exceeding S$5mm to non-residential financial entities where they have reason to believe that the proceeds may be used for speculation against the SGD."

BCCS was merged with the MAS in March of 2003, at last bringing the function of currency issue under the jurisdiction of the MAS and thus effectively wrapping all financial and monetary responsibilities of the country into that institution.

According to its constitutional mandate, the MAS is trusted to maintain a stable non-inflationary environment for economic growth:

> *The primary objective of monetary policy is to ensure low inflation as a sound basis for sustained economic growth. In Singapore, monetary policy is centred on the management of the exchange rate, rather than money supply or interest rates. This reflects the fact that, in the small and open Singapore economy, the exchange rate is the most effective tool in maintaining price stability.*

The history of price stability and economic growth in Singapore is a testament to the success of the MAS in its objective. For instance, through the 1980s when inflation in OECD countries averaged 8 percent, Singapore's inflation was less than half of that, at about 3.5 percent (see Graph 1.2 on page 28). Just as much, real growth in Singapore over that time was twice the level for OECD countries, as it played a game of catch-up with the developed economies. (Now it stands as peers with western Europe with regards to per capita GDP.) Moreover, Singapore's superior record on prices and growth extended through the 1990s and into the first half this decade as well, with only a slight blemish on its record as a result of contagion from the Asian crisis. Nevertheless, in spite of such success, the nature of Singapore's choice of exchange rate regime has not been without its critics who find grievances, foremost, for the fault of not being either a hard peg or a pure free float.[15] These

[15] These solutions are often referred to as "corner solutions" and have been advocated by many

critics note the poor track record of intermediate regimes in developing countries and advocate corner solutions – i.e., either a hard fix (such as through a currency board), or a pure float.[16]

In spite of the failure of intermediate regimes elsewhere, Singapore's special brand of monetary management has had a successful track record. It has been a key component of Singapore's successful industrialisation and remained relatively stable while its neighbours floundered in the wake of the Asian crisis. Moreover, the success of Singapore's intermediate regime may yet serve as a model for other countries in spite of the failures of other intermediate regimes over the years. For instance, Soto (2003) writes in a Central Bank of Chile working paper on the consequences of monetary policy targeting the real exchange rate.[17] Just as much, countries such as Malaysia and China are now also keen to manage their currency against a basket of currencies.[18] Nevertheless, the key point is that monetary policy is not a one-size-fits-all solution. As argued in an MAS research paper (*Staff*, 2000), an intermediate regime may not be the ideal solution for all, but within Singapore's context and sound macroeconomic management and superior institutions, a non-corner solution might be optimal:

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as superior to intermediate regimes. Opponents of intermediate regimes (e.g., Frankel, Schmukler & Servén, 2000) castigate them as prone to speculation and collapse.

[16] Yet, critics of intermediate regimes somehow ignore the disaster that engulfed Argentina in 2002 when its currency board failed, or other cases where corner solutions have clearly been wrong. Indeed, the Argentine currency board, which set the Argentine peso to parity with the US dollar, was, in hindsight, a poor policy as it led to vast overspending and huge currenct account deficits.

[17] She finds that targeting the real exchange rate is advantageous for mitigating fluctuations in the current account, although it may introduce greater volatility in prices; nevertheless, Singapore's experience has shown otherwise.

[18] McCallum (2006) writes that Singapore's system of monetary management may be a model for China's future system of exchange rate management.

Singapore's experience with the managed float, however, has shown that perhaps some middle option along the continuum running from fixed to floating exchange rates is a viable option, if it is buttressed by strong institutions and consistent macroeconomic policies.

But the choice of exchange rate regime is perhaps less a choice than one that is innate to the nature of Singapore's economy. As a recent paper from the MAS (Khor et al, 2004) notes, the determination of exchange rate arrangement in the Lion City may be an exogenous variable: "In the case of Singapore, the choice of its exchange rate system was to a large extent conditioned by its small size and high degree of openness."[19]

I.2 The exchange rate as monetary policy

Central banking functions in Singapore fall on the lap of the Monetary Authority of Singapore. The MAS is responsible for the general financial and monetary stability of the city-state and is the source for the origination and execution of monetary and exchange rate policies in the Lion City. Key to its role in origination and execution the MAS manages the monetary system of Singapore and in it practices a unique form of management: It follows a system of monetary policy rule that is said to be exchange rate-targeted in the sense that the pillar of monetary management targets the exchange rate. In consequence, the interest rate takes on a secondary and complementary role of accommodating a stable exchange rate, which is uncharacteristic of

[19]The interested reader might want to consult the MAS webpage as well as an MAS staff paper published in January 2000 ("A Survey of Singapore's Monetary History"), for a more thorough account of the history of monetary policy and their institutions in Singapore.

the mandates of most other central banks. This characterisation for monetary policy has been the guiding principle of the MAS since the early 1980s – i.e., for about 25 years, which actually gives it a deeper history than the currently vogue notion of targeting the inflation rate.[20] The impetus behind the MAS to target the exchange rate lies in the fact that Singapore is an SOE where trade has a disproportionate impact on national income – in 2006 trade was valued at over four times the level of GDP. Thus the value of the exchange rate has profound and amplified effects on economic activity; so it is targeted as a variable to achieve macroeconomic goals. This stands in contrast to many of its Asian neighbours who favour fixed exchange rates or open inflation targeting, the latter of which is the policy of the Bank of Thailand, a regional peer of the MAS.

Singapore is often described as a newly industrialised economy (NIE) and is supported by a vast network of international financial linkages. A large component of its economy is dependent on trade and the service sector.[21] The objective of the Singapore government since the 1960s has been to build up the economy into a leading regional hub in Asia and also as an international financial centre. To promote this goal the government has assumed a business-friendly facade, enabling and encouraging foreign businesses and their capital – as well as foreign labour – to establish itself in the city with minimal red tape. (Nevertheless, the government takes direct interests in promoting targeted sectors and industries to advance its objectives, most notably it exerts its influence through Temasek Corporation, a government-owned holding company, or sovereign wealth fund (SWF), although Temasek operates independently of

[20] The Bank of New Zealand was the first central bank to formally implement inflation targeting.

[21] The CIA Factbook lists the share of output to services at 66.3 percent (2007).

the government.) In consequence of its aspiration as an international financial centre, capital moves around with great ease and speed and, further being part of the global financial market, the domestic interest rate is thus mostly determined by those prevailing elsewhere. In that regard, the MAS has less scope to conduct independent monetary policy, although that is not to say it has no tools at its disposal. Moreover, the former British colony operates a managed floating exchange rate – which will be described at greater length later – so it does not surrender all control of monetary policy unlike an SOE with a fixed exchange rate. (However, even in such a case, a country can still retain some power in setting monetary policy, and this topic is further explored in the third chapter of this dissertation.)

I.2.1 The exchange rate and monetary management

> *"[T]he choice of exchange rate regimes is likely to be of second order importance to the development of good fiscal, financial and monetary institutions in producing macroeconomic success in emerging market economies... This suggests that less attention should be focused on the general question whether a floating or fixed exchange rate is preferable, and more on these deeper institutional arrangements."* Calvo & Mishkin (2003).

The MAS does not target the money supply or the interest rate or the inflation rate (the latter of which is advocated by, among others, the Federal Reserve chairman Ben Bernanke); rather it targets the exchange rate within a moving band. Nevertheless, the MAS's goals are similar to all central banks: The primary tenet of exchange rate policy in Singapore is to maintain domestic price stability to facilitate non-inflationary economic growth (although the priority of stable prices may take a backseat to growth

or fixing the level of the exchange rate in some cases). The major difference with the MAS, however, is the choice of target variable it perceives to be best in steering the economy to those lofty aims. The challenges to the goal of non-inflationary growth are many and Singapore's position as an SOE that is highly dependent on trade complicates the matter even more. Being a small open economy it takes world prices, including the world interest rate, as given. This matters for a country whose total merchandise trade as a share of GDP, amongst industrialised nations, is the highest. Moreover, the import content of expenditures and exports is very high, ranging from between 60 to 75 percent.[22] All in all, owing to the importance of trade in the economy, the exchange rate becomes a crucial tool in achieving macroeconomic policy goals as it influences the prices of large set of goods in the economy and these prices have amplifying effects on macroeconomic activity.

Being a small economy Singapore is a price taker in global trade. Thus changes in the exchange rate have powerful effects on the economy through pass through in prices for imported goods, which tend to be invoiced in foreign currency. This effect is particularly strong given the high import content as noted in the preceding paragraph. The appreciation of the Singapore dollar vis-à-vis the US dollar (and most other major currencies) over the 1980s and most of the 1990s, however, has limited the extent by which the country imported inflation (see Graph 1.2 on page 28).[23] Domestic cost pressures are reflective of the position of fiscal and monetary policies. The other major influencing factor on inflation is labour costs. From a global

[22] *Source*: Abeysinghe & Choy (2005).

[23] The Singapore dollar experienced a general pattern of appreciation over the 1980s and the 1990s. However, this overall upward trend was coupled with moderate depreciation during the mid-1980s recession and the Asian crisis of the late 1990s.

perspective, correlation between (changes in) unit labour costs (ULC) and inflation has abated over the years, though the correlation factor between the two is still significant, with a measured correlation of 0.3 between 1991-2004 in OECD countries (although this correlation was 0.8 in 1965-1979).[24] Tightness in the labour market over the final decade of the last century, nevertheless, has not produced bouts of inflation due to the country's policy of importing labour at times of shortage (and the fact that the government plays a very proactive role in guiding the macroeconomy). Notwithstanding the assistance of labour policy, exchange rate policy has been the principal driver used to steer aggregate demand and dampen labour-induced inflation.

Even with trade weighing so heavily on the economy of Singapore, the exchange rate has not been a tool used to promote export competitiveness. For one, such behaviour is always seen as a beggar-thy-neighbour policy that often starts bouts of mutually destructive competitive devaluations.[25] Secondly, the high import content of exports makes the incremental gain in export competitiveness small compared with most countries. Over the long run, increases in consumer prices would be offset by rising wages, and a tightening of the labour market would raise ULC, leading to a suboptimal outcome. Instead, a policy of promoting a constant and robust purchasing power of the currency has been the priority of the MAS. In attaining this goal the MAS manages the Singapore dollar against a basket of currencies of its trading partners

[24] *Source*: OECD, Bureau of Labour Statistics and Bank for International Settlements. (An often-cited reason for this disconnect in recent times is the emergence of China and India – and the abundance of their labour – into the global marketplace.)

[25] It has even been argued that such supposedly competitive devaluations could be even self-detrimental or "beggar-thyself". See, e.g., Michaelis (2004).

with weights roughly proportional to the share of trade from each trading partner.[26] The exchange rate is often described as following a "snake in the tunnel" or system of "bands", whereby the currency is allowed to float and the MAS intervenes only when the value of the exchange rate exceeds a boundary value. The width of the tunnel is generally broad and the boundaries are often re-set when the band is hit. This is precisely the nature of BBC regimes.

The long-term objective of the MAS is to influence the trade-weighted exchange rate (also often referred to as the trade-weighted index, or TWI) of the Singapore dollar within the tunnel whilst achieving price stability in a non-inflationary environment. With a floating exchange rate – at least when the spot rate is within its bands – the MAS can directly influence the exchange rate only by intervening to act either as a buyer or a seller in the foreign exchange market. To its credit, the MAS is well-financed to intervene in the market to either influence the exchange rate or defend it against speculation: As at February 2008 it had over $172bn in foreign reserves[27] and has displayed a commitment to intervene. The large reserves, in and of themselves, also act as a deterrent to speculators, as has been argued by Feldstein (1999) and others, since they credibly show the strength of the MAS to unwanted speculation. In addition, the MAS has safeguards to limit the role of speculators in the SGD market. This principally is its policy of "non-internationalisation" of the SGD, which limits

[26] Major export partners (2006): Malaysia (13.1%), USA (10.2%), Hong Kong (10.1%), Indonesia (9.2%), China (9.7%), Japan (5.5%), Thailand (4.2%). Major import partners (2006): Malaysia (13.0%), USA (12.7%), China (11.4%), Japan (8.3%), Taiwan (6.4%), Indonesia (6.2%), South Korea (4.4%). *Source: CIA Factbook 2008*

[27] By law the MAS must back all its currency in gold or official reserves, although it is *not* obligated to maintain convertibility.

the availability of the SGD for non-market (i.e., speculative) activities.

In the open economic environment of Singapore both the money supply and the interest rate have relatively modest impacts on inflation and the volume of economic activity. This is due to their disproportional contribution of external demand to growth, rather than that of domestic demand. Moreover, because of the significant presence of foreign multinationals in Singapore[28] and their ability to access external sources of funds (and also because Singapore does not restrict the mobility of capital), the domestic cost of borrowing is not as influential as in larger modern economies. Additionally, the laissez-faire nature of Singapore towards the movement and ownership of capital – and in particular, with respect to exchange rate controls – also means that there is rapid movement of capital whenever there exists differentials between domestic and foreign interest rates. Consequently, the domestic interest rate is, in large part, determined by rates prevailing elsewhere and market expectations of the trend in the exchange rate. On the other hand, changes in the money supply are primarily the resultant net flow of funds from international sources. For these reasons and others, it is difficult to target either the money supply or interest rates, and this is precisely why these policy variables are not the instruments of choice of the MAS.

With regards to how the MAS exerts control over the Singapore dollar, its policy is unique on more than one level. Consider, for one, the fact that the Singapore dollar follows a system of managed float of the "intermediate" variety (that has fallen afoul with many policymakers as of late). Second, note that the bands of the managed float are not public information and the composition of the currency basket is like-

[28] According to the International Development Research Centre's 2004-05 Annual Report (see www.idrc.ca), Singapore is home to over 4000 foreign multinational corporations.

wise not disclosed. (Nevertheless, the composition is not a secret and can be fairly deduced by public information.) Such information is released only after the fact, and so those who wish to speculate on the movement of the exchange rate are left double-guessing the MAS. Still, the MAS has been lauded for its transparency and clarity in signalling its intents and in explaining to the public the mechanisms and decisions behind which monetary policy is enacted. For example, the MAS releases periodic reports explaining their *modus operandi*. This has enhanced the institution's credibility and therefore given it greater scope to steer the macroeconomy.[29]

Akin to other central banks, the MAS exerts influence over short horizons by intervening in the foreign exchange market, usually for the purpose of dampening excess movement in the exchange rate. Parrado (2004) notes that the MAS follows a forward-looking policy rule that reacts to inflation and output volatility.[30] In particular he finds that monetary policy in Singapore reacts to large changes in inflation and large output gaps (though not to small ones), which is consistent with the idea that monetary policy targets the nominal exchange rate to achieve stable output and prices. Furthermore, it is noted that Singapore's policy suggests that its emphasis has been on controlling inflation, which agrees with Gerlach & Gerlach-Kristen

[29] Petra M Geraats (2006, 2005, 2002), and Geraats & Eijiffinger (2006), are good references on the link between transparency and reputation and the effectiveness of central banks in conducting monetary policy.

[30] Parrado (2004) defines a policy reaction function:

$$\Delta e_t^* = \overline{\Delta e} + \beta \left(E \left[\pi_{t+n} | \Omega_t \right] - \pi^* \right) + \gamma \left(E \left[y_{t+m} | \Omega_t \right] - y^* \right)$$

where e is the nominal exchange rate, E is an expectations operator, π is inflation, y is output, Ω is an information set and β and γ are parameters of the equation. He tests this reaction function with 1991-2002 data using generalised method of moments estimation on a variant of the above equation.

(2006) in that inflation volatility in Singapore has been relatively low. Over longer horizons, however, the MAS may guide the direction of the exchange rate by influencing long term interests rates or by announcing to the market its intentions (and having the credibility to act on its words). But the day-to-day interventions in the foreign exchange market remain the most important channel through which the MAS can influence the macroeconomy and muffle volatility in the foreign exchange market. Such measures are required to achieve long-term stability as the long-term credibility of Singapore's exchange rate policy, as with others, is influenced to a great extent by short-term fluctuations in the exchange rate. Excessive short-term volatility in the exchange rate – which are characteristic of floating nominal exchange rates[31] – if not accommodated by policies to dampen fluctuations, can lead to a misallocation of market attention and thus suboptimal uses of resources and capital. In particular, when the market becomes overly focused on the value of the exchange rate this may undermine confidence in the currency in the long run, with potentially detrimental consequences for the macroeconomy. Similar to other monetary authorities, a policy of "leaning against the wind" is all that can be expected in the face of global pressures.

But the use of the exchange rate as a policy tool does not obviate the necessity of monetary policy. There are tools within monetary policy that are still at the disposal of the MAS and that are vital in ensuring that the macroeconomic objectives are the country are best met. For instance, the MAS still has the ability to regulate the level of liquidity of the banking sector, which goes hand in hand with exchange rate policy to promote non-inflationary growth. Yet another tool employed by the MAS to support

[31] See Chapter 2 for a model illustrating the Dornbusch (1976) overshooting result in small open economies with no non-traded goods sector.

its foreign exchange intervention is the interest rate. An example of this behaviour was in the 1990s when interest rates were allowed to fall to dampen the strength of the Singapore dollar in periods of strong capital inflows, and conversely in times of major outflows. Moreover, since the BCCS was merged with the MAS, monetary and exchange rate policies have been more effectively coordinated (notwithstanding that the formerly distinct institutions and their roles were complementary rather than competitive).

I.2.2 How monetary policy works

Monetary policy in Singapore is centred on the exchange rate with a goal of maintaining the exchange rate at a level consistent with accommodating inflation, growth and external balances. This stands in contrast to its Asian neighbour, Hong Kong, which sets monetary policy to target a fixed level of the exchange rate (via a currency board). An interesting comparison on the monetary management in between Hong Kong and Singapore is featured in the Bank for International Settlements by Gerlach & Gerlach-Kristen (2006). The comparison is quite telling because of the different approaches that policymakers in Hong Kong and Singapore took in light of very similar macroeconomic shocks and the success enjoyed by both in achieving relatively stable prices and growth in a turbulent economic environment. They conclude that whereas for Hong Kong monetary can be modelled as an econometric model comprising of a Phillips curve and an IS curve for changes in the nominal effective exchange rate (NEER), the Singapore experience displays a policy reaction function to inflation. They find that inflation variability lower in Singapore relative to Hong Kong although the volatility of real GDP in their period of study (1984-2004) are

similar; i.e., real economic patterns have been very similar, in spite of the very different approaches to monetary policy. In the following parts of this section the details of Singapore's exchange rate-targeted monetary policy are laid out.

Monetary policy is most often associated with open market purchases of bonds or currency issuance. Yet, there remain other effective means of monetary policy including moral suasion, changes in capitalisation, reserve requirements, changes in the collateral requirement, discount-window lending, and "open mouth operations" whereby the monetary authority talks the desired policy to the market. In the early 1970s, the MAS favoured varying the minimum reserve requirement of banks as a means of conducting monetary policy. The reserve ratio – which limits the ability of banks to create liquidity – was revised on several occasions in the stagflationary era of the 1970s to help quell inflation. As an example of this type of monetary policy conducted by the MAS, the minimum ratio was raised from 3.5 percent to 5 percent in August 1972, following shortly in the heels of the collapse of the Bretton Woods pact, and then again to 9 percent less than one year after the first increase. The purpose was to absorb liquidity and curtail high credit growth aimed at speculative activities in the equity market, although it succumbed to the law of unintended consequences and strengthened the local currency. Through the mutual agreement of banks and the MAS, interest rates were also raised when the MAS in partnership with the Association of Singapore Banks (ASB) acted as a single entity, and instituted minimum lending rates. At that time Singapore's financial institutions were still developing and its exposure to the international banking sector was limited, so such actions effectively helped contain credit growth and inflation. But the lumpy nature of these moves were not flexible enough for coping with the fast-changing environment of the

market, especially as the global economy grew more integrated in the environment of deregulation in the 1980s. Thus, as the money and foreign exchange markets matured, the MAS started using market operations in overseeing monetary policy.

Table 1.1 Size of Singapore Money Market (in SGD millions)

Beginning of Year	Interbank Market	Bills Discounted or Purchased	T-bills Outstanding	Total	Change (in %)
1988	9,271	2,175	2,780	14,226	--
1989	8,833	2,693	2,360	13,886	-2.4
1990	15,166	3,010	1,900	20,070	44.5
1991	18,438	3,416	2,070	23,924	19.2
1992	12,058	4,134	3,420	19,662	-17.8
1993	11,936	4,100	4,940	20,976	6.7
1994	17,402	4,305	4,990	26,696	27.3
1995	28,411	4,301	5,000	37,712	41.3
1996	30,927	4,668	5,750	41,345	9.6
1997	33,555	5,765	5,990	45,310	9.6

Source: MAS Monthly Statistical Bulletin

The money market in Singapore is still small compared to larger markets such as London or New York, or even Hong Kong. Nevertheless, since the 1980s it has grown from being virtually non-existent to being a significant player in Asia, coincident with Singapore's rise as a global financial centre, although much of that growth has been post-1998 and so coming after the focus of this study.

A network of discount houses dealing in commercial papers, T-bills and interbank deposits and transfers served well in the initial progression of Singapore's economy from a developing economy as it transitioned to an international financial hub. A shared platform of liquidity between banks and the MAS served to level the interest rate effects of oversupply and/or excess demand. However, as with most latent instruments of monetary policy, the burden fell on the commercial banks to identify the shortages and surpluses and absorb them through the MAS for liquidity indirectly through the discount windows. This system of controlling the money supply, although mainly fulfilling the needs of the market, was not without its faults, espe-

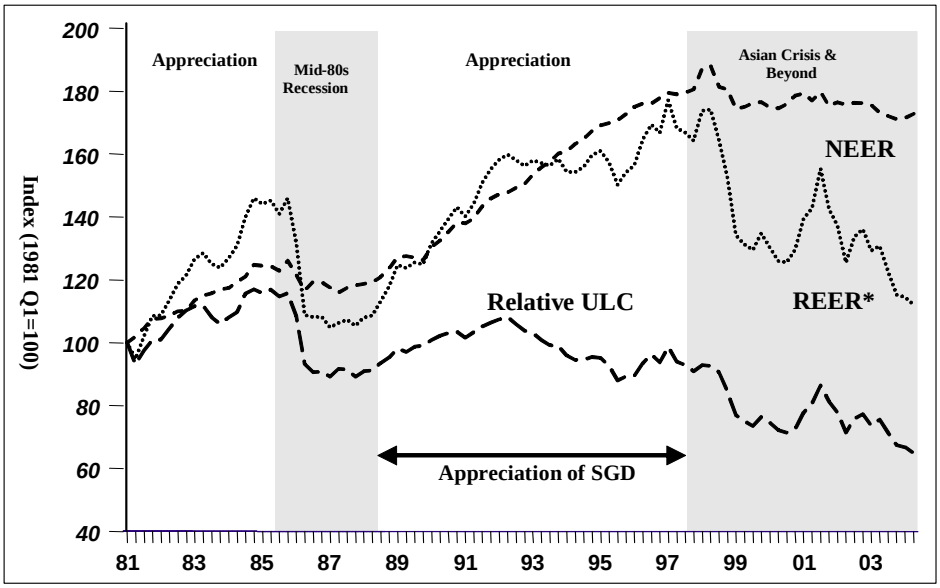
cially as money market activity hastened. Instances where liquidity was not uniformly distributed across banks, or where several banks were not aware of the imbalances in the system until they caused interest rates to move appreciably,[32] tended to result in considerable intraday volatility of interest rates. Such outcomes were, without doubt, unsettling to the market and to be avoided when possible. The challenges ahead for the Singapore money market then is to increase market liquidity and improve the depth and breadth of its investor base.

To be sure, reserve requirements and other forms of passive measures have remained useful in the toolkit of the MAS as a means of monetary policy, but the efficacy of money market operations conducted at the initiative of the MAS have grown at a greater rate in stabilising market conditions. As such, in deciding the amounts and timing of money market operations, the MAS is well guided to take a more proactive stance. Indeed, over time, such operations have become more prominent as a policy implementation tool. With Singapore now firmly entrenched into the global financial system the foreign exchange and money markets – which developed in tandem to accommodate these flows – have provided the MAS with a natural conduit for monetary intervention. However, since the 1980s the MAS has used more sophisticated tools – chief among them foreign exchange swaps and options – to control the level of liquidity in the banking system, complemented by unsecured borrowing and lending to commercial banks.

Today, Singapore has one of the most sophisticated markets in Asia and is, indeed, a major regional hub and international financial centre. The MAS's involvement in

[32] An example of this is when government fiscal operations result in sizeable withdrawals or additions of funds through just one or a handful of banks.

these markets has further enhanced the depth and breadth of the market by providing it with liquidity and a larger platform of execution. In fact, the rapid growth of the Singapore dollar money market, as well as its foreign exchange market, provided the MAS with more liquid means to impel monetary policy than compared with more traditional instruments. Table 1.1 (above, page 22) highlights the growth of the primary money market in Singapore over the period 1988-97. The value trebled within ten years leading up to the Asian financial crisis although it has since leveled off. Nevertheless, the money market in Singapore is now sizeable and plays a key role in the infrastructure of Singapore's financial system.



Graph 1.1 Singapore's exchange rate (NEER, REER) and labour costs (ULC). Reproduced with permission of the Monetary Authority of Singapore (MAS). All rights reserved (2004).

The commercial banking sector of Singapore is highly sophisticated and the city acts as a regional headquarters for many banks with international ambitions. The city-

state is home to three domestic banks – United Overseas Bank (UOB), Development Bank of Singapore (DBS) and Overseas Chinese Banking Corporation (OCBC).[33] Foreign banks also have a presence in the city-state, and all banks face regulations on the scope of domestic and foreign currency transactions, which the MAS oversees and provides clearing house services for the market. The intraday cash balances of banks with the MAS are cleared daily and influenced by a host of factors. Transactions amongst banks and with the MAS and the public dictate the amount owed to the MAS from the commercial banks at the end of the business day. The activities which affect domestic liquidity conditions, on the other hand, include changes in banks' cash holdings, net balances of T-bills and other government-issued securities, as well as foreign exchange transactions and financial transactions by the government, among others. In daily management, the MAS monitors the money market rates keenly as a bellwether of market conditions. It eases fluctuations in the market by way of absorbing or dispersing of funds, as it finds necessary, via foreign exchange swaps and by entering the borrowing and lending markets. The MAS often takes a role in supplying funds to the market, as a means of fiscal management by the government, and this usually leads to the transfer of public sector surpluses from the commercial banking sector to itself. This flow of funds is demonstrated in Figure 1.1 (page 26), which shows how the MAS interacts with other institutions to exercise a mix of fiscal, monetary and exchange rate policies; these establishments include the Central

[33] The Post Office Savinsg Bank (POSB) – which had duties and functions very similar to that of the Japanese Post Office banks – was taken over recently by DBS and integrated into the commercial sector. This has made the banking sector more stable and provided greater depth for domestic lending activities. In recent times UOB also bought out Overseas United Bank (OUB), which made the banking landscape, if nothing else, more simplified with the 3-letter acronyms.

Provident Fund (CPF),[34] government accounts, and the national commercial banking sector.

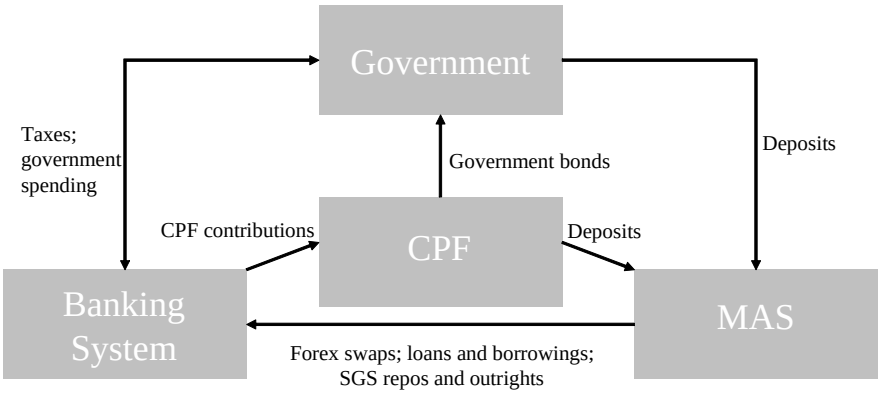


Figure 1.1. Flow of funds in Singapore with the CPF playing a pivotal role connecting government with the MAS and the banking system.

The Central Provident Fund receives contributions from employers and employees and diverts these funds either to government bonds or as deposits with the MAS. Because of this arrangement the CPF is able to move funds from the banking system to the MAS; the MAS, in turn, has many tools available to it to influence the banking sector. The banking sector, in turn, is injected by funds from the government through traditional fiscal routes. Finally, in addition to its traditional fiscal role, the government also holds deposits with the MAS, thus enabling it to influence the liquidity of the MAS. These interconnectivities are laid out in Figure 1.1 (above).

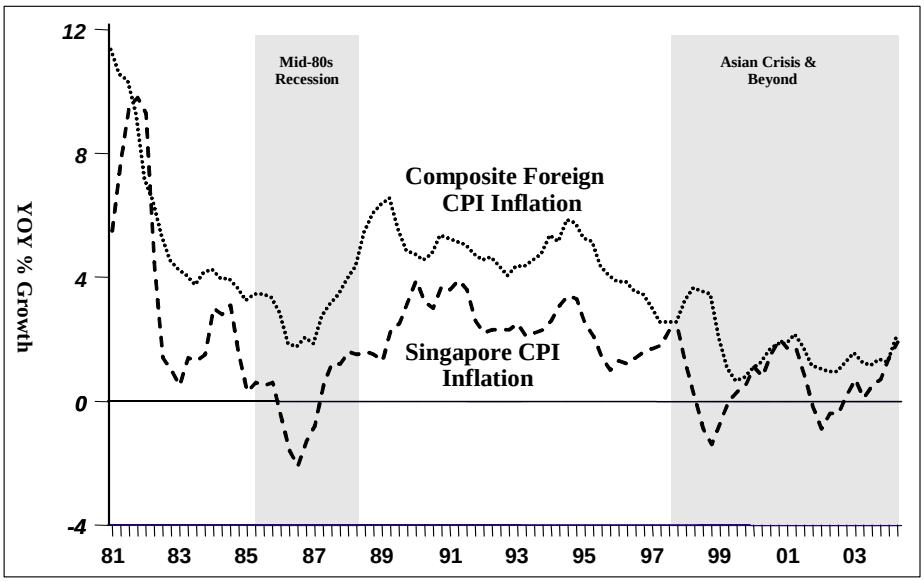
Timing is critical in the money market and so the institutions and infrastructure need to accommodate the nature of activities. For instance, to allow adequate time for settlement, foreign exchange swaps for same-day settlement are transacted in the

[34]The Central Provident Fund is a mandatory social security savings plan that the Singapore government initiated on 1 July 1955.

morning, while borrowing and loans can be done throughout the day. Unsecured loans, however, are usually transacted overnight or on very short-term basis, while term loans are less frequent.

Of course, good banking supervision to ensure that banks operating in Singapore are sound and adequately capitalised will enhance the use of this instrument.[35] Of the various interest rates in the market, the one that is most directly affected by money market operations of the MAS, as is in most other places, is the interbank offer rate (or Singapore interbank offered rate, Sibor), the rate at which banks lend amongst each other in settling daily activities with the central clearing house. Changes in this rate feed through to other interbank rates and so have a steering effect on rates that more directly affect businesses and consumers. However, the MAS has no specific targets for the level of the money supply or the interest rate – it targets the exchange rate, after all. Instead, its longer term position, and the mandate of the MAS, is to maintain money market conditions that complement exchange rate policy to sustain non-inflationary growth.

[35] Most banks in Singapore will be Basel II compliant by 2009 and may well be able to manage their own risks under the IRB approach (for those that choose to apply for such accredition/status). Thus capital adequacy and risk management will be mostly done in-house.



Graph 1.2 Inflation in Singapore relative to foreign inflation.

Reproduced with permission of the Monetary Authority of Singapore (MAS). All right reserved (2004).

The debt market is another important venue in the workings of the financial system. However, the market for government-issued securities is small owing to the dual reasons that: (*i*) The country is small and; (*ii*) the government usually runs a fiscal surplus and so does not need to borrow in the marketplace. Even with respect to raising capital for targeted projects, the domestic debt market is often not exploited. (Instead, often the government seeks investment partners that have the requisite financial viability to work in tandem with, as is the case with the development of Sentosa Island, Singapore's beach resort island.) Nevertheless, the MAS has the power to auction debt on behalf of the government and to enter into secondary trading markets and do repurchases to mop up liquidity. This means that the MAS is the de facto central bank for the country and is responsible for conducting open market

operations (OMO).

The principal conduit for monetary policy is through money market operations; nevertheless, the MAS still uses direct credit controls where appropriate. For example, in May 1996, in response to surging residential property prices fuelled by loose credit, the MAS imposed a limit on financing residential properties at 80 percent of the value of the property. As expected, this act limited the rapid increase in property process and helped steer the economy from creating a bubble in the real estate sector. And as property prices declined amid the Asian crisis, the exposure of the banking sector to the real estate sector was modest.[36] (The foresight of the MAS – as well as by authorities in Hong Kong – to limit lending for property might serve as a good model for other countries that might be in the midst of a housing market bubble. But it seems that this advice might be too late for at least one country that is currently facing a severe correction in real estate prices.)

I.2.3 A blind BBC and how the MAS signals its intents

Unlike the United States, which has a highly quoted Federal funds rate, within Singapore the MAS has no parallel, well-recognised rate which it targets and which the market keenly follows. Although it is public knowledge that the MAS manages the

[36] Hong Kong banks also imposed similar measures, but the limit of the northern rival city-state was set at 60 percent. The measure was helpful in protecting the stability of Hong Kong banks when the property market plummeted. Indeed, Hong Kong's banking sector was one of the few areas of the economy in good shape after the Asian crisis as the Chinese special administrative region (SAR) suffered a prolonged period of deflation and depressed demand post 1997. (In contrast to the US which in the credit crisis of 2007-08 has seen its financial sector, and especially banks, fall apart at the seams.)

Singapore dollar against a trade-weighted basket of currencies, neither the weights in the basket nor the bands of the BBC are publicly disclosed, although it is common knowledge that the weights are roughly proportional to trade flows and adjusted periodically. However, this is not to say that the intentions of the MAS are not known by the public. The MAS often discloses its aspirations through announcements and publications or by comments from senior officials. And even if the specifics are not known, the public does know the general direction of policy, or can infer them from movements in the interest and exchange rates. Moreover, there are scores of private firms that hire analysts and economists to second-guess the intentions and the management of the MAS. Nevertheless, the "blind" band assuages speculative pressure that is oftentimes found in countries whose monetary authorities have prescribed periodical meetings or openly announce their intentions (and cannot support their stated goals with supporting actions).

The gradual implementation of policy revisions through market mechanisms, in contrast to announcing discrete changes in key variables, allows policy makers the ability to gauge the efficacy of policy changes and, if necessary, fine-tune the stance of such. The blind nature of the bands used in the exchange rate management is key to its success. For consider otherwise: If a target exchange rate or interest rate were to be made known to the market, the gradual implementations of policy as spoken of would not be possible as markets would jump to the new announced level. This is because any deviation from the prevailing rates to those announced need to be explained to the market – with just cause – in order for the monetary authority to remain credible in the eyes of the market. This would be akin to the US Fed announcing rate changes that are to occur in the future and expecting that the Fed funds rate would move

incrementally to the new level rather than instantly jumping to the new announced level.

To appreciate this problem consider the following point. Suppose that the official target were known yet disputed. But markets would not just acquiesce a contentious target. As such, holding up a contended target by the market would be to welcome disaster – or speculators at the very least. So from this view, then, it is a moot point whether the announcement of a targeted rate would actually help, rather than hurt, the implementation of policy.[37] A case in point is what happened in the early 1990s, where in 1993 Sibor was set to zero whilst the SGD experienced massive appreciation due to extensive capital inflows in the run-up to a forthcoming initial public offering (IPO) of Singapore Telecom (SingTel), the national phone carrier. The government found itself in a quagmire: To have permitted the exchange rate to appreciate beyond its course would have been unwise, but the alternative would have been for the market to swallow a weaker Singapore dollar and it seemed that even a zero Sibor could not stop the bullish sentiment that pervaded the Singapore dollar. Instead, the low-key style of policy implementation has served the MAS well up until now, and there has been scant pressure for more transparency from the markets in revealing the intentions of the MAS's policies. But to say that the MAS operates with a lack of transparency is also misleading. In fact, to reiterate a point made earlier, the MAS is very explicit in detailing how it conducts monetary policy and it publishes the models that it uses for public scrutiny.[38] This follows a general trend in global central banking to

[37] Nevertheless, credible announcements have enormous power in directing the market. See, for example, "Open Mouth Operations" by Guthrie & Wright (2000).

[38] The MAS publishes a semi-annual statement of its actions in a review called *Monetary Policy Statement*, as well as a more recent publication *Macroeconomic Review*.

show greater transparency to the public in their decision-making process – e.g., until recently all the actions of the US Federal Reserve were eerily secretive.[39]

I.2.4 Monetary management

Amidst the financial turmoil of the Asian crisis in 1997-98, the Singapore currency was not spared from the contagious effects spread from Indonesia, Malaysia and Thailand. Similar to other Asian currencies, the Singapore dollar weakened in the exchange markets, declining against the US dollar by almost 20 percent at the peak of the crisis.[40] But this depreciation was minimal compared to the drops experienced in Korea, Indonesia, Malaysia and Thailand. In defending the value of the Singapore dollar, the MAS doubled the three-month interbank rate from 3.625 percent to over 7 percent to prop the currency. The jump in the interbank rate in Singapore, however, was rather modest in comparison to the chaos that embroiled other countries in the region, most notably in the four aforementioned countries, where the International Monetary Fund (IMF) eventually led a multi-billion dollar rescue packages in an effort to avert a global crisis.[41]

In Singapore the MAS intervened in the foreign exchange market with the explicit

[39] Keynes had once hoped that monetary poliy would someday become as routine as dentistry. The credit crunch of 2007-08 that is embroiling the US is a testament, however, that those days are still far away.

[40] Currency crises are typically defined when the currency loses more than 20 percent of its value within a space of a few months.

[41] However, some note that the austerity measures implemented by the IMF actually exasperated the crisis in these countries (including the World Bank, as reported in the 3 December 1998, edition of the New York Times), and the crisis of 1997-98 is often referred to as the "IMF crisis" in the afflicted countries.

purpose of promoting monetary and market stability. To this end, the MAS had a policy of ensuring that there was sufficient – though not excess – liquidity in the money market. In the face of the intragency, market forces had mandated a significant depreciation of the SGD as a response to negative externalities from other Asian economies. A lower exchange rate was also needed to preserve its competitiveness in export markets as other exchange rates plummeted (though not the Chinese renminbi). On the matter of cost competitiveness, the government tackled this problem by originating a package of cost cutting and tax cutting measures. This combination of basic re-examination of Singapore's cost position and adjustments to the exchange rate was similar to that used during the recession of the 1980s and, as an approach towards confronting economic stress, again proved effective. Of all the countries that were affected by the crisis in Asia Pacific, Singapore fared best; within a few years of the crisis its economy was already expanding at close to 10 percent per annum and its flexible exchange rate did not leave it with the overhang of deflation as was the case in Hong Kong. It was this success that has given Singapore's fiscal and monetary management some spotlight and that may provide some insightful lessons for its neighbours in dealing with (and avoiding) future crises.

The success of its management naturally begs the question of the operating procedures of monetary policy in Singapore. The *modus operandi* of the MAS in the currency markets remained unchanged in the face of the Asian crisis; its only adjustment was to widen the bands of the BBC arrangement. The low-key intervention operations succeeded despite, or perhaps because of, the undisclosed nature of policy. And the adjustment of the MAS to allow a wider band during the crisis proved effective. While exchange rate management is described as an intermediate regime

and the bands undisclosed, there is a clear commitment from the MAS to maintain a stable SGD in an environment of non-inflationary growth. It is this commitment and the transparency in conveying this commitment to the public for which the MAS is lauded.

The monetary policy of Singapore is centred on the exchange rate. Consequently the MAS's primary role in the foreign exchange market has been to ensure just as much liquidity as is required in the banking system to sustain a desired level of the SGD. This lies in contrast to those authorities who signal their intentions through interest rate or inflation targets.[42] In periods of intense exchange rate pressure the MAS has allowed the Singapore dollar to move in wider bands and these boundaries are subject to modification to facilitate market flows. But for the most part, the principal challenge for the MAS over the years has been to contain the government's regular fiscal surpluses from growing domestic liquidity too high (thus ultimately leading to inflationary pressure). The enviable financial health of the government has allowed the MAS room to commit to a low-inflationary environment. Such price stability has been a foundation for the city-state's price-stable growth.

In implementing exchange rate and monetary policies, the progressive shift from administrative means to market operations has allowed the MAS to react promptly to economic and financial developments to influence the direction of the economy. Given the destabilising effects that often accompany surges in capital flows (which are usually worse when capital is leaving), the importance of flexibility in dealing with such problems in an expeditious manner is paramount to a well-functioning financial

[42] For a perspective on inflation targeting in an open economy see Svensson (2000); for the case of inflation targeting in a small open economy see Bharucha & Kent (1998).

system, and the banking sector in particular.

Finally, this brings one of the unique facets of Singapore's management of monetary and exchange rate policies to the forefront: The role that an obligatory retirement savings plan plays in sterilising capital inflows in the country. Earlier, the roles of the government, banking sector, MAS and the Central Provident Fund were illustrated to show the flow of funds in Singapore's financial system (Figure 1.1 on page 26). In the next section the role of CPF savings as a tool for sterilisation of capital inflows is explored.

I.3 CPF savings and sterilisation in Singapore

Monetary sterilisation – the act of using open market operations to counteract the effects of exchange market intervention on a country's monetary base – is usually performed through a country's monetary authority or central bank. Usually, this involves the monetary authority buying or selling bonds to mitigate changes in the monetary base as a result of capital flows into and out of the country as a result of foreign exchange market interventions. Typically this practice is considered mundane, but has been in the spotlight during the credit crunch of 2007-08 as the technique has been pivotal in the Fed's policies. Herein, the monetary sterilisation mechanism of the Singapore economy is explored in tandem with the role that CPF savings play in that process. The evidence suggests that due to the underdeveloped nature of Singapore's financial markets, the CPF has, in lieu, acted as a pseudo-market mechanism in sterilising the effect of foreign exchange assets inflow. This is done because of how CPF savings are allocated amongst the various financial institutions

in Singapore (refer to Figure 1.1 on page 26). In particular, the CPF plays a pivotal role in allocating savings towards various venues of Singapore's financial market, and its judicious movement has acted in ways to mitigate capital flows and manage the monetary flows of the country.[43]

The error corrections mechanism (ECM) methodology herein is used to model the *implicit* monetary sterilisation mechanism that results from the management of CPF savings. The ECM approach is described by Clive Granger (2004) in his Nobel lecture as a methodology in which the data under study is believed to be generated by a process in which "the change of one of the series is explained in terms of the lag of the difference between the series, possibly after scaling, and lags of the differences of each series." The choice of this procedure rests on the assumption of cointegration in the data; as will be shown, this is precisely the case for the data used to look at the effects of monetary sterilisation in Singapore.

This part of the paper attempts to ascertain the offset coefficient between the net domestic credit component and the net foreign asset component of the monetary base, i.e., to measure the responsiveness of net foreign credit to changes in the domestic component of the monetary base (and so the direction of causation posited is that changes in the foreign monetary base induce implicit changes in the domestic credit component of the monetary base, measured in terms of domestic currency). This is done using data from 1988 through to 1997 to estimate the offset coefficient. Over this period the SGD appreciated over 50 percent, both in nominal and real terms (see Graph 1.1, page 24). As will be demonstrated, the results suggest that monetary

[43] The US Fed would have greater sway over monetary policy if it too had a strong balance sheet courtesy of a national pension savings pool.

sterilisation in Singapore is nearly perfect over this period. Furthermore, as will be shown, the estimates of other macroeconomic relations also support the hypothesis of the pseudo-market monetary sterilisation mechanism.

Monetary sterilisation is a widely used technique by capital-receiving countries and developing countries, in particular, to forestall nominal currency appreciation (beyond what is acceptable by the monetary authority) and stifle monetary base expansion, or similarly to avoid a drop in the interest rate. Broadly speaking, monetary sterilisation can be conducted through either open market operations, discount window lending, or a change in the reserve requirement depending on the sophistication of the financial market (ignoring soft measures such as moral suasion and open mouth operations), or any means by which the monetary authority exchanges pieces of credit with the public so that liquidity levels do not change. Nevertheless, sterilisation via foreign exchange market interventions tend to be cumbersome, although they are more responsive than changes made to the reserve requirement of banks, which take considerable time to wind through the system (both in terms of legislation and implementation). But sterilisation in the foreign exchange market often comes with its own problems: It is neither fully effective, nor is it free from the principle of the law of unintended consequences, and foreign exchange is not directly controlled by the central bank (only how much to hold, though not its market value).[44] Moreover, intervention in the foreign exchange market by a monetary authority assumes a given level of sophistication of the local financial markets and competency of the agents of the

[44]For a treatment on the topic of monetary sterilisation Edison (1993), and Dominiguez & Frankel (1993) are good reference points. A perspective on the macroeconomic effects are discussed in Frankel (1994) and Kletzer & Spiegel (1996).

monetary authority.

Sterilisation through open market operations has been noted to prevent interest rate differentials from ameliorating capital inflows (Calvo, 1991; Kiguel & Leiderman, 1993). This is because the "natural" changes in the monetary base that should be engendered, and thus also the natural changes in the interest rate, are prevented from occurring by a deliberate role of the monetary authority to keep the monetary base unaltered. This means that the central bank needs to provide or mop up liquidity to counteract capital flows that would normally perturb the monetary base. Such actions are used to minimise interest rate feedback effects; nevertheless, such tactics often have the counterproductive result of increasing the interest rate differential and consequently extend the length of time in which capital inflows are abnormally high. This is because interest rates are kept at artificially high levels – higher than the market would justify – and so continue to attract capital inflows. Meanwhile, these actions impose a penalty on the government as it invests in potentially non-performing fiscal investments, in the sense that it purchases "strategic" (i.e. low-yield) foreign reserves in lieu of better performing investments.[45] This is further complicated when it has to issue domestic debt at higher yields than it gets from its investment in foreign reserves (and especially when domestic debt is subject to "original sin" for those countries that cannot borrow in local currency). However, active buying and selling of bonds or currencies is not the only way to mute the effects of capital inflows on the

[45] Nevertheless, in Singapore, the government does have prudent fiscal investments through Temasek Corporation, a government-owned holding company that invests public funds on behalf the citizens of Singapore. Although government-owned, the government's role is described as passive, and Temasek is free to choose its investments without political interference – or so at least in theory.

monetary base. Sterilisation can also be carried out by raising the reserve requirement or the rate charged on last-resort lending, or by changing the collateral mix and quality which the monetary authority will lend against to commercial banks. The former procedure effectively limits the ability of commercial banks to create liquidity via lowering the money multiplier. Sterilisation via the reserve requirement has the effect of mitigating monetary expansion and the pseudo-fiscal cost is then transferred to the customers of commercial banks as the spread between loan and deposit rates widen. Such actions, however, have the problem of exacerbating distortions to the market for loanable funds, so its use as a tool for sterilisation is usually avoided.

Since the early 1990s, a host of Asian economies have been large recipients of financial capital. Sterilising capital inflows has been achieved (for those seeking such a solution) through two primary forms: (*i*) Shifting public sector deposits from commercial banks to the central bank or; (*ii*) Shifting government-directed pension funds from commercial banks to the central bank. Both procedures act to sterilise capital inflows and are different from how developed countries normally sterilise capital inflows because the standard tools are often absent in emerging markets. Nevertheless, sterilisation by means of transferring savings from public institutions to the central bank possesses some advantages over the traditional means of monetary sterilisation by open market operations. For one, it normally avoids and/or reduces the central bank's pseudo-fiscal costs (of investing in low-yield foreign exchange) associated with OMO. Secondly, non-conventional sterilisation does not appear to increase interest rates as much as open market sales of bonds. Finally, the method of savings transfers does not impose a burden on bank intermediaries such as in the case of an increase in the reserve requirement.

This section of the first chapter of the dissertation examines the experience of Singapore in sterilising capital inflow surges over the interval 1988-97, a period in which the Singapore dollar experienced a steady appreciation against major currencies, such as the US dollar (*cf* Graph 1.1, page 24). This period also closely coincides with the time at which the exchange rate was adopted by the Singapore authorities as a target variable of monetary policy (the exchange rate was targeted as a variable beginning in 1981). By coincidence, this period of currency appreciation also ignores the volatility of the stock market crash of 1987[46] and the Asian crisis and so provides a good reference for which to base the study. Indeed, the mid-1980s recession dampened the exchange rate and since the Asian crisis the Singapore dollar has not demonstrated a similar pattern of appreciation (see Graph 1.1, page 24). Instead, since 1998 the Singapore dollar has hovered at around $0.60 with no clear sizeable steady appreciation or depreciation. (However, the real effective exchange rate has dropped considerably post 1997, although it has strengthened since 2006 due to a general weakness in the US dollar.)

Unlike many of its Asian counterparts who fix their currency, Singapore maintains a managed float, and has little in the way of capital controls. The managed nature of the exchange rate allows some degree of flexibility for adjustments – primarily to lean against the wind. In this way, the size of net capital inflows that need to be sterilised are relatively smaller than some of its Asian counterparts with fixed exchange rates. However, by maintaining a managed floating exchange rate, the MAS limits, in theory, its ability at controlling monetary policy: Only one nominal variable

[46] The crash of 1987 began in the US but its reprecussions reverberated throughout Asia – "decoupling" had not entered the lexicon of global macroeconomics yet – and the rest of the world.

– either the exchange rate or money growth – is open to it to conduct monetary policy in the conventional sense. Nevertheless, Singapore data suggest that the Monetary Authority of Singapore can, in fact, effectively manipulate two variables, namely the exchange rate and the growth of the monetary base.[47] Notwithstanding that foreign exchange market interventions are non-sterilised in nature, the MAS can foresee with reasonable accuracy the liquidity shortage caused by such factors as: (*i*) Compulsory national savings through the CPF; (*ii*) Consistent government budget surpluses and; (*iii*) Rising government debt as a result of sales of government securities to the CPF. In consequence, the MAS *can* manipulate foreign exchange interventions *and* the CPF's holding of government securities to produce desirable offsetting changes in the determinants of the monetary base to neutralise any expansionary effect of foreign exchange interventions on the monetary base. So it is with these variables that tests for sterilisation or its equivalent can be drawn. Moreover, the fiscal policy that transfers funds from the CPF to the MAS, is then de facto monetary policy that enables Singapore to maintain a low growth of the monetary base (see, e.g., Spiegel [1995], and Chan & Ngiam [1998]).

The central thesis argued herein is that the existence of the CPF, a national and mandatory programme of retirement savings, and the management of government securities via the CPF, has played a critical role in Singapore's success in coordinating its exchange rate objectives whilst maintaining monetary stability. Chiefly, the management of CPF savings through the pseudo-fiscal measure of transferring savings between the MAS and the CPF has acted as a de facto mechanism of mon-

[47] The Singapore dollar appreciated steadily and moderately while money supply registered a stable and low rate of growth in most periods of time under study (1988-97).

etary sterilisation in the period 1988-97, when the Singapore dollar experienced a steady appreciation. The use of the CPF funds further allowed Singapore to achieve seemingly conflicting goals. In essence, the sterilisation of capital inflows through sales of government securities to the CPF offset the interest rate effect that normally accompanies sterilisation done by open market operations. Another beneficial point is that the CPF's investment in government securities is relatively inelastic, thus the interest rate is subject to less upward pressure in the wake of sterilisation. As a result, there is also less pressure stemming from sterilisation and consequently this lessens the pressure for further capital inflows and currency appreciation.

Now the crucial part remains on how to identify and measure sterilisation. To gauge the strength of sterilisation this paper follows some classic works, namely that of Kouri & Porter (1974) and also that of Cumby & Obstfeld (1983).[48] In this vein, the offset coefficient is measured as the extent to which net changes in the foreign reserve component of the monetary base are offset by domestic credit contractions. In essence, this measures the degree of monetary sterilisation in the wake of capital inflows.

I.3.1 Evidence of monetary sterilisation

It is not uncommon for countries in APR to achieve monetary sterilisation of capital inflows by shifting funds from commercial banks to their respective central banks. An exemplary list of countries from this region that undertake this practice include

[48] Kouri & Porter (1974) estimated offset coefficients for a number of industrialised countries and found that they fall in the range $(0.4, 0.8)$. Cumby and Obstfeld (1983), on the other hand, presented evidence for the feasibility of sterilisation in an economy with balance of payment surplus and an appreciating exchange rate.

Indonesia, Malaysia, Singapore, Taiwan and Thailand.[49] This procedure of shifting funds from commercial banks to a central bank is not what is typically thought of as standard monetary sterilisation. Nevertheless, it achieves a similar result by reducing the commercial banks' reserves at the central bank and thus limiting the commercial banks' abilities to create deposit money and, as alluded to because of avoiding strategic investments, may even have some advantages over standard operating procedures.

For comparison, two of Singapore's neighbours, Indonesia and Thailand, practice monetary sterilisation that is more dependent on direct and straightforward operations (be they either market or non-market means) in public sector deposits. But in Thailand public sector deposits account for a large share of the sources of funds in financial institutions; these range from commercial banks to various specialised financial intermediaries. For example, Thailand is a nation where the government directly owns some commercial banks, has meaningful interests in others, and is often the principal investor or conduit of money to key financial intermediaries.[50] In Singapore, there exist two vehicles that are controlled at arm's length by the Singapore government, namely Temasek Corporation and the Government of Singapore Investment Corporation (GIC).

[49] Park & Song (1996) investigate the policies of South Korea, Thailand, Malaysia, and Indonesia in managing capital inflows from 1990-94. They attribute, inter alia, monetary sterilisation in promoting a stable exchange rate.

[50] Thai governments – or those in politics, in particular – have also come under heat for being too close to business. For example, Thaksin Shinawatra, the erstwhile prime minister of Thailand until he was removed from the office by a military coup in September 2006, held various investments, including Shin Corp, which he sold tax-free to Singapore's Temasek Holdings (and which was a major factor in his unpopularity with the Bangkok elite).

Temasek, whose name derives from the Javanese word for "sea town", is a vast 100-plus billion (USD) holding company (SWF) that owns, *inter alia*, Singapore Airlines, as well as the recent and controversial purchase of Shin Corp (sold by the Thaksin family to Singapore in early 2006).[51] Nevertheless, the government remains a passive investor in Temasek, although critics argue that it is impossible for an authoritarian regime – even a benevolent one – to fully insulate itself from abusing its power to further business interests within Temasek's favour (or those of the ruling governing family).

The GIC is an investment management company whose primary task is to manage Singapore's foreign reserves, complementing Temasek, whose role is to invests the collective retirement funds of Singapore. With over $100bn in assets it is one of the largest investment management vehicles in the world and a model upon which the Chinese may emulate in investing its own horde of foreign reserves – indeed, China recently launched its own $200bn SWF, the China Investment Corporation (CIC).

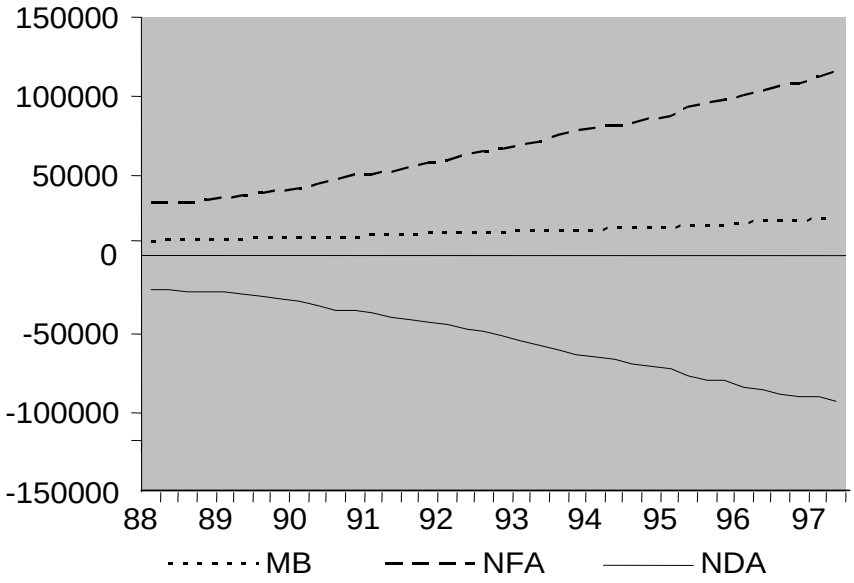
Finally, consider the fact that since Singapore is an open country, it has only a minimal share of its public sector deposits in its commercial banking system as compared with Indonesia and Thailand. As such, sterilisations in Singapore are not implemented through the direct shift of state-owned funds; instead the CPF plays a pivotal role in its lieu.

[51] Temasek is one of the earliest sovereign wealth funds (SWF) and has been in the news in 2008 as an investor injecting capital into beleaguered investment American banks.

I.3.2 The macroeconomy and sterilisation

This section presents some stylised facts of Singapore's macroeconomy and outlines the hypothesis of the CPF-based mechanism of monetary sterilisation in Singapore. The analysis restricts attention to the period from 1988 to 1997 for this study, as this period has seen steady appreciation of the Singapore dollar against major currencies such as the US dollar, thus permitting for an analysis of Singapore's response to steady and *anticipated* capital inflows over that time. Moreover, it was since 1981 that the exchange rate became the primary tool of monetary policy.[52] A pronounced fact that stands out in the Singapore economy during this time was that the monetary base remained surprisingly stable over the years of the appreciation of the SGD. This phenomenon seems rather unusual given that there was a substantial net increases in capital inflows. This begs the question why such stability was observed in spite of the inflows of capital. The conclusion, of course, is the judicious manipulation of CPF deposits from the commercial banks to the central bank (MAS) to offset (i.e., sterilise) the effect of capital inflows on the monetary base.

[52] Before then the MAS targeted the money supply and the interest rate. The presently vogue option of inflation targeting, however, has never been a key policy for the MAS.



Graph 1.3. Monetary base and its components (net foreign assets and net domestic assets trending in opposite directions).

As Graph 1.3 (above) shows, whilst there were steady and large increases in capital inflows and net foreign assets (NFA) held by the MAS, Singapore still managed to maintain a consistently low and approximately constant level of the monetary base (MB) for the period 1988-1997. What explains this seemingly paradoxical outcome? One conjecture is that there exists a long-run equilibrium relationship between the two components of the monetary base – i.e., decreases in net domestic credit tend to cancel increases in net foreign assets. Nevertheless, such a phenomenon appears inadequate to explicate the outcome for an economy that is deficient in financial market sophistication for conventional sterilisation. (In an economy with developed capital markets, if the monetary authority is to target monetary growth, the gap between changes in foreign reserves and changes in the monetary base is just the amount that needs to be sterilised.) This begs the question, then, whether there

exists a scheme in Singapore that is similar to the standard sterilisation mechanism but not operating through standard OMO. Of course, the mechanism being alluded to, and as shall be argued henceforth, is the role of CPF savings in acting as an implicit monetary sterilisation tool. To be able to understand the mechanisms of monetary sterilisation it is required to understand the nature of monetary flows in Singapore.

Monetary sterilisation is an integral part of the long-run macroeconomic relations in the Singapore economy; it is a tool that has also been used in other Asian countries that have experienced massive capital inflows (see, e.g., Ouyang & Rajan [1995], for the case of sterilisation in China). Sterilisation of foreign capital inflows has been widely used in Singapore; for example, Nadal-De Simone (2000) and Moreno & Spiegel (1996) both note that the MAS has engaged in extensive sterilisation operations in response to capital inflows, particularly over the 1990s. This was mainly in response to the growth of the MAS's net foreign asset holdings that came on the heels of growing current account surpluses and capital inflows. The mechanics of Singapore's sterilisations involve several institutions and is best explained through diagrams, as illustrated in Figure 1.2 (below, page 48):

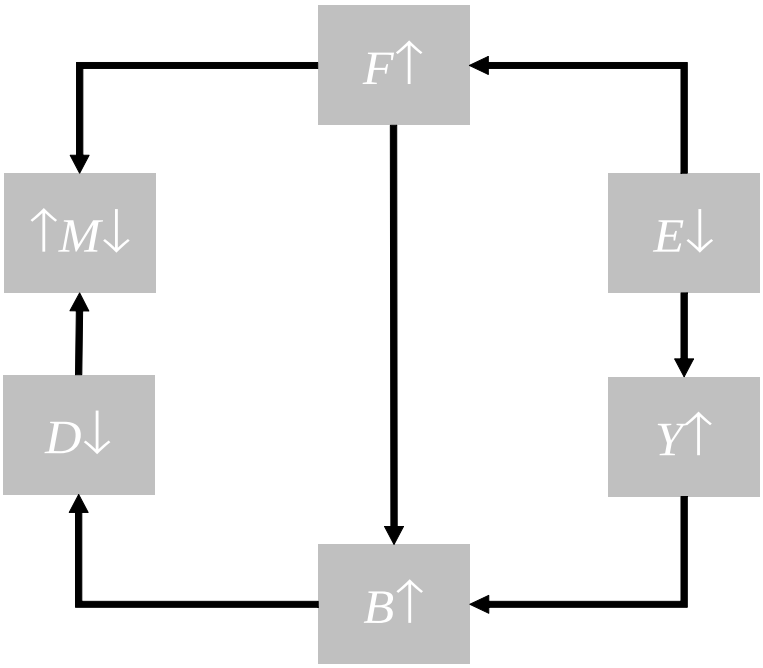


Figure 1.2. Monetary flow of sterilisation (an appreciating currency has expansionary effects on income due to the structure of labour and import costs; monetary base movements offset each other).

The variables presented in the diagram above are explained as follows: E is the nominal exchange rate (NER), expressed as the price of foreign currency in terms of domestic currency; Y is output, which is assumed to be a composite tradeable good; B is the volume of government bonds outstanding; D and F measure the net domestic-credit and net foreign-assets components of the monetary base, respectively. In the problem at hand, the most important dimension is the expansionary effect on Singapore's monetary base due to the persistent currency appreciation of the SGD. It is the management of the concomitant capital inflows which holds the key for an

effective monetary sterilisation mechanism.[53]

In a small, but highly open, economy such as Singapore, production costs of tradeables depends very much on the price level of various imported goods. Indeed, an increase in prices of intermediate goods also leads eventually to an increase in wage costs through increasing the cost of living, thus indirectly pushing up the price of exports. Because of this, given manufacturing costs, an *appropriate* amount of appreciation lowers production costs proportionally more than it raises foreign-currency denominated prices (i.e., pass through is not uniform); as a consequence, real output increases. (This is depicted in Figure 1.2 page 48.)

Graph 1.1 (page 24) demonstrates the upward trend co-movements in real GDP (Y), the nominal exchange rate (E), and the real exchange rate Q (RER, expressed as the nominal exchange rate adjusted by the ratio of Singapore CPI to American CPI). This then opens the hypothesis that these series may have unit roots and also be cointegrated. And so long as currency appreciation leads to expansionary effects,[54] the sage management of government debt and the coordinating operation of the CPF funds work to establish offsetting movements in the foreign and domestic components of the monetary base.

Unlike Social Security in the United States, the CPF is fully funded, both by contributions from employees and employers, and accounts are specific to individuals. The CPF is also compulsory for all Singapore citizens and permanent residents.

[53] For early works that analyse the unconventional real effect of appreciation in general, see Branson (1986), and Gylfason & Risager (1984).

[54] This phenomenon is peculiar to places like Singapore because of the high content of imports in tradeables as well as the cost structure of labour. It also depends on currency appreciation of an appropriate size in relation to the macroeconomy.

(Foreign nationals legally working in Singapore are paid an amount equivalent to the CPF contribution with which they can invest themselves.) Employers and employees contribute respective amounts of a basic share of employee wages to the CPF, and the CPF funds also help members finance major outlays such as housing, health, investment and retirement, so its role is actually an augmented savings/retirements programme.

CPF contributions represent a large proportion of Singapore's national savings,[55] which is among the highest in the world – some economists even muse that Singaporeans may oversave.[56] With these savings, the CPF in turn acquires Singapore government securities (SGS) and advance deposits, and in so doing acts as a financial intermediary between its members and the government.[57] The funds that the government receives from selling securities to savers, including the CPF, are initially held as government deposits with the MAS and later channeled into the Government of Singapore Investment Corporation (GIC), an investment company tasked with managing the funds of the government. As such, CPF liabilities ultimately produce incoming foreign assets held by the government; however, the yields on those foreign assets are earmarked to support the returns to CPF savings. Therefore there exists a significant pattern of co-movement among the CPF funds to its members (DUE), government

[55] Mukul Asher (1995) estimates that, depending on how CPF savings are defined, they account for between 16.3 and 30.4 percent of gross national savings. This value has likely not changed much since the study.

[56] It is often said that Singapore's savings go beyond that of the "golder rule". See, e.g., Kasa (1997), for a brief note about the possible dynamic inefficiency of oversaving in Singapore.

[57] For a detailed report on the CPF's balance sheets and its macroeconomic fluctuations see Luckett, Schulze & Wong (1994).

debt (GD) and official international reserves (NFA) over the period of study (1988-97). One very important point is to note, as can be seen in Graph 1.4 on page 52, is that increases in CPF liabilities (DUE) are almost one-to-one to increases in government debt (GD), which suggests interrelated mechanisms are driving this result. This suggests that the processes may be cointegrated.

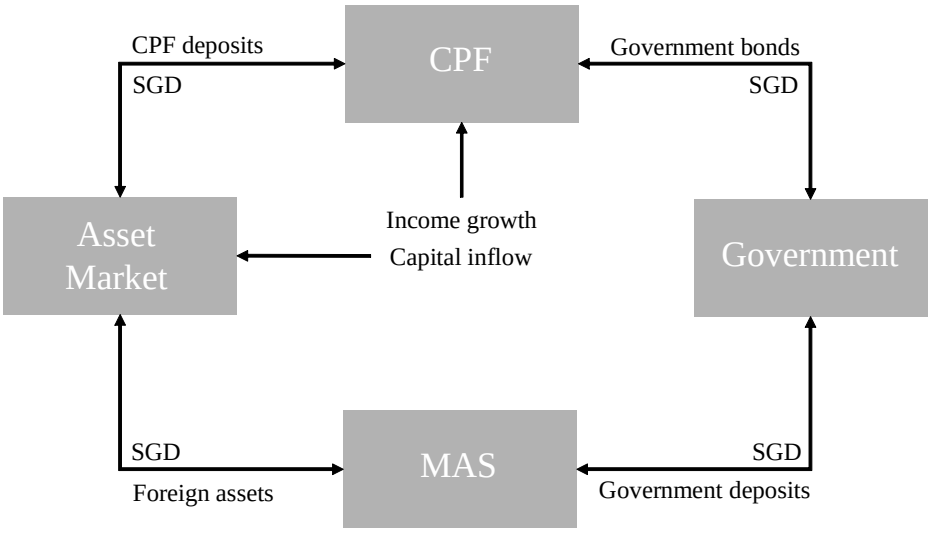
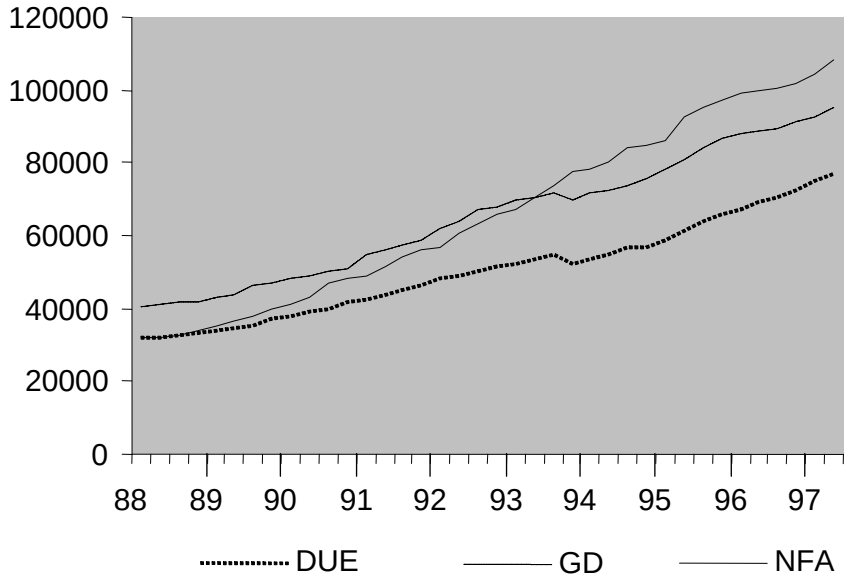


Figure 1.3. The role of the CPF in Singapore (note that SGD here is S$); the CPF absorbs money from the asset market as well as from the government bonds market.

What dimension does the existence of the CPF give to the MAS in setting its goals? The MAS is, in fact, able to use the CPF scheme as a buffer against unwanted fluctuations in the monetary base caused by external shocks. Although the contribution rate is not itself used as a discretionary tool (albeit subject to periodic adjustments), the CPF still functions as an automatic stabiliser because the contributions are positively correlated with wages and salary levels of employees (i.e., contributions rise

in good times and lessen in bad times). Furthermore, foreign capital inflows and the flow of international reserves are as procyclical as the CPF contributions. It follows then that periods of high (low) economic activity are correlated with high (low) levels of CPF contributions and so cushion swings in output.

The conventional mechanism of sterilisation is through OMO, but such mechanisms rely on many factors, including the presence of a well-functioning domestic debt and financial markets. As noted, the depth and breadth of the domestic debt market in Singapore at the time was not as deep as in larger advanced economies, so monetary sterilisation in Singapore, in contrast, took an alternative route: Financial intermediation through the CPF channel.



Graph 1.4. The growth of CPF contributions in tandem with government debt and net foreign assest from 1988-1997.

Macroeconomic stability (excluding the Asian crisis of 1997-98 and the collapse of the IT boom) and liberal trade investment policies, along with a business-friendly

regulatory environment in Singapore, have resulted in continuous income growth and capital inflows over the years. Growth was particularly pronounced in the period of this study (1988-97) and has led the CPF to be in position where at any time it was ready and able to purchase SGS with its vast and ever-growing stock of accumulated loanable funds. Approximately 95 cents per dollar of CPF assets are held in government securities and that level has been relatively steady so that the purchase of government securities tends to be demand inelastic.[58] And this inelastic nature of demand has made the CPF a remarkable choice for the channel of sterilisation since it has resulted in much smaller increases in the interest rate and so reducing pressures on capital inflows and currency appreciation. That is, the sterilisation burden with the CPF has been relieved compared with more standard sterilisation through open market operations. Indeed, the government has been issuing new government securities to soak up the excessive amounts of money in circulation so that Singapore still has a considerably large debt-to-GDP ratio which, *prima facie*, seems unusual in the face of increasing fiscal surpluses. Sterilisation is clearly then the principal reason why government debt tends to accumulate over time in the face of substantial annual budget surpluses by the government. It is such a particular fiscal-monetary policy mix that explains why annual increases in the international reserves can be readily neutralised by the corresponding decrease in the domestic credit so that the growth of the monetary base is maintained at an almost constant level. Refer again to Figure 1.1 (page 26) and Figure 1.3 (page 51): The charts summarise the role

[58] Likewise, in the United States the vast majority of Social Securities assets are invested in government bonds. There are obvious difficulties associated with having a large government-run investment vehicle purchase equities and other riskier and/or politcal assets.

of CPF within the money market and the mechanisms by which the CPF acts as a conduit for sterilisation. This visualisation makes clear the interconnectivity of the MAS with the CPF and the government and the financial markets. It is also evident that the investment decisions of the CPF directly influence the policies of the MAS. In essence, the roles of fiscal, monetary and exchange rate policies all congregate to formulate sterilisation.

I.3.3 The offset coefficient

At the heart of this paper is to know the extent to which capital inflows are sterilised via the CPF's actions. In particular, it is desired to understand what happens to the composition of the monetary base in the face of increasing appreciation of the domestic currency and, ergo, a surge in net foreign assets. Are such increases mitigated – *sterilised* – by a decrease in the domestic credit component of the monetary base? And if so, how has this affected the scope of monetary policy – which tends to be exchange-rate focused – in Singapore? To answer these questions and shed light on Singapore's unique mix of monetary and exchange rate policies, this section applies an error corrections model (ECM) to Singapore's data to examine its monetary sterilisation mechanism and associated macroeconomic framework. As noted earlier, the ECM framework rests on the assumption of cointegration of the variables. With the monetary sterilisation scheme as the focus of this paper, the priority is to first establish evidence for a cointegration relationship between the net-domestic-asset and the net-foreign-asset components of the monetary base. From there it remains to estimate the long-run equilibrium equation of these two factors. The latter estimation will depend very much on the short-run adjustment mechanism that is posited.

Using the monetary authority's balance sheet, an equation that determines the monetary base can be expressed in terms of five basic components:

$$MB = FA + SGS + LAFI - GD - OL \tag{1}$$

The variables in equation (1) merit some explanation and discussion: MB is the monetary base; FA is foreign assets; SGS is government securities; $LAFI$ is loans and advances to financial institutions; GD is government deposits held at the MAS; and OL are other liabilities.

Now consider the balance sheet's asset side. From here there are at least three ways to increase the monetary base. For one, an increase in FA when the MAS pays for the foreign assets with domestic currency increases MB. Likewise, an increase in the holding of government securities (SGS) when the MAS buys them from the public and/or the government raises the monetary base. Finally, an increase in the monetary authority's $LAFI$ term when it generates more business with financial institutions positively affects MB. Note that the last two channels (SGS and $LAFI$) when combined are associated with variations in the net-domestic-credit component of the monetary base, whereas the first term is tautologously part of the foreign component of the monetary base.

The preceding paragraph noted the relationship of $LAFI$ and SGS on MB. In practice it is observed that the effects of $LAFI$ and SGS on MB are relatively small in Singapore.[59] The government has consistently maintained budget surpluses over the years, so that the public sector's demand for credit from the monetary authority is weak. Moreover, because of the openness of the economy, the amount of $LAFI$

[59] Wong (1988) provides further evidence for this point in a study of the MAS balance sheet and the monetary multiplier for Singapore.

in MB is also believed to be modest as banks can secure such funds from outside of Singapore otherwise. Nevertheless, since the 1980s or even earlier, the inflow of foreign capital has been large over the years, which has effectively increased the MAS's holdings of foreign assets. Thus the net foreign assets in the MAS's balance sheet become the major component in determining MB.

Now this begs the question of which factors matter to movements in MB. The answer is that changes in the monetary base depend on the co-movement of its determinants and their offsetting power. To investigate the effects of the implicit sterilisation mechanism as proposed in the hypothesis of this paper, it is then necessary to seek an estimate of the offset coefficient.

Recall that the offset coefficient refers to the extent to which changes in the net foreign reserves are counter-complemented by changes in net domestic credit, which further measures the resulting effect on the monetary base. A value of minus one for the offset coefficient implies complete sterilisation, whereas a value of zero implies that sterilisation is non-existent – i.e., that changes in net foreign reserves induce no changes in net domestic credit. Mathematically the offset coefficient can be expressed as the following (partial) derivative

$$\frac{\partial\left(NDA\right)}{\partial\left(NFA\right)}$$

where NFA is net foreign assets (likely extended by the MAS to, amongst other things, purchase securities and grant discount-window loans) held by the MAS and NDA is net domestic assets. Now it remains to determine whether it is possible to write a deterministic relationship between NFA and NDA, i.e., whether it is possible to express $NDA = NDA\left(NFA;\bullet\right)$. The next paragraph outlines a very

simple relationship and it is worth a brief comment.

First any such relationship should note that NDA might very well have a time trend to reflect its general trajectory. Secondly, the relationship between the two variables is assumed to be linear. These are the two key features of any relationship that might exist between the two variables. The model to be estimated is thus a set of linear equations in the ECM framework

$$NDA_t = \alpha_0 + \alpha_1 NFA_t + \alpha_2 T_t + u_t \tag{2}$$

$$\Delta NDA_t = \beta_0 + \beta_1 \Delta NFA_t + \beta_2 \chi_{t-1} + \varepsilon_t \tag{3}$$

where u and ε are random innovations with zero mean and assumed to have Gaussian distributions. (Now it is also clear that the derivative in the preceding paragraph is α_1.) Equation (2) is the long-run equilibrium relation that holds for co-movement of net domestic credit and net foreign assets in the monetary base. Finally, T is a variable that picks up a time trend or growth rate of NDA, which appears *prima facie* to be linearly negative. The second expression, equation (3), is a short-run disequilibrium relationship between the first-order difference of NDA and that of NFA (where the symbol Δ denotes a first differencing). Equation (3) includes χ_{t-1}, which reflects the estimated equilibrium error term based on the least squares estimation of (2), which is used as a regressor to correct the series of NDA for the disequilibrium error in the previous period. Thus, the series of disequilibrium error links the short-run behaviour of NFA to its long-run value; i.e., $\chi_{t-1} = NDA_t - \alpha_1 NFA_t - \alpha_0 - \alpha_2 T_t$. Equation (3) states that changes in the official foreign net foreign assets depend on the disequilibrium errors from the previous period as reflected in the χ_{t-1} term, as well as on changes in net domestic credit extended by the monetary authority, or the

MAS in the case of Singapore.

The ECM estimation merits some more thought. The postulated ECM setting rests on the existence of a cointegration relationship between the NDA and NFA series. Thus it is required to check that they are indeed cointegrated. To assess this the Dicky-Fuller test is used to verify the existence of cointegration. Based on the values displayed in Table 1.2 (page 59), both NDA and NFA are non-stationary processes, which supports the idea that they may be cointegrated and is also supported by the pattern of their time plots in Graph 1.5 (page 63). To derive a stationary process it is required to difference the variables. As it turns out, a first difference turns them into stationary series, i.e., they are $I(1)$ processes. (Most economic variables of interest require just a first differencing to make them stationary.)

Now consider the values from the second regression. Table 1.2 (below) shows that the Dickey-Fuller statistic for ΔNDA is significant at the 1 percent level of significance. Furthermore, the augmented Dickey-Fuller statistic (ADF) is significant at the 1 percent level up to the first-order lagged change in NDA when there is no time trend included. Similarly, the Dickey-Fuller statistic for ΔNFA suggests the rejection of the hypothesis of a unit root at the 5 percent level of significance, and the augmented Dickey-Fuller statistic with one-period lag for NFA favours stationarity for the change in NDA at the same significance level. Therefore, NDA and NFA are both integrated of order one, i.e., they are $I(1)$ processes, and the ECM framework gains credence.

Table 1.2 Unit Root Tests

	Test Statistic				
	DF	ADF(1)	ADF(2)	ADF(3)	ADF(4)
Variables					
NDA w/ trend	-0.27	-0.28	0.17	0.06	0.19
Δ(*NDA*) w/o trend	-4.34*	-3.55*	-1.79	-1.41	-1.11
NFA w/ trend	-0.29	-0.27	0.04	-0.07	0.07
Δ(*NFA*) w/o trend	-4.11*	-2.98*	-1.27	-1.14	-0.88
χ w/o trend	-3.76**	-3.37**	-3.15**	-2.37*	-2.23*

A test value with a single asterisk (*) denotes significance at the 5% significance level; a double asterisk (**) denotes significance at the 1% significance level.

Now consider the series of disequilibrium errors that result from the cointegrating regressions of equation (2). First, reflect on the consequence if χ_{t-1} is stationary: If χ_{t-1} is stationary, then so in any linear combination of NDA and NFA. This, in turn, implies that NDA and NFA are cointegrated (as their linear combination is stationary). Indeed, from the cointegration ADF test in Table 1.2 (above), it is evident that the value of the ADF statistic is significant at the 1 percent level up to the second-order lagged changes in the disequilibrium error term. This result holds at the 5 percent significance level all the way up to the second-order lagged change. Thus the existence of an equilibrium relationship between NDA and NFA is clearly supported by the data, and so is supportive of having used ECM modelling for this problem.

In Table 1.3 (below, page 61) the estimation results of the ECM model are presented. In Table 1.3, the NDA variable exhibits a downward trend, as is suggested by $\alpha_2 < 0$, the coefficient for the variable controlling for a time trend. Of particular interest, however, is the estimated coefficient for NFA, which is -1.06. The result is telling: The absolute value of the coefficient is almost unity, implying that there exists a near perfect monetary sterilisation relationship in the *long run* between NDA and NFA. That is, based on the estimated coefficient, every dollar of contraction in net foreign credit is associated with an expansion of approximately one dollar in net domestic assets in the long run. In fact, with the absolute value of the offset coefficient being slightly greater than unity, this implies that an upward trend path for the monetary base that arises from imperfect sterilisation. (Recall that each dollar of expansion in NFA is sterilised by a decrease of $1/1.06 = 0.94$ dollars in NDA.) Given the statistical error in its estimation, what can be said is that a hypothesis of perfect sterilisation cannot be rejected – anyhow, sterilisation of 94 cents to the dollar is very high. Furthermore, the finding is consistent with the observed patterns of the well-matched movement for the two series in sustained long periods (see Graph 1.3, page 51). These findings are consistent with their visual displays: Note that the graph of NDA appears to be an almost perfect mirror image of that of NFA (reflected along the horizontal axis). The estimation of the long-run equilibrium relationship above explains it and actually predicts almost the same pattern as observed from the plots. But thus far the discussion has remained on the long run. The short-run paths, however, are just as important but its dynamics are not as straightforward.

Table 1.3 The Long-run Static Equilibrium Relationship

Equation: $NDA_t = \alpha_0 + \alpha_1 NFA_t + \alpha_2 T + u_t$

	α_0	α_1	α_2
Estimates	859.14	-1.06	-144.88
t-ratio	2.59	-118.09	-12.56
other statistic	$R^2 = 0.999$	$R^2 = 0.998$	DW = 0.881

Although it supports the thesis of this paper, the long-run relationship that were discovered in the preceding paragraph need not always hold at any point in time. What is often observed, instead, is a disequilibrium relationship and the associated adjustment back towards equilibrium. So this suggests the need to model both the long-run and short-run dynamics. Now the question remains on how to estimate the short-run disequilibrium model. The answer is straightforward as this is actually given by equation (3). According to the cointegration result discussed earlier, all the RHS variables, as well as the explained variable ΔNDA on the LHS, are stationary. This is comforting news because it means that OLS estimation is exempt from the problem of spurious correlation and this further justifies the modelling procedures undertaken (see, e.g., Greene, 2000).

Table 1.4 Short-run Disequilibrium Adjustment Equation

Estimation Equation: $\Delta(NDA_t) = \beta_0 + \beta_1 \Delta(NFA_t) + \beta_2 \chi_{t-1} + \varepsilon_t$

	β_0	β_1	β_2
Coefficient Estimates	201.81	-1.07	-0.45
t-ratio	3.37	-30.98	-3.31
other statistics	$R^2 = 0.957$	$R^2 = 0.955$	DW = 2.033

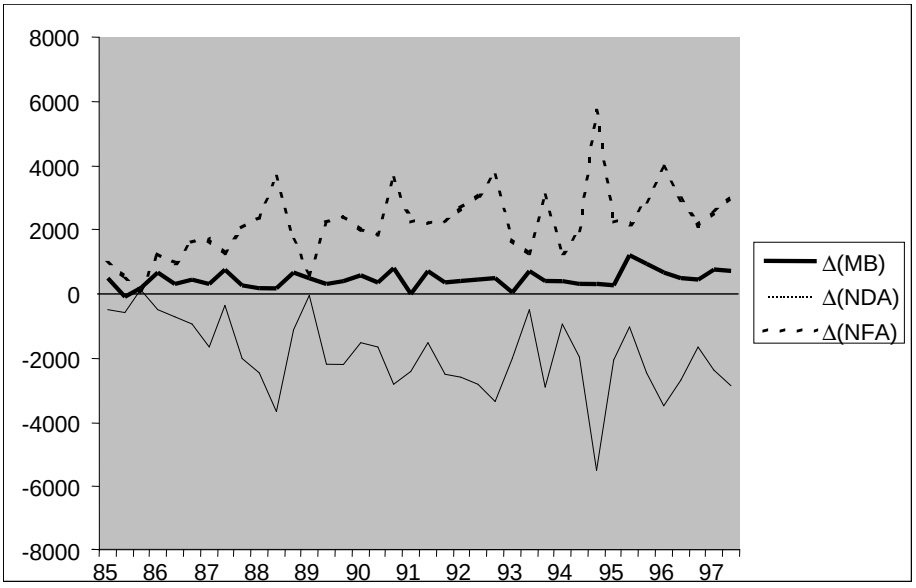
Table 1.4 shows the estimated coefficient for the differenced series of net domestic assets (ΔNDA) as -1.07 and is significant at the 5 percent level. This implies that a change in net foreign asset is almost exactly offset ($1/1.07 = 0.935$) with a change in net domestic assets (ΔNDA). And once again, because of the margin of statistical error, the hypothesis that the offsetting change is perfect cannot be rejected. This

result is consistent with what can be visualised in Graph 1.5 (page 63). Namely, the series of ΔNFA appears to have an associated mirror-image in the series of ΔNDA; in tandem, the series neutralise the associated changes in the monetary base. In addition, the estimate of the coefficient of χ_{t-1}, which is -0.45 and significant at the 5 percent level, indicates that the lower (higher) is the series of NDA compared with its equilibrium value relative to the series of NFA and T, the greater (smaller) will be the immediate rise in the series of NDA. What does this mean? For each dollar of the disequilibrium error with respect to the long-run equilibrium path that arises in the previous period, only 45 cents on the dollar is recouped in the current period. But this discussion is moot in the sense that a short-run coefficient of -1.07 means that there will not be much disequilibrium to begin with.

I.3.4 The exchange rate and public debts

The previous section examined the offset coefficient and provided a way of understanding how the monetary sterilisation mechanism in Singapore affects the composition of the monetary base. In Section I.3.1 the long-run macroeconomic scheme was illustrated and explained; however, the estimated sterilisation mechanism provides only the empirical evidence for the interconnectivity of net domestic and foreign assets with the monetary base. It remains unclear what links the exchange rate, output and government bonds in the scheme of sterilisation. The next issue that naturally arises, then, is the existence of a complementary mechanism through which the monetary sterilisation mechanism works. Recall that the offset relationship between the domestic and foreign components of the monetary base depends on the expansionary impact of exchange rate appreciation and the contractionary effect of government debt policy.

This section attempts to provide further empirical support for the mechanisms that shore up monetary sterilisation. To get at this point it is first necessary to assess which mechanisms aid monetary sterilisation.



Graph 1.5. The cointegration of the net foreign assets and net domestic assets from 1985-1997.

Price stability is a principal tenet of the MAS but this goal often clashes with other macroeconomic goals.[60] To maintain price stability in an economy that is highly dependent on imports, the MAS needs to ensure the necessary strength of the domestic currency relative to the currencies of its trading partners. Hence a steadily rising exchange rate injects an expansionary pressure on the real GDP directly due to declining import costs, and indirectly through reducing labour costs. But this makes

[60] The dilemma of trading-off inflation versus unemployment is of historical significance. Of course, as policymakers disciovered in the 1960s and 1970s, the tradeoff – as illustrated in a Phillips Curve – was not exploitable.

its own goods more expensive in world markets (albeit that most trade contracts are denominated in foreign currency). Moreover, a strong domestic currency, *ceteris paribus*, results in more favourable trade balances and thus increases the value of net foreign assets held by the Singapore monetary and fiscal authorities; therefore the monetary base increases in value as well. Given the consistent expansionary pattern of Singapore's open-economy monetary policy, maintaining a sterilisation mechanism needs to be measured with contractionary fiscal policy. Of course this contractionary fiscal stance was a focus of discussion in Section I.3.1 and it operates through the management of government debt and the CPF fund.

Now it remains to measure the extent of contractionary fiscal policy. One approach is to run two sets of regressions to the complementary ECM model that aims at estimating the expansionary effect of exchange rate appreciation and the contractionary fiscal effect of the government's CPF debt scheme. In other words, does exchange rate appreciation exert any expansionary influence on the net foreign assets held by the monetary authority? (It does, and it is thus to find how NDA responds to changes in NDF.) And does Singapore's output grow with the exchange rate appreciation that accompanies the steady increase of foreign capital? Furthermore, it also needs to be asked whether as income rises, if net domestic credit tends to fall whilst government debt is rising via the CPF saving scheme. Considering that the preceding section has empirically established the sterilisation relationship, the positive answer to those questions posed above should justify the rest of the linkages specified by the long-run macroeconomic scheme in Section I.3.1 that depicted the interconnectivity of the exchange rate, output and bonds with the components of the monetary base (Figure 1.2, page 48).

In Table 1.5 below, a series of unit root tests are conducted. The variables examined are those used in the complementary error-corrections model. As is customary the variables merit explanation: y is the (natural) logarithm of GDP; mb is the logarithm of the monetary base; q is the logarithm of the real exchange rate Q; GD is the volume of government debt outstanding; CN is the quarterly fund contributions from CPF members; and Δ is the first-order difference operator. (In line with tradition, all lower case variables are the log of the upper case analogues.) As reported in the Dicky-Fuller statistic, and also in its augmented version, all variables are stationary in their first difference form, while most of them are not in their original level form, which was the underlying justification for the use of ECM analysis.

Table 1.5 Unit Root Tests for Non-residual Series in Complementary ECM

	Statistic	
	DF	ADF(1)
Variables		
y (with trend)	-4.22	-4.91
Δ*y* (w/o trend)	-7.55	-7.36
mb (with trend)	-3.41	-2.88
Δ(*mb*) (w/o trend)	-8.80	-6.74
q	-3.51	-3.25
Δ*q*	-5.03	-4.45
GD	-3.19	-1.82
Δ(*GD*)	-10.79	-6.47
CN	-3.96	-2.08
Δ(*CN*)	-11.81	-7.25

I.3.5 Long run equilibrium relationships

The ECM estimates of long run equilibrium relationships are presented in Table 1.6 below (values in parentheses are the t-statistics). The regression estimates are of the long-run equilibrium relations in the complementary error-corrections mechanism

under the assumption that there exist cointegration relationships amongst the relevant variables. (As will be demonstrated, these assumptions are justified.) The second column gives the estimated coefficients in the income equation, where T is the time trend, and the Q_i (for $i = 2, 3, 4$) are quarterly dummies. The first thing to note is that the inverse income elasticity with respect to the real appreciation rate is 0.32, whereas it is 0.41 with respect to the monetary base, suggesting a significant positive effect of real appreciation on income. At first glance this seems like a paradoxical result. Yet it is just a matter that Singapore's consistent and significant merchandise trade deficit has been paid for by the capital account surplus as well as a surplus of the service account.[61]

The third column of Table 1.6 (nfa) presents the estimates for the foreign reserve equation. The principal conclusion to be taken from here is that the foreign reserve component of the monetary base is unit elastic with respect to the exchange rate. This result is very strong with a t-statistic over 7. Moreover, the regression with just the log of the RER and a time trend as explanatory variables yields a very high R^2 statistic (0.99). These findings support macroeconomic linkages that posit the interconnectivity of E with respect to income (Y) and the net-foreign assets component of the monetary base (see Figure 1.2 on page 48).

[61] See Rumbaugh (1995) for a treatment on this topic.

Table 1.6 ECM Estimates of Long-run Equilibrium Relationships

	Regressand				
	y	*nfa*	*NDA*	*CN*	Δ(*GD*)
Regressor					
Constant	3.91 (3.95)	4.69 (7.73)	11101.88 (4.39)	-99.17 (-0.84)	613.25 (1.39)
mb	0.41 (3.35)	… …	… …	… …	… …
q	0.32 (3.17)	0.99 (7.11)	… …	… …	… …
GD	… …	… …	-1.69 (-10.79)	… …	… …
GPFG	… …	… …	… …	… …	1.17 (3.15)
Y	… …	… …	… …	0.31 (8.88)	… …
T	0.01 (2.66)	0.03 (25.99)	807.80 (3.89)	-50.31 (-4.35)	… …
Q_2	0.04 (3.51)	… …	… …	-749.23 (-8.89)	… …
Q_3	0.06 (5.58)	… …	… …	-682.19 (-7.74)	… …
Q_4	0.05 (4.12)	… …	… …	-584.47 (-6.69)	-1262 (-1.98)
R^2	0.99	0.99	0.98	0.93	0.62
DW	0.46	0.30	0.46	1.14	2.21

The equations to be estimated are the equations describing log of output (y), log of NFA (nfa), NDA, CN and $\Delta(GD)$. The linear regression model applies and all the estimation equations include a time trend, except the equation for $\Delta(GD)$ which is stationary by first differencing. In what follows, all time subscripts are omitted for ease of exposition, but remain as an argument for each regression. Thus the five set of linear relationships to be estimated are:

$$y = \gamma_0 + \gamma_1 mb + \gamma_2 q + \gamma_3 T + \gamma_4 Q_2 + \gamma_5 Q_3 + \gamma_6 Q_4 + z_1 \tag{4}$$

$$nfa = \delta_0 + \delta_1 q + \delta_3 T + z_2 \tag{5}$$

$$NDA = \zeta_0 + \zeta_1 GD + \zeta_2 T + z_3 \tag{6}$$

$$CN = \eta_0 + \eta_1 Y + \eta_2 T + \eta_3 Q_2 + \eta_4 Q_3 + \eta_5 Q_4 + z_4 \tag{7}$$

$$\Delta\left(GD\right) = \theta_0 + \theta_1 CPFG + \theta_2 Q_4 + z_5 \tag{8}$$

All the variables have been previously explained, except the $z_i's$, but they are standard with $z_i \sim N\left(0, \sigma_i^2\right)\ \forall i$ and uncorrelated.

Now consider the intermediary role of government debt in absorbing national savings through the CPF (refer to Figure 1.1 on page 26). This action reduces net domestic credit and which feeds into the linkages of the mechanism of monetary sterilisation. An estimate of the domestic credit equation and the CPF contribution equation are reported in columns 4 and 5. The most important results are two-fold: (i) CPF contributions increase by about 31 cents to the dollar on income gains; (ii) Net domestic credit extended by the monetary authority tends to fall by S$1.69 for every S$1 increase in government debt (fourth column). Now it remains to establish a connection between government debt and the net CPF contributions. To do this define a new variable, $GPFG = CN - WD$, as the difference between quarterly CPF contributions (CN) and quarterly CPF withdrawals (WD). Then the procedure is to run a regression as specified in the sixth column, i.e., regress the differenced government debt (ΔGD) on the newly defined gap measure. The conclusion from such a procedure is that the regression indicates that public debt goes up as the net CPF contribution does. In fact, the rate at which public debt accumulates is highly proportional to the net CPF savings. As the regression indicates, a one dollar increase in savings leads to an increase of a dollar-seventeen in public debt.

I.3.6 Short-run adjustment

Now it remains to analyse the dynamics in the short run. The short run adjustment is more complicated than the long-run adjustment because the short run is (by definition) impeded by transitory shocks. To analyse the short run dynamics first start off with the standard unit root tests for the regression residuals. This is applied to all the long-run regression equations to ensure the validity of the short-run adjustment equations, as highlighted in Table 1.7 below (page 70). In Table 1.7, YR is the regression residual from the equilibrium income equation for y; $NFAR$ is the regression residual from the equilibrium net-foreign asset equation for $nfa \equiv \log(NFA)$; $NDAR$ is the regression residual from the equilibrium net-domestic asset equation for $nda \equiv \log(NDA)$; and CNR the regression residual from the equilibrium CPF equation for CN. The results, which are based on both the regular and augmented versions of the Dicky-Fuller test and the Phillips-Perron test, show that all the regression residuals are highly stationary. Indeed, all the tests, with the ADF taken up to the fourth degree (ADF(4)), are significant at the 5 percent level, with the exception of the ADF(3) test on CNR, which is significant only at the 10 percent level. Needless to say, the empirics show that all the residuals are well behaved.

Now consider the results of Table 1.8 below (page 72). Table 1.8 is a series of deviations-regressions in the sense that it provides the estimates of the dynamic adjustment parameters in the short run when the macroeconomic performance of relevant variables deviate from what theory says should be their long-run equilibrium values. Note that the lagged variables of Δq, $\Delta(GD)$, $\Delta(NDA)$, $\Delta(CON)$, ΔY and the four residuals with respect to $YRES$, NFA, NDA, and CN are included. The

Table 1.7 Unit Root Tests for Regression Residuals of the Complementary ECM

	Regression Residuals			
	YR	*NFAR*	*NDAR*	*CNR*
Statistics				
DF	-2.54	-1.97	-2.50	-4.14
ADF(1)	-2.88	-2.27	-2.40	-2.55
ADF(2)	-2.82	-2.11	-2.50	-2.51
ADF(3)	-2.43	-2.63	-2.39	-1.71
ADF(4)	-2.43	-3.51	-3.13	-2.88
PP	-2.61	-2.31	-2.58	-4.19

log of NFA is also included; however, it enters the second regression equation with a second degree lag. From the first column (with Δy being regressed) the coefficient on Δq_{-1} is seen to take the value 0.25. This means that the expansionary real effect of appreciation increases with the real appreciation rate in the previous period at a rate of 0.25. Now consider the same regression equation again and note that the coefficient on the lagged value of the output residual is -0.13. How does one interpret this result? It means that the growth rate of real GDP is negatively related to the residual term of the steady-state regression. The minus sign here means that output performance is around its long run equilibrium value and tends to return its stable path once a deviation occurs in the long run. Another corollary is that real GDP will grow faster if there are fewer impediments on the adjustment towards its equilibrium path. So consider the three equations that follow, where the error terms w_i for $i = 1, 2, 3$, are presumed to be normally distributed with zero mean and uncorrelated.

$$\Delta y = \kappa_0 + \kappa_1 \Delta (mb) + \kappa_2 \Delta q_{-1} + \kappa_3 YR_{-1} + \kappa_4 Q_2 + \kappa_5 Q_3 + \kappa_6 Q_4 + w_1 \tag{9}$$

$$\Delta (nfa) = \lambda_0 + \lambda_1 \Delta q + \lambda_2 \Delta (nfa_{-2}) + \lambda_3 NFAR_{-1} + w_2 \tag{10}$$

$$\Delta(CN) = \mu_0 + \mu_1 \Delta(CN_{-1}) + \mu_2 \Delta Y_{-1} + \mu_3 CPFR_{-1} + \mu_4 Q_2 + \mu_5 Q_3 + \mu_6 Q_4 + w_3 \quad (11)$$

Now consider the second regression (equation (10)), where Δnfa is regressed on the following: A constant, Δq, $\Delta(nfa_{-2})$ and $NFAR_{-1}$. The major estimates for the adjustment equation of net foreign reserves are consistent with *a priori* expectations and are significant at the 5 percent level. From Table 1.8 it is inferred that a one percentage point real appreciation of the exchange rate leads approximately to a half percentage increase in net official foreign assets (the coefficient on Δq is $0.49 \approx 1/2$). The 0.25 coefficient on $\Delta(nfa_{-2})$ means that net-foreign-asset growth registers a one-quarter lagged impact on itself, but this result has a t-statistic of only 1.75 and so is significant at the 10 percent level, but not at the customary 5 percent level.

Now consider the coefficient on the third regressor, λ_3. The interpretation here is that, as an equilibrium mechanism, the growth rate of net foreign assets adjusts with the residual in the previous period at a rate of -0.14. For all three regressions the Durbin-Watson statistics are less than 2, suggesting that the (successive) error terms are positively correlated. The evidence of positive correlation is greatest in the first regression (Δy) and smallest in the second ($\Delta(nfa)$). Given the 5% critical value of DW statistic (1.506), the evidence suggests that the residuals of the first regression are likely positively correlated, whereas the evidence is weak that the residuals in the second and third regressions are positively correlated.

Table 1.8 ECM Estimates of Short-run Adjustment Relationships

	Regressands			
Regressors	Δy	$\Delta(NDA)$	$\Delta(nfa)$	$\Delta(CN)$
Constant	-0.04 (-8.18)	-600.88 (-2.22)	0.02 (4.09)	399.58 (8.60)
$\Delta(mb)$	0.14 (1.41)	… …	… …	… …
Δq	… …	… …	0.49 (3.37)	… …
Δq_{-1}	0.25 (2.28)	… …	… …	… …
$\Delta(nfa_{-2})$	… …	… …	0.25 (1.78)	… …
$\Delta(NDA_{-1})$	… …	0.32 (2.31)	… …	… …
$\Delta(GD)$	… …	-0.21 (-2.12)	… …	… …
$\Delta(GD_{-1})$	… …	-0.14 (-1.89)	… …	… …
$\Delta(CN_{-1})$	… …	… …	… …	3199.45 (1.98)
ΔY_{-1}	… …	… …	… …	0.16 (2.25)
YR_{-1}	-0.13 (-1.37)	… …	… …	… …
$NFAR_{-1}$	… …	… …	-0.14 (-1.99)	… …
$NDAR_{-1}$	… …	-0.11 (-1.89)	… …	… …
CNR_{-1}	… …	… …	… …	-0.30 (-2.24)
Q_2	0.09 (14.77)	… …	… …	-700.17 (-7.62)
Q_3	0.07 (11.79)	… …	… …	-521.99 (-4.37)
Q_4	0.04 (6.42)	… …	… …	-299.39 (-4.59)
R^2	0.875	0.331	0.255	0.91
DW	1.291	1.891	1.816	1.811

Finally, consider the last regression equation (11), the last column in Table 1.8, where the change in contributions is explained by ΔCN_{-1}, ΔY_{-1}, CNR_{-1} and quarterly dummies. The implication of this regression is that the accumulation of CPF funds exhibits a stable dynamic path since it has a negative coefficient (-0.31) with

respect to its deviation from the long-run relationship. This result is significant at the 5 percent level and is comforting for the hypothesis explored herein. Moreover note that contributions growth, $\Delta(CN)$, is positively (and significantly) related to income growth in the *previous* period (ΔY_{-1}).

All of these results support the idea that the CPF savings act as an implicit de facto tool for monetary sterilisation. Indeed, the prolonged appreciation of the Singapore dollar over the period of study coupled with minimal growth in Singapore's monetary base is indicative of some kind of sterilisation of the inflows of foreign capital. Herein, it was shown that shifting CPF savings from commercial banks to the MAS resulted in limiting the expansion of domestic credit, thus maintaining constant monetary balances. The technique of moving retirement savings as opposed to standard OMO puts Singapore in contrast to developed countries in sterilising capital inflows. Such actions are only pseudo-market and act as a de facto means of sterilisation in an economy with a small domestic money and debt markets (with respect to the time frame studied). The transfer of funds by the MAS to the banking sector also entailed the benefit of burdening neither the commercial banks nor their customers (as is the case with changes in the reserve requirement) nor on governments whom might have otherwise been forced to invest in low-yielding foreign assets.[62] So, although non-standard, Singapore's implicit approach to monetary sterilisation may

[62] Consider the case of China, which invests most of its trade surplus (and ergo foreign reserves) back into American T-bills. Almost any other investment strategy would earn a few percentage points more in return without undue risk. Given China's huge foreign reserves, even a 1 percent differential translates into USD 10 billion forgone in a given year. This is probably why China set up a sovereign wealth fund – modelled after Singapore's GIC – to manage a portion of its trillion-plus dollars of international reserves.

actually be superior for its own unique circumstances in relation to conventional means of sterilisation.

I.4 Conclusion

This paper began by examining the history of monetary management in Singapore and, in particular, looked at the unique circumstances that constitute the MAS and its policies. Monetary policy in Singapore targets the exchange rate using a BBC system of management where the bands are not publicly disclosed. The system of targeting the exchange rate began in 1981 and has been successful in achieving price stability and facilitating economic growth. Furthermore, the role of the CPF and the blind-BBC nature of exchange rate policy by the MAS makes Singapore a unique and interesting study. The country's high dependence on trade and open capital markets further complicates monetary and exchange rate policies in Singapore. With these factors weighing in, the mechanisms of monetary arrangement in the former British colony are constrained, and perhaps it is worth repeating here what Khor et al (2004) noted: That the exchange rate regime is not necessarily chosen by the country, but rather that which is forced upon them by circumstances. All these factors come into play when examining the actions undertaken by the MAS, especially since 1988 and up until just before the Asian crisis, as this period was when the Singapore dollar experienced a steady appreciation and concomitant surges in capital inflows. From there this paper explored, from an empirical perspective, a particular fiscal/monetary policy mix that underlies the monetary sterilisation mechanism in Singapore. This was built up on first understanding the unique nature of Singapore's macroeconomy;

namely, that the trade-dependent port-city is characterised as a small open economy with a blind-BBC system of exchange rate targeting, and where also a unique structure of national savings plays a key role in the flow of funds. But the findings here should not be extrapolated or taken out of context (Lucas critique).

Although there is clear evidence for implicit sterilisation via the movement of CPF funds, it is indeterminate, however, whether the government was *proactive* with this tool. Consequently, it is also difficult to ascertain whether the Singapore government could have used this vehicle to fight the currency attack of the 1997-98 Asian crisis, even with hindsight being 20/20. Nevertheless, the analysis suggests the existence of an effective pseudo-market mechanism for monetary sterilisation. The system of managed savings as a response to capital inflows helped produce an approximately constant growth of the monetary base and the resulting stable and low inflation over the period 1988-97. The success of monetary management has also enhanced the credibility of the MAS and has been a factor in its continued success even to this day (2008). Regardless, the empirical analysis on the offset coefficient grants support for the monetary sterilisation hypothesis and is an example of non-conventional monetary policy at work in Singapore.[63]

Finally, it is also of interest to note that the estimated coefficient for Singapore

[63]Singapore's "twin city", Hong Kong, is also famous for non-conventional monetary policy. In Hong Kong's case it was the actions of the HKMA during the Asian crisis to thwart speculators who had "double-played" the city-state by going short on both the local currency (which is managed uder a currency board system) and the local stock market. The HKMA took the unusual step to intervene in the stock market, going long. It ultimately won over the speculators as the market did go up and with that no pressure to drop interest rates (and effectively devalue the local currency). Although the HKMA actually made a profit from its actions, the move was not well-received by some observers.

is much higher than those for some developed countries with well-developed financial markets but lower than less developed countries (see, e.g., Mohan, 2005). This is very intuitive and natural as Singapore was rapidly industrialising at the time, and its economy was in transition from a developing-markets paradigm to NIE status. In particular, the identified monetary sterilisation mechanism suggests that the CPF as a financial intermediary in Singapore has actually played a pseudo-market role in sterilising the impact of loanable funds. With the mandatory saving scheme and judicious management of government debt, the monetary authority in a small open developing economy such as Singapore does not completely lose control of its money supply while manipulating its exchange rate. Instead, the fiscal and monetary authorities can maintain a balance between the targeted growth rate of money and the targeted band of foreign exchange rate so as to maintain price stability and a desired real exchange rate. □

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Chapter II

Overshooting in small open economies: The Dornbusch overshooting result revisited

"*[O]verly rigid exchange-rate regimes are a recipe for disaster, setting up one-way bets for speculators.*" Kenneth Rogoff (2004).

"*Every currency crisis has been connected with pegged rates... [They are] ticking time bomb[s].*" Milton Friedman (2001).

II.1 Introduction

To float or not to float? This is the dilemma faced by currency-issuing institutions across the world. In the view of Nobel laureate Robert Mundell (2001), however, this may seem a moot point: "*The choice between fixed and flexible exchange rates is an oxymoron. The alternatives are incomparable.*" Nevertheless, disregarding the tongue-

in-cheek comment of Mundell, the consequences between fixed-versus-floating have even more significance for small trade-dependent economies that are also susceptible to, as Céspedes et al (2003) note, "original sin" – that is, they cannot borrow in international capital markets in their own currency. This phenomenon is often an acute problem for emerging economies and whose implications in a globalising world are not inconsequential.

Although there have been many studies that tout the efficacy and proficiency of floating rates, especially in insulating an economy from external shocks, a fixed exchange rate still provides an anchor of stability for an economy with international ambitions.[1] This is why choosing a fixed exchange rate may still be optimal in light of the stabilising effects of a floating exchange rate to economic volatility: A country whose stability depends on trade and positions itself as an international financial centre stands to benefit from a stable currency. Thus it is important for policymakers who are contemplating switching from a fixed to a floating regime to understand the extent to which floating exchange rates impact economic variables and how they respond to shocks. More precisely, it is desired to understand how a floating exchange rate with its inherent volatility impacts the macroeconomy. It is the innate volatility of exchange rates, and the need to manage it, that has led many countries with inexperienced authorities to display, in the words of Calvo & Reinhart (2000), a "fear of floating". Nevertheless, as Hakura (2005) notes, there has been an increasing

[1] Devereux & Engel (1998) look at the tradeoffs between fixed versus floating and show that the optimal regime depends on the price setting structure of the economy. They note, among other things, that when prices are set in consumer's currency, floating exchange rates always dominate fixed rates.

willingness of emerging market economies engaged in "learning to float".

Nominal exchange rates are notoriously volatile and, as has been noted in many scholarly studies, there even appears to be an intrinsic disconnect in the short-run nominal exchange rate and the fundamentals.[2] In particular, what might interest policymakers at a central bank, and especially for an emerging market monetary authority considering moving to a floating regime, is the cost of switching across exchange rate regimes. Consider the case where a central bank switches from a fixed-rate regime to a flexible-rate regime. For sure there will be some efficiency gains – most notably with a flexible exchange rate, one price, the exchange rate, adjusts for changes in demands for a country's goods instead of a vector of prices. But this needs to be tempered against the inherent instability of flexible rates. Moreover, the exchange rate may be prone to excess volatility in the sense that it may overshoot its long-run implied value in the short-run in response to news or changes in monetary policy, and that such volatility amplifies rather than mollifies external shocks. As Dornbusch (1976) showed, such behaviour persists even when agents are fully rational and capital markets are efficient. (The original Dornbusch model will be revisited in the next section as a refresher.)

This paper examines the behaviour of a small open economy's exchange rate under a dynamic general equilibrium framework. In particular, the question at hand is whether the phenomenon of overshooting, as first presented in Dornbusch's (1976)

[2] This anamoly is referred to as the "exchange rate disconnect puzzle". It notes that the volatility of exchange rates is much higher than what is plausible by the "fundamentals". For example, Hairault et al (2004) note the transition to flexible regimes leading to sharp increases in exchange rate volatility without any similar changes to underlying fundamentals.

seminal work, can be achieved in a simple framework of the modern new open economy model omitting a nontraded goods sector. It is in this regard that the model diverges from previous work. In spite of the emphasis on more recent models, the essence of the original Mundell-Fleming-Dornbusch (MFD) model will be retained to motivate this paper. Nevertheless, the paper takes a fully micro-founded approach, but the intuition remains from Dornbusch. In keeping with the setup of the MFD model it is assumed that both Home and Foreign produce specialised outputs. Under these conditions the domestic economy has the power to affect its terms of trade but remains small in financial markets and so takes the world rate of interest as given (among other variables). The model herein also assumes, as has become standard, a form of stickiness – namely that nominal wages are rigid. The framework for wage rigidities is rooted in the assumption of monopolistic competition in the labour market. (This is, essentially, the general framework of the new open-economy macroeconomics models.)

The small open economy (SOE) assumption is a reality of many developing countries; territories such as Hong Kong and Singapore, where trade is valued at multiples of GDP, are perfect examples. Moreover, small open developing economies (SODEs) are more prone to greater economic volatility due to factors such as original sin, underdeveloped capital and/or financial markets, political corruption, etc. For instance, both Hong Kong and Singapore recently survived financial crises at the end of the 1990s brought on by loss of investor confidence spilled over from Thailand and Indonesia. However, after the Asian crisis of 1997-98 many of the countries which had previously fixed their exchange rates have since abandoned them in favour of flexible rates. For a market such as Hong Kong that has kept its exchange rate fixed, the

perennial question at hand is whether or not to move to a floating regime.[3] A salient question in such economies, then, is the dynamics between monetary policy and the exchange rate. What are the implications for monetary policy on the behaviour of the exchange rate in an SOE that is heavily dependent on trade? Moreover, a poignant question remains: In an economy where nontraded goods are an inconsequential feature of the economy, are exchange rate dynamics still similar to that postulated in the MFD model?

There are two general frameworks used in analysing exchange rate dynamics in an SOE. The first of these is to assume a common endowment good (which seem to be, *de rigeur*, coconuts with economists). The second route is to assume that domestic production is introduced by way of a nontraded goods sector. The supposition of a nontraded sector has the advantage of introducing transparency to the effects of monetary policy on relative prices. Furthermore, with nontraded goods purchasing power parity (PPP) need not hold even if the law of one price (LOP) holds for the traded goods. This deviation from PPP was a welcome relief to researchers who have found that, although PPP is good at determining long-run values for the exchange rate, in the short and medium horizons, PPP performs very poorly as an empirical reality.[4] Indeed, as has often been noted in the profession, the "glacial" rate at which deviations from PPP move back to their implied long-run levels leaves researchers without much thought other than to concede that PPP is, at best, a long-run wishful result (see, e.g., Rogoff, 1996). Nevertheless, more recent research (e.g.,

[3] Previously when the US dollar was strong it was said that the HK dollar was overvalued, making Hong Kong's economy uncompetitive. But now with the weak USD the opposite is true and there are fears of importing inflation with the weak currency.

[4] Taylor & Taylor (2004) provide a good background on the purchasing power parity debate.

Rey et al, 2005) may yet be more sanguine on PPP as a useful theory for exchange rate modelling.

Models featuring traded and nontraded goods have been used widely since the mid-1970s. One of the first was Jones (1974), who showed that a nontraded goods sector is a *necessary* component for models of international trade. Dornbusch (1983), further showed that nontraded goods force a wedge between the domestic and foreign real interest rates in an analysis of the exchange rate. The traded-nontraded framework has continued to play a role in understanding exchange rates through the blossoming of new open economy macroeconomic – notably through the redux model of Obstfeld & Rogoff (1995), and all are based on fully micro-founded model with sticky prices.

The traded-nontraded goods structure has interesting implications. Among other things, consider the fact that because trade only occurs in a common good, and the home country ("Home") is assumed small, a necessary consequence is that the domestic economy can influence neither world prices levels nor the world interest rate. Nevertheless, the SOE models based around the Mundell-Fleming tradition assume that the domestic economy produces a specialised output which is traded on world markets. In this case, although Home is small in most senses of the definition, it may nonetheless be large with respect to its export good. This means that demand for Home's goods depends explicitly on the relative price of Home and Foreign goods – its terms of trade (TOT). An ensuing implication of the SOE assumption in this setting is that the share of Home's good in the foreign country's ("Foreign's") consumption basket must be negligible. For consider otherwise: If the consumption baskets were identical in both economies, this would then have the counterfactual implication that the domestic economy exported all of its output while consuming only the foreign

good. Thus, when there are two traded goods, heterogeneity in preferences (across countries) is a necessary consequence of the SOE assumption. Moreover this also yields an extreme form of consumption home-bias in the model.

A key assumption made herein is the ability of Home to alter its terms of trade, defined as the relative price of exports relative to imports: $TOT = p_x/p_m$. This assumption is unlikely to hold for any given SOE, but it might be very true for economies such as Hong Kong (which in 2006 was the eleventh largest trading entity). Nevertheless, there is much truth to the assertion that a small economy is more likely to have a larger share of its consumption basket being composed of foreign goods and, as in the case of large countries such as Japan and the United States, it is true that foreign goods comprise only a very small share of the domestic consumption basket. Simply put, a large country is more likely to be self-sustainable (autarkic) than a small country, especially an open one.

The model introduced in this paper uses an import-export structure to focus on the implications of consumption home-bias for the behaviour of the exchange rate. As for how the model treats money, its role is never simple; as Obstfeld & Rogoff (1996) note, readers should always be wary of claims by those who have found the "correct" way of modelling money. Heeding such advice, it is with a grain of salt that the model introduces the value of money by assuming it (directly) enters the utility function of households. This feature helps to emphasise the role of interest elasticity of money demand as suggested by Dornbusch (1976) which, as will be shown, plays an important role in the model.

A brief review of the literature shows that prior work has examined (peripherally) the implications of consumption home-bias for the behaviour of the exchange

rate. For example, Warnock (2003) introduces a form of consumption home-bias ("home-product bias") within a setting of two (equal-sized) countries. His model has the simplicity and beauty of symmetry, which may also be its shortcoming: With few exceptions – such as the United States or Japan – most countries are small in world markets. Warnock's model used a variant of the Dixit-Stiglitz (1977) preference combined within the redux models of Obstfeld & Rogoff (1995). Under this setting, consumption home-bias generates the infamous overshooting result when there is a change in the money supply. In such a case, the world interest rate is endogenous. Thus it is standard to simplify the analysis by assuming that preferences are identical. But this has the implication that consumption-based PPP holds and in this case each country faces an identical real interest rate and consumption growth path. Given an uncovered interest-parity (UIP) condition, a direct implication is that the exchange rate will be equal to the magnitude of the change in the money supply. This can be solved, however, once the SOE assumption is introduced then the import-export structure implies PPP cannot hold and this allows for additional exchange rate dynamics.

Even as many economies are small and trade has opened up over the years, the specialised outputs assumption has been adopted in the SOE setting only recently, and only in a select number of papers. Among some of the notable works are Parrado & Velasco (2002) and Monacelli (2004), both of which incorporate the import-export structure to re-examine traditional topics with a more fresh perspective. The first of these focuses on optimal monetary policy in the face of demand and supply shocks, similar in spirit to Poole's (1970) seminal analysis. Monacelli's paper, on the other hand, focuses on the behaviour of the real and nominal exchange rate in relation to

the work of Mussa (1986), who himself helped to place greater rigour in the Dornbusch model. More recently, Galí & Monacelli (2005) provide an interesting piece on the linkages across monetary policy and exchange rate volatility in an SOE framework and characterise the volatility of various policy regimes for an SOE. But each has its shortcomings because the demand for money is not explicitly modelled, thus relegating it a secondary and passive role in maintaining money market equilibrium. Sweeping the money quagmire under the proverbial rug is surely a flaw that needs to be remedied and this model addresses that issue.

In line with earlier research, the model introduced here finds that the nominal exchange rate overshoots in response to a permanent increase in the money supply. This is both comforting and illustrative. The fact that this model delivers results consistent with the established models of the new open economy confirms the usefulness of past works. But it is also of interest because it establishes the overshooting phenomenon in a more realistic framework – or at least a perspective that is more reflective of smaller trading nations. Thus it comes with greater relevance to countries living in an asymmetric world. Most importantly, it is *not* necessary to introduce a nontraded sector to generate additional exchange rate dynamics and overshooting is the result of the SOE assumption. Here, overshooting depends on the extent to which the real side of the economy – and hence the nominal wage rigidity – interacts with the monetary side, and this depends on the elasticity of money demand. The model is also consistent with Hau (2002) in that the degree of volatility and overshooting depends on the openness of the economy to trade. This is both intuitive and more technically satisfying.

Consider the standard mental exercise in monetary policy of an increase in the

money supply. This depresses the real interest rate and stimulates domestic output (assuming price stickiness). Conversely, a decrease in the money supply increases the real interest rate (RIR) and dampens domestic output. (Deflation is associated with depressed aggregate demand conditions.) When the interest elasticity of money demand is suitably low, this creates a liquidity effect reducing the short-run nominal interest rate. Overshooting, as in Dornbusch (1976), is then a consequence of financial arbitrage. But overshooting is also dependent on all the structural parameters of the model, including the extent of openness (as defined by the share of foreign goods in the domestic consumption basket). Furthermore, restrictions are imposed on consumer preferences of the model to generate a closed-form solution. This stands in contrast to much of the literature which alternatively uses log-linear approximations so that such analyses only hold for small changes in policy variables. In contrast, the results in this paper are not restricted to small changes in the policy variables, so have more realism in a world where gradualism in interest rate adjustments is a thing of the past.[5] And it will be shown that the degree of overshooting is a function of the openness of the economy. However, the model does *not* yield a simple expression for this relationship; nevertheless, the general conclusions remain.

The Dornbusch (1976) overshooting result has been reproduced in micro-founded models, yet the models that have been worked out are theoretically incomplete. The ones to date fall short because the micro-founded models that do replicate overshooting do so omitting factors that are key to understanding real-world economies. For one, such models do not explicitly model small countries. Secondly, they do not

[5] Moreover, even a 25 basis point change in the interest rate is a discrete jump in a policy variable and it is not even possible to have an ε change in the interest rate,

take into account countries where the non-traded sector of the economy is negligible. Although a nontraded component obviously exists, it may be overshadowed by the traded sector for certain economies. Thus it needs to be asked whether such SOEs with a negligible (or non-existent) nontraded sector are subject to the same dynamics. In particular, do theoretic micro-founded models produce overshooting? Understanding the dynamics of exchange rate volatility are important in comparing across various exchange rate policies, as well as being able to understand how monetary policy works through the various channels to affect an exchange rate. If the overshooting phenomenon is consistent with micro-founded models then from a theoretic view it shows that the original overshooting result are well established. Then it behooves the profession to further understand how overshooting within the context of micro-founded models work their way into the exchange rate through the various channels of monetary policy. But first it still remains to establish this link and only afterwards should the time come to examine the details. For instance, do credit channels (*cf* Chapter 3 of this dissertation) have an impact on the overshooting effect, and if so, what links the credit channels to the overshooting phenomenon?

II.1.1 Motivation

> "*[A]ttitudes about exchange rate instability have repeatedly shifted, proving ultimately as poorly grounded in fundamentals as the rates themselves.*"
>
> Paul Krugman (2002).

Why should researchers or policymakers care about the Dornbusch overshooting result being replicated in the framework outlined herein? Consider the financial crisis of 1997-98 in Asia that had put Hong Kong's currency arrangement at the forefront

of the minds of economists and policymakers. This episode shone a spotlight on the viability of fixed exchange rate regimes in emerging markets in an era of increasing trade flows and international capital mobility. Hong Kong's currency, which is pegged to the American dollar via a currency board arrangement, came under intense speculation, especially as it seemed overvalued and was a key driver of deflation that would mire Hong Kong for over six years (Schellekens, 2003) following the Asian crisis. The alternatives available to the Hong Kong Monetary Authority (HKMA) would have been to either allow the currency to devalue or to abandon the currency board. But what impacts can be expected on an economy that transitions from fixed to floating rates? How does the volatility of a floating rate impact an economy? And how should the knowledge of excessive fluctuations in the exchange rate impact decisions on monetary policy?

Hong Kong's run with its present currency board, which began in 17 October 1983, is considered by many as the most successful. The fact that it has survived almost a quarter century unchanged is reason to celebrate given the ephemeral success of its peers. Recently it weathered through the Asian crisis, the collapse of the property market as well as the implosion of the technology bubble and severe acute respiratory syndrome (Sars). Through it all the peg has remained – some say for better, some say for worse. Since the crisis there have been major corrections in prices (i.e., deflation, especially in the property market), thus the pressure for devaluation has abated. In fact, the pendulum may have swung the other direction now with the feeble dollar, and the Chinese renminbi (CNY) worth more than the HKD. Given the ebbing of tide against the fixed rate, the peg will likely see many more days at its current

rate – although this has not quieted the loudest opponents of fixed exchange rates.[6] Nevertheless, there will always be calls for countries with fixed exchange rates to abandon them in favour of floating regimes. But are floating regimes – or even managed floats of the BBC genre – the elixir to all that ail emerging markets?

An economy such as Hong Kong is an interesting case study of the choice of exchange rate regimes. Foremost, Hong Kong is an SOE highly dependent on trade, but possibly large with respect to its own good. Furthermore, the Chinese special administrative region (SAR) is an international financial centre (governed by the rule of law) whose government actively tries to promote itself as *the* place for business. With these characteristic, what ramifications exist, then, for an economy such as Hong Kong in switching from a fixed exchange rate to a floating regime? The answer to this has a very wide scope, so instead, this paper focuses solely on ascertaining the excess volatility (overshooting) that can be expected from a trade dependent SOE economy such as Hong Kong. Finally, independent of whatever evidence there is for overshooting and the sluggishness of fixed exchange rates to react to macroeconomic shocks,[7] it must be remembered that the desire for a fixed exchange rate in the former British colony is also rooted in the city-state's ambition to be the leading international financial centre.

[6] Gone are the days when Hongkongers sneered at people from mainland China with their mainland currency. Now the opposite is true – those from the mainland sneer at Hongkongers with their HKD!

[7] Since the nominal exchange rate cannot react under a fixed regime, it falls upon the price level to adjust the real exchange rate, but prices tend to be sticky and so adjustments long.

Revisiting Dornbusch's original model

The original Dornbusch (1976) overshooting result was composed in a neat model nested within a very simple and elegant framework, and for comparison it is worth noting briefly. The overshooting result rested on just six equations – the parsimony and elegance of the paper were a great factor in making it one of the most widely cited papers in economics.[8] In summary, there are:

(*i*) An uncovered interest rate parity condition

$$i_{t+1} = i^* + E_t \left(e_{t+1} - e_t \right);$$

(*ii*) A money demand equation

$$m_t - p_t = -\eta i_{t+1} + \phi y_t;$$

(*iii*) An aggregate demand equation

$$y_t^d = \overline{y} + \delta \left(e_t + p_t - \overline{q} \right);$$

(*iv*) A sticky-price adjustment formula (based on Mussa (1982))

$$p_{t+1} - p_t = \Psi \left(y_t^d - \overline{y} \right) + e_{t+1} - e_t;$$

(*v*) A real exchange rate ($q \equiv e + p^* - p$) adjustment equation

$$\Delta q_{t+1} = q_{t+1} - q_t = \Psi \delta \left(q_t - \overline{q} \right);$$

(*vi*) And finally an adjustment mechanism for the nominal exchange rate

$$m_t - e_t + q_t = -\eta \left(e_{t+1} - e_t \right) + \phi \delta \left(q_t - \overline{q} \right).$$

[8] Rogoff (2002) notes that the Dornbusch model was cited 917 times in published papers before it reached its 25th anniversary of publication. That number is now over 1000.

The equations are straightforward and not worth too much attention so as to not create any confusion with the notation used in the ensuing model of this paper.

Dornbusch arrived at his infamous overshooting result by way of running a simple thought experiment of seeing what this model would predict in the wake of an *unanticipated* increase in the money supply. When the money supply increases there is an increase in m, but if prices are sticky[9] – which they surely are – this means that they do not adjust immediately. It follows then that real money balances, $m - p$, must also rise. Now the system is not stable until demand for real money balances rises to equilibrate the model. But output, like prices, is thought to be rigid in the short run so the only variable that can adjust to equilibrate the system is the interest rate. However, the uncovered interest rate parity condition shows that interest rates can fall only when the home currency appreciates in the future. But the impact of an increase in the money supply is known to engender a proportionate depreciation in the exchange rate in the long run. So then, and herein lies the punch-line of Dornbusch's logic, if the domestic currency is to appreciate it must be the case that the initial depreciation of the currency must be larger than the long run depreciation so that the currency is allowed to appreciate to its proper long run level. (This follows even with fully rational and informed agents.)

This is the overshooting result parlayed very neatly into six equations. But now the question at hand is whether this result and the overall logic still hold in richer models. Of course the overshooting result has already progressed to fuller models since Dornbusch, but even the newer models that incorporate overshooting have not

[9] Economists usually cite four reasons for why prices are sticky: (i) menus costs, (ii) money illusion, (iii) imperfect information, (iv) fairness concerns.

incorporated all the flavours that are of interest to researchers. In this paper, the overshooting result is thus tested in the new open economy setting within the context of different size countries, as well as considering the case where the nontraded sector is negligible. The unique feature of this model, however, is in assuming asymmetry in size and relegating the nontraded sector as a negligible portion of the economy. The next section of this paper outlines the model and works through the dynamics of overshooting within this newer flavour of open-economy economics.

II.2 The model

A striking feature of real world economies is the existence of nominal wage rigidities. This sticky price feature was first articulated by John Maynard Keynes (1936) in his seminal book *The General Theory of Employment, Interest and Money.* Since his postulation about the imperfect flexibility of prices (in an ad hoc manner), recent works have moved to rooting greater microfoundations upon this feature. The new open economy macroeconomic models have come to dominate the profession. They assume optimising agents, nominal rigidities and monopolistic competition. Chief among these models is the redux model of Obstfeld & Rogoff (1995). The model presented here is very much of that brand, with some modifications; namely, this paper takes the view of the home country as small in relation to the foreign country.

The outline of the model will be laid out in the following several paragraphs; specifics will follow in sections on each of firms, households and the government (the three actors in the model). Briefly, there are two economies that interact in the world market. They are, *de rigueur*, called "Home" and "Foreign". Home consists

of a continuum of households that supply differentiated types of labour. Households in Home hold money balances, bonds, and consume goods from Home and Foreign. Households are also imagined to own the firms that operate in the economy and firms choose amongst labour types to produce a single specialised output good that is consumed domestically and exported. With respect to the public sector, a benevolent government controls the supply of money and makes lump sum transfers directly to households with its seigniorage revenues (alternatively, it imposes a tax on households in the presence of deflation). The government has no role in the economy other than to act as an agent that issues money (it is the ultimate authority behind the central bank) and then as a transferring agent on behalf of the central bank that rebates seigniorage revenues to households.

Foreign is assumed to be large relative to Home, which means that the domestic economy takes financial conditions in Foreign as given. Here, smallness also implies that domestic exports form a negligible component of the foreign economy's consumption basket. Note that domestic production and foreign production are designated with H and F subscripts. That is, consumption, output and the nominal prices of domestic production are denoted with H-subscripts and for foreign consumption, output and prices F-subscripts are used. And, as is standard in international economics, an asterisk ($*$) denotes foreign-economy variables. Finally, for simplicity, the model assumes a world of perfect foresight for ease of exposition (the underlying results of the model are not influenced by this assumption).

II.2.1 Firms

The economy is populated by firms and households. Households supply labour and are also the residual owners of the firms in the economy. A simplifying assumption herein also made is the abstraction of capital; output is assumed to be a function of labour only. This is an innocuous assumption and does not materially affect the conclusion of this paper.

Firms with identical technologies take differentiated labour, and produce a homogenous output, denoted by y. Labour, as noted, is differentiated – each unit of labour is unique and the standard assumption of constant elasticity of substitution amongst the labour types is made. Thus labour can be thought of as indexed by $z \in [0, 1]$, where each z signifies a particular type. As the output market is competitive, firms take price as given and are thus left to solve a simple static profit maximisation problem, where the choice variable is the quantity of aggregated labour. The z^{th} producer's problem is thus

$$\max_{\{L_s(z)\}} \pi_s(z) = p_{Hs} y_{Hs} - \int_0^1 w_s(z) L_s(z) dz \tag{1}$$

The variables are defined as follows: y_H is the domestically produced good; p_H is the price of the domestically produced; $w(z)$ is the wage of labour input; $L(z)$ is labour input chosen by the firm; and s is a time subscript. Now it remains to define how labour is converted to output. The restriction imposed is that the production function is of a form as dictated in Blanchard & Kiyotaki (1987). Under this specification output is a homogenous, constant elasticity of substitution (CES) function in labour (the only input), whose technology is defined by a returns-to-scale parameter $\alpha \in$

$(0, \infty)$:

$$y_{Hs} = \left[\left(\int_0^1 L_s(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}} \right]^{\alpha} = L_s^{\alpha} \tag{2}$$

$L_s(z)$ and $w_s(z)$ are the z^{th} individual's labour supply and nominal wage at time s. Date s output price is denoted p_{Hs}, and as the economy produces only one good, it can also be viewed as the GDP deflator. Period s domestic output, y_{Hs}, is identical for all producers, who produce identical goods with identical technologies but with differentiated input. For $0 < \alpha < 1$ the production process is said to exhibit decreasing returns to scale (DRS). For $\alpha > 1$, the production function displays increasing returns to scale (IRS). And as will be demonstrated, when the solution to the firm's problem is solved, the case of constant returns to scale (CRS), i.e., $\alpha = 1$, is ruled out as plausible to avoid infinite output. The constant $\sigma > 1$ measures the elasticity of substitution among the various types of labour. Thus the firm's period s problem can then be expressed as

$$\max_{L_s(z)} \; p_{Hs} \left[\left(\int_0^1 L_s(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}} \right]^{\alpha} - \int_0^1 w_s(z) L_s(z) dz \tag{3}$$

The level of $L_s(z)$ chosen by a representative firm is gotten by taking the first order condition (FOC) of the above equation. Differentiation with respect to labour yields

$$\alpha p_{Hs} \left[\left(\int_0^1 L_s(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}} \right]^{\alpha-1} \left(\int_0^1 L_s(z)^{\frac{\sigma-1}{\sigma}} dz \right)^{\frac{\sigma}{\sigma-1}-1} L_s(z)^{-1/\sigma} - \int_0^1 w_s(z) dz \tag{4}$$

Since the output market is competitive a zero-profit condition (ZPC) applies. This holds not just for the industry as a whole, but for each individual producer. Thus

$$p_{Hs} y_{Hs} - w_s(z) L_s(z) = 0 \tag{5}$$

Setting the derivative equal to zero and using the ZPC and a bit of manipulation

yields the conditional labour demand (CLD) as

$$\alpha L_s(z) = \left(\frac{w_s}{w_s\,(z)}\right)^{\sigma} y_{Hs}^{1/\alpha} \tag{6}$$

where $w_s = \left(\int_0^1 w_s(z)^{1-\sigma} dz\right)^{1/(1-\sigma)}$ is the wage index and σ measures the elasticity of demand with respect to the relative wage. Since all households set the same wage in equilibrium it must be true that $w_s = w_s(z)$ for all $z \in [0, 1]$. From the equilibrium condition the CLD reduces to

$$\alpha L_s(z) = y_{Hs}^{1/\alpha} \tag{7}$$

and since the zero-profit condition implies that

$$L_s(z) = \frac{p_{Hs} y_{Hs}}{w_s(z)} \tag{8}$$

then final labour demand is given by

$$y_{Hs} = \left(\frac{w_s}{\alpha p_{Hs}}\right)^{\frac{\alpha}{\alpha-1}} \tag{9}$$

A key point is to note that the supply of output depends on the ratio of wage to domestic price. The standard competitive model of labour demand condition is taken by re-substituting (8) into the production function. Now from the above equation (9) it is clear that $\alpha = 1$ is not a viable value for the technology parameter. This is because for $\alpha = 1$ (i.e., with CRS technology) output is infinite. This case needs to be ruled out to have a meaningful solution. Nevertheless, with predetermined nominal wages, the price of the domestic good will also be predetermined such that the domestic component of the inflation rate will be independent of monetary surprises.

II.2.2 Households

Now examine the household's problem. Households face the familiar problem of optimising an intertemporal flow of utilities subject to a set of restrictions as defined by their budget and wealth constraints. It is assumed, as is standard, that agents derive utility from holding cash balances by introducing it directly into their utility function.[10] Just as much, suppose that workers have disutility in working (à la Homer Simpson). Last, suppose the existence of a riskless nominal bond that households can buy that pays interest rate i. Thus household z is thought of as picking a sequence of bonds, nominal money holdings, consumption and a desired wage rate at time t to maximise its current lifetime utility, U_t.

As the model assumes two countries and open trade, households also face the dilemma of how to allocate expenditures between domestically and foreign produced goods. For notational simplicity, the subscript z will henceforth be omitted when there is no confusion in its omission. The household's intertemporal maximisation problem is determined by four choice variables, namely bonds, consumption, money balances, and labour:

$$\max_{\{B_s,C_s,M_s,L_s(z)\}_{s=t}^{\infty}} U_t = \sum_{s=t}^{\infty} \beta^{s-t} u\left(C_s, m_s, L_s\left(z\right)\right) \tag{10}$$

The maximisation is subject to the sequence of constraints on the path of savings (bonds), which defines the flow budget constraint (FBC) of the household

$$\Delta B_s \equiv B_s - B_{s-1} \geq \pi_s\left(z\right) + w_s(z)L_s(z) - P_s C_s - G_s + \left[\left(1 + i^*_{s-1}\right)\frac{X_s}{X_{s-1}} - 1\right] B_{s-1} \tag{11}$$

[10] The money in the utility function framework is the work of Sidrauski (1967) and Brock (1975). Under this scheme money brings direct utility to agents and so has a positive price.

and conditional labour demand, as given by equation (7). The notations are standard: $\beta \in [0,1]$ is a discount factor; B_s are domestic bonds that pay nominal interest i_s; C_s is consumption; $m_s = M_s/P_s$ is real money balances; P_s is the consumer price index (CPI); G_s are lumps-sum transfers made by the government;[11] and X_s is the nominal spot exchange rate. It is also taken that the uncovered interest parity (UIP) condition holds and implies that

$$\left(1 + i^*_{s-1}\right) X_s / X_{s-1} = 1 + i_{s-1} \tag{12}$$

The felicity function is taken to be additively separable in their components, and is further assumed to be of the quasi-CRRA (constant relative risk aversion) form and is standard

$$u\left(C_s, m_s, L_s\left(z\right)\right) = \log C_s - \psi \frac{1}{\upsilon} L_s^{\upsilon}\left(z\right) + \frac{1}{1-\varepsilon} b m_s^{1-\varepsilon} \tag{13}$$

The parameters of the utility function merit some explanation: $b > 0$ measures monetary frictions; $\varepsilon > 0$ measures the interchangeability of real balances with consumption and labour; $\psi > 0$ measures the strength of disutility from providing labour services; $\upsilon > 1$ is a measure of the elasticity of labour substitution. Combining all this gives a simple constrained optimisation problem. The Lagrangian that households solve[12] is then

$$\mathcal{L} = \sum_{s=t}^{\infty} \beta^{s-t} \left\{ u\left(C_s, m_s, L_s\left(z\right)\right) - \lambda_1 \left[\text{FBC}\right] - \lambda_2 \left[\text{CLD}\right] \right\}$$

The first order conditions (FOCs) with respect to consumption (∂C) and bonds (∂B)

[11] Note that G does enter the budget constraint with a negative sign becasue, as will be shown later, it is defined as $M_{s-1} - M_s$ (rather than $M_s - M_{s-1}$), where M is money balances.

[12] Note that the FBC and CLD restrictions are written in zero-form.

yields the familiar consumption Euler equation

$$P_{s+1}C_{s+1} = P_s C_s \beta \Gamma_s \tag{14}$$

where for notational brevity $\Gamma_s \equiv (1 + i_s)$ denotes the gross nominal interest rate (NIR). Taking the derivative of the Lagrangian with respect to real money holdings (∂m) and labour ($\partial L(z)$), which implicitly defines the wage rate, yields two more FOCs

$$b m_s^{-\varepsilon} \frac{1}{P_s} = \frac{1}{P_s C_s} - \frac{1}{\beta P_{s+1} C_{s+1}} \tag{15}$$

$$w_s = \psi \frac{\sigma}{(\sigma - 1)} \frac{P_s C_s}{L_s^{1-\upsilon}} \tag{16}$$

Equation (15) is the money Euler equation. This can be simplified using the consumption Euler equation

$$\begin{aligned} m_s^{\varepsilon} &= b \frac{\beta P_{s+1} C_{s+1} C_s}{\beta P_{s+1} C_{s+1} - P_s} \\ &= b \frac{\beta \left(\frac{P_{s+1} C_{s+1}}{P_s} \right)}{\beta (\beta \Gamma_s) - 1} \\ &= b \frac{C_s \Gamma_s}{\Gamma_s - 1} \end{aligned} \tag{17}$$

The last expression implies that the demand for money can be expressed in a form seen in many other models:

$$m_s^{\varepsilon} = b C_s \Gamma_s / i_s = b C_s \left(\frac{1 + i_s}{i_s} \right) \tag{18}$$

Now it is clear that money demand depends on the amount of consumption and the interest rate and upon the monetary frictions parameter b. Note too the relation of money demand to consumption and the nominal interest rate:

$$\frac{\partial}{\partial C_s} m_s^{\varepsilon} = b \frac{1 + i_s}{i_s} > 0 \tag{19}$$

and

$$\frac{\partial}{\partial i_s} m_s^{\varepsilon} = -bC_s i_s^{-2} < 0 \tag{20}$$

So, as is standard, the demand for money is increasing in the amount of desired consumption (equation 19) and decreasing in the interest rate (equation 20). Also, from this it can be seen that $\varepsilon > 0$ now measures the interest and consumption elasticities of money demand.

The wage equation (16) demonstrates that the optimal wage is a function of the monopoly mark-up $\sigma/(\sigma - 1)$, i.e., the desired mark-up of households over marginal cost, and also as a function of the marginal rate of substitution (MRS) between consumption and leisure. The condition gives a natural way of incorporating nominal rigidities into the model, as the money wage is negotiated one period in advance. Finally, note that the usual arbitrage equation (UIP) connecting the exchange rate with the domestic and foreign interest rates holds in the model (though probably not in the real world): $X_{s+1}\Gamma_s^* = X_s\Gamma_s$.

As yet, the real relation between the consumer price index and the domestic price level is undefined. Following convention, a Cobb-Douglas form for the consumption index is used to aggregate prices, which defines this relationship. This feature, in combination with some other mild restrictions, simplifies the behaviour of the current account, defined as the difference between output and consumption. This assumption then isolates the behaviour of the exchange rate, thus allowing focus to fall on this aspect of the adjusting mechanism. The household's intratemporal problem (between domestically produced goods, C_H, and goods produced in Foreign, C_F) is therefore

$$\max_{\{C_{Hs}, C_{Fs}\}} C_s = \kappa C_{Hs}^{\gamma} C_{Fs}^{1-\gamma} \tag{21}$$

subject to

$$P_s C_s = p_{Hs} C_{Hs} + p_{Fs} C_{Fs} \tag{22}$$

where $\kappa = \left[\gamma^{\gamma} (1-\gamma)^{1-\gamma}\right]^{-1}$ is an inconsequential constant, and p_F is the domestic price level of the foreign good. Setting up the Lagrangian and solving for the two first order conditions yields the solution to the constrained maximisation problem. Of course, given the Cobb-Douglas nature of the objective function the familiar result that households consume each good in proportion to the exponential parameter obtains:

$$C_{Hs} = \gamma \frac{P_s C_s}{p_{Hs}} \tag{23}$$

$$C_{Fs} = (1-\gamma) \frac{P_s C_s}{p_{Fs}} \tag{24}$$

The two equations above are the derived demands for Home's and Foreign's goods. Whence the CPI – which includes domestic and foreign goods prices – is defined by the aggregator

$$P_s = p_{Hs}^{\gamma} p_{Fs}^{1-\gamma} \tag{25}$$

The parameter γ is a measure of the openness of Home; it is a measure of the share of domestic price in the CPI. As such, it becomes evident that as $\gamma \to 1$ the domestic economy becomes autarkic. The elasticity of substitution between domestic and foreign goods in such a case is simply 1.

Except with respect to size – Home is thought of as small relative to Foreign – the problem abroad is identical. In particular, Foreign households face the same problem but the assumption of Home as an SOE implies that the share of Foreign's CPI attributable to the Home good is negligible: $\gamma^* \to 0$ so that $C_F^* = C_{Fs}^*$ and $P_s^* = p_{Fs}^*$. It is possible to assume that Foreign's price level is unity as it is completely exogenous.

However, this assumption does not mean that Foreign's demand for domestic goods is zero since C_s^* is large; it merely states that it is relatively negligible (of zero measure). Now using the assumption that LOP holds ($p_{Hs} = X_s p_{Hs}^*$) Foreign's consumption of domestic output can be shown as

$$C_{Hs}^* = g_s^* \frac{X_s}{p_{Hs}} \tag{26}$$

so that $g_s^* \equiv \gamma^* C_s^*$ is a measure of Foreign's demand. (Note, if C^* is approximately equal to Foreign income, then $g^* = \gamma y_F$ approximates foreign demand.) The parameter g_s^* is restricted to be non-zero and bounded, and is exogenous from the viewpoint of Home.

As stressed above, an important point is that despite assuming that LOP holds for both traded and nontraded goods, the SOE assumption implies consumption-based PPP does not hold, and the real exchange rate (RER) is not constant in the face of changes in monetary policy. For future reference it is thus therefore useful to define consumption-based RER as the ratio of the nominal exchange rate to the domestic price level: $Q_s = X_s/P_s$. Moreover, given the form of the price aggregator, the RER can be simplified to a ratio of the domestic prices of Foreign and Home goods: $Q_s = (p_{Fs}/p_{Hs})^{\gamma}$.

II.2.3 Government

The government plays a dual role in this model – it is both a fiscal and a monetary entity. As a monetary authority it issues currency as it is the ultimate authority behind the central bank. With regards to fiscal policy it has a policy of rebating seigniorage revenue, which it earns as the monopolist in issuing domestic money, to

households. In effect, the monetary authority (central bank) is the issuer of money and collects seigniorage revenue, but then transfers these funds to the government, who then rebates it to households. So the government is thought of as a benevolent agent that transfers wealth from the central bank to households.[13] It has no spending of its own and neither does it engage in any form of redistributive policies. (Households are homogeneous anyhow.) The rule for the government, thus, is to rebate seigniorage – the growth in money balances – where its rule of rebating is described by

$$G_s \equiv M_{s-1} - M_s = \left(\frac{1}{\mu_s} - 1\right) M_s \tag{27}$$

As is standard, $\mu_s = M_s/M_{s-1}$ is the growth rate of money: $\log(M_s/M_{s-1}) = \log \mu_s > 0$ for $M_s > M_{s-1}$.

Note that the government is strictly neutral with respect to aggregate distributional effects. This is because an increase (decrease) in the monetary supply is concomitant with a lump sum transfer (tax) of equal size to all households. And as households are identical, there exists no marginal redistribution associated with such transfers. With the representative agent taking nominal prices as given when choosing a desired path of nominal money holdings, and the government rebating revenues in lump-sum form to the public, inflation is still seen to discourage holding nominal balances. This result derives from the fact that the money transfer is unrelated to the optimal money demand decision.

[13] It also transfers wealth insomuch as it creates unexpected changes in inflation if debtors and creditors are not one and the same.

II.3 Model solution

Because of the parsimonious representation of the economy, the model admits a simple analytic result. This section goes about sketching such a solution. In the process of solving the model, an AD-AS system is derived to allow examination of the effects of changes in the money supply on the behaviour of the exchange rate, i.e., to verify/test the overshooting conjecture. Because of the specification of preferences, it is necessary to solve the real and the monetary side of the model jointly. The RIR and the RER in the domestic economy are initially thought of as independent of monetary factors. The key, then, is to connect the interest rate and exchange factors with the monetary side of the economy. The two sides of the economy can be shown to be connected to the current period while accounting for the nominal rigidity. Although it is not possible to appeal to the exogenous foreign rate of interest in any solution to the monetary side, the analysis of the real side is simplified by this exogeneity condition.

II.3.1 Real side

This model starts first by assuming that all future variables are known with certainty. The assumption that markets are nonstochastic means that agents can only be surprised in the initial period; markets clear in all future periods, and so for periods $s \geq t+1$ the monopolistic supply of labour equals the demand for labour:

$$y_{Hs} = \left[\alpha^{-1}\psi\frac{\sigma}{\sigma-1}C_s\left(\frac{P_s}{p_{Hs}}\right)\right]^{\frac{\alpha}{\alpha-\upsilon}} \quad \text{for all } s \geq t+1 \tag{28}$$

From the preceding expression it is clear that domestic output depends on a price ratio, namely the ratio of CPI to the GDP deflator, both of which are endogenous. Also recall that domestic output is a function of the openness of the economy, as

parameterised by $\gamma \in [0,1]$, with a value of 0 implying autarky.

The second condition required to determine the real side of the economy is a goods market equilibrium condition. First, the resource constraint of the economy needs to be satisfied so that world consumption of the domestic good is matched by domestic production levels

$$y_H = C_H + C_H^* \tag{29}$$

Given the identity for y_H it is possible to write an expression for output in relation to the real side of the economy. Combining this with the price index as given by equation (25) and the demand conditions (23) and (26), where the steady state condition $C_t^* = C^*$ is imposed for all s such that $g_s^* = g^*$.

To derive an explicit expression for the real side of the economy note the fact that $C_H = \gamma P_t C_t$, then multiply C_H^* by p_H/p_H and use the relationship that $C_{Hs} = g^* X_s$. This produces an equation describing the real side of the economy (and can be taken to be the IS equation for this economy)

$$y_{Hs} = \left(\gamma P_s C_s + g^* X_s\right)/p_{Hs} \quad \text{for all } s \tag{30}$$

Now an increase in g^* can be viewed as an IS-shifter. Because output need not equal consumption, since the economy is open, a trade deficit (surplus) satisfying excess demand (supply) in the domestic economy is possible. This is captured by the second term in the parenthesis on the right hand side of the above equation because $g^* X_s$ represents exports of the domestic good.

Again output depends on relative prices so that for periods $s \geq t+1$ equations (28) and (30) form an explicit system. To make this clearer, recall the definition of the RER earlier: $Q_s \equiv X_s/P_s$. Using this definition, (28) and (30) now form an

implicit real system specifically in the variables y_{Hs}, Q_s, and C_s. This demonstrates a key difference between micro-founded and ad hoc approaches. In many respects, the supply side of the model here is similar to the ad hoc model of Sachs (1980). Solving Sachs' ad hoc model, however, is more routine because the aggregate supply and market clearing conditions can be solved simultaneously to determine the natural rate of output and the RER. Instead, here the pair of equations form an implicit system which will be denoted $Q_s = Q(C_s)$ and $y_{Hs} = y_H(C_s)$. With this result in hand, it is possible to characterise the behaviour of the RIR.

To solve for the real interest rate combine the uncovered interest parity condition with the Fisher parity equation

$$\Pi_{s+1} = \frac{\Gamma_s}{1 + r_s} \tag{31}$$

where $\Pi_s \equiv P_s/P_{s-1}$ is the gross inflation rate at time s. At the same time it is also convenient to introduce one more short-hand notation: $R_s \equiv 1 + r_s$ (and likewise for the foreign equivalent with an asterisk). The Fisher equation thus implies a real-analogue to the uncovered interest parity condition:

$$Q_{s+1}R_s^* = Q_s R_s \tag{32}$$

It is also necessary to assume that the foreign economy is in a steady state, and as $\beta = \beta^*$ is required to rule out the small economy growing faster than the big economy (and hence growing large over time), then $R_s^* = 1/\beta$ for all s. Given the implicit system above, the Euler equation in the RER can be defined as

$$R_s = \frac{Q(C_{s+1})}{\beta Q(C_s)} \tag{33}$$

and the real version of the consumption Euler equation now yields

$$\Delta \widehat{C}_{s+1} \equiv \widehat{C}_{s+1} - \widehat{C}_s = 0 \text{ for all } s \geq t+1 \tag{34}$$

where $\widehat{C}_s \equiv C_s/Q\left(C_s\right)$ is consumption adjusted by the consumption-based RER. Thus for periods $s \geq t+1$ the real side can be expressed as a self-contained difference equation. It implies that the real interest rate is at its steady state level for periods $s \geq t+1$ so that $R_s = 1/\beta$ for all $s \geq t+1$.

But now consider the start date of the system. In the initial period the money wage is set at the level $\overline{w}_t$. But in this case households are off their labour supply curves and labour is then (à la Keynes) demand determined. Yet, labour demand is conditional on the domestic price level, which is exogenous. So from the definitions of the RER and consumer price index it is possible to rewrite the domestic price as a combination of the real and nominal exchange rate that will be determined below, thus solving for endogeneity problem – at least temporarily. Using the result for final labour demand, $y_{Hs} = \left(\alpha^{-1} w_s/p_{Hs}\right)^{\alpha/(\alpha-1)}$, and the fact that $p_{Ht} = X_t/Q_t^{1/\gamma}$ gives an initial period value of Home's output as a function of initial wage and a ratio of the real and nominal exchange rates:

$$y_{Ht} = \left(\frac{\overline{w}_t Q_t^{1/\gamma}}{\alpha X_t}\right)^{\frac{\alpha}{\alpha-1}} \tag{35}$$

Now domestic output depends on the nominal exchange rate and rigid wages through the supply side relations. The IS equation still holds on the current period so that domestic output also depends implicitly on consumption and the RER. Now adding equation (35) with the IS condition (30), it follows that there is an equivalent implicit system for the current period. For brevity, now denote the real side in the current

period,

$$Q_t = Q\left(C_t | X_t, \overline{w}_t\right) \tag{36}$$

and

$$y_{Ht} = y_H\left(C_t | X_t, \overline{w}_t\right) \tag{37}$$

The last two expressions are telling: Current period values of the RER and domestic output depend on current consumption given the current exchange rate and the current wage rate; by contrast, future domestic output and future RER is conditioned only upon consumption.

Now it is possible to derive a current-period consumption Euler equation. Following the same steps above, the current period domestic RIR is

$$R_t = \frac{Q\left(C_{t+1}\right)}{\beta Q\left(C_t | X_t, \overline{w}_t\right)} \tag{38}$$

Examining the above equation it is apparent that there is a shortcoming in pinning down the equilibrium path of the model. This is because the RIR is not invariant to monetary policy, so it is not possible, in the current period, for the real side of the economy to be in steady state under the conditions examined thus far. To correct this flaw one more facet of the model must be examined to get the complete picture: The model must be expanded to include the money side to pin down the steady state.

II.3.2 Monetary side

Now the problem at hand is to tie in the monetary side of the system to the real side of the model. To describe the behaviour of the monetary side first combine the money demand function (18) and the consumption Euler equation (14) to express the period s nominal interest rate as a function of the future nominal interest rate and

the current period domestic real interest rate

$$i_s = i_{s+1}\left[\left(\frac{\Gamma_s}{R_s}\right)^{1-\varepsilon}\cdot\frac{\mu_{s+1}^{\varepsilon}}{\beta\Gamma_{s+1}}\right] \tag{39}$$

$$\Leftrightarrow i_s\Gamma_s^{\varepsilon-1} = R_s^{\varepsilon-1}\frac{i_{s+1}}{\Gamma_{s+1}}\frac{\mu_{s+1}^{\varepsilon}}{\beta}$$

Observe that the NIR is non-predetermined, but rather based on forward variables. Thus the system needs to be unstable in its forward dynamics and satisfy a saddle path property to be well behaved. Since $R_s = 1/\beta$ for all $s \geq t+1$ when money growth is constant ($\mu_s = \mu$), this implies that the NIR is also a constant in all future periods: $\Gamma_s = \mu/\beta$ for all $s \geq t+1$. What should be made of this? From the preceding expression the implications of home-bias in consumption for the monetary side of the model become clear. Suppose that home-bias in consumption were not present, then the domestic real interest rate would be pinned to the world real interest rate, which in this setting is exogenous. Thus with home-bias in consumption it is possible to solve for the level of the domestic NIR in all periods. Here though, it is necessary to solve for equation (39) recursively for the current period. Doing this yields a relationship between the two rates of interest in the model:

$$i_t\Gamma_t^{\varepsilon-1} = R_t^{\varepsilon-1}\left(1-\beta/\mu\right)\mu^{\varepsilon}/\beta \tag{40}$$

Consider the case when the interest elasticity of money demand is greater than unity. In this case, as a result of the rigid money wage, monetary policy has additional effects on the NIR. So what is the consequence of this finding? The impact of this is that it gives rise to a liquidity effect, defined as a responsiveness of the NIR to monetary policy. The regime for money growth is such that $\mu_s = \mu$ for all $s \geq t+1$ but μ_t may differ from μ so that the complete time path is described by (μ_t, μ), i.e. an initial period value and a constant value in all periods thereafter.

A careful observer will note the role of preferences in forcing the particular solution method used. If the interest elasticity of money demand was normalised at 1 it would be possible to exploit a separability condition between the real and the monetary sides. In that case, it would then only be necessary to consider the monetary side when solving.

II.3.3 The exchange rate

The heart of this paper is the behaviour of the exchange rate. Indeed, the question at hand is to study the behaviour of the exchange rate and, in particular, its response to changes in monetary policy. Given the behaviour of NIR it is possible to solve for its initial level (X_t). To solve, it will be necessary to first consider how savings, or effectively the supply of bonds, evolve over time. Bonds, in essence, represent the balance-of-payment equation for the economy since it represents the flow-difference between consumption and output. In equilibrium this condition can be written

$$\Delta B_s = p_{Hs} y_{Hs} - P_s C_s + i_{s-1} B_{s-1} \tag{41}$$

The net change in position of bonds is income minus spending – i.e., savings – plus interest claims from last period's bonds. In following, take the resource constraint, $y_H = C_H + C_H^*$, and use the demand functions, $C_{Hs} = \gamma P_s C_s / p_{Hs}$ (23) and $C_{Hs}^* = g_s^* X_s / p_{Hs}$ (26) to substitute out domestic output and the GDP deflator. Finally, it is possible to solve the transformed condition forward by repeated iterations, which implies

$$\Gamma_{t-1} B_{t-1} = -\sum_{s=t}^{\infty} \frac{X_s g^* - P_s C_s (1-\gamma)}{\Gamma_t \cdots \Gamma_{s-1}} \tag{42}$$

For clarity, define $\Gamma_t \cdots \Gamma_{s-1} \equiv 1$ when $s = t$ and the initial level of debt has been set equal to zero (the latter assumption is just a matter of convenience). Also, a common restriction made is that the size of debt by household cannot grow faster than the interest rate. This is to say that Ponzi games are ruled out. Such a scheme cannot happen in equilibrium as the following transversality condition (TVC) holds

$$\lim_{s>t\to\infty} \frac{B_s}{\Gamma_{s-1} \cdots \Gamma_t} = 0 \tag{43}$$

Now split the present value constraint (42) into two parts: One where the nominal rigidity takes effect (short-run, $s = t$); and one where it does not (long-run, $s \geq t+1$). Then denote the trade balance as

$$T_s \equiv X_s g^* - P_s C_s \left(1 - \gamma\right) \tag{44}$$

Now using the fact that Γ_s is constant for periods $s \geq t + 1$ it is straightforward to demonstrate that $T_{s+1}/T_s = \mu$ for all $s \geq t + 1$, or rather that in all periods after the current period the trade balance grows at a constant rate: $\log\left(T_{s+1}/T_s\right) = \log \mu$ (and so it is evident that the growth rate is positive only when $\mu > 1$). From this it is possible to to rewrite the transformed forward equation on bonds as a forward equation (42) in the trade balance:

$$T_t + \frac{\mu T_{t+1}}{\beta \Gamma_t} = 0 \tag{45}$$

The above relation for the trade balance pins down its value in each period. Since $\Gamma_s = \mu/\beta$, for all s, this implies that $T_t = T_{t+1} = 0$ and more generally $T_s = 0$ for all s. Therefore, despite the non-unit interest elasticity of money demand in this SOE framework, there nevertheless is a zero current account balance in all periods. But this result holds only when both the intertemporal and intratemporal consumption

elasticities are unity as in Gali & Monacelli (2005). If either departs from unity it is possible to generate current account surpluses or deficits from changes in the money supply depending on parameter restrictions. In contrast, a zero current account balance condition holds even when the intertemporal elasticity differs from unity as in a recent work by Corsetti & Pesenti (2000). Their result, however, hinges on the assumption of PPP holding at all times. Here, relaxing PPP requires a more stringent restriction on preferences to generate similar result.

It is now possible to derive the nominal exchange rate. Using the result of the above and taking the definition of the trade balance the nominal exchange rate can thus be written as

$$X_s = P_s C_s \left(1-\gamma\right)/g^* \quad \text{for all } s \tag{46}$$

Note, in particular, that the nominal exchange rate depends on the degree of openness $(1-\gamma)$. Finally, using the IS equation (30), $y_{Hs} = \left(\gamma P_s C_s + g^* X_s\right)/p_{Hs}$, and the period $s \geq t+1$ money demand function (18), $m_s^{\epsilon} = xC_s\Gamma_s/i_s$, it is possible to tie the nominal exchange rate to the monetary shock variable M_s, whence

$$X_s = aM_s \quad \text{for all } s \geq t+1 \tag{47}$$

Here the coefficient $a > 0$ is a (messy) function of openness, domestic output, the discount rate and elasticity of money balances:

$$a = \left[\left(\frac{1-\beta/\mu}{b}\right)^{1/\varepsilon} \overline{y}_H^{\gamma(\varepsilon-1)/\varepsilon} \frac{(1-\gamma)}{g^*}\right]^{(\gamma(\varepsilon-1)+1)/\varepsilon} \tag{48}$$

The assumption that $a > 0$ holds so long as $\beta \neq \mu$ and $\gamma \neq 1$ and steady state output is non-zero. This expression makes clear how in period $s = t$ the reaction of the exchange rate to a change in the money supply is augmented through changes in

output. The changes in output derive from changes in the RIR, which in turn also depends on (nominal) wage rigidity.

II.3.4 AD-AS system

To tie down equilibrium in the current period it is first necessary to consider for periods $s \geq t+1$. To offer a full solution to the model the key insight is the behaviour of the current account:

$$T_s \equiv X_s g^* - P_s C_s \left(1-\gamma\right) \tag{49}$$

Recalling that a zero trade balance ($T_s = 0$) implies that consumption is $C_s = y_{Hs} Q_s^{(\gamma-1)/\gamma}$ and then using this in periods $s \geq t+1$ real side systems, there is an analogous system which ties down Q_s, y_{Hs} and C_s for all $s \geq t+1$:

$$Q_s = Q\left(y_{Hs} Q_s^{(\gamma-1)/\gamma}\right) \tag{50}$$

$$y_{Hs} = y_H\left(y_{Hs} Q_s^{(\gamma-1)/\gamma}\right) \tag{51}$$

Although previously it was not possible to solve for domestic output and the RER simultaneously because each was implicitly dependent on consumption, in all periods after the current period it is possible to solve for domestic output, the RER and consumption simultaneously because the current account does not react to exogenous changes in the money supply. These equations provide explicit solutions for the natural rate of output and the RER that, for periods $s \geq t+1$, are denoted with bars: $Q_s = \overline{Q}$, $y_{Hs} = \overline{y}_H$ and $C_s = \overline{C}$.

For example, the natural rate of output appears in equation (48) above, but because the current account is zero there is an explicit expression that depends only on preference parameters and technology. Using (28) and exploiting the definition of

the RER along with the fact that $C_s = y_{Hs} Q_s^{(\gamma-1)/\gamma}$ when the trade balance is zero yields a simple expression for the steady state value of output

$$\overline{y}_H = \left[\frac{\alpha (\sigma - 1)}{\sigma \psi} \right]^{\alpha/\upsilon} \tag{52}$$

As the distorting effect of monopoly power wanes (that is as $\sigma \to \infty$ so that $(\sigma - 1)/\sigma$ approaches 1), employment reaches the competitive level $\overline{L} = (\alpha/\phi)^{1/\upsilon}$ (recall that $y = L^{\alpha}$). Moreover, from equations (50) and (51) the steady state level of the RER can be gotten in terms of the steady state level of consumption and the degree of openness: $\overline{Q} = \overline{C}(1 - \gamma)/g^*$. Then using the zero-current-account condition, $\overline{T} = 0$, and y_H, it is clear that $\overline{Q}$ and $\overline{C}$ are uniquely related to one another.

Tying down output and consumption for periods $s \geq t + 1$ turns out to be the most important step in pinning down all remaining endogenous variables in the model because by substituting $T_t = 0$ into the $s = t$ implicit equations (system), it is now possible to solve for the initial variables y_{Ht}, Q_t and C_t, conditioning on X_t. Therefore, output and the nominal exchange rate are related via the real sector relations, so there is a closed-form solution which describes aggregate supply (AS):

$$y_{Ht}^{1/\alpha} = \frac{\overline{w}_t X_t g^*}{\alpha (1 - \gamma)} \tag{53}$$

Now that the AS relationship has been derived the logical extension is to ask about aggregate demand (AD). Luckily a similar expression for AD is also obtainable. To derive AD first note that from the UIP (12) and Fisher parity (31) conditions that the current (gross) nominal and (gross) real interest rates can be written as

$$\Gamma_t = \frac{a M_{t+1}}{\beta X_t} \tag{54}$$

and

$$R_t = \beta^{-1}\left[\frac{\overline{y}_H}{y_H\left(C_t|X_t,\overline{w}_t\right)}\right]^{\gamma} \tag{55}$$

The above results are deduced from a combination of the IS equation (30), as well as the solution to the exchange rate (46), with a given in (48) and $\overline{y}_H$ given in (52). Substituting out the real and NIR from the current period difference equation (40) therefore produces a second closed-form relation between output and the nominal exchange rate. This yields the following AD relationship:

$$y_{Ht}^{\gamma(1-\varepsilon)} = \frac{\left(aM_{t+1} - X_t\beta\right)\left(\frac{aM_{t+1}}{X_t\beta}\right)^{\varepsilon-1}}{n\beta X_t} \tag{56}$$

with n strictly positive (and messy) and defined as:

$$n = \frac{\left(\beta/\mu\right)^{\varepsilon}}{\left(1-\beta/\mu\right)\left(\frac{\alpha(\sigma-1)}{\sigma\psi}\right)^{\alpha\gamma(1-\varepsilon)/\upsilon}} \tag{57}$$

(An astute reader will note that the expression relating domestic output to money balances and the NER comes from using the relations (40), (54) and (55).) Finally, note that the remaining variables in the expression for n are exogenous since M_{t+1} is the policy variable.

The preceding sections have yielded a set of equations, but what is of interest are the solutions to these expressions. So the question remains, How should the solution to the system be gotten? Consider a method whereby the current period implicit system is transformed for y_{Ht}, Q_t and C_t into a simple pair of implicit equations for y_{Ht} and X_t. This method proves useful as it has the added advantage of tying down the current period values of the system. With this modification all future period variables are at their natural rate levels, thus it is relatively straightforward to consider the effects that exogenous changes in money supply have on output and the exchange rate.

The intuition behind the dynamics of the AS-AD system can be shown with a little math. If one is to be precise, the real side and monetary side equilibrium conditions can be expressed in canonical form by two zero-form equations:

$$F_r\left(y_{Ht}, X_t|\overline{w}_t\right) = 0 \tag{58}$$

and

$$F_m\left(y_{Ht}, X_t|M_{t+1}\right) = 0 \tag{59}$$

The first equation, $F_r(\bullet) = 0$, describes the equilibrium real-side (supply) relations. The second zero-function, $F_m(\bullet) = 0$, describes the equilibrium monetary-side (demand) relations. Together, this system allows to determine the effect of a permanent and unanticipated monetary expansion on the model. This just requires to implicitly differentiate the equations describing the real and monetary equilibrium conditions. So the response of the economy to a permanent and unanticipated increase in the money supply can be summed by a straightforward matrix equation:

$$\begin{pmatrix} \partial F_r/\partial y_{Ht} & \partial F_r/\partial X_t \\ \partial F_m/\partial y_{Ht} & \partial F_m/\partial X_t \end{pmatrix} \begin{pmatrix} \partial y_{Ht}/\partial M_{t+1} \\ \partial S_t/\partial M_{t+1} \end{pmatrix} = - \begin{pmatrix} 0 \\ \partial F_m/\partial M_{t+1} \end{pmatrix} \tag{60}$$

From here it is routine to recover the response of output and the NER to nominal money balances; i.e., $\partial y_{Ht}/\partial M_{t+1}$ and $\partial X_t/\partial M_{t+1}$. For example, applying Cramer's rule to the above equation (60) and rearranging the resulting expression the reaction of the exchange rate to a change in the money supply is given by

$$\left(\frac{\partial X_t}{\partial M_{t+1}}\right)\left(\frac{M_{t+1}}{X_t}\right) = \left(1 - \frac{\left(\partial F_m/\partial y_{Ht}\right)\left(\partial F_r/\partial X_t\right)}{\left(\partial F_r/\partial y_{Ht}\right)\left(\partial F_m/\partial X_t\right)}\right)^{-1} \tag{61}$$

In this case the derivatives of concern are how the real and monetary sides of the economy react to output and the NER, namely the changes in F_r and F_m for (small)

changes in y_H and X:

$$\frac{\partial F_r}{\partial y_{Ht}} = \alpha^{-1} y_{Ht}^{1/\alpha - 1} \tag{62}$$

$$\frac{\partial F_r}{\partial X_t} = \frac{\alpha g^*}{\overline{w}_t (\gamma - 1)} \tag{63}$$

$$\frac{\partial F_m}{\partial y_{Ht}} = \frac{n\gamma (1-\varepsilon) y_{Ht}^{\gamma(1-\varepsilon)-1}}{y_{Ht}} \tag{64}$$

$$\frac{\partial F_m}{\partial X_t} = \frac{aM_{t+1}\varepsilon + X_t\beta(1-\varepsilon)}{(aM_{t+1})^{1-\varepsilon} X_t^{1+\varepsilon}\beta^{\varepsilon}} \tag{65}$$

Now, of course, it remains to be determined the directions of these derivatives. It is a straightforward exercise to determine the signs of all of these derivatives. The first derivative is always positive while the second derivative is always negative:

$$\alpha^{-1} y_{Ht}^{1/\alpha - 1} > 0$$

and

$$\alpha g^* / (\overline{w}_t (\gamma - 1)) < 0$$

The latter two derivatives, equations (64) and (65), however, are not immediately evident. Consider the derivative of F_m with respect to y_{Ht}: If $\varepsilon < 1$ then the derivative is positive, otherwise the reverse holds. As for the last expression, note that the gross nominal interest rate is defined by $\Gamma_t = (xM_{t+1}/X_t\beta)$ and this expression is strictly greater than $(\varepsilon - 1)/\varepsilon$ for all positive ε, hence (65) is also positive.

To derive the overshooting result, the RHS of (61) needs to be greater than unity when $\varepsilon > 1$. Immediately apparent from (64) is that $\varepsilon = 1$ implies that $\partial X_t/\partial M_{t+1} = X_t/M_{t+1}$ so that the exchange rate rises in proportion to changes in the money supply. Therefore, all that is needed for overshooting is the condition that

$$\left(\frac{\partial F_r}{\partial y_{Ht}}\right)\left(\frac{\partial F_m}{\partial X_t}\right) > \left(\frac{\partial F_m}{\partial y_{Ht}}\right)\left(\frac{\partial F_r}{\partial X_t}\right) \tag{66}$$

Plugging back in the two zero conditions $[F_r(y_{Ht}, X_t) = 0,\ F_m(y_{Ht}, X_t|M_{t+1}) = 0]$ back into the above condition one then gets an expression in terms of exogenous parameters and the nominal interest rate. Thus, for (66) to hold it is required that

$$\Gamma_t > \frac{1-\gamma\alpha}{\frac{\varepsilon}{\varepsilon-1}-\gamma\alpha} \tag{67}$$

This condition is satisfied so long as $\varepsilon > 1$ since for $\varepsilon > 1$ it is true that $\gamma/\alpha < 1$ and $\varepsilon/(\varepsilon-1) > 1$. The RHS of (67) is always less than one, whereas the LHS, which is the gross nominal interest rate, is always greater than one, so the result follows immediately.

II.4 Effects of a monetary expansion

Now take into account the effects of a monetary expansion on the exchange rate in this model. For clarity and simplicity, the analysis restricts itself to permanent and *unexpected* increases in the money supply focusing on domestic output and the NER. To understand more precisely how output and the exchange rate behave in response to a monetary expansion it is necessary, therefore, to implicitly differentiate the aggregate supply and demand relations, (53) and (56), with respect to their arguments. The next section goes about to solve that.

II.4.1 Monetary expansion absent of a liquidity effect

The preceding discussion made evident that the reaction of the exchange rate when money demand is interest unit-elastic will be proportional to the change in the money supply. Setting the interest elasticity to unity in the difference equation (40) implies $\Gamma_t = \mu/\beta$ so the NIR jumps directly to its steady state value. In this case a change

in the money supply has the additional effect on the NIR and the NER increases each period by the money growth rate adjusted by the discount rate. Underlying this result is that money demand responds one-for-one with the change in consumption because ε measures the interest and consumption elasticities of money demand. This corresponds to the type of effect in models where PPP holds.

More formally, the reaction of the economy to a change in the money supply can be summarised by the following pair of equations describing the exchange rate and output:

$$\frac{\partial X_t}{\partial M_{t+1}} = \frac{X_t}{M_{t+1}} \tag{68}$$

$$\frac{\partial y_{Ht}}{\partial M_{t+1}} = \frac{g^* \overline{w}_t X_t}{(1-\gamma) M_{t+1} y_{Ht}^{\alpha-1}} \tag{69}$$

The above results are the result of implicitly differentiating (54) and (53). The first derivative comes from the relationship

$$X_t = aM_{t+1} / (\beta \Gamma_t)$$

which is gotten from (54). The second derivative is a result of the AS equation,

$$y_{Ht}^{1/\alpha} = \alpha^{-1} \overline{w}_t X_t g^* / (1-\gamma)$$

and then using the result of the first derivative since the current period NER is a function of the one period ahead money balance.

From these two expressions several points are obvious. First, since elasticity is given by

$$\eta = (\partial X_t / \partial M_{t+1}) M_{t+1} / X_t = 1$$

this means that the short-run change in the exchange rate is proportional to the increase in the money supply. A second comment is that when there is a *permanent*

increase in the money supply output increases (this is always true when $\varepsilon > 0$). Intuitively, output increases because increases in the money supply cause prices to rise leading to a lower real wage. As labour is demand determined in the short-run there is an increase in the labour supply, and ultimately an increase in output. When the economy is more open, i.e., when γ is smaller, monetary policy is less effective at increasing output although this has no impact on the reaction of the exchange rate.

II.4.2 Monetary policy in the presence of a liquidity effect

The prior section considered the case when liquidity effects are not a feature of the economy. In such circumstances, a positive money supply shock does not drive down the NIR. This simplification is too strong as foreign exchange rates are fundamentally determined in part by price levels and ergo also the money supply. The presence of liquidity effects is a more realistic assumption, thus consider the empirically more plausible case that money demand is interest inelastic and so positive money supply shocks do indeed drive down the NIR. Equations (53) and (56) form a two-variable system. From here, appealing to a diagrammatic analysis is useful because in this case the loci of points in (X_t, y_{Ht}) space is plottable. First, since aggregate supply is independent of the interest elasticity of money demand, ϵ, and $\alpha > 1$ along with the fact that $\gamma \in (0, 1)$, it follows that the slope of (53) is unambiguously positive in (X_t, y_{Ht}) space. But the interest elasticity of money demand determines the slope of the AD locus, i.e., equation (56). So when $\varepsilon = 1$, preferences are logarithmic over real balances, and aggregate demand is horizontal in (X_t, y_{Ht}) space. But with $\varepsilon > 1$ the AD curve slopes upwards. (See Figure 2.1 below.)

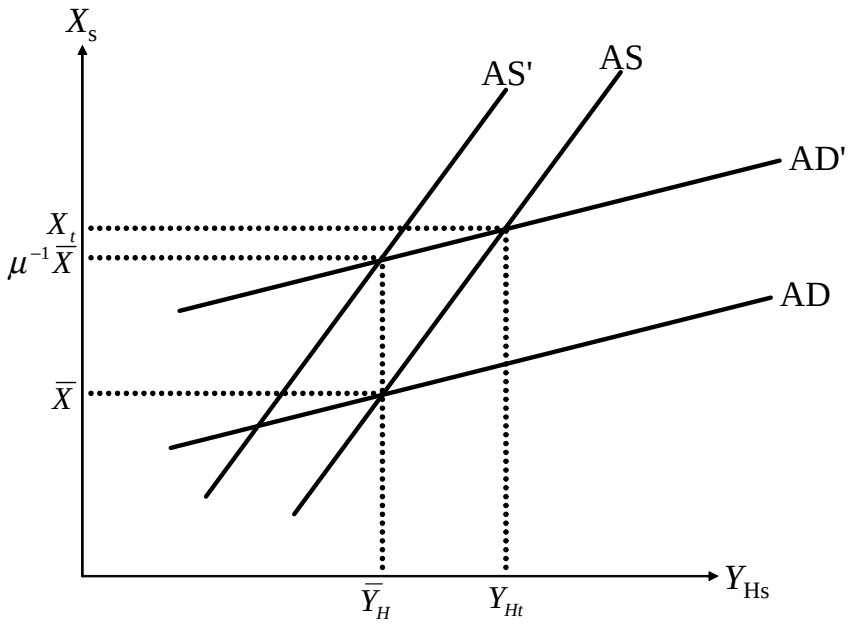

Figure 2.1. Monetary expansion has positive effects on aggregate demand, but the real side of the market adjusts to return output to its full-employment level.

Now to understand the effect of the monetary shock on the system as a whole, it is straightforward to see that an exogenous increase in the money supply shifts the monetary relation up. Again output is higher as wage costs are lower, but the shift in the aggregate demand curve also implies there is an additional change in the exchange rate. To evaluate the impact it is necessary to examine the immediate impact as well as the aftermath when variables are allowed to adjust to the shock. In the short run, the response of the exchange rate is more than proportional to the change in the money supply and X_t is greater than its long run level, given by $\mu\overline{X}$. The overshooting of the exchange rate is greater the lower is the sensitivity of money demand to changes in the interest rate (a higher value of ε) because in this case the

asset market compensates more and more for the distortion produced by the rigid money wage. As wages adjust and the economy reaches its new long-run steady state the AS curve shifts to intersect with AD$'$ and output returns to its natural rate level given by equation (52).

Now the model is in a poised to make a very strong statement about the verity of overshooting: *When the substitutability of real balances with consumption and labour, as defined by ε, is greater than one, the short-run exchange rate overshoots in response to a permanent unanticipated increase in the money supply.*

What should be the interpretation of this result? This is just the overshooting result of Dornbusch (1976), but set within a model of a small open economy with the nuances of this particular model. Note that when $\varepsilon > 1$, then the elasticity of money with respect to the exchange rate is greater than one:

$$\frac{\partial X_t}{\partial M_{t+1}} \frac{M_{t+1}}{X_t} > 1$$

This mechanism is present because the SOE assumption implies a difference in the the internal real interest rate versus the world (external) interest rate, $R_s \neq R_s^*$; and when $\varepsilon > 1$ the domestic RIR influences the NIR, altering the behaviour of the exchange rate when there is a change in the money supply. As output always rises with a monetary expansion, note again equation (69), and is uniquely related to the RER the real interest rate decreases. When $\varepsilon > 1$, the NIR also falls causing the exchange rate to overshoot by way of the uncovered interest parity condition.

This result can be more directly observed from simply looking at the AD curve (see Figure 2.1, page 129). Since output rises when there is an increase in the money supply it is sufficient to differentiate both sides of AD with respect to y_{Ht}. This produces

the following equation showing how the NIR changes with respect to infinitesimal changes in domestic output:

$$\frac{\partial i_t}{\partial y_{Ht}} = \frac{n\gamma\left(1-\varepsilon\right) i_t^{1-\varepsilon} y_{Ht}^{\gamma(1-\varepsilon)-1}}{\left[\varepsilon-\left(\varepsilon-1\right)/i_t\right]} \tag{70}$$

Note that $y_{Ht}^{\gamma(1-\varepsilon)-1}$ is positive since $i_t > (\varepsilon-1)/\varepsilon$ for $\varepsilon > 1$, and clearly the sign of the derivative depends only on the magnitude of the interest elasticity of demand. To verify these results if this is unity there should be no overshooting. Thus note that setting $\varepsilon = 1$ in (70) implies $\partial i_t/\partial y_{Ht} = 0$, but if $\varepsilon > 1$, then $\partial i_t/\partial y_{Ht} < 0$, and so that the NIR falls through an induced liquidity effect and so the exchange rate overshoots. This is just the much-famed overshooting result repackaged.

Of course the model is symmetric with respect to undershooting. That is, a permanent and unexpected decrease in the money supply has the mirror-image effect of inducing the exchange rate to fall below its long run level in the short run. This is true of the original overshooting model so long as money demand is sensitive to changes in output. As Rogoff (2002) notes, this is rather unrealistic, but the overriding difference between the model presented here (and this class of models in general) and the original Dornbusch (1976) model is that the interest elasticity determines the relationship between money demand and consumption, not money demand and output. Thus a swifter response may be more plausible.

II.5 Conclusion

What conclusions should be drawn form this exercise? The Mundell-Fleming approach assumes that wage rigidities allow monetary policy to affect output via the standard IS-LM model. But in an open economy the CPI is a function of both do-

mestic and foreign prices. The CPI changes even when domestic prices are rigid so that monetary policy has a direct link to prices via changes in the exchange rate (pass through). In a closed economy there is a one-for-one relationship between the real wage (nominal wage divided by the CPI) and aggregate supply. This is not necessarily true in an open economy because the output of domestic firms is determined by the nominal wage adjusted by the domestic price. Since monetary policy affects the terms of trade in this framework this means that different aggregate output levels are consistent with the same real wage. Finally, in the closed economy an increased money supply reduces the nominal interest rate; it also raises prices lowering the real wage, leading to an increase in output. In an SOE the foreign rate of interest is taken as given and thus increases in output come about through changes in the exchange rate and the mechanism by which output increases is different. In this model all three of these effects are clear because of the assumption of nominal wage rigidity and a goods market structure consistent with the Mundell-Fleming model.

Using the SOE assumption with import-export structure the resulting implication is that the exchange rate overshoots in response to a permanent unanticipated rise in the money supply when the interest (and consumption) elasticity of money demand is sufficiently low. This suggests the introduction of a traded-nontraded goods structure as in Obstfeld & Rogoff (1995) is *not* essential to generate the well known overshooting result. The Mundell-Fleming assumption of specialised outputs delivers the type of dynamics as in Dornbusch (1976) when using a fully-specified dynamic general equilibrium model.

This paper thus finds that the overshooting phenomenon is inherent even in countries without (or with a very small) nontraded goods sector. An SOE without a sig-

nificant nontraded goods sector still assumes the inherent volatility of floating rates that is known to be true of standard models of economies. Thus, with trade facing the inherent instability of an overshooting exchange rate a monetary authority needs to weigh the utilities of the trade sector against any increased efficiencies from a flexible exchange rate that is better fared to insulate against certain external shocks. Moreover, the predictability and confidence that are associated with a currency board by the market and, in particular, the trades sector, are vital to an open economy.

From a theoretic perspective it is reassuring to see that the Dornbusch result of overshooting is supported yet again with another model. On the other hand, such a result complicates the task of a central banker weighing the options of choosing between fixed versus flexible exchange rate regimes. □

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Chapter III

Credit rationing in a small open developing economy: The implications for monetary policy

III.1 Introduction

In 1997, almost immediately after Hong Kong's sovereignty returned to China from British hands, the Hong Kong dollar (HKD) came under immense pressure for devaluation.[1] At its height, the currency crisis in Hong Kong suffered a two-pronged speculative attack. On one front, Hong Kong's currency was sold short by speculators who inferred that the currency was overvalued – Hong Kong's price level had grown

[1] The return of Hong Kong's sovereignty to China, however, was not the catalyst for the downward pressure on Hong Kong's exchange rate. Instead, the problems in Thailand and Indonesia spread its ways to the rest of Asia through a phenomenon of "contagion". See, for example, Allen (2000) for the literature on contagion.

at a significantly higher rate than that in the United States since 1983, when it first pegged its currency to the greenback – or believed that the HKD would succumb to contagion from Thailand and Indonesia, as did other countries in the region. And in the equity market, speculators likewise took a short position, betting that the Hong Kong Monetary Authority (HKMA) would defend the HKD by raising interest rates and ultimately dampening stock prices. Either way, a bevy of financiers took a negative stake in the financial health of the special administrative region (SAR).[2]

In a highly unusual move for the HKMA, those that gambled against the Hong Kong economy were foiled by proactive measures of the monetary authority. The HKMA took the unusual step of thwarting the (rogue) traders by taking a long position on equities and keeping the interest rate fixed. This action, though successful in defending the peg (and which also netted the HKMA a tidy profit at the end), engendered a lot of criticism. The currency board, though intact, had lost some of its credibility as a rules-based, non-discretionary regime when it forayed into the financial markets as an active player. The actions of the HKMA, along with other unique features that define the institution (among which are that the HKMA more resembles a central bank than a currency board),[3] has garnered itself the title of an "unorthodox" currency board and its operating procedures have been a source of

[2] Whether George Soros was involved in selling against Hong Kong is still unclear, although Soros has repeatedly claimed absolvement with respect to the Malaysian ringgit, and for which even Dr Mahathir now accepts Soros' innocence.

[3] The HKMA is also far more advanced than its peers in that it pays its staff a salary more commiserate with the market. For example, Joseph Yam, the head of the HKMA draws an annual salary of $850k (serving a constituency of 7 million people), while Ben Bernanke earns $190k (serving a country of 300 million).

interesting research for academics and business people alike. It is within this setting that this chapter explores the dynamics of monetary policy in a small open developing economy (SODE).[4]

Ever a bastion of free-wheeling capitalism – although some would argue that the actions of the former British colony in defending the exchange rate were very interventionist (and rightly so!) – Hong Kong kept its capital markets open throughout the Asian crisis (1997-98) unlike, for instance, Malaysia under then-Prime Minister Mahathir. Countries, such as Malaysia (and Indonesia) imposed capital controls to stifle the efforts of speculators and to slow the withdrawal of capital out of the country. (In hindsight these were good policies for these countries given their circumstances.)

The 1997-98 crisis impacted a swathe of countries in Asia Pacific with various degrees of potency. For instance Indonesia, Korea, Malaysia and Thailand saw their currencies lose over half their values within a span of a few months at the peak of the exigency, while places such as Singapore and Taiwan had only mild exchange rate shocks; still, others such as China (and Japan) were immune from the effects. Beyond sharp depreciations in currency values, the crisis also induced severe recessions in many Asia Pacific countries, with output contracting, in some cases, by over 20 percent in one year (measured in dollar terms). As noted, the HKD survived unscathed (or at least without nominal adjustments) – thanks to the deep pockets of the HKMA, as reflected in its large foreign reserves[5] – nevertheless, the crisis did

[4] An SODE is a small open economy in economic transition. Oftentimes it also possesses one (or more) of the following characteristics: (*i*) Suffers from original sin; (*ii*) Has underdeveloped capital and/or financial markets; (*iii*) Subject to severe political corruption; (*iv*) Lacking in rule of law and/or institutions.

[5] As at February 2008 official reserves were over $160bn making the currency board a "super

actuate a severe recession and a long bout of deflation in the SAR.[6]

Managing the severity of the crisis became the number one task of many governments within the Asia Pacific region. South Korea, at one point on the verge of bankruptcy and collapse, implored its citizens to make sacrifices, such as donating their gold jewellery to the state to avert dissolution.[7] Political points were also to be gained by politicians who castigated the west for instigating the crisis.[8] Various actions were taken by governments to quell the financial panic including, *inter alia*, limiting convertibility of local currencies for hard currencies and restricting the movement of capital. Limiting capital mobility, however, is not the sole means by which governments can stem such a crisis. Credit channels – the ability to influence the banking sector by manipulating their liquidity and so affecting output through monetary policy – is also another means by which governments can sway the macroeconomic outcomes of economic policy. The trials of Hong Kong, and the experiences of other Asian nations during the crisis highlighted, among other things, the role of credit channels in influencing monetary policy within small open economies (SOEs)

currency board" in the sense that there were more dollars held in reserves than the equivalent amount of domestic currency circulated in the economy.

[6]The Asian crisis triggered the implosion of the Hong Kong real estate market. Land prices fell over 60 percent from their peak just before the onset of the crisis. It was this drop in real estate that led to the prolonged period of deflation in Hong Kong (Schellekens, 2003).

[7]Why some countires, such as Korea, chose to honour their debt while others, such as Argentina, chose to repudiate theirs is a study in contrast in sovereign debt commitments.

[8]A poignant note was the acrimonious diatribe by then-Prime Minister Mahathir Mohamad, who blamed George Soros and the west for the woes that befell his country. Aside from his vitriolic words, Mahathir, in hindsight, acted very wisely in placing capital controls to combat the crisis. Much was said at the time of the mismatch in timing between investor capital and government revenues, and his restriction in capital movement was beneficial in abating the crisis.

trying to retain fixed exchange rates.

Leading up to the Asian crisis most countries of east Asia maintained fixed exchange rates vis-à-vis the US dollar (USD). Chief among the countries that faced calamitous drops in their exchange rates were Thailand, Indonesia and South Korea – those with currencies tied to the US dollar. Taiwan and Singapore, which have (managed) floating exchange rates, experienced milder perturbations. (Although China also pegged to the USD it was not maligned by the Asian crisis because of the closed nature of its capital markets.) Indeed, given the crisis that consumed these countries it was interesting to see how they individually managed their respective crisis. For instance, Hong Kong held steadfast to its currency board and its fixed exchange rate, while in South Korea the won was allowed to shed over 70 percent of its value in a matters of a few months.[9] Moreover, there were many commentators who second-guessed the HKMA and its approach to the crisis. But given a commitment to a fixed exchange rate by the SAR, one wonders what leverage, if any, a central bank (or monetary authority) has in influencing monetary policy or what scope lies in the economic policies chosen by these institutions.

By standard accounts, monetary policy is impotent in a country with fixed exchange rates.[10] Or more precisely, monetary policy is, by virtue, mandated to accom-

[9] Images of South Koreans donating their jewellery to the central bank to stave off a national bankruptcy are one of the most enduring pictures from the Asian crisis. In a matter of weeks Korean output had shrank about one quarter. Since then, South Korea, as well as most other Asian nations, have amassed a hefty pool of international reserves within their central banks as insurance against such future calamities.

[10] Jay Shambaugh (2004) shows that even within floating arrangements monetary policy is not totally independent. However, he does find that pegging countries follow base country interest rates

modate the country's external balances. If interest rates in the pegging country are high relative to the pegged country then the country experiences capital inflows; if it is low relative to the pegged country it experiences capital flight. Either way, whenever the rates are not equal – minus any differences for political and country-specific risk – then there will be an external balance.[11] And thus monetary policy is forced upon the pegging authority, namely to provide as much liquidity as is necessary to abate the flow of capital from the country. This is, after all, the standard theory espoused in any undergraduate textbook in international economics, and which was most eloquently argued by giants in the field such as Robert Mundell[12] and Marcus Fleming. In the IS-LM-BP world envisioned by the pair, monetary policy was not a tool at the disposal of policy makers in countries with fixed exchange rates. Yet real-world economies are not as simple as their example would dictate. (Of course they made no claims of such and it is well understand that models are just abstractions of the real world.)

The tools available to central banks to influence the economy are varied. Consider the case of Singapore, where the Monetary Authority of Singapore (MAS), which operates as the de facto central bank for the small open economy of Singapore, imposed credit ceilings on banks and finance companies, in tandem with selective credit guide-

more so than non-pegging countries.

[11] This is an (uncovered) interest parity condition: $i_t = i_t^* + E_t\left(s_{t+1} - s_t\right) + \phi = i_t^* + \phi$ by virtue of the spot rate being fixed, although there is no claim made herein whether this condition actually holds for Hong Kong, although Khor Hoe Ee (2006) claims it holds for Singapore.

[12] Mudell would in 1999 be recognised by the Swedish Academy of Sciences for his contributions and insights into monetary economics. The Nobel committee cited him "for his analysis of monetary and fiscal policy under different exchange rate regimes and his analysis of optimum currency areas."

lines during the Asian crisis. So monetary authorities do have some control over the tools of monetary policy at their disposal, even at times of difficulty. Singapore's actions also proved to be highly successful: The city-state managed to avoid a serious economic contraction and also averted high levels of inflation (or deflation) or prolonged underemployment. So credit controls, whether they be voluntary (by banks acting optimally withholding credit to bad customers) or by moral suasion or even direct intervention by a central bank, remain an important means of effecting monetary policy and the stability of an exchange rate. Ultimately, what is desired is to understand the role of credit and credit channels in the transmission of monetary policy and the interplay of capital markets in affecting economic policy and what macroeconomic factors condition the scope for monetary management. On the aspect of credit channels in monetary policy, Bernanke (1993) and Hubbard (1995) are two early papers that explore this topic. Nevertheless, their early works ignore the implications of a capital market impeded by imperfect information. However, as will be shown, in a world with a plurality of investment options, imperfect substitutability between assets gives rise to a role for central banks in an SOE, especially when the loan market is constrained, as will be explained in this paper.

The general consensus in economics is that within an SOE with international capital mobility and a fixed exchange rate, monetary policy is ineffective in affecting real output. Any undergraduate textbook in international economics (e.g., Krugman & Obstfeld, 2003) will drive this point home. The reason being because with fixed exchange rates and capital mobility money supply loses its role as a nominal anchor in the economy.[13] Under the traditional view of money, the interest rate is the

[13]The logic of money being impotent in the face of fixed exchange rates and capital mobility is

only conduit through which monetary policy (as well as monetary shocks) affects the real side of the economy.[14] As a consequence, when the monetary authority commits to a fixed exchange rate, the ensuing foreign exchange intervention by the monetary authority to maintain the peg necessarily washes out any real effect of the monetary policy it had previously initiated. This is simply the result of the central bank buying or selling official foreign reserves that end up sterilising the original position. Nevertheless, this view is not rigid. For example, Svensson (1992) shows that fixed rates do not necessarily imply that the monetary authority surrenders monetary sovereignty in the case where bands – even be they very small – can restore significant leeway for a central bank to conduct independent policy.

The traditional IS-LM models, however, take a different approach. Under this view, the role of bank liabilities and bank loans garner far too much attention as key drivers in the literature on SOEs. Herein, with orthodox IS-LM models, banks are passive with respect to economic outcome in the sense that they have no active leverage to play with other than influencing the interest rate via manipulating deposits, which are at the same time a monetary asset and bank liability. As such, the role of bank loans is not clearly distinct since bank loans are amalgamated together with other non-monetary assets such as bonds. But such an assumption may have non-innocuous ramifications if loans and bonds are asymmetric in their value to banks. It is on this point that this paper will elaborate and demonstrate that this result can affect monetary policy.

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most eloquently espoused in the works of Fleming (1962) and Mundell (1963).

[14] It is also worth noting that the interest rate channel of monetary policy is highly correlated with exchange rates.

In contrast with the strict monetary view, the credit view of monetary transmission mechanisms provides a major theoretical underpinning of the efficacy of monetary policy under fixed exchange rates. Under such a view, the notion that all non-monetary assets are perfect substitutes are overturned in favour of imperfect asset substitutability. According to the credit view, information asymmetries between borrowers and lenders in financial markets act as a transaction barrier. Indeed, the friction in the loans market is the *raison d'être* of financial intermediaries, namely banks. Herein banks play a role in reducing information costs and absorbing risk. This is a logical and reasonable assumption: Quite a number of firms are, in fact, bank dependent because of the risk-sharing, liquidity and informational services that financial intermediaries provide. Furthermore, according to the credit-view literature, an increase in the loan rate, *ceteris paribus*, raises the bank's expected return by increasing interest payment when the borrower is solvent, but lowers it by raising the probability of default. Consequently, because of the competing effects, the bank's loan supply curve *can* become backwards bending and credit rationing *may* occur as an equilibrium phenomenon when the default rate is sufficiently high.[15]

An essential point of this paper is that the loan market is complicated by asymmetric information on the part of banks and investors. It is within this context that a micro-foundation for investment is built. Then this paper develops a macroeconomic model of an SOE under a regime of fixed exchange rates with perfect capital mobility

[15] The seminal works in this field are Stiglitz & Weiss (1981), who provide information-based analysis of equilibrium credit rationing. Blinder & Stiglitz (1983) further argue that monetary policy works via bank credit. This is because there are no close substitutes for bank credit, at least as it concerns most medium and small firms where economic and financial risks are relatively high. Kashyap & Stein (1993) provide a comprehensive review of the credit-view literature for the interested reader.

(PCM) in the bond market, but with imperfect substitutability between bonds and loans. The difference in the fungibility of the assets rests on information asymmetries (or alternatively a risk premium in lending) and is a good reflection of real-world markets. This is the essential driver of the model because this means that for borrowers taking a loan or issuing a bond are not perfectly equivalent. And if a further restriction of non-negativity in bond holdings is applied this develops a framework where monetary policy has implications for an SOE. While bonds can be traded on international markets, loans often must be made by local banks with specialised knowledge (e.g., HSBC runs an advertising campaign calling itself the "world's local bank"). This restriction is very natural and arises because of, say, banking restrictions imposed by third parties. This may be the case when regulators require banks to set aside different amounts of capital for various facilities due to differences in accounting for risk structures, expected losses or other technical reasons.[16]

With regards to the way that credit enters the picture, this paper follows the line of Bernanke & Blinder (1988) in the sense that, similar to them, this paper addresses the credit channel of monetary policy in a variant of the IS-LM framework. But this piece differs markedly from their work on several aspects; in contrast to Bernanke & Blinder, the model in this paper incorporates the possibility of equilibrium credit rationing while maintaining the assumption of imperfect substitutability of bank loans and bonds.[17] Furthermore, although credit rationing is not a necessary assumption for

[16] It is also of note that the Basel accords (both Basel I and Basl II) treat bonds isssued by commercial banks differently than comparable bank loans.

[17] The impact of imperfect asset substitutability on monetary policy in economies with fixed exchange rates was explored by Obstfeld (1979). In his analysis the imperfect substitution rested between bonds denominated in different currencies.

investigating the distinct role of credit, it does take place under some circumstances when customer market credit becomes indispensable. And while credit rationing does enter the picture for the model, the conclusions of this paper are primarily resultant from the asymmetry of loans and bonds and how banks respond to economic policy in an SOE framework. Given imperfect substitutability between bonds and bank loans, this paper examines several scenarios where monetary policy can be conducted in a world of PCM and fixed exchange rates. First the case where credit is rationed and not rationed give rise to equilibrium regimes within the framework of a risk premium in lending. However, to properly tackle the issue of monetary policy it is also necessary to introduce a (natural) constraint on the balance sheet of banks, which then opens the door for monetary policy, per se. As discussed earlier, this constraint is simply that banks cannot issue their own bonds. This restriction is not entirely realistic as some big banks can indeed issue bonds; nevertheless, suppose that this restriction holds.[18] Additionally, by placing the credit channel of monetary policy in a setting of an SOE, this paper allows the possibility to explore the relevance of the monetary policy-ineffectiveness proposition. This idea of monetary ineffectiveness represents the status quo thought of the current SOE literature.

Now by incorporating bank credit into an SOE with fixed exchange rate two fundamental changes ensue. First, it extends the scope of monetary policy to affect the economy from standard interest rate channel to the one that includes both the

[18] Big banks do issue their own bonds, but this is highly unlikely for developing market banks, which by most measures (e.g., total assets) are only a fraction of the size of banks domiciled in mature markets. Moreover, even in the case where big banks issue their own bonds the credit rating on their bond offerings are capped at a sovereign ceiling (and often lower than the sovereign in which they are domociled) so that these papers may be viewed as different from a riskless bond.

bank-lending channel as well as the balance-sheet channel. (What makes this point interesting is that the latter two pipelines are often non-related to changes in interest rates.) Second, and more importantly, monetary policy is no longer seen as impotent since it can directly shift the goods market as well as the money market equilibrium schedules in such a way that the targeted real effect could be achieved while the fixed exchange rate is sustained. But this rests not on direct open market operations, but rather through discount window lending and/or relying on a balance-sheet constraint on bank lending. Accordingly, thanks to the credit availability channel, money in the fixed exchange rate model will not be a completely endogenous variable.

In a similar vein, Christiano & Eichenbaum (1992) look at the impacts of credit rationing as they relate to liquidity effects and the monetary transmission mechanism. They note that it is possible that positive money shocks generate long-lasting, quantitatively significant liquidity effects, as well as persistent increases in aggregate economic activity. This is consistent with Zeira (1991), who explored the fiscal impacts on open economies in the presence of credit rationing. What differs here, however, is that this paper considers the monetary side of the macroeconomy and the credit constraint here comes, not from individuals, but rather banks and their balance sheets. And as in Zeira, the role of credit market imperfections is the driver behind the non-standard macroeconomic outcomes.[19] Yet another interesting perspective is Denisova (2000) who writes an interesting take on Russia's post-communist experience with a two-sector model from the perspective of "asymmetric credit rationing", defined as uneven degrees of credit rationing between the two sectors of the econ-

[19] Zeira's (1990) paper demonstrated how imperfect credit markets and lumpy investments could lead to a separating equilibrium.

omy. She concludes that monetary policy and, in particular, how it was transmitted through underdeveloped credit channels in Russia exacerbated the post-communism economic downfall of the country.

An alternative and popular approach to addressing credit channels in monetary policy is rooted in the work of Bernanke, Gertler & Gilchrist (1999) who use a financial accelerator model to amplify economic shocks through credit market frictions.[20] This seminal work incorporated money, price stickiness and heterogeneity of firms (to account for differing access to capital markets) and showed that under such a system that the financial accelerator can have large impacts on the business cycle. Taylor (2000) surveys the literature on the view taken by the profession on the means of exactly how the monetary transmission mechanism influences the choice of monetary policy rules chosen by a central bank. He compares the "credit" view with the "financial market price" view and concludes that from either perspective a policy of stabilising output and inflation performs well. A work closer in spirit to this one can be found in Bracoud (2000) who examines the impact of credit rationing on monetary policy and finds that in such a case, "monetary policy is transmitted through quantities." Finally an empirical test of credit rationing and its impact on monetary policy can be found in Afonso & Aubyn (1998) who examine the case of Portugal and do not find conclusive evidence of credit rationing in Portuguese banks.

The remainder of Chapter 3 of this dissertation is divided into four parts. Section III.2 presents the analytical structure of bank behaviour and the credit market. Section III.3 looks at how credit market conditions pin down macroeconomic equilibrium

[20] This model was a hot topic in 2008 as the credit crisis unfolded and banks began pulling back credit.

in an SOE within the IS-LM framework. Section III.4 demonstrates the real impacts of monetary shocks through the credit channel. Finally, Section III.5 concludes and offers some thoughts on policy.

III.2 Banks and the credit market

One normally thinks of supply curves for a good as upwards sloping. This standard assumption derives from the fact that, *ceteris paribus*, at higher prices, firms are willing to supply more of a good. In the case of loans, however, an increase in the price of loans – i.e., the interest rate on loans – does not necessarily induce greater supply. In particular, at higher interest rates the buyer market for loanable funds changes, so that the *ceteris paribus* clause is not ensured. Higher interest rates are likely to attract a pool of demanders of loanable funds who are more likely to default on their loans. This is the classic adverse selection or "lemons" problem,[21] whereby the higher default ratio on debt swamps the increased revenue associated with a higher interest rate, thus leading banks to withhold loans to some people, even as they are willing to pay the going rate for loans. This phenomenon may lead to the presence of a backwards bending supply curve for bank loans (see Figure 3.1 on page 153). This outcome is well known and is often explained as a result of credit risk associated with adverse selection and moral hazard, whereby some borrowers ("subprime"?) are willing to borrow at high rates precisely because they are likely to default.

[21] See Akerlof's (1970) seminal work on why the used car market may fail to appreciate the terminology of "lemons".

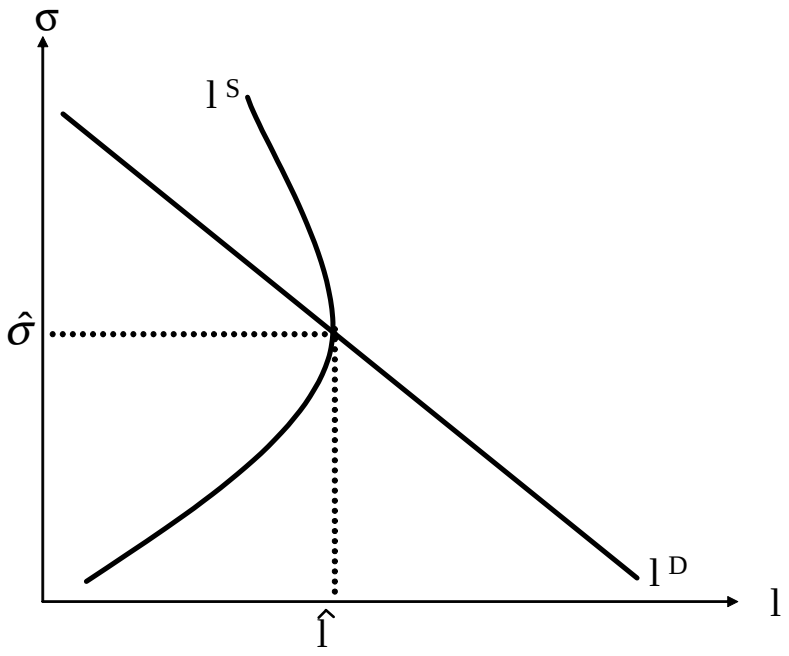

Figure 3.1. The familiar backwards-bending loan-supply curve under the case when an increase in demand actually leads to a lower level of loans brought to market.

In what follows, a simple model of bank behaviour, based on Lewarne & Waller (1994), gives rise to the efficacy of monetary policy, even under fixed exchange rates and mobile capital markets. Underlying this is the assumption that the domestic loan market is serviced by local banks as they possess specialised knowledge about the local market. The major modification in this paper is by expanding the selection of bank investments into the portfolio choice between bonds and loans. This is a natural place to extend established models that seem to ignore the importance of portfolio management (i.e., asset allocation) on the part of banks. The core business of commercial banks remains lending, i.e., making loans, but the purchase of bonds

by banks is also a major function of banks in financially mature economies, and even in some developing ones. Indeed, so-called "open market operations", or OMO for short, is a tool whereby central banks can influence the monetary supply by inducing commercial banks to either absorb or provide liquidity to the market by acting as a buyer or seller of bonds and other government securities. It is through this behaviour that central banks are most able to influence the money supply in an economy. Nevertheless, OMO is not the only means for the central bank to steer the volume of the money supply and thus ultimately the market interest rates. For instance, moral suasion and changes in the reserve requirement of banks, as well as other forms of legislation on bank capitalisation and last-resort lending, are also effective ways to influence the money supply. The last method of the list is better known as discount window lending. This is the rate at which the central bank or monetary authority lends to commercial banks, usually on a last-resort basis (and usually at a punitive rate).[22] And as will be shown, this can be a very vital component of monetary policy in an SOE with fixed exchange rates. The effectiveness of discount window lending will also depend on whether banks are constrained from lending due to external pressures and the presence of a vertical supply of funds, as determined by deposits (see Figure 3.4 on page 176).

This paper attempts to convince the reader that the existence of a loan market in a setting of a balance sheet constraint on banks can create a relationship between the money supply and economic activity, even if there exist PCM in the bond market. In turn this opens the possibility that monetary policy in an SOE with fixed exchange

[22] However, in the credit crisis of 2008 the discount window attained a stigma of a "desperation window" as parties using Fed credit were perceived as financially weak by their peers.

rates retains efficacy. Management of discount window lending and bank reserve requirements are thus the tools used to effect monetary policy in an SOE with fixed exchange rates.

It is also assumed herein that firms – who are in need of money to finance their investments – cannot issue commercial paper. That is, they cannot sponsor their own investments by issuing debt; instead, if they wish to borrow they must do so through banks. This view is taken in light of the informational asymmetry between borrowers and investors: The rate at which it is profitable for firms to borrow is exceeded by the rate at which investors demand in return for financing their projects because of imperfect knowledge of the riskiness of projects by investors. In that sense, banks act as intermediaries, smoothing out the friction of the financial market. Thus banks are thought of us empowered with the ability to overcome the informational friction that would otherwise impede a market, since they are able to monitor and assess the projects of firms because of their size and devotion to that market. And this is precisely why the domestic loan market is serviced by local banks. Since bank lending is dependent on information, which is costly to obtain, only those banks with a local presence can properly assess the specialised conditions of the market.

In the model below, the representative banking firm is assumed to lend out all excess reserves. This is a consequence of the bank's profit maximising nature: Excess reserves do not add to the bottom line of the bank. Consequently the bank allocates all of its excess reserves between the two bank assets, bonds and loans. Thus, it chooses loans, ℓ, subject to its balance-sheet identity, that the sum of bonds and loans is supported by the reserves it is legally obliged to hold. Thus the bank faces a

simple profit maximising function restricted to its choice of loans:

$$\max_{\ell \in \mathbb{R}_0^+} \pi(\ell) = p(\sigma)\,\ell\sigma + b_b i - \delta i - \frac{\theta}{2}\ell^2 \tag{1}$$

$$\text{s.t.} \quad b_b + \ell = (1-\kappa)\,\delta \tag{2}$$

The variables are defined as follows: $p(\sigma) \in [0,1]$ is the probability of loan repayment; this in turn depends on the loan rate, $\sigma \geq 0$, expressed in percent; $b_b \geq 0$ denotes bonds held by the banking firm; $i \geq 0$ is the interest rate on bonds (of which, only one simple bond exists in the universe of investments); $\delta \geq 0$ represents total deposits (an exogenous variable); $\theta > 0$ is the cost parameter of servicing loans; and $\kappa > 0$ is the required reserve ratio for deposits. Here, the low-risk or risk-free interest rate on bonds is assumed to be the same as the interest cost of taking in deposits.[23] Thus, deposits and bonds are perfectly substitutable assets to depositors, so that they pay the same per-dollar expected return. But, as will be demonstrated later, banks do not perceive these two assets to be perfectly substitutable, and this gives rise to an interesting result on bank behaviour. Also note that equation (2) is properly defined in terms of a weak inequality, but since excess reserves do not add to income, whereas b_b always pays a safe positive rate of return – even if loans might represent a bad investment (negative return) in the face of a backwards bending loan-supply curve due to default risk – the safe option of bonds guarantees that the balance sheet identity holds as an equality. Finally, the assumption that $b_b \geq 0$ has strong consequences for the model which will be made clear when considering the different

[23] The risk-free rate is usually taken as the rate at which the central bank, acting on behalf of the government, borrows from the public. Such debt is free from the risk of default when fiat money is costless to print. (Such a negation of default risk is not present when governments borrow in the financial markets in foreign currencies.)

equilibria outcomes and becomes a defining characteristic for determining the role that a monetary authority has in affecting economic policy. When banks cannot issue bonds, then in the case where $b_b = 0$ this balance-sheet restriction gives rise to scope for monetary management.

The key characteristic of the bank profit is the nature of dependence of the repayment probability on the loan rate, σ. In line with the existing conventional literature on equilibrium credit rationing, an increase in the loan rate makes it more likely for borrowers to default; hence, the repayment probability is a decreasing function of the loan rate (after some threshold level).[24] The representative bank takes the flow of deposits as given when making its portfolio decision. Substituting the restriction equation (2) into the optimisation equation yields an unrestricted maximisation problem

$$\max_{\ell \in \mathbb{R}_0^+} \pi(\ell) = p(\sigma)\,\ell\sigma + ((1-\kappa)\,\delta - \ell)\,i - \delta i - \frac{\theta}{2}\ell^2 \tag{3}$$

The first order condition (FOC) is

$$p(\sigma)\,\sigma - i - \theta\ell = 0. \tag{4}$$

This gives rise to the (individual) banking firm's loan supply curve, denoted here with an S superscript (and indexed by $j \in J$ to reflect that this is just one of many firms

[24] Stiglitz & Weiss (1981) show that the loan rate and intermediary charges may have dually an adverse selection effect and a moral hazrad effect on the overall risk of a loan pool. In such a case, raising the loan rate shifts the mix of borrowers to riskier ("subprime") clients and unto projects financed by such loans to them. This reduces the expected return to the lender. Consequently, the intermediary may try to maximise profits by choosing an interest rate that actually results in excess demand for bank credit.

in the economy, but this is omitted to not obscure the analysis):

$$\ell^S = \frac{p(\sigma)\,\sigma - i}{\theta} \tag{5}$$

The derivative of the loan supply curve with respect to the loan rate is

$$\frac{\partial \ell^S}{\partial \sigma} = \frac{1}{\theta}\left[p'(\sigma)\,\sigma + p(\sigma)\right] \tag{6}$$

Now several implications of the loan supply curve can be derived. First, and most importantly, the loan supply curve, in (l, σ)-space, *can* be backwards bending (see Figure 3.1, page 153), and this happens precisely when $(dp/d\sigma)/(p/\sigma) < -1$, which is just a simple statement of elasticity of repayment with respect to the interest rate. This coincides with the prior assumption of higher lending rates leading to adverse selection in the market for loanable funds. Moreover, this is consistent with the problems of moral hazard in lending.

The co-movement of the loan rate and loan volume depends on the elasticity of the odds of repayment with respect to the loan rate. Only when the repayment probability is inelastic can there exist a positive relationship between the loan rate and loan volume. To be specific, consider a linear repayment probability $p(\sigma) = \eta - \Psi\sigma$,[25] where $\eta \in (0, 1]$ is the autonomous repayment probability determined by non-interest factors such as the liquidity of balance sheet positions, and $\Psi \geq 0$ measures the sensitivity of of the repayment probability to the loan rate. Figure 3.2 (page 159) depicts the loan-repayment probability function.[26] Facing the linear loan repayment probability function, the loan volume supplied increases with the loan rate until the

[25] The linear repayment probability poses a few technical challenges but is helpful because of its general simplicity and is used just as an expository tool.

[26] The same qualitative results would follow for any repayment probability that is negatively related to σ, or in the case where the $p(\bullet)$ is differentiable, for $p'(\sigma) \leq 0$.

loan rate achieves $\frac{1}{2}\eta/\Psi$; after that, a higher loan rate actually reduces the loan volume. That is, $\widehat{\sigma} = \frac{1}{2}\eta/\Psi$ is the solution to the maximisation problem below:

$$\max_{\sigma \in \mathbb{R}_0^+} \frac{(\eta - \Psi\sigma)\,\sigma - i}{\theta} \tag{7}$$

where the optimisation is chosen with respect to the loan rate, assumed to be non-negative.

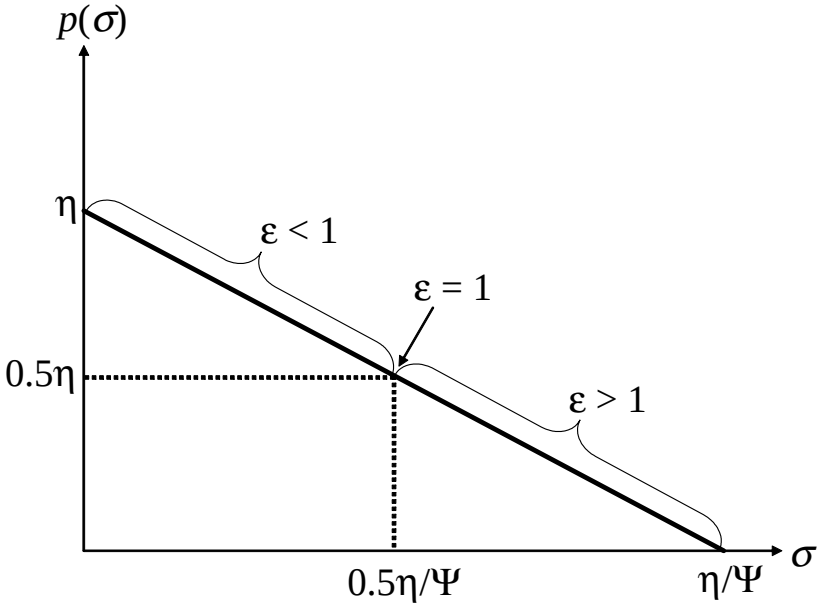

Figure 3.2. A simple linear odds of repayment graph.

In Figure 3.2 (above), the loan rate at which the loan supply curve begins to bend backward points to the repayment probability halfway to its maximum in the possible range. This is because the curve is inelastic, $\varepsilon \equiv [\partial p(\sigma)/\partial\sigma] \cdot \sigma/p < 1$, for $\sigma < \frac{1}{2}\eta/\Psi$, which then implies that profitability can be increased by increasing the loan rate (σ). Just as much, along the elastic portion of the curve ($(p(\sigma), \sigma)$ for $\sigma > \frac{1}{2}\eta/\Psi$) profitability in lending is increased by decreasing σ. And so it is follows that at the point where $\varepsilon = 1$, which corresponds with the value $\sigma = \frac{1}{2}\eta/\Psi$, that

banks are lending optimally. When the probability of repayment, as a function of the loan rate, is relatively insensitive to the loan rate, this means that it is profitable for the bank to continue lending. However, in the converse, when repayment is sensitive to the loan rate, then it is not profitable for the bank to continue lending since higher rates also induce higher levels of default and the default factor outweighs the higher loan rate.

Now to ascertain some properties of the loan supply function substitute $p(\sigma) = \eta - \Psi\sigma$ into equation (5) and differentiate this expression with respect to the arguments i, η, Ψ and θ. This produces other results related to the responses of loan supply to parameters of servicing loans.[27] These results can be summarised with the following derivatives (which are assumed to exist as $\ell^S(\bullet)$ is the composition of continuous and differentiable functions):

$$\frac{\partial \ell^S(i,\eta,\Psi,\theta;\sigma)}{\partial i} = -\frac{1}{\theta} < 0 \tag{8}$$

$$\frac{\partial \ell^S(i,\eta,\Psi,\theta;\sigma)}{\partial \eta} = \frac{\sigma}{\theta} > 0 \tag{9}$$

$$\frac{\partial \ell^S(i,\eta,\Psi,\theta;\sigma)}{\partial \Psi} = -\frac{\sigma^2}{\theta} < 0 \tag{10}$$

$$\frac{\partial \ell^S(i,\eta,\Psi,\theta;\sigma)}{\partial \theta} = -\frac{[(\eta - \Psi\sigma)\sigma - i]}{\theta^2} < 0 \tag{11}$$

Equation (8) says an increase in the bond interest rate, i, *ceteris paribus*, makes holding onto bonds more attractive; accordingly, banks will reoptimise their portfolio by reducing loans and holding more bonds. Another interpretation of the decrease of bank loans is based on the equivalence between the bond interest rate and the

[27] Note that $p(\sigma)$ is interpreted as a probabilty of repayment, not a probability density function, so that in particular the area under its curve is not unity. What is true, however, is that the probability of default is, by definition, $1 - p(\sigma)$.

deposit rate. The higher is the interest expense of raising loanable funds by issuing deposits, the higher the economic cost of making loans. Equation (9) says banks tend to issue more loans when the (autonomous) repayment probability, η, is higher due to the stronger liquidity-of-balance sheet positions on the part of borrowers. Equation (10) says the larger the sensitivity of the repayment probability to the loan interest rate, Ψ, the more deteriorating the problem of adverse selection and moral hazard. Thus, it is more likely for credit rationing to be employed. Finally, the last of the above equations (11) says an increase in the cost of servicing loans, θ, tends also to reduce loans as the expected return per dollar of loans exceeds the corresponding real opportunity cost.

Given the linear form of the probability of default function, $p(\sigma) = \eta - \Psi\sigma$, as well as the functional form for the (individual) bank's loan supply curve, $\ell^S = [p(\sigma)\sigma - i]/\theta$, it is possible, then, to write the representative bank's profit function as an argument of the loan rate:

$$\pi(\sigma; \bullet) = (\eta - \Psi\sigma)\left[\frac{(\eta - \Psi\sigma)\sigma - i}{\theta}\right]\sigma + b_b i - \delta i - \frac{\theta}{2}\left[\frac{(\eta - \Psi\sigma)\sigma - i}{\theta}\right]^2 \tag{12}$$

The above expression is a quartic expression in the loan rate. As such, finding the optimal level for σ is a straightforward exercise in calculus. Taking the derivative of the profit function π with respect to σ and applying the envelope theorem – which allows the interest rate to be considered as a constant since small changes in σ have no effect on i at an optimum – gives the representative bank's marginal profit function as a third degree polynomial in σ:

$$\frac{\partial\pi(\sigma)}{\partial\sigma} = \frac{1}{\theta}\left[2\Psi^2\sigma^3 - 3\Psi\eta\sigma^2 + \left(2\Psi i + \eta^2\right)\sigma - \eta i\right] \tag{13}$$

The expression on the right-hand side (RHS) in brackets is a cubic that, when $\Psi \neq 0$,

generates three roots. But two of these roots are degenerate in the sense that their values imply an outcome where loans are zero.[28] The only non-trivial solution for the marginal profit, then, is $\widehat{\sigma} = \frac{1}{2}\eta/\Psi$, which is the solution for *maximising* the bank's profit function.[29] Recall that the bank's loan supply curve peaks exactly at the same value of σ as the profit-maximising loan rate $\widehat{\sigma}$ found above. Therefore, the result is illuminating for equilibrium credit rationing: Banks will hold back making loans even to firms that are willing to pay a rate as high or higher as other firms that have similar loans because making more loans actually eats into profits. Furthermore, the result for profit maximising loans also imply that the loan interest rate exceeds the bond interest rate such that $\sigma > \sqrt{i/\Psi} > i$ (for $\Psi/i < 1$, i.e., for when the sensitivity of the repayment probability to the loan rate is less than the interest rate on bonds). This indicates a risk premium of bank lending – i.e., that the loan rate, the rate at which the bank lends to firms, exceeds the rate at which is paid on bonds (or deposits) – and therefore bonds and loans are no longer perfectly substitutable. As these assets are not perfectly fungible, this means that local banks must be providers of local loans, even as bonds are tradeable in the global market. This point then makes explicit the idea that under credit rationing a friction arises in the financial markets. Moreover, such a relationship implies that the sensitivity of loan repayment to the loan rate, Ψ, is less than the inverse of the interest rate.

[28] For $\Psi \neq 0$ the roots for the cubic are $\left\{\frac{1}{2}\eta/\Psi, \frac{1}{\Psi}\left(\frac{1}{2}\eta - \frac{1}{2}\sqrt{-4i\Psi + \eta^2}\right), \frac{1}{\Psi}\left(\frac{1}{2}\eta + \frac{1}{2}\sqrt{-4i\Psi + \eta^2}\right)\right\}$ The solutions $\frac{1}{\Psi}\left(\frac{1}{2}\eta - \frac{1}{2}\sqrt{-4i\Psi + \eta^2}\right)$ and $\frac{1}{\Psi}\left(\frac{1}{2}\eta + \frac{1}{2}\sqrt{-4i\Psi + \eta^2}\right)$ each imply a loan supply of zero as can be seen by substituting these values of σ into $\frac{(\eta - \Psi\sigma)\sigma - i}{\theta}$. When $\Psi = \eta = 0$ the cubic has no real solution. When $\Psi = 0$ and $\eta \neq 0$ then the solution is i/η.

[29] To check that the solution is indeed a maximisation one should calculate the second derivative of $\pi(\sigma)$ and evaluate it at $\sigma = \sigma^*$.

The preceding work demonstrated the individual bank's behaviour. Now consider the macroeconomic view. Since the above analysis was for a generic bank it is possible then to consider an outcome where all banks are assumed to be identical, and in that way it is possible to examine the aggregate outcome when the N identical banks arrive at symmetric equilibrium. That is, consider the case where $\sigma_1 = \sigma_2 = \cdots = \sigma_{\dot{N}}$. The aggregated bank balance sheet identity is thus given by

$$B_b = \Delta - \mathcal{L} - R \tag{14}$$

where $B_b = \sum_{j=1}^{N} (b_b)_j$ are bonds held by banks, $\Delta = \sum_{j=1}^{N} \delta_j$ represents total deposits, and $\mathcal{L} = \sum_{j=1}^{N} \ell_j$ is the aggregate volume of loans. Also, note that R represents the monetary authority's liabilities (high-powered money, H), which are generated by its acquisition of bonds and foreign exchange. The monetary authority's reserve identity – its control of high-powered money – is then just the sum of bonds and foreign reserves:

$$H = B_m + F \tag{15}$$

This identity is referred to often and thus worth further thought. Explicitly, B_m are bonds held by the monetary authority or central bank (as distinct from bonds held by commercial banks), and F is the central bank's net holding of foreign liquid assets, namely foreign currency and foreign liquid bonds. High-powered money in this simple policy framework is composed exclusively of required reserves. Alternatively, money can be expressed as a multiple of high-powered money, with the multiple being the inverse of the required reserve ratio: $\frac{1}{\kappa} H$.[30]

[30] This result assumes all excess reserves to be fully lent which, as stated earlier, is presumed to be true of the model.

Aggregating over the representative bank's supply of loans specified in equation (5) generates the total supply of loans $\mathcal{L}^S = \sum_{j=1}^{N} \left(\ell^S\right)_j$. A structural view of the aggregated balance sheet of banks suggests that if banks allocate a fraction of their disposable deposits (that is, deposits not subject to the reserve requirement) into loans and the remainder into bonds, then aggregate supply of loans is given by $\omega \cdot [(1-\kappa)\, H/\kappa]$, where ω represents the ratio of loans to disposable deposits. Accordingly, the fraction of loans in disposable deposits must characterise banks' loan-making behaviour and it is thus actually a function of the same set of variables that determine aggregate supply of loans:

$$\mathcal{L}^S = \omega\left(\sigma, r, \eta, \Psi, \theta, N\right) \frac{1-\kappa}{\kappa} H \tag{16}$$

The function $\omega\left(\bullet\right)$ is characterised by the following set of derivatives:

$$\omega'_{\sigma}\left(\sigma, i, \eta, \Psi, \theta, N\right) \lessgtr 0 \tag{17}$$

$$\omega'_{i}\left(\sigma, i, \eta, \Psi, \theta, N\right) < 0 \tag{18}$$

$$\omega'_{\eta}\left(\sigma, i, \eta, \Psi, \theta, N\right) > 0 \tag{19}$$

$$\omega'_{\Psi}\left(\sigma, i, \eta, \Psi, \theta, N\right) < 0 \tag{20}$$

$$\omega'_{\theta}\left(\sigma, i, \eta, \Psi, \theta, N\right) < 0 \tag{21}$$

$$\omega'_{N}\left(\sigma, i, \eta, \Psi, \theta, N\right) > 0 \tag{22}$$

Recall it was assumed that bank credit is the only debt instrument for firms to finance their investment; and here it is further structured that investment demand and demand for bank loans are taken to be equal.[31] Thus, the aggregate demand for

[31] More broadly speaking, the demand side of the loan market is influenced by two interest rates – that on bonds and loans. Additionally, aggregate income influences this side of the market. See, for example, Bernanke & Blinder (1988) on this topic.

loans is negatively related to the loan interest rate, and its standard linear form is

$$\mathcal{L}^D = \zeta - \xi\sigma \tag{23}$$

for parameters ζ and ξ that are real positive numbers. Indeed, as demonstrated by the existing literature on markets in disequilibrium, the loan market may or may not be at the market-clearing equilibrium depending on the relative magnitudes of $\mathcal{L}^S$ and $\mathcal{L}^D$.[32] Nevertheless, contrary to the model of disequilibrium economics, the loan quantity traded in the market is not uniformly characterised by the minimum of demand and supply sides. Instead, and herein lies a fundamental point of the paper, loan rationing arises in an unrestricted market setting impaired only by asymmetry in information between lenders and borrowers. So what is the consequence of this phenomenon? The answer is that the loan rate can always freely adjust to a level consistent with market forces driven by the profit-maximising incentives. Therefore, credit rationing could exist at the profit maximising loan rate, $\widehat{\sigma} = \frac{1}{2}\eta/\Psi$. Moreover, this event sustains itself as an equilibrium phenomenon. Excess demand fails to adjust the loan rate upwards because the associated credit risk would actually reduce banks' profits in the territory where bad borrowers, and their associated higher default rate, overwhelm the higher interest rate. However, if at the same loan rate there is an excess supply of loanable funds, the loan interest rate will adjust downward to clear the loan market since holding excess reserves is anathema to profit maximisation. This asymmetry translates into a loan rate which is subject to a ceiling at the rate $\widehat{\sigma} = \frac{1}{2}\eta/\Psi$. Nevertheless, the important case for this study remains the case when $B_b = 0$, i.e., when there is a supply constraint on banks, as the potency of monetary

[32] Barro & Grossman (1971) as well as Muellbauer & Portes (1978) provide excellent early studies on disequilibrium markets under price rigidity.

policy rests on the ability to change bank behaviour.

Now consider the demand for and supply of loans as given in equations (16) and (23). From these two conditions the equilibrium interest rate in the loan market can be derived as a knife-edged rule:

$$\sigma = \begin{cases} \frac{1}{2}\eta/\Psi & \text{if } \mathcal{L}^D \geq \mathcal{L}^S \text{ at } \eta/(2\Psi) \\ \min\left\langle \sigma_1, \sigma_2 | L^D = L^S \right\rangle & \text{if } \mathcal{L}^D < \mathcal{L}^S \text{ at } \eta/(2\Psi) \end{cases} \tag{24}$$

Here σ_1 and σ_2 are the two roots of the quadratic equation given implicitly by the equilibrium condition $\mathcal{L}^D = \mathcal{L}^S$. Recall that $\widehat{\sigma} = \frac{1}{2}\eta/\Psi$ is the loan rate that corresponds to the maximum loan quantity. So if excess supply exists at $\widehat{\sigma}$, $\mathcal{L}^D$ must intersect $\mathcal{L}^S$ precisely once at loan rate below $\widehat{\sigma}$ and once at a loan rate above $\widehat{\sigma}$. Since $\widehat{\sigma}$ is the loan rate consistent with maximum profits, the bank has no incentive to raise the loan rate above this level – credit is rationed at the equilibrium outcome. On the other hand, the profit-maximsing loan rate is not attainable if there is excess supply at $\widehat{\sigma}$ since the bank cannot force loans down the necks of firms in excess of of their desired level.[33] It thus follows that if a bank cannot maximise its profits at $\widehat{\sigma}$ due to deficient demand, the best attainable outcome for the bank is to allow a downward adjustment in the loan rate until the loan market clears. Therefore, the loan quantity traded is at the market-clearing equilibrium level if the market interest rate of loans is below the banks' desired level of $\widehat{\sigma}$. Otherwise, it would be supply-determined at the profit-maximising loan rate, or it could also be constrained by a vertical supply curve when $B_b = 0$ (see Figure 3.4, page 176).

[33] This might not be entirely true and depends on the term sheet and convenants that are written into a loan document. But such instances are rare and perverse enough to sweep under the rug.

III.3 Macroeconomic equilibrium

Now consider the macroeconomic consequences on the model. First, suppose that investment is completely dependent on the availability of bank credit. If this is the case then investment demand, which is a function of the bond interest rate and denoted by $I(i)$, is determined by the demand for loans, $\mathcal{L}^D$. Furthermore, based on the works of the preceding section, there exists an implicit positive relationship between the interest rates on loans and bonds. From this, it is possible to explicitly express the loan rate as an argument of the interest rate: $\sigma = f(i)$. Hence, if loan demand is not rationed, we have $I(\sigma) \equiv \mathcal{L}^D(f(i))$, whence by the chain rule

$$I' = \left(\mathcal{L}^D\right)' f' < 0 \tag{25}$$

with investment decreasing in the loan rate. However, with credit rationing, investment demand is totally determined by the aggregate supply of loans. In this case, output is lower and the credit constraint has global consequences for monetary transmission since banks are not responsive to inducements to expand the amount of loans to make to the public.

Consider the following scenarios for the macroeconomy. The first is one in which there is no credit rationing. This is the case when agents who wish to borrow are not limited and so that investment is demand-determined. Output is given by $Y = C + I + G + X$ with G assumed to be zero for simplicity and I given by the demand for loans, $\mathcal{L}^D(\sigma) = \zeta - \xi\sigma$. Then it follows that output is $Y = C + \mathcal{L}^D + X$. The second equilibrium is when the economy is constrained in the sense that credit is rationed, so that investment is determined by the amount of funds which banks are willing to make available. The third case is when the supply of loanable funds is vertical,

as determined by deposits. This case generates scope for monetary policy when the corresponding supply and demand conditions are as depicted in Figure 3.7 (page 169). Again, with G set at zero, the output equation is $Y = C + \mathcal{L}^S + X$. The cases for full credit and credit rationing are both examined below. In the case where banks face a supply constraint and credit is rationed, monetary policy will retain some degree of independence as Section III.4 shows following the analyses of each of the cases of credit rationed and unconstrained equilibria nested within a framework as depicted in Figure 3.4 (page 164) in the loans market.

III.3.1 Absence of credit-rationing

Consider the case when loans are not rationed. Here there are four endogenous variables of the system: The loan quantity, $\mathcal{L}$; the loan interest rate, σ; income, Y; and the international reserves of the central bank, F. Note that within this context F is fixed because of the need by the central bank to peg the exchange rate, i.e., $F = \overline{F}$ so that $\overset{\bullet}{F} = 0$.

What determines the outcome herein are four equations that form a general equilibrium model. The first equation is the loan supply equation (16), i.e., $\mathcal{L}^S = \omega(\sigma, r, \eta, \Psi, \theta, N) \frac{1-\kappa}{\kappa} H$. The second is the monetary version of the balance-of-payments equation

$$B_m + F = \kappa l(Y, i^*) \tag{26}$$

Then there are two other basic equations that describe output and loan demand:

$$Y = C(Y) + (\zeta - \xi\sigma) + X(Y, ep^*) \tag{27}$$

$$\zeta - \xi\sigma = \omega(\sigma, i, \eta, \Psi, \theta, N) \frac{1-\kappa}{\kappa} (B_m + F) \tag{28}$$

As is customary, an asterisk $(*)$ denotes foreign variables. These equations merit explanation. Equation (26) represents the monetary version of the open-economy LM equation (or the balance-of-payments equation), where $l(Y, i^*)$ is the liquidity demand for money, which is increasing in income but decreasing in the interest rate. That is, the quantity of loans is increasing in output, $l_1(Y, i^*) > 0$, and the quantity of loans is decreasing in the interest rate, $l_2(Y, i^*) < 0$. In short, the monetary authority's high-powered cash holdings are given by the bonds held by the central bank plus its holdings of foreign reserves. This, in turn, is equal to a fraction, κ, of money demand by the reserve ratio requirement. Note that the foreign interest rate on bonds, given by i^*, is equal to the domestic interest rate i by assumption of perfect capital mobility in the bond market. The last two equations describe output and the loan demand market.

Equation (27) is the standard IS equation composed of consumption, investments and net exports. Consumption and investment are straightforward, but net exports requires a bit of clarification: $X(Y, ep^*)$ are net exports where e is the domestic currency price of foreign currency, and p^* is the price level abroad. The relevant derivatives in the above model satisfy the two following standard conditions: (i) Consumption is increasing in income, $C'(Y) > 0$; (ii) Net exports are decreasing in income, $X_1(Y, ep^*) < 0$. Notice here for the IS equation that the interest rate plays a role in the determination of income through the dependence of investment, $\zeta - \xi\sigma$, on the interest rate as given in (28). Finally, in equation (28) the LHS is the demand for loans, and the RHS the supply of loans.

Thus using equations (16), (26), (27), and (28) it is possible to solve the equilibrium levels of Y, $\mathcal{L}$, σ, and F. As in the case with rationing (see next section),

although money is partly endogenous due to perfect capital mobility in the bond market and the commitment to the fixed exchange rate, money endogeneity is not full because of the credit channel of monetary transmissions mechanisms and money – thus it is not completely neutral. So changes in the money supply serve to shift not only the LM curve but also the IS curve so that the responsive change in money does not totally annul the real effect generated by the original change in money. In this case, the credit channel is able to influence the efficacy of monetary policy. This answers Hubbard's (1995) question of whether there exists a credit channel in monetary policy, although in a very different context.

III.3.2 Credit-rationing as an equilibrium

Now examine the alternative case, where the (possible) existence of credit rationing offers a new aspect to monetary policy by way of opening a credit channel in the transmission mechanism of monetary policy. With credit rationing, (i.e., a situation where demand for loans exceeds supply at the prevailing interest rate) the effective investment demand and the quantity of loans traded are given by $\mathcal{L}^S$ as specified in equation (16). Grouping equation (16) with the standard equilibrium conditions of the goods market and the money market yields the following simple macroeconomic model in two equations (in income and high powered money):

$$Y = C(Y) + \mathcal{L}^S + X(Y, ep^*) \tag{29}$$

and the banking identity

$$B_m + F = \kappa l(Y, i^*)$$

as given in equation (26). The first equation is the IS equation that prevails under credit rationing. Note that in this equation the domestic price level is normalised to unity since this model assumes (in the tradition of Keynes) sticky prices, so that price rigidities apply to the short-run dynamics of the model. The second equation is just exactly equation (26) as given in the case without credit-rationing.

This is a very simple system to explain. The open economy output is equal to consumption plus the available supply of loans plus net exports. Note that here credit-rationing exists, so that investment is limited to the supply of loanable funds. The characteristics of the loan-supply function, $\mathcal{L}^S$, can be inferred by equations (17) through (22), which defines the derivatives of $\omega(\bullet)$ with respect to each of its arguments. The equation for liquidity preferences of money is identical to the one described in the previous section, so merits no more discussion. However, the IS equation under credit rationing does deserve a second glance. Think of equation (29) as the IS equation for the private sector with the presence of a loan market in an open economy where credit rationing exists. This means that policies that increase loan demand have no bearing on output. Likewise, even if more liquidity is provided to banks they will not lend out any more than they have already lent. So policies that try to expand output by giving the bank liquidity are ineffectual. As for consumption, $C(Y)$, it is exactly the same as in the case without credit rationing; however, of course, the argument Y differs between the imagined outcomes. Finally, $\mathcal{L}^S$ is is a rationed investment function – rationed in the sense that the demand for loans is not met by banks even in the case where borrowers are willing to pay a fair price for loanable funds.

When credit-rationing exists as an equilibrium outcome there are three endogenous

variables of the model: (i) Income (Y), (ii) the supply of loanable funds ($\mathcal{L}$), and (iii) international reserves (F) of the central bank's monetary base. The equilibrium levels of these variables are determined by a system of equations given by equations (16), (26) and (29).

Finally consider the case of a vertical loan-supply curve explicitly in isolation. This is a third outcome from which there are two types of monetary policy that are effective. First, changes in the reserve requirement (which makes more or less funds available to lend) give rise to potency of monetary policy. Second, changes to central bank lending to commercial banks through the discount window relaxes the supply constraint on loan supply as depicted in Figure 3.4 (page 176). In that case the relaxing of the constraint will affect the loan interest rate and the volume of loans made by banks. This then is propagated through to the macroeconomy, empowering monetary policy to have real effects on the economy.

III.4 Comparative statics

Now consider how the equilibrium economy responds to shocks. In particular, examine the responses of equilibrium income (Y), loan quantity ($\mathcal{L}$), loan interest rates (σ), and the international reserve component of the monetary base (F) to a monetary shock, as from, perhaps, discount window lending and changes in the reserve requirement, as conducted by the monetary authority. Thus this gets to the core question of the paper: Does a monetary authority retain the use of monetary policy as an endogenous tool even in the setting of an SOE that maintains a fixed exchange rate and that works in a framework of perfect capital mobility? These impacts vary depending on whether

credit is meted out or not and, more importantly, whether the (aggregate) loan supply is responsive. This in turn depends on whether banks are constrained by their balance sheets, so that monetary policy – in the form of discount window lending and reserve requirement modifications – will in effect relax their constraints and thereby allow banks to make more loans, and through that channel to affect the macroeconomy.

III.4.1 Credit-rationing equilibrium

Consider the credit-rationing model first. Taking the partial derivative of equations (16), (29), and (26) with respect to B_m for expressions of $\mathcal{L}^S$, Y, and F yields a system of three equations:

$$\frac{\partial \mathcal{L}^S}{\partial B_m} = \omega \frac{1-\kappa}{\kappa} > 0 \tag{30}$$

$$\frac{\partial Y}{\partial B_m} = \frac{\omega \frac{1-\kappa}{\kappa}}{1 - C' - X'} > 0 \tag{31}$$

$$\frac{\partial F}{\partial B_m} = \kappa l_1 \frac{\omega \frac{1-\kappa}{\kappa}}{1 - C' - X'} - 1 < 0 \tag{32}$$

The result in equation (32) is derived, for the given rate of interest in the foreign country, from the differential version of equation (26):

$$\frac{\partial F}{\kappa} = l_1 \partial Y - \frac{\partial B_m}{\kappa} \tag{33}$$

With a system of fixed exchange rates, changes in the official international reserves mirror the status of the balance-of-payments. Beginning with the open market purchases on the part of the monetary authority, increases in the money supply (bank deposits) get amplified through the money multiplier $1/\kappa$ as high-powered money balances, B_m, increase. Banks usually tend to make more loans due to an expanded volume of deposits (and is true so long as they are not on a backwards-bending portion of the supply curve). Additionally, more loans relax the credit constraints facing

the economy so that income rises, as measured in equations (30) and (31). Finally, transaction demand for money also increases with higher income, but the money demand associated with the credit channel is less than the initial increase in the money supply credit; i.e., the money creation propagated by the central bank overwhelms the growth of the (concomitant) money demand. The resulting excess supply of money is consequently spent and is allocated between foreign goods and financial assets. As domestic residents adjust their portfolio in favour of foreign money, the central bank loses international reserves ($dF < 0$) and the money account of the balance of payments moves into the red. This yields a contraction of the money supply, and so consequently this contraction will sustain until the disequilibrium in the money market disappears and the balance-of-payment account is returned to equilibrium. Now it remains to be answered when this condition satisfied. This happens when the the interest rate is back to the foreign rate, i^*, as dictated by the monetary authority's commitment to a fixed exchange rate (ignoring considerations of country-specific risk in repayment of debts).

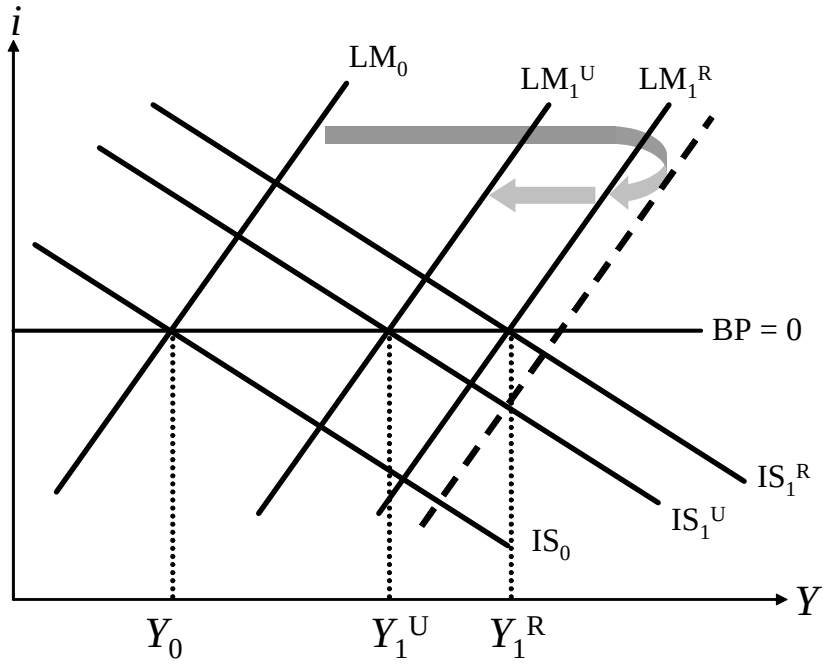

Figure 3.3. The LM curve partially adjusts from its original shift; output is determined by the intersection of LM and BP.

Now consider how the offset coefficient works. Examining equation (32) suggests that the credit channel, per se, plays a role to preserve the legacy of monetary policy since the change in F for a given change in B_m is less than unity. The increase in money demand generated from the credit-driven income expansion lessens the adjustment burden fallen upon the official international reserves so that the absolute value of the offset coefficient is less than unity and monetary control is still potent.[34] Without considering the credit channel, however, the endogenous change in foreign reserves completely offset the initial change in the credit brought about by the cen-

[34] There is evidence for the degree of monetary autonomy under fixed exchange rates. Of note are early works by Cumby & Obstfeld (1983) and Rennhack & Mondino (1988). They find that structural estimates of offset coefficients are less than unity.

tral bank's OMO. In this scenario the traditional result is obtained. The economic intuition behind this is that the first term on the RHS of equation (32) is a positive fraction, and a large credit multiplier of size $\omega \cdot (1 - \kappa) / \kappa$ works to reduce the magnitude of the offset coefficient given by equation (32). Hence, the stronger is the credit channel, the more potency that can be retained by monetary policy.

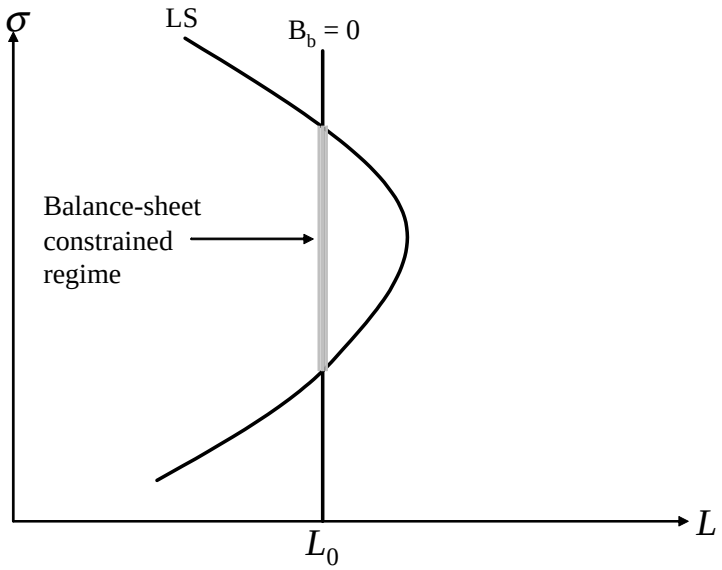

Figure 3.4. The case for the central bamk to implement monetary policy in its strictest sense rests upon an equilibrium with a balance sheet constraint as given by a vertical $B_b = 0$ curve.

Figure 3.3 through Figure 3.7 summarise the analytical results graphically. The first graph depicts an IS-LM-BP relationship in the traditional general equilibrium framework, with the initial credit-rationing equilibrium as shown in Figure 3.3 (page 175).

To see the intuition behind this, consider an expansionary monetary policy ini-

tiated by open market purchases. The LM curve moves rightward initially to the position of the dashed line, causing the IS curve to shift in the same direction through the credit channel. This is reflected in Figure 3.6 (page 180) by the downward shift of the aggregate loan supply curve, with the loan interest rate remaining at the profit-maximising level. Due to the tight credit market, however, the resulting increase in loans directly translates into the corresponding increase in income at the full scale, as depicted in Figure 3.7 (page 181). The increased money demand mitigates the excess-supply pressure on the money account of the balance of payments, but still entails a reduction of official international reserves held by the central bank to restore equilibrium in the money market and the foreign exchange market. As a result, although the LM curve shifts backward away from its initial post-shock position as given by the dashed line, it does not shift all the way back to its initial position (LM_0). Instead, the partial adjustment means LM_1^{CR} intersects IS_1^{CR} at Y_1^{CR}. Under credit rationing, then, the result is that money adjustment is not full and depends on the strength of the credit channel.

III.4.2 Equilibrium in absence of credit rationing

Now turn to the alternative situation in which credit rationing is not a problem. Differentiating equations (16), (26), (27), and (28) with respect to $\mathcal{L}$, Y, σ, F, and B_m yields a system of four equations:

$$\frac{\partial \mathcal{L}}{\partial B_m} = \omega \frac{1-\kappa}{\kappa} \left[1 - \left(1 + \frac{\xi}{\frac{1-\kappa}{\kappa} H \omega'_\sigma} \right)^{-1} \right] > 0 \tag{34}$$

$$\frac{\partial Y}{\partial B_m} = \frac{\xi}{1 - C' - X'} \left(\frac{\omega \frac{1-\kappa}{\kappa}}{\frac{1-\kappa}{\kappa} H \omega'_\sigma + \xi} \right) > 0 \tag{35}$$

$$\frac{\partial \sigma}{\partial B_m} = -\left(\frac{\omega^{\frac{1-\kappa}{\kappa}}}{\frac{1-\kappa}{\kappa} H\omega'_\sigma + \xi}\right) < 0 \tag{36}$$

$$\frac{\partial F}{\partial B_m} = \kappa l_1 \frac{\xi}{1 - C' - X'}\left(\frac{\omega^{\frac{1-\kappa}{\kappa}}}{\frac{1-\kappa}{\kappa} H\omega'_\sigma + \xi}\right) - 1 < 0 \tag{37}$$

When credit rationing is not a phenomenon the credit channel operates through its impact on the loan interest rate (σ). This must be the case for consider otherwise: If the loan rate did not adjust or the loan traded in the market did not respond to the adjustment in the loan rate, that is, $\omega'_\sigma = 0$, then all the comparative static results above would be reduced to those in the case of credit rationing. That is to say that the full scale impact of money-driven loan expansion would pass through to income directly. With the downward loan rate adjustment, however, the desired loan supplied falls, thus the actual loan quantity traded is lower at the market-clearing equilibrium than in the presence of credit rationing, which can be observed by comparing equation (34) with equation (30). Accordingly, as reflected in the comparison between equations (35) and equations (31), income expansion is lowered by the decrease in the loans supplied, which, in turn, is dampened by the loan rate.

The four derivative above express the change in the loan supply, output, the loan interest rate and the responsiveness of the foreign reserves (the offset effect) to a *small* change in the bonds held by the monetary authority. The results are intuitive as increased bond holdings lead to more loans, which lowers the price on loans. But tellingly, the offset coefficient is less than one, meaning that OMO have real effects.

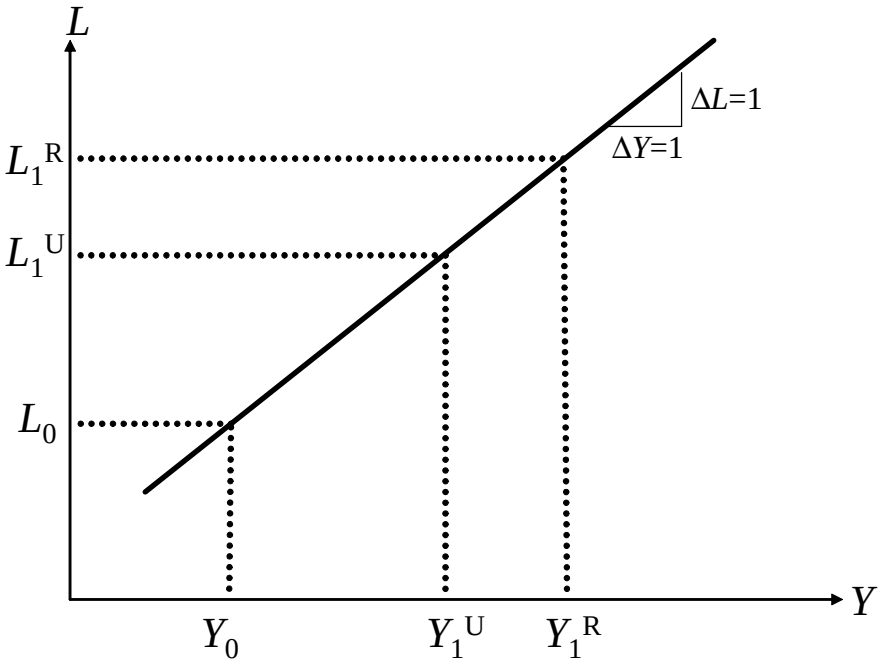

Figure 3.5. The loan market grows in step with output when unconstrained.

Finally, the comparison centres on the degree by which the real legacy or impact of monetary policy can be preserved in an SOE under a fixed exchange rate system. Following the previous analysis, the relatively moderate increase in income has less power in inducing an increase in transaction demand for money, and thus a weaker capacity in restoring the disequilibrium in both the money and foreign exchange markets. The central bank has to sell more official international reserves in the foreign exchange market to meet the excess supply in the money market. Alternatively, comparing equation (37) with equation (32) suggests that when credit rationing does not exist, an increase of a given amount in the central bank credit entails a decrease of larger amount in the official international reserves held by the central bank; therefore the magnitude of the offset coefficient becomes larger. This gives rise to a key finding

of this paper: *Monetary autonomy tends to be more impaired under a market-clearing credit regime than under a credit-rationing regime.* Moreover, the potency of monetary policy depends on the presence of a supply constraint as introduced by a vertical $B_b = 0$ curve.

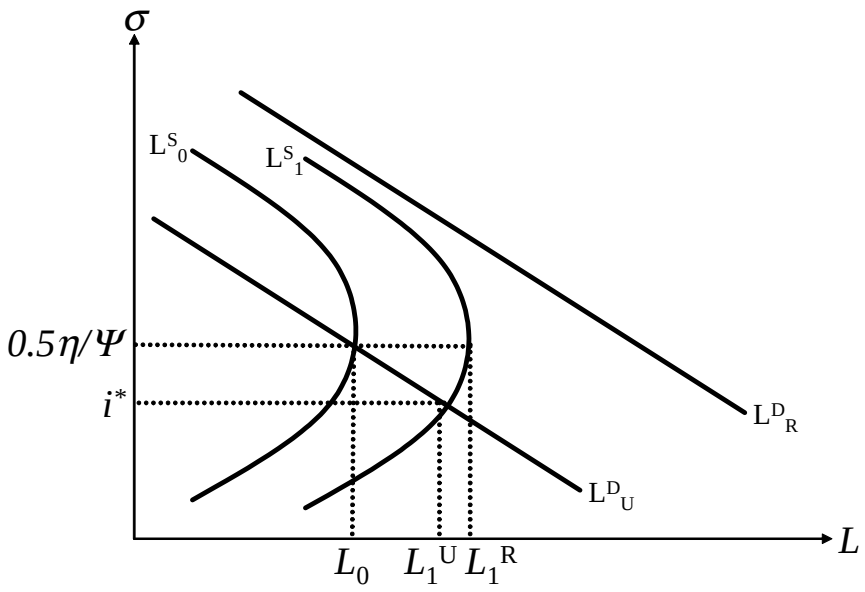

Figure 3.6. The backwards-bending shape of the loan-supply curve and its consequence in an expansionary environment.

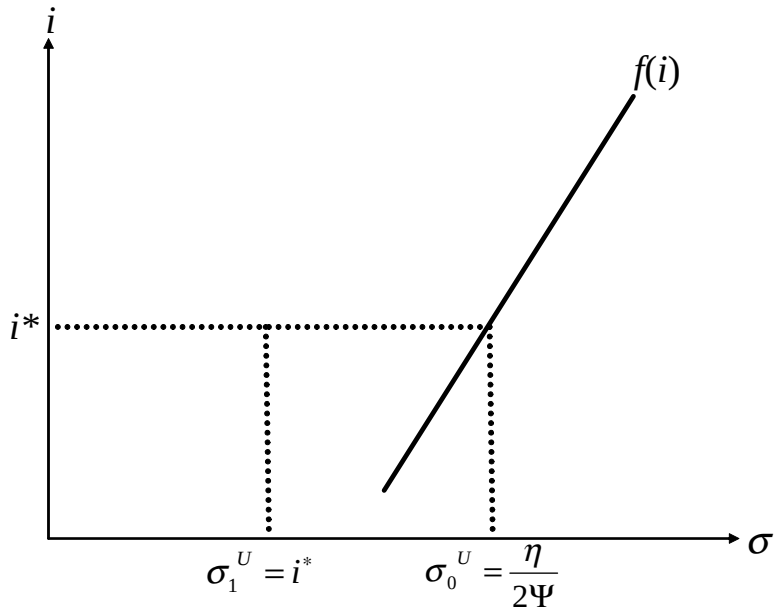

Figure 3.7. The linearised relationship between i and σ as given by f. Note that at i^* f gives the value of the loan rate when credit is not rationed.

As before, Figure 3.6 (page 180) depicts the credit market equilibrium. To simplify the graphical illustration, let the first-best loan rate, $\widehat{\sigma} = \frac{1}{2}\eta/\Psi$, be the initial market-clearing equilibrium loan rate, σ_0^{NCR}. Responding to an increase in money supply, the loan supply expands and the excess supply exerts downward pressure on the loan rate. The loan market rate moves along the downward-sloping loan demand curve to a new equilibrium level, $\sigma_1^{NCR} < \sigma_0^{NCR}$. The resulting equilibrium loan quantity is also below its counterpart in the presence of credit rationing. Accordingly, the real impact of monetary shock on income is weaker as LM_1^{NCR} intersects IS_1^{NCR} at the income level Y_1^{NCR}, which also happens to be less than the level of period one income with credit rationing.

The above result suggests that credit-rationing, induced by moral suasion or forced upon the banking sector by a monetary authority, is an option that can give potency to monetary policy in an SOE with fixed exchange rates. Of course, certain assumptions were made to derive this conclusion and one can argue whether the bank behaviour proposed within this paper are realistic. Additionally, transporting these findings to real-world policy decisions requires a more holistic view on the general economy. Only beginning with such considerations, then, can policymakers decide whether or not to act on influencing the banks to preserve the legaty of monetary policy. But this also depends on the optimisation problem of the central bank versus the social welfare function of the economy, which is better left for practitioners of political economy to debate rather than on these pages.

III.5 Conclusion

This paper began by building a micro-foundation of credit and credit rationing. Analysing the model herein, it was demonstrated that the credit channel plays a role to maintain the efficacy of monetary policy even under a regime of fixed exchange rates with perfect international capital mobility within a small economy. This can happen with market imperfections in the economy, namely imperfect asset substitutability between bonds and loans and in the presence of balance-sheet constraints on commercial banks as given by a vertical $B_b = 0$ constraint as shown in Figure 3.4 (page 176).

The efficacy of monetary policy rested on the distinction between bonds and loans, and this was nested in the context where, although bonds are freely traded on inter-

national markets, loans are made by local banks. Thus, so long as taking loans and issuing bonds are not equivalent, the implication for an SOE is that fixed exchange rates are not necessarily a poison pill for monetary policy. While bonds can be traded on international markets (and PCM is assumed to hold), it is often the case that the domestic loan market is restricted to local firms who have a specialised knowledge of the home market. So the existence of a loan market then creates a relationship between the money supply and economic activity, even under the assumption of PCM in bonds. And this relationship gives rise to a potential role for monetary policy. Why should this be the case rather than the simple view that monetary policy becomes completely exogenous? This is because credit-dependent investments serve to transmit a monetary shock into changes in real income and thus transaction demand for money. Therefore the compensating factor, which would otherwise be the onus of the official international reserves, is also borne by money demand when banks are facing a binding constraint on lending not dictated by self-induced credit rationing. That is, the offset coefficient becomes less than unity when the credit channel is taken into account, since any expansion of domestic assets of the monetary authority gives rise to only a partially offsetting spatial outflow. This leaves the stock of money increased and implies an outcome where there is partial retention of monetary autonomy.

The degree of monetary autonomy that can be retained depends on the magnitude of the credit multiplier and the existence of an aggregate loan-supply constraint on banks. Most importantly, these conclusions do not rest on whether or not the commercial loan market is subject to credit rationing, although the credit channel itself is key. (In fact, the primary driver is the presence of a supply constraint in the loans market.) Consider, for a given monetary shock, due to the upward rigidity of

the optimal loan rate, the loan market with credit rationing generates more loans for the loan-dependent economy than the market without credit rationing. The resulting expansion in income has more power to restore the disequilibrium in both the money market and the foreign exchange market. It appears, thus, that the credit view of monetary transmission is supported: A monetary authority tends to be less impaired under a credit-rationing regime than under a market-clearing regime.[35]

The implication is that a monetary authority such as the HKMA was not powerless with respect to monetary policy in the face of the crisis it fought off at the peak of the Asian crisis. Besides, the HKMA behaves as an unorthodox currency board and is not limited to the simple task of maintaining full convertibility – it can also intervene in markets and take on central banking-like duties. Of course, such a result rests with the phenomenon where credit rationing by commercial banks is a reality. But even in the case where credit rationing is not a phenomenon, it has been shown that monetary policy retains its efficacy so long as bonds and loans are imperfect substitutes from the perspective of banks and that furthermore the domestic loan market is serviced by local banks. But the point to note is that if it is believed that the banks are lending optimally at a point where credit rationing is just binding, then a monetary authority retains potency of monetary policy. Even without credit rationing it still retains this independence. The question remains whether the institutions in place support a positive role for monetary policy. But the option of monetary policy in this model was limited to the case where commercial banks are restricted to a non-negative quantity of bonds (i.e., they can buy bonds but not sell them) and where the "balance-sheet

[35] This is consistent with the financial accelerator phenomenon espoused by Bernanke, Gertler & Gilchrist (1995) in their seminal work on monetary tranmission.

constrained regime" was consistent with the loan market. Nevertheless, in spite of the assumptions and restrictions, it does show that monetary policy can still be a tool for a small open developing economy, even in the face of fixed exchange rates.

Future research should broaden the scenarios and relax the restrictions to get more general cases where monetary policy remains a tool for an SOE with a fixed exchange rate. Of course, a more general setting may not be as benign in showing the legaty of monetary policy. But it needs to be substantiated first whether this insight for the special case may have broader implications, which is as yet inconclusive. Nevertheless, the finding here within that monetary policy may have efficacy even within an SOE with fixed exchange rates opens the door for greater scope and responsibility for central bankers. Such findings may prove beneficial as more and more countries are embracing the open economy paradigm along with a desire to use hard currencies to establish market confidence in emerging economies. □

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