Yen Carry Trade and the Subprime Crisis*

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Abstract

Yen carry trades have traditionally been viewed in narrow terms purely as a foreign exchange transaction. We argue that the carry trade should instead be viewed in the broader context of global credit conditions. We show that the volume of Yen funding that is channeled for use outside Japan is mirrored by fluctuations in the size of US broker-dealer balance sheets. Differences in short-term interest rates across currencies help to explain the incidence of the carry trade, as does the measure of implied equity risk given by the VIX index. The conjunction of deteriorating credit conditions in the US and the weakness of the US Dollar against the Yen in the early stages of the credit crisis of 2007/8 can thus be seen as two sides of the same coin. Both can be seen as consequences of financial sector deleveraging in the US.

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1. Introduction

The tightening of credit conditions that started in the subprime sector of the US mortgage credit market in the summer of 2007 has implications for external adjustment for the United States. As the credit crisis unfolded over the ensuing months, weakness in credit markets was accompanied by the conspicuous weakness of the US dollar, with short-term exchange rate fluctuations mirroring closely overall conditions in the credit market. The financial press[1] at the time referred to a collective "margin call" on the United States in which foreign creditors sought to reduce their exposure to the deteriorating creditworthiness of US borrowers (including financial intermediaries) by cutting back lending or demanding higher premiums to cover potential losses.[2]

The purpose of our paper is to examine one component of the external adjustment - namely, the unwinding of the so-called "yen carry trade". A carry trade refers to the borrowing of a low interest rate currency to fund the purchase of a high interest rate currency - that is, in selling currencies forward that are at a significant forward premium. The "yen carry trade" in particular has been a topical subject of debate over the last decade or more given the extended period of low interest rates in Japan.

Although the carry trade is often portrayed purely as a bet on exchange rate movements, the significance of the carry trade extends far beyond the confines of the FX market. The key to understanding the wider significance of the carry trade is to follow the trail of leveraged bets through the financial system through interlocking balance sheets of the financial intermediaries involved. Take an example, illustrated in figure 1.1. A hedge fund that wishes to take on a spec-

[1] "Debt Reckoning: US Receives a Margin Call" *Wall Street Journal*, March 14th 2008.

[2] See Brunnermeier (2008), BIS (2008), IMF (2008) and Greenlaw et al. (2008) for a chronology of the credit crisis of 2007/8.

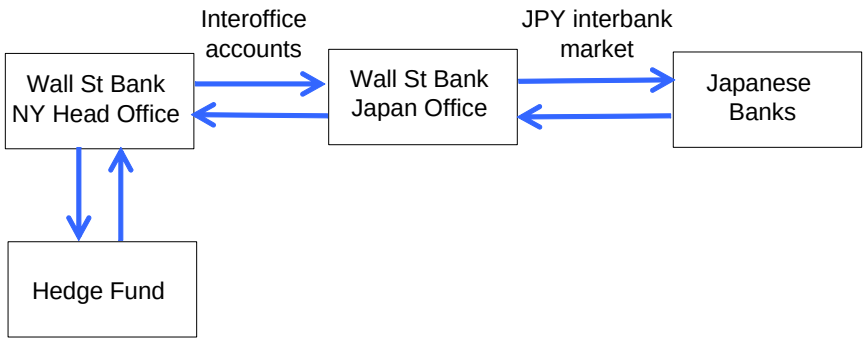

Figure 1.1: The figure depicts the balance sheet trail from a hedge fund in New York to the interbank market in Tokyo. The prime broker to a hedge fund can borrow from Japanese banks in Tokyo to fund the lending to the hedge fund.

ulative leveraged position in subprime mortgage securities must obtain funding from its prime broker. In figure 1.1, the prime broker is depicted as a Wall Street investment bank, but the scenario would be equally applicable to a hedge fund operating from London, who obtains funding from banks headquartered in Zurich, Frankfurt, London or Paris. The prime broker, for its part, is also a leveraged institution. An investment bank is typically leveraged 25 to 30 times. It must fund the loan to the hedge fund by borrowing from another party. But who lends to the prime broker and at what rate?

If the Wall Street bank borrows dollars in New York, it will pay a rate closely tied to the short term US Dollar interbank rate. However, if it were to borrow in Tokyo, and in Japanese Yen, it can borrow at the much lower yen overnight rate. A bank with global reach can borrow yen through its Tokyo office. Having borrowed yen in Japan, the investment bank can recycle the yen funding to other users such as their hedge fund clients, or be kept on the bank's books for its own use (such as funding its own holding of mortgage assets).

In figure 1.1, the Tokyo office of the Wall Street bank has yen liabilities to

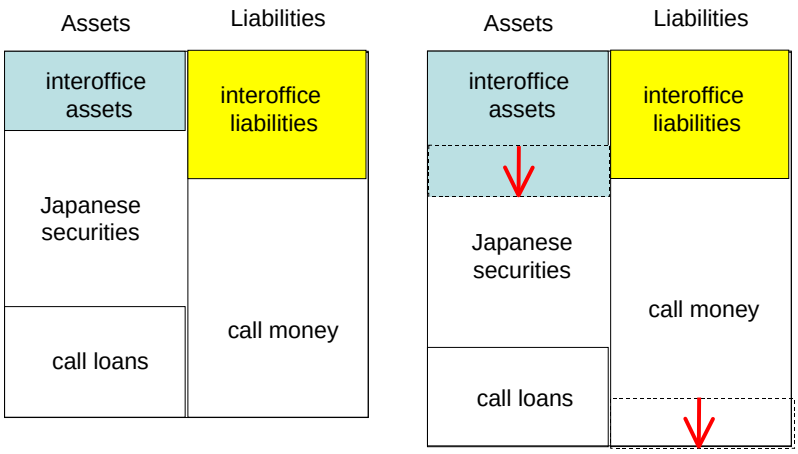

Figure 1.2: The channeling of yen funds by a foreign bank for use outside Japan will be reflected in the balance sheet of the Tokyo office of the foreign bank in terms of the expansion in the net interoffice assets.

Japanese banks, but has yen assets against its New York head office. The lending by the Japan office of the Wall Street bank to its head office is captured in its "interoffice" accounts. Although the interbank liabilities (the final link) will give some idea of the aggregate yen liabilities, the interoffice account (penultimate link) gives an insight into how much of the yen liabilities are used to fund activities *outside* Japan. The tell-tale signs of the channeling of yen funding for use outside Japan would be the conjunction of large yen liabilities of foreign banks in the yen interbank market and large net assets of foreign banks on the interoffice account

This is because when yen funds are channeled for use outside Japan, there is the conjunction of large yen borrowing and then the on-lending of these yen funds to entities outside Japan. Figure 1.2 illustrates the trail through the balance sheet of the Japan office of the global bank. The left hand panel shows the initial stylized balance sheet of the Japan office. The Japan office holds various assets - such as Japanese securities and loans to Japanese entities ("call loans")

- and funds the asset holding partly by borrowing locally in the yen interbank market ("call money"), and partly by funding from its headquarters through the interoffice liabilities. In the left hand panel, the net interoffice account (interoffice assets minus interoffice liabilities) is negative, meaning that the global bank holds a net long position in Japanese assets.

The right hand panel of figure 1.2 shows the incresed channeling of yen funds to the head office of the global bank via the interoffice account. The Japan office borrows more yen (increases call money), and then lends on the proceeds to its headquarters through increased interoffice assets.

The fluctuations in the interoffice accounts of foreign banks in Tokyo therefore provide a window on the credit market events of 2007 and 2008. Interoffice accounts of foreign banks in Japan are published by the Bank of Japan. A study of the interoffice accounts yields several insights.

First, as we will show below, foreign banks have generally maintained negative interoffice net assets, consistent with the foreign banks maintaining a net long position in Japanese assets. However, in the period leading up to the beginning of the credit crisis of 2007, yen liabilities of foreign banks surged, leading to an unprecedented net *positive* interoffice accounts of foreign banks. Such positions are tantamount to the foreign banks maintaining a net short position in Japanese assets. These net short positions were unwound sharply in August 2007, coinciding with the initial stages of the credit crisis, and were reduced further as the credit crisis developed into the latter half of 2007 and into 2008.

We show below that the period when yen funding was being channeled out of Japan also coincides with the rapid growth of financial intermediary balance sheets. Using data for the US, we show that the growth of total assets of the US security broker dealer sector (which includes the major investments banks) is closely related to the evolution of the size of net interoffice accounts.

By tracking proxies for the prices of subprime mortgages, such as the ABX index supplied by the London firm Markit[3], it is possible to put the reversal of the interoffice accounts into the context of the wider subprime crisis. We show below that the sharp price declines in mortgage securities secured on subprime mortgages are mirrored by the fluctuactions in the net interoffice accounts. In this respect, the credit crisis and the external adjustment of financial intermediary balance sheets can be seen as two sides of the same coin. They are both manifestations of the de-leveraging of financial intermediaries and their hedge fund clients.

We also examine a number of related questions. As found in Adrian and Shin (2007) for the fluctuations in US primary dealer balance sheets, we find that the fluctuations in the size of the net interoffice accounts is related to the state of overall risk appetite, as measured by the VIX index of implied volatility on the broader US stock market. The periods when foreign banks have large yen liabilities are also those periods with low readings of the VIX index. This fact gives a clue as to why major global stock indices have been so closely aligned with the exchange rates of high yielding currencies vis-à-vis the yen in recent years.

In addition, we find that the difference between the yen overnight rate and a summary measure of overnight rates in developed countries mirrors closely the overall size of the net interoffice accounts. Yen liabilities are high when foreign overnight rates are high relative to overnight rates in Japan. Conversely, when foreign overnight rates are close to Japanese rates, foreign banks have low yen liabilities. During the period of historically low US interest rates in 2002 to 2005, foreign banks maintained low yen liabilities, suggesting that they could satisfy their funding needs by borrowing in US dollars without tapping the yen market. Indeed, in a regression where both VIX and the interest rate differential appear together as regressors, both are highly significant, suggesting that they are two

[3]www.markit.com

windows on the same underlying phenomenon.

Our findings hold potentially important lessons for monetary policy. Although monetary policy is conducted primarily with domestic macroeconomic conditions in mind, there are inevitable global spillovers of monetary policy. In recent years, with the advent of formal inflation-targeting and moves toward greater focus on managing market expectations of future central bank actions, attention has shifted away from short term rates as an important price variable in its own right. Our findings suggest that short term rates and balance sheet size may be important in their own right for the conduct of monetary policy.

The outline of our paper is as follows. We begin with a sketch of an analytical framework that links external balance with the balance sheet adjustments of financial intermediaries. We then chart the fluctuations in the interoffice account, and highlight the relationship between the interoffice accounts and the subprime mortgage assets. We go on to investigate how the fluctuations in the net interoffice accounts relate to risk appetite, as measured by the VIX index, and how they relate to the difference between foreign overnight rates and the yen interest rate. We conclude by showing how the unwinding of the carry trade has been mirrored by the fall in subprime mortgage prices, adding weight to the main hypothesis that the dollar and subprime are two sides of the same coin - both being the manifestations of the deleveraging of financial intermediaries.

2. Balance Sheet Perspective

There have been many proposed explanations of how the United States has managed to fund its current account deficit with such ease in recent years. One explanation has been the higher return from US assets due to the higher productivity growth and stronger fundamentals in the US. However, as noted by Balakrishnan, Bayoumi and Tulin (2008, this issue), explanations that rely on

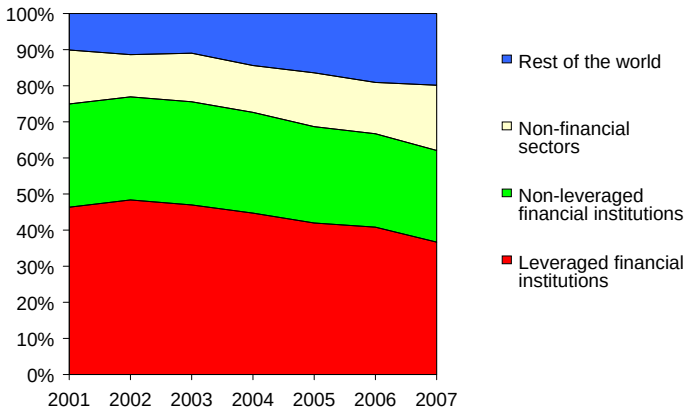

Figure 2.1: The figure depicts the holdings of US Agency and GSE-backed securities by different types of holders. (Source. Flow of Funds, Table L.210, Federal Reserve)

prospective higher returns fall foul of one key fact - namely that the bulk of the funding of the current account deficit has been in the form of debt claims, especially the mortgage-backed securities issued by the US government sponsored enterprises, such as Fannie Mae and Freddie Mac.

Figure 2.1 plots the proportion of US agency and GSE-backed securities holdings by various classes of holders from end-2001 to end-2007. The data are drawn from the US flow of funds accounts (table L.210). The striking feature is the increased holdings of the "rest of the world" category, which itself is mostly accounted for by foreign central banks or other official holders. In dollar amounts, the "rest of the world" holding has more than tripled from $504 billion at the end of 2001 to $1,540 billion at the end of 2007. Since debt claims have little exposure to the upside of any potentially higher returns, explanations that rely on future higher returns do not sit comfortably with the facts.

An alternative perspective is to focus on the actions of the financial intermedi-

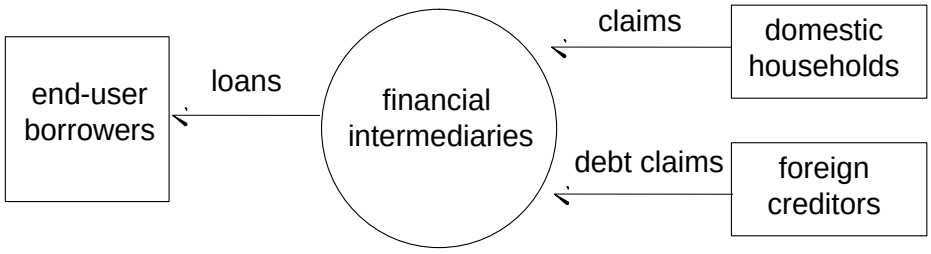

Figure 2.2: The figure depicts a stylized financial system where the financial intermediaries lend to the end-user borrowers by obtaining funding either from domestic claimants or from foreign creditors.

aries themselves, and to chart how the waxing and waning of the risk appetite of such intermediaries to shifts in measured risks can explain external adjustments. Adrian and Shin (2007) have emphasized the pro-cyclical nature of financial intermediary balance sheets and its role in amplifying financial cycles. We can illustrate the effects of fluctuating risk appetite by means of a simple example, modifying the framework in Shin (2008). The framework rests on a stylized financial system depicted in figure 2.2.

The financial system consists of four sectors. The end-user borrowers are US households who rely on financial intermediaries to supply mortgage funding. The funding comes ultimately from two sources - domestic households who hold equity and debt claims on the financial intermediaries, and foreign creditors who hold debt claims against financial intermediaries.

There are n leveraged financial intermediaries that we call "banks" for convenience but in principle, they encompass intermediaries such as broker dealers and other entities involved in the securitization process. The banks are indexed by $i \in \{1, \cdots, n\}$. The domestic claim holders and the foreign creditors are gathered together, and labeled as sector $n + 1$.

Denote by y_i the market value of loans made by bank i to end-users. The

financial intermediaries also hold claims against each other. Suppose that proportion π_{ij} of bank i's debt is held by bank j. The proportion $\pi_{i,n+1}$ is held by sector $n+1$, consisting of domestic non-bank claim holders and foreign claim holders. Denoting by x_i the market value of bank i's debt, we can write the market value of bank i's assets as:

$$a_i = y_i + \sum_j x_j \pi_{ji}$$

Total liabilities of bank i are then given by the sum of equity and debt.

$$e_i + x_i$$

Denote the leverage of bank i as λ_i, where leverage is defined as the ratio of total assets to equity. That is

$$\frac{a_i}{a_i - x_i} = \lambda_i \tag{2.1}$$

Then, for $\delta_i = 1 - \frac{1}{\lambda_i}$, we have

$$\begin{aligned} x_i &= \delta_i \left(y_i + \sum_j x_j \pi_{ji} \right) \\ &= \delta_i y_i + \begin{bmatrix} x_1 & \cdots & x_n \end{bmatrix} \begin{bmatrix} \delta_i \pi_{1i} \\ \vdots \\ \delta_i \pi_{ni} \end{bmatrix} \end{aligned} \tag{2.2}$$

Let $x = \begin{bmatrix} x_1 & \cdots & x_n \end{bmatrix}$, $y = \begin{bmatrix} y_1 & \cdots & y_n \end{bmatrix}$, and

$$\Delta = \begin{bmatrix} \delta_1 & & \\ & \ddots & \\ & & \delta_n \end{bmatrix} \tag{2.3}$$

Then we can write (2.2) in vector form as:

$$x = y\Delta + x\Pi\Delta$$

Solving for x,

$$\begin{aligned} x &= y\Delta\left(I-\Pi\Delta\right)^{-1} \\ &= y\Delta\left(I+\Pi\Delta+\left(\Pi\Delta\right)^{2}+\left(\Pi\Delta\right)^{3}+\cdots\right) \end{aligned} \tag{2.4}$$

The matrix $\Pi\Delta$ is given by

$$\Pi\Delta=\begin{bmatrix} 0 & \delta_2\pi_{12} & \cdots & \delta_n\pi_{1n} \\ \delta_1\pi_{21} & 0 & & \delta_n\pi_{2n} \\ \vdots & & \ddots & \vdots \\ \delta_1\pi_{n1} & \delta_2\pi_{n2} & \cdots & 0 \end{bmatrix} \tag{2.5}$$

The infinite series in (2.4) converges since the rows of $\Pi\Delta$ sum to a number strictly less than 1. Hence, the inverse $\left(I-\Pi\Delta\right)^{-1}$ is well-defined.

Equation (2.4) is just a re-writing of the balance sheet identity of all financial intermediaries in the system. However, (2.4) can be given empirical content once we model the banks' choice of leverage, as given by the diagonal matrix Δ. Leverage will be determined by banks' measured risks on their asset portfolio.

2.1. Value at Risk

For bank i its *value at risk* at confidence level c relative to the face value of its assets $\bar{a}_i$, is defined as the smallest non-negative number V such that

$$\Pr\left(\hat{a}_i<\bar{a}_i-V\right)\leq 1-c \tag{2.6}$$

where $\hat{a}_i$ is the realized value of assets of bank i at some future terminal date. In other words, the value at risk V can be seen as the "approximately worst case" loss that the bank may suffer, where "approximately worst case" is defined so that anything worse than this approximately worst case happens with probability less than some benchmark $1-c$.

The concept of value at risk has been adopted widely among financial institutions in their risk management practices. The annual reports and regulatory

filings of major banks devote a substantial part to a discussion of their value at risk estimates. Moreover, value at risk has been adopted in the regulatory framework for capital since the 1996 Market Risk Amendment of the Basel Accord, and in the Basel II regulations. See Adrian and Shin (2008b) for a microeconomic model where value at risk emerges as the outcome of a contracting problem between banks and their creditors.

2.2. Determination of Leverage

Risk management is intimately tied to the leverage of the bank. Suppose that a bank aims to adjust its balance sheet so that its market equity e_i is set equal to its value at risk. The term "economic capital" is sometimes used interchangeably with the bank's value at risk.

Of particular interest is the comparative statics effect on leverage and debt of improvements in the credit quality of the underlying end-user loans. In particular, consider a first-degree stochastic dominance shift in the repayments associated with an improvement in the credit quality of the loans to end-users. The direct effect on the market values $\{y_i\}$ of the loans to end-users is immediate, but there is also an indirect effect on the market values $\{x_i\}$ of the debt issues by the n banks. This follows from the fact that the market value of bank i's debt is increasing in the value of its assets, since the bank's debt is a promise backed by its assets (Shin (2008)).

The overall effect of a first-degree stochastic dominance shift in the repayment density associated with loans to end-users is that the possible asset value realizations of the banks also shifts in a first-degree stochastic dominance sense.[4] Figure 2.3 illustrates the comparative statics effect. As before, $\bar{a}_i$ is the face value of bank i's assets. Initially, the probability density over realized assets is such that

[4] See Shin (2008) for the details of the analysis.

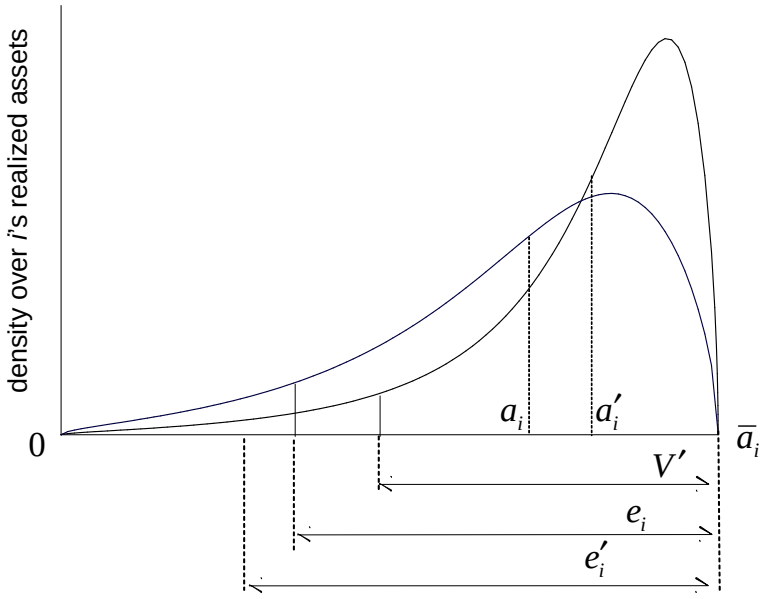

Figure 2.3: Reduction in credit risk leads both to an increase in the market value of equity to e_i' and to a decrease in the value at risk to V', so that $e_i' > V'$. Bank i then has surplus capital relative to the initial point when equity was equal to value at risk.

the market value of assets is a_i, and the value at risk is given by initial market equity e_i. After the first degree stochastic dominance shift in the repayment density, there is an associated first degree stochastic dominance shift in the density over possible asset value realizations, both directly through the end-user loans, and indirectly through the strengthening of other banks' balance sheets. Figure 2.3 illustrates the shift.

The new market value of assets is given by a_i', and economic capital falls to the bank's value at risk V', while the market value of equity rises to e'. We have $V' < e_i'$, since the area under the density to the left of $\bar{a}_i - e_i$ under the old density must be equal to the area to the left of $\bar{a}_i - V'$ under the new density. Thus, market equity e' after the shift exceeds economic capital, given by value at risk V'. Hence, banks seek to adjust their leverage upward, so that equity is once again in line with the new (lower) value at risk. The banks expand their balance sheets by increasing the face value of debt. The mechanism works exactly in reverse "on the way down".

The actions of individual banks in reaction to balance sheet changes have an aggregate effect on the sector as a whole. As a sector as a whole, the increased balance sheets of the financial intermediaries are achieved through greater borrowing from either the domestic claimholders or the foreign creditors. Thus, part of the increased financial intermediary balance sheets will be financed through greater borrowing from foreign creditors. Hence, external adjustment through greater borrowing from foreign creditors will be an important component of the funding necessary to accomplish such an expansion.

In particular, if the domestic claim holders in figure 2.2 are already heavily committed to the financial intermediary sector through deposits and holdings of mortgage backed securities, then most of the adjustment will have to take place through increased commitment of the foreign creditors. Notice also why the for-

eign claim holders hold debt claims rather than equity. The increased expansions of the financial intermediary balance sheets are intended to raise leverage - i.e. to increase assets to a level that once again equates total value at risk with market equity. Thus, it is debt, rather than equity that is raised by the financial intermediaries. This feature of our model explains the fact discussed by Balakrishnan, Bayoumi and Tulin (2007) that most of the financing of the US current account deficit has been met with debt rather than equity.

Finally, we note one further consequence of our framework. Asset price booms (especially housing booms) and current account deficits go hand in hand. They are both reflections of the booming leverage of the financial intermediary sector. Going forward, as the US housing market declines, we would expect to see the accompanying reversal of the US current account deficit.

3. Role of the Yen Carry Trade

We now turn to the role of the yen carry trade in the external adjustment described above. Before going to the key plots we describe some background. Consider first the total assets of foreign banks in Japan in figure 3.1. Total assets of foreign banks increased rapidly in the late 90s, and have stayed high since. The composition of total assets (given in figure 3.2) gives clues as to the reasons for the increase in the late 90s.

The sharp increase in foreign bank assets in 1997 and 1998 is accounted for by the increase in "bills bought". The Japan premium ruling at the time meant that non-Japanese banks had a considerable pricing advantage over local Japanese rivals, and managed to exploit this advantage.

Even as the "bills bought" amount falls in 1999 and 2000, the slack is taken up by holdings of Japanese securities in 2000 and 2001. Lately, the item "due from banks" has taken up the slack left by falls in other categories. This period

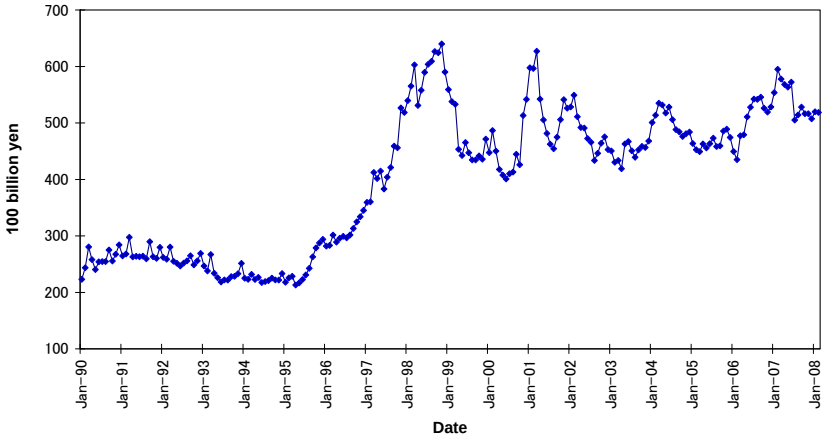

Figure 3.1: Total Assets of Foreign Banks in Japan

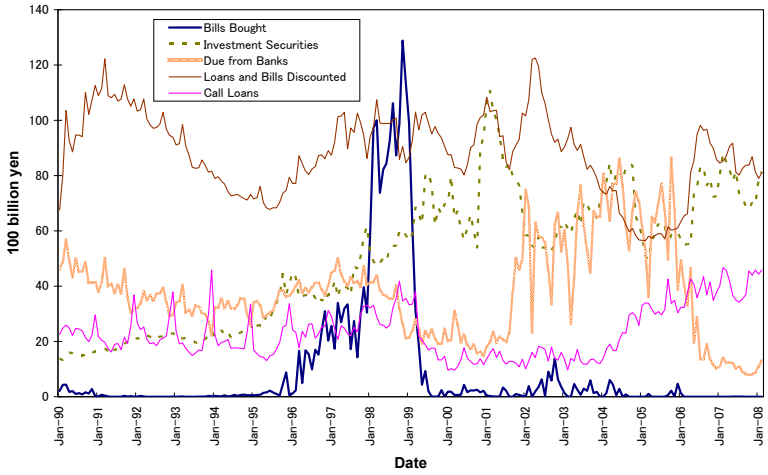

Figure 3.2: Composition of Assets of Foreign Banks

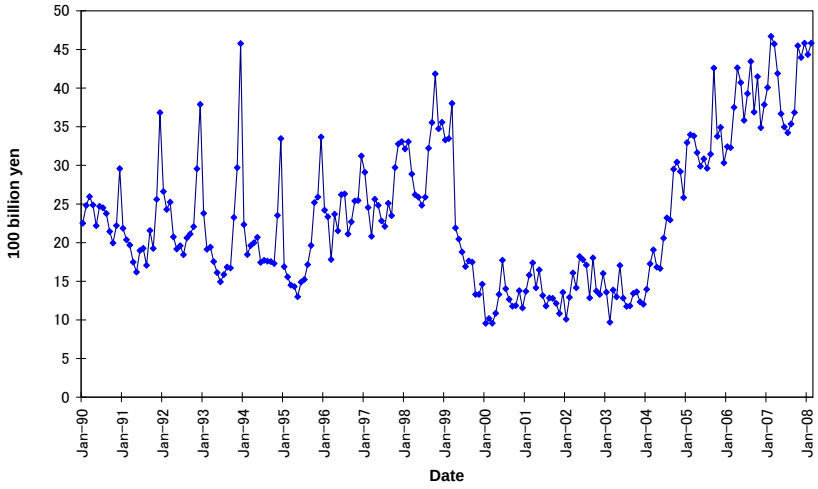

Figure 3.3: Interbank Assets (Call Loan) of Foreign Banks in Japan

coincides with the period of quantitative easing by the Bank of Japan, and suggests that even foreign banks had surplus balances at the BOJ.

We now focus on the key series for the yen carry trade. Figures 3.3 and 3.4 plot, respectively, the aggregate interbank assets of foreign banks in Japan ("call loan") and the aggregate interbank liabilities of foreign banks in Japan ("call money"). Call loans have fluctuated over the years, and were low in the early part of the decade when US interest rates were exceptionally low. Call money (yen liabilities) have fluctuated even more, with a surge in the period after 2004, when the US interbank rate was rising. Note that the scale is different in the two series, so that the surge in yen liabilities is larger than at first meets the eye.

As a result of the surge in yen liabilities, the net interbank position of foreign banks becomes sharply negative in the most recent period leading up to the credit crisis (see figure 3.5) but has subsequently fallen back with the onset of the crisis. However, the important piece of evidence is the stance on the interoffice account.

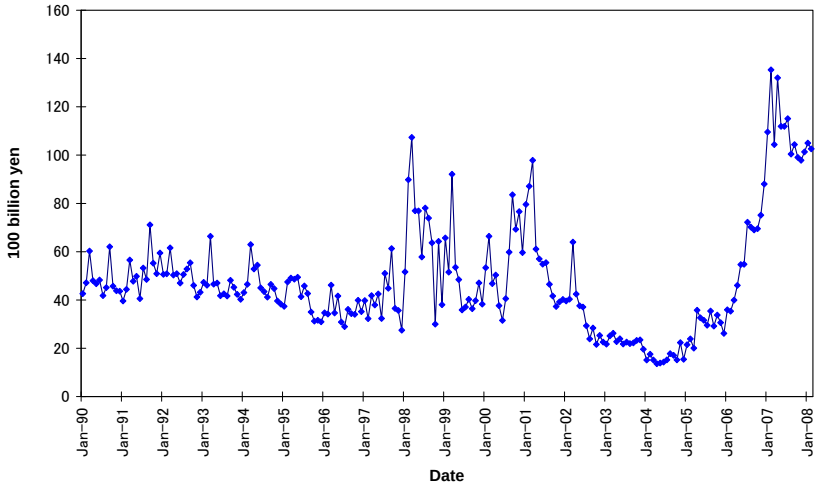

Figure 3.4: Interbank Liabilities (Call Money) of Foreign Banks in Japan

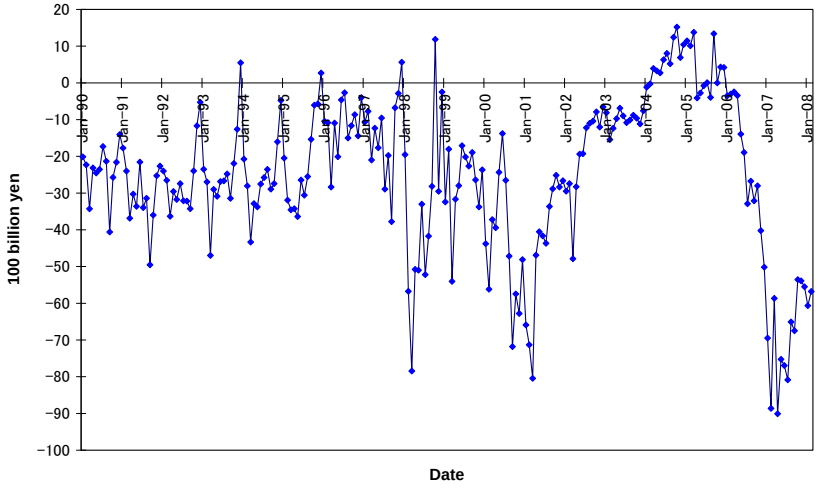

Figure 3.5: Net Interbank Assets of Foreign Banks in Japan

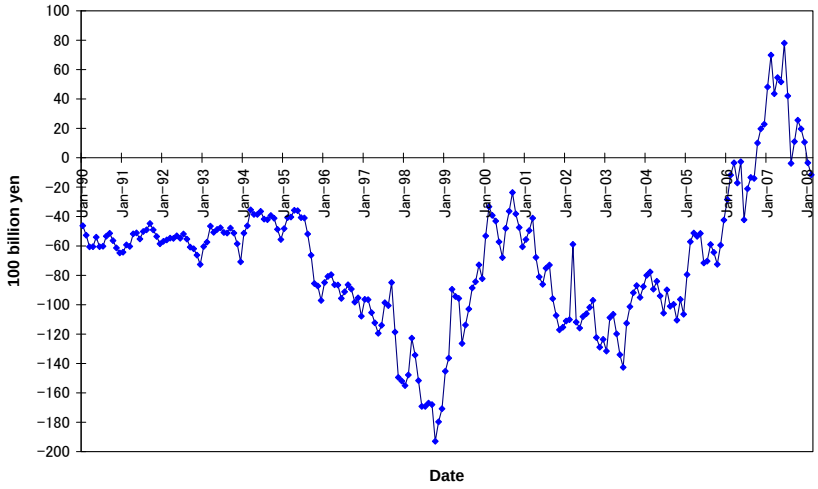

Figure 3.6: Net Interoffice Accounts of Foreign Banks in Japan

In order to conclude that the surge in yen liabilities is associated with the carry trade, we need to verify that the increased yen liabilities have been channeled out of Japan to other offices of the banks concerned. The crucial piece of evidence is therefore the net interoffice accounts, as presented in figure 3.6.

As previously discussed, the net interoffice accounts of foreign banks have normally been negative, implying that foreign banks have held a net long position in Japanese assets. In the period of the "Japan premium" (roughly 1997 to 1998) foreign banks held large net long positions in Japanese assets, given their funding advantage over Japanese rivals handicapped by the Japan premium.[5]

However, the most noteworthy feature of figure 3.6 is the surge in net interoffice accounts in the most recent period, dating from around 2005. The increase in the net interoffice account is so large that the usual sign of the net interoffice account was reversed in the period leading up to the crisis of 2007. The implication is

[5]The Japan premium explains the very sharp spike upward in the "bills bought" component of foreign banks' assets, as shown in figure 3.2.

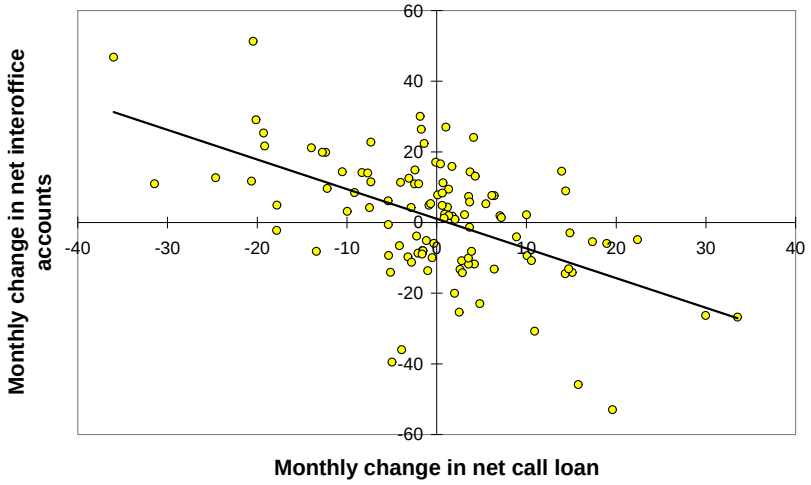

Figure 3.7: The figure is a scatter chart of change in net interoffice accounts against change in net call loans (units: 100 billion yen). The negative relationship is evidence that foreign banks' borrowing in the Tokyo interbank market is being channeled for use outside Japan.

that yen funding had been channeled out of Japan immediately prior to the credit crisis of 2007. The surge has subsequently been reversed as the 2007 credit crisis has progressed.

Figure 3.7 is a scatter chart of the monthly change in the interoffice accounts of foreign banks against the monthly change in the net interbank assets (call loan minus call money) of foreign banks from 1999. If our hypothesis is correct that the fluctuations in yen liabilities reflect the broad yen carry trade, then the points on the scatter chart should be negatively sloped. The slope of the relationship would depend on the degree to which the yen liabilities of the foreign banks' Japan office merely reflects the channeling of yen to uses outside Japan. If the slope is -1, then there is a one-for-one relationship between increases in yen interbank liabilities and yen interoffice accounts, suggesting that changes in yen liabilities

reflect the broad yen carry trade. If the slope has a lower absolute value, then the fluctuations in yen interbank liabilities would reflect other motives for borrowing yen (such as funding the purchase of Japanese securities)

In the scatter chart, we see, indeed, that the relationship is strongly negative. The slope of the OLS regression is close to -1 at -0.89.[6] We take this to be evidence consistent with the hypothesis that the Japan offices of the foreign banks play the role of channeling yen liquidity out of Japan in the broad yen carry trade.

The evidence focuses attention on the question of how such yen funding has been used by the headquarters offices of the foreign banks. At this point, the trail becomes murkier, but it would be a reasonable conjecture (to be verified through other evidence) that the increased yen funding has either been recycled for use by the customers of the foreign banks in their home markets (e.g. hedge funds), or have funded the mortgage-backed securities and other assets on the banks' own balance sheets.

We have focused on the yen interbank for evidence of the carry trade, but there are other means through which foreign institutions can raise funding in Japan, such as the issuance of "Samurai bonds" - i.e. yen-denominated bonds issued by non-residents, especially when the issuer is a foreign bank. A more comprehensive study of the carry trade would need to take account of such alternative funding sources.

3.1. Carry Trades and Balance Sheet Size

We turn now to the final piece in the jigsaw. If the close comovement of net interoffice accounts and the net interbank assets of foreign banks in Tokyo is an indication that yen funding is being channeled for use outside Japan, then the increased incidence of the carry trade should show up on the balance sheets

[6]The t-statistic is -7.15.and the R^2 is 0.34.

of financial intermediaries outside Japan, especially for the period in which the yen carry trade is expected to have played a key role in the funding of financial intermediaries outside Japan.

We examine data for the aggregate security broker dealer sector for the United States, as given by the Flow of Funds accounts for the US. Adrian and Shin (2007) have shown that the security broker dealer sector (which includes the major US investment banks) respond sensitively to shifts in measured risks and other market conditions by active adjustment of their balance sheets. Also, given the importance of the market-based funding of residential mortgages in the US (with two thirds now being held by mortgage pools rather than banks), the security broker dealer balance sheets provide a timely window on the market-based banking system.

The flow of funds is a quarterly series, while our net interoffice account is monthly. Therefore we took quarterly snapshots of the interoffice accounts. In order that we minimize the influence of short-term noise in the series and focus on the long-run trends, we take longer-term growth rates, but measured at quarterly intervals. Figure 3.8 plots the two year growth rate of the US security dealer sector total assets together with the two year change in the net interoffice accounts.[7] Thus, the first observation for the security dealer series is the growth from March 1st 1999 to March 1st 2001, the next is the growth from June 1st 1999 to June 1st 2001, and so on.

For the period from 2001 to 2008, the two series track each other closely. The dip in the early years of the decade coincides with the period of low US short term interest rates, when the carry element was small.[8] Later in the decade, when the interest rate differential starts to widen, both series move up. In particular, the

[7]The reason why we take changes rather than growth rates for the net interoffice accounts is that the series changes sign frequently, with some observations close to zero.

[8]We will see later some independent confirmation of the role of the interest rate differential.

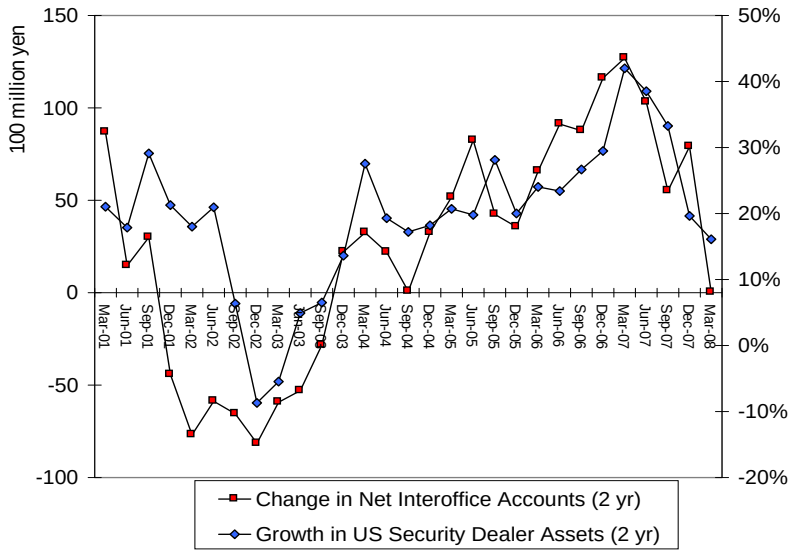

Figure 3.8: This figure charts the two-year growth in US security dealer assets and the two-year change in the net interoffice accounts. The two series move together, suggesting that yen funding is associated with balance sheet expansions of US intermediaries.

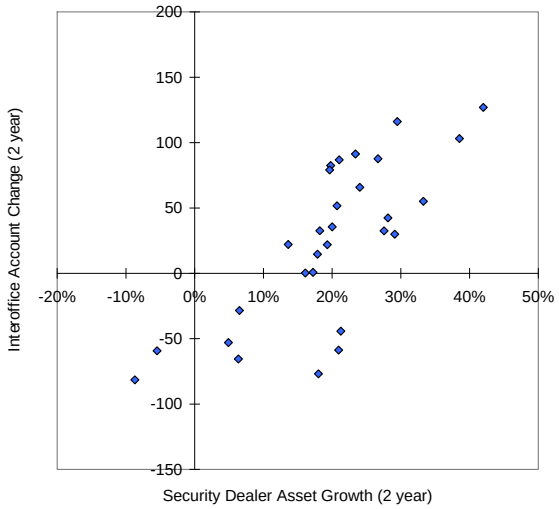

Figure 3.9: This figure is a scatter chart of the two-year growth in US security dealer assets and the two-year change in the net interoffice accounts. There is a positive relationship between them, suggesting that yen funding is associated with balance sheet expansions of US intermediaries.

boom in US housing markets and the associated period of rapid growth in broker dealer assets coincide in the interval from 2005 to early 2007. Then, with the onset of the credit crisis of 2007, both series move down sharply.

The scatter chart given in figure 3.9 confirms the close co-movement in the two series. A linear regression yields an R^2 of 57%, and a t-statistic on the regressor of 6.0.

4. Carry Trades and Risk Appetite

We now examine the wider implications of the carry trade. Our focus is on the implications of expansions of balance sheets for the appetite for risk. In a financial system where balance sheets are continuously marked to market, changes in asset

prices show up immediately on the balance sheet, and so have an immediate impact on the net worth of all constituents of the financial system. The reactions of financial intermediaries to such changes in net worth is a critical influence on overall market risk appetite.

If financial intermediaries were passive and did not adjust their balance sheets to changes in net worth, then leverage would fall when total assets rise. Change in leverage and change in balance sheet size would then be negatively related. However, as documented by Adrian and Shin (2007), the evidence points to a strongly *positive* relationship between changes in leverage and changes in balance sheet size. Far from being passive, financial intermediaries adjust their balance sheets actively, and doing so in such a way that leverage is high during booms and low during busts.

As we have seen in our sketch of the stylized financial system, procyclical leverage can be seen as a consequence of the active management of balance sheets by financial intermediaries who respond to changes in prices and measured risk. For financial intermediaries, their models of risk and economic capital dictate active management of their overall value at risk (VaR) through adjustments of their balance sheets. Credit ratings are a key determinant of their cost of funding, and they will attempt to manage key financial ratios so as to hit their credit rating targets.

From the point of view of each financial intermediary, decision rules that result in procyclical leverage are readily understandable. However, there are aggregate consequences of such behavior for the financial system as a whole that are not taken into consideration by an individual financial intermediary. Such behavior has aggregate consequences on overall financial conditions, risk appetite and the amplification of financial cycles.

For these reasons, it would be important to draw a distinction between the

capital outflows from Japan due to the carry trades by financial intermediaries and the outflows due to the household sector's purchase of foreign assets, or the diversifaction of the portfolios of institutions such as mutual funds and life insurance companies that are not leveraged, or have minimal leverage. Indeed, the purchase of foreign currency assets for these entities should not be seen as part of the yen carry trade we have discussed so far. In contrast, the most important marginal players are the financial intermediaries whose fluctuating balance sheets determine overall financial market liquidity conditions.

Aggregate liquidity can be understood as the rate of growth of aggregate balance sheets. When financial intermediaries' balance sheets are generally strong, their leverage is too low. The financial intermediaries hold surplus capital, and they will attempt to find ways in which they can employ their surplus capital. In a loose analogy with manufacturing firms, we may see the financial system as having "surplus capacity". For such surplus capacity to be utilized, the intermediaries must expand their balance sheets. On the liabilities side, they take on more short-term debt. On the asset side, they search for potential borrowers that they can lend to. It is in this context that the broad yen carry trade comes into sharper focus. By allowing intermediaries to expand their balance sheets at lower cost, the broad carry trade fuels the financial boom. Aggregate liquidity is intimately tied to how hard the financial intermediaries search for borrowers. In the sub-prime mortgage market in the United States we have seen that when balance sheets are expanding fast enough, even borrowers that do not have the means to repay are granted credit - so intense is the urge to employ surplus capital. The seeds of the subsequent downturn in the credit cycle are thus sown. Jimenez and Saurina (2006) show from their study of Spanish banks that the loans granted during booms have higher default rates than those granted during leaner times.

Adrian and Shin (2007) have shown that balance sheet changes are closely

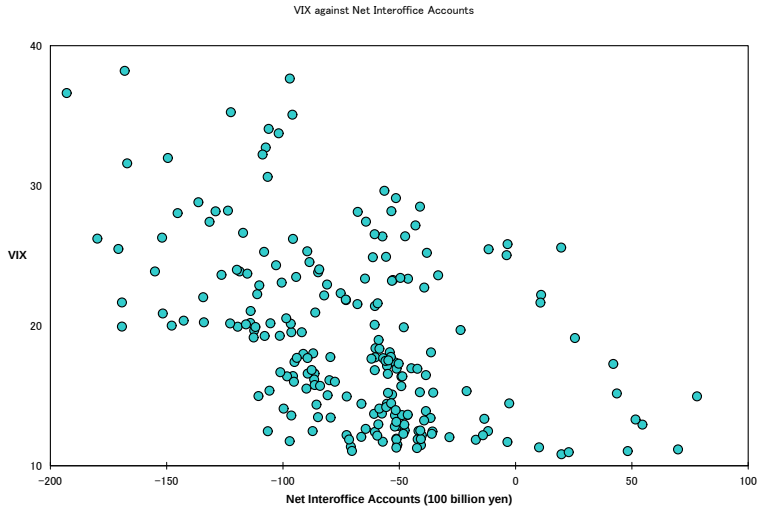

Figure 4.1: This figure is the scatter chart of the VIX index of implied volatility derived from options on the US stock market against the net interoffice account. There is a negative relationship between the two, suggesting that the yen carry trade is associated with periods of greater risk appetite.

related to the overall market risk appetite, as measured by the VIX index of implied volatility of stocks. In the context of the broad yen carry trade, it would be reasonable to conjecture that something similar holds, too.

Figure 4.1 is a scatter chart of the VIX index against the net interoffice account of foreign banks in Japan. There is a striking negative relation, where large net interoffice accounts are associated with lower implied volatility - i.e. large balance sheets with greater risk appetite. We know from the period immediately preceding the 2007 credit crisis that implied volatility had plumbed historical lows. As we have seen earlier, this was precisely the period when the net interoffice accounts became positive - also an unprecedented event. More worryingly, the unwinding of these large net interbank assets to return the system to its historical norm will undoubtedly have adverse aggregate consequences.

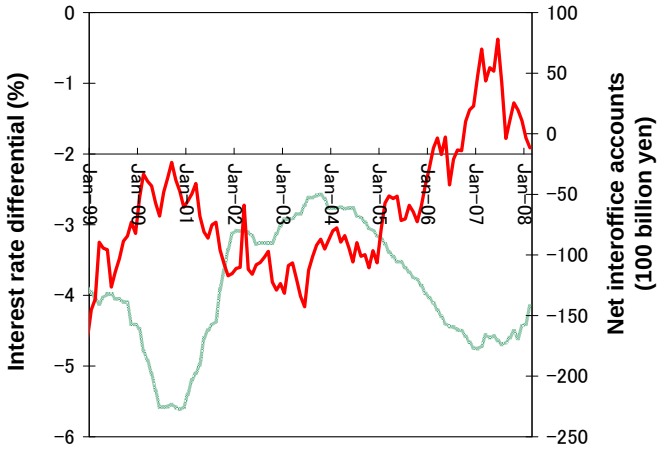

Figure 5.1: This figure charts the net interoffice accounts and interest rate differetial between Japan and simple average of the US Dollar, the Euro and the Australian Dollar. There is a negative relationship between the two series, suggesting that the yen carry trade is most active when interest rate differentials are large.

5. Carry Trades and Monetary Policy

Given the importance of balance sheet fluctuations for overall risk appetite and their spillover effects for the economy as a whole, the role of the carry trade in facilitating or amplifying the balance sheet fluctuations make it a prime concern for monetary authorities. We examine the determinants of the size of the yen carry trade, especially the role of the short term interest rate.

The important role played by the overnight rate can be gleaned from the relationship between the extent of the broad yen carry trade and the interest rate differential between Japan and other developed countries. Figure 5.1 charts the net interoffice accounts with the difference between the overnight rates in Japan

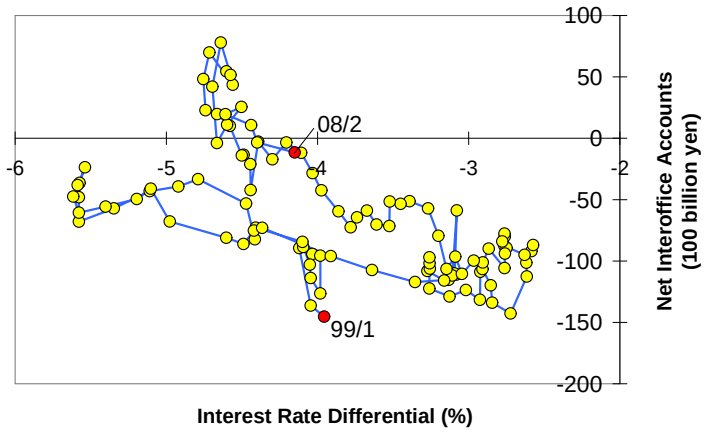

Figure 5.2: This figure is a timed scatter chart of the net interoffice accounts and interest rate differetial between Japan and simple average of the US Dollar, the Euro and the Australian Dollar. There is a negative relationship between the two series, suggesting that the yen carry trade is most active when interest rate differentials are large.

and a simple average of the policy rates in the US, Eurozone and Australia. The chart suggests that since 1999, we have a negative relationship between the two. The larger is the difference in short term rates between Japan and the group of countries we consider (US, Eurozone and Australia) the greater is the broad yen carry trade. It is notable, especially, that in the period 2002 - 2004 when US interest rates were low, and hence close to that of Japan's, the net interoffice account shows little evidence of large scale carry trades. In contrast, the period from 2005 onwards shows a surge in net interoffice accounts coming at the time when US interest rates were moving back up to historically more normal levels.

The same information can be represented as a timed scatter chart as in figure 5.2. There is a strongly negative relationship in the two series. The first and

last data points (January 1999 and August 2007) are indicated with the red dots. An OLS regression has a t-statistic of -7.8.

The importance of the interest rate differential for the carry trade is also apparent in the skewness of returns, as shown by Brunnermeier, Nagel and Pedersen (2008), and Gagnon and Chaboud (2007) since the unwinding of the carry trade is likely to be more abrupt than the build-up of positions.[9] Interest rate differentials also figure in theoretical models of the carry trade (see Plantin and Shin (2006)). The carry element combined with a procylical leverage ratio (illustrated in the previous section) serve to increase the spillover effects of one currency speculator's actions on others, making speculative trading strategic complements. The carry element turns out to be crucial in this regard. Without the carry element, speculators' actions are strategic substitutes.

5.1. Combining Information from VIX and Interest Rate Differential

So far, we have discussed the role of the changes in the VIX index and the interest rate differential separately, and shown that they individually have some explanatory power as determinants of the net interoffice accounts. Both VIX and the interest rate differential continue to have explanatory power when combined, as seen in Table 1. As seen from column (1) of the table, in a linear regression where both series are included, both VIX and the interest rate diffrential term are highly significant. Indeed, we see that the R^2 rises to 59.5%, from 37.7% when only the interest rate differential is used as the regressor, and from 19.6% when only VIX is used.

[9]See also Burnside et al. (2007) on the excess returns on the carry trade. See Gyntelberg and Remolona (2007) for the evidence of carry trades in other Asian currencies.

Table 1: Determinants of Net interoffice accounts

Explanatory variable	(1)	(2)	(3)
Interest rate differential	-37.349	-36.299	
	(0.000)	(0.000)	
VIX	-3.679		-3.490
	(0.000)		(0.000)
constant	-134.380	-204.850	8.083
	(0.000)	(0.000)	(0.568)
R-squared	0.595	0.377	0.196

Note: The sample period is from January 1999 to February 2008. P-value in parentheses.

Figure 5.3: This table reports results of regressions where the dependent variable is the net interoffice accounts of foreign banks. Regression (1) uses both the interest rate differential and the VIX index as regressors. Both are highly significant. Regressions (2) and (3) report results from the regressions with, respectively, the interest rate differential and the VIX index.

5.2. Implications for Monetary Policy

Our empirical findings suggest that the overnight rate set by central banks may have an important role in influencing the scale of the carry trade, but more broadly in determining balance sheet size in the financial sector as a whole. Our results are in line with the results of Adrian and Shin (2008a), who show that the residuals from a Taylor rule regression is closely (negatively) related to the growth of financial sector balance sheets in the United States. These results suggest that overnight rates may have some importance in their own right when conducting monetary policy, not merely as an instrument to signal the central bank's intentions of future actions.

Our conclusions run counter to some key tenets of central bank thinking in recent years, especially at those central banks that practice inflation-targeting. Under this alternative view, the overnight rate is important only as a means of communicating with the market on future central bank actions, and thereby managing market expectations (see, for instance, Blinder (1998) and Bernanke (2004a, 2004b)).

However, to the extent that financial stability concerns should impinge on monetary policy, the insignificance of the overnight rate may have been somewhat overdone. On the contrary, short term rates could be conjectured to play an important role in their own right, since it is the short term rate that determines the cost of rolling over liabilities.

In addition, although monetary policy is conducted primarily with domestic macroeconomic conditions in mind, there are undoubted international spillover effects. The experience of the 2007 credit crisis is a lesson in the importance of financial stability in the conduct of monetary policy.

6. Carry Trade and Subprime Crisis

The main theme of our paper has been that the external adjustment of the US current account deficit should be viewed in terms of the deleveraging of the US financial intermediary sector. The fate of the yen carry trade is tied up with this overall process. Although sometimes the yen carry trade is viewed narrowly simply as a trade in the foreign exchange market, we have seen that the phenomenon should be viewed within the larger context of the waxing and waning of the balance sheets of the financial intermediary sector as a whole.

We illustrate the way in which the unwinding of the leverage has been proceeding during the current credit crisis. Figure 6.1 is a scatter chart that plots the monthly change in the net interoffice accounts against the AA tranche of the ABX index (the vintage being the first half of 2007), compiled by the London firm Markit. The ABX index summarizes the information from polls taken from dealers who quote prices for credit default swaps (CDSs) on various tranches of collateralized debt obligations (CDOs) built on subprime residental mortgages. To the extent that the CDS prices reflect underlying prices, the ABX index is a reflection of the prices of the underlying subprime mortgage assets. The qualification is that the ABX index may also reflect liquidity effects arising from balance sheet constraints, and so the index should be seen as a composite of the underlying "true" values in a non-distressed market, together with a liquidity premium that increases during periods of distress.

The scatter chart reveals that the subprime crisis has been intimately linked with the unwinding of the yen carry trade in terms of the reversal of the net interoffice account positions of foreign banks. The scatter chart shows the monthly changes in the net interoffice accounts from the beginning of 2007.

In the early months of 2007, the ABX index is trading at very close to par, as

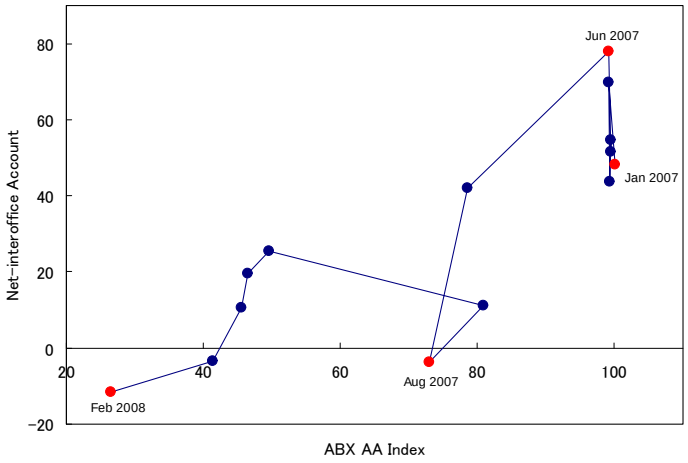

Figure 6.1: This figure is the scatter chart of monthly change in net interoffice account and the ABX AA 07-1 index of implied subprime mortgage security prices. There is a negative relationship between the two, suggesting that the carry trade is being unwound as the price of subprime mortgage securities fall.

befits a credit rating of AA. Even the minor ripple that occurred in the foreign exchange market in February and early March of 2007 barely registers on the chart.

However, the picture changes radically from the end of June 2007. Thereafter, there is a rapid fall in the ABX index, accompanied by the unwinding of the net interoffice accounts. The sharpest movement occurs in August, when (beginning on August 9th) the subprime crisis took hold in the interbank credit market resulting in the drying up of liquidity in the interbank credit market. We see that August saw a sharp adjustment of the net interoffice account, consistent with the rapid unwinding of the yen carry trade positions of the foreign banks in Japan.

As the crisis has unfolded in the subsequent months, the net interoffice account has once again become negative - back to the historically normal position in which foreign banks hold a net positive position in Japanese assets. In doing so, it would be reasonable to conjecture that the funding for repayment of the yen debt to the Japanese banks has been obtained through the deleveraging process of foreign banks, and in particular through the sale of assets previously held on the balance sheets of the banks. Mortgage assets and related fixed income securities would have been a key component of such asset sales.

7. Concluding Remarks

In the lead-up to the credit crisis of 2007/8, purchases of mortgage assets and related securities by hedge funds and their intermediaries was financed (at least in part) by money that was ultimately borrowed in Japan. With the bursting of the credit bubble and the gathering pace of the deleveraging, the hedge funds and their intermediaries have had to unwind such bets by selling mortgage assets and repaying their Japanese creditors. Thus, we saw in the early stages of the crisis the conjunction of a fall in asset prices and a fall in the US dollar.

More broadly, we have examined the broader implications of the yen carry trade for risk appetite and financial cycles. Although the yen carry trade has traditionally been viewed in narrow terms purely as a foreign exchange transaction, we have argued that they hold broader implications for the workings of the financial system and for monetary policy. The evidence from the waxing and waning of balance sheets of foreign banks operating in Japan points to a broader notion of the carry trade. Yen liabilities fund not only pure currency carry trades, but also fund the general increase in balance sheets of hedge funds and financial intermediaries. Finally, we have shown that the difference in overnight rates across countries is a crucial determinant of balance sheet changes. Therefore, the short term interest rate may be more important as a gauge of the stance of monetary policy than is given credit for by current monetary thinking. Domestic monetary policy has a global dimension through the workings of the global financial system.

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