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Impact of macroeconomic surprises on carry trade activity

Michael Hutchison[a], Vladyslav Sushko[b*+]

[a]*University of California Santa Cruz, E2, Santa Cruz, CA 95064 United States*
[b]*Bank for International Settlements, Centralbahnplatz 2, Basel, CH-4002, Switzerland*

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Abstract

Can official news and policy announcements affect foreign exchange speculation? A widespread speculative strategy in foreign exchange markets is carry trade. This paper explores the links between macroeconomic news and foreign exchange options to identify macroeconomic fundamentals most relevant to the pricing of downside risk – measured by risk reversals options contracts – to carry trade activity. Focusing primarily on the Japanese yen carry trade, we identify a significant impact of macroeconomic surprises on dollar/yen risk reversals. The effect is sizeable, with news related to bilateral trade balance of particular concern. Moreover, there is a close link between risk reversals and speculative futures positions in Japanese yen. This allows us to quantify a substantial effect of macroeconomic news on carry trade activity, with the cost of hedging as the transmission mechanism.

JEL classification: C22; F31; G14
Keywords: Macroeconomic news; Risk reversals; Foreign exchange futures; Carry trade

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[*] Corresponding author. Tel.: +41 61 280 8757; fax: +41 61 280 9100.
E-mail addresses: hutch@ucsc.edu (M. Hutchison), vlad.sushko@bis.org (V. Sushko).
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1. Introduction

One of the consequences of the zero-interest rate policy in Japan was the emergence of massive yen (JPY) currency carry trade activity where investors borrowed in yen (funding currency) and bought higher-yield assets in other currencies (target or investment currency). Specifically, a carry trader borrows in a low interest rate currency and takes a long position in a higher interest rate currency betting that the exchange rate will not change so as to offset the profits made on the yield differential. For example, an investor can fund higher yielding deposits in the U.S. by borrowing from commercial banks in Japan at low interest. This strategy will necessitate a foreign exchange transaction to sell yen for U.S. dollars (USD) in order to convert yen liabilities into dollar assets. In addition to issuing liabilities in low-interest currencies, carry trade can be conducted using currency forwards and futures on the margin (Gagnon and Chaboud 2007). For example, a hedge fund could enter a forward contract to sell yen for dollar at some future date. Such carry trade strategies generated persistent excess returns (e.g. Burnside et al., 2007; Darvas, 2009; Hochradl and Wagner, 2010), but also exposed carry traders to substantial currency risk and large losses if the yen were to appreciate substantially (Gyntelberg and Remolona, 2007). Brunnermeier et al. (2009) confirm the presence of such crash risk (negative skewness) in carry trade returns due to rare occurrences of unexpected shocks to the interest rate differential between low and high yield currencies. Nirei and Sushko (2011) find that during periods of heavy carry trade yen appreciation jumps exhibit dependence and extremes not explained by random shocks alone. Both studies find that crash risk, whether measured as negative skewness or realized volatility jumps, is increasing in net speculative positions. It is as if spurs of carry trade unwinding when faced with risks of funding currency appreciation amplify

the impact of otherwise random shocks. Anzuini and Fornari (2012) provide an examination of this channel by exploring the impact of specific macroeconomic shocks on carry trade profitability and positioning, as such shocks would drive fluctuations in exchange rate as well as the interest rate differential. We add to this literature by explicitly focusing on market expectations of such crash risk – the market price of skewness in carry trade currencies derived from currency options – and how changes in these expectations serve to transmit macroeconomic shocks into actual position taking by carry traders.

Figure 1 shows the U.S.-Japan interest differential and the JPY/USD exchange rate during 2004-06 when the yen carry trade was at its height. The prolonged low interest policy and weak economy in Japan, during which short-term money market rates were continuously near zero, combined with a strong economy and rising interest rates in the U.S., led to a rising, large and persistent interest differential. The figure also shows that the JPY/USD depreciated on average over this period, but that trend depreciation was interrupted by several episodes of sharp appreciation and considerable volatility. This seeming violation of uncovered interest parity (UIP) allowed profit opportunities (ex post) for carry traders, but the riskiness of this strategy was also exposed during the bouts of large yen appreciation.[1, 2]

Figure 2 presents a broader look at the ex-ante attractiveness of carry trade by currency pair during the sample period. Following the methodology of Menkhoff et al. (2012), we rank currencies based on their forward premium/discount vis-à-vis the USD, assuming that the covered interest rate parity (CIP) still holds.[3] If the differential is above (below) 0.25 (-0.25) percentage points the currency is classified as funding (target) currency. Based on this

[1] An appreciation of the high yield currency is an example of the forward premium puzzle and the violation of the uncovered interest parity (UIP) well documented by Hansen and Hodrick (1980) and Engel (1996).
[2] Ichiue and Koyama (2011) estimate the UIP regression coefficient as low as -2.79 for the yen.
[3] Unlike the USD, which could have been used as either funding or target currency depending on the counterpart, JPY was always a funding currency.

methodology, JPY and Swiss franc (CHF) traded at significant forward premiums to USD and Australian dollar (AUD). This implied an ex-ante profitable investment opportunity for carry trade (a bet against the CIP) is to short JPY or CHF and go long AUD or USD. Accordingly, we supplement the main analysis using JPY/USD with data from the CHF/USD and JPY/AUD foreign exchange market.

One way to hedge against the risk of substantial funding currency (e.g. JPY) appreciation is to enter into a risk reversal contract. A risk reversal is the simultaneous purchase of a deep out-of-money (OTM) call option and the sale of a deep OTM put option.[4] The holder of the risk reversal hedges the risk of sharp JPY appreciation by accepting the (unlikely) downside risk of sharp JPY depreciation, taking on a one-sided bet. Carry traders would lose on this risk reversal contract if JPY depreciates sharply, but this loss is more than offset by gains from holding an open yen carry position. As such, the value of risk reversals serves as a proxy for expectations of the risk of very large exchange rate movement.[5] Figure 3 shows that during the latter half of the "great moderation" chosen as our time sample, when financial institutions borrowed heavily in JPY (or CHF) investing in assets denominated in USD (or AUD), the values of the risk reversals, with one exception of USD/CHF in 2005 Q3 and Q4, reflected a market hedge against sharp carry (funding) currency depreciation (appreciation). Note the consistency of the direction of the risk-reversal hedge with forward premiums (discounts) of respective currencies.

This paper investigates market perceptions of the risk of large exchange rate movements with information gleaned from risk reversal contracts and macroeconomic news surprises.[6] We focus

[4] A risk reversal is a directional bet on (or hedge against) a large price movement constructed by a simultaneous purchase of out-of-money call and sale of out-of-money put option (usually 25 or 10 delta) of the same maturity. The value itself is the implied volatility for the call minus the implied volatility of the put.

[5] Brunnermeier et al. (2009) interpret such persistent UIP violations as a compensation to carry traders for the downside risk of sharp funding currency appreciation.

[6] Evans and Lyons (2008) investigate the impact of macro news on order flow, while Ito and Hashimoto (2010) and Fatum, Hutchison, and Wu (2012) investigate high frequency responses to macro surprises in JPY/USD exchange

on the height of the carry trade period in Japan (March 2004 through December 2006), where the sample is delimited at the beginning by the cessation of the Bank of Japan large-scale intervention operations and ends before the financial crisis emerged. In our view, concerns about sharp yen appreciation were particularly evident during the period of heavy carry trade activity and are more likely to show up in the price of risk.

We find that macroeconomic news is an important determinant of risk reversals during periods of heavy carry trade volume, particularly when the cost of hedging against large yen appreciation is increasing. The results are consistent with Anzuini and Fornari (2012), who find that macroeconomic shocks can have significant impact on carry trade profitability. Estimates using predicted values based on regression coefficients show that the cumulative impact of macroeconomic surprises can account for more than a third of the total change in risk reversals during particularly dramatic episodes of changing risk perceptions in the JPY/USD market. Moreover, there is a close causal link between risk reversals and net speculative positions in JPY. Hence, the costs of hedging via options appear to capture a substantial portion of transmission of macro shocks to positioning in FX markets. We then calculate the impact of macroeconomic news surprises on carry trade activity using Granger-causality coefficients from risk reversals to net non-commercial positions in futures markets. Depending on the subsample and calculation method macroeconomic news surprises can translate into more than one third of the total adjustment in yen speculative positions. Such importance of carry trade factors provides additional context to the finding by Chen and Gau (2010) that the contribution of futures prices to overall price discovery in foreign exchange markets increases markedly around the times of macroeconomic announcements.

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rate. Galati et al. (2006) and Disyatat and Galati (2007) consider the impact of official foreign exchange market intervention on risk reversals in the JPY/USD market and Czech Koruna – Euro market, respectively.

The paper is organized as follows. Section 2 describes the data and institutional features of the carry trade and market for risk reversals. Section 3 presents the main empirical analysis and results. This section establishes a link between macroeconomic surprises and the value of risk reversals which is robust to a number of empirical model specifications. Section 4 investigates the link between risk reversals and carry-trade activity. Specifically, we show that the volume of net speculative positions in yen shrinks (rises) following an increase (decrease) in the cost of insurance against a substantial yen appreciation. Section 5 tests the robustness of the results by adding to the mix the Australian dollar (AUD) as a target currency and the Swiss franc (CHF) as a funding currency. Section 6 concludes the paper.

2. Data and institutional features

2.1. Risk reversals

A risk reversal is a directional bet (or hedge) against large price swings. It is a contract long one unit out-of-the-money (OTM) (typically 25-delta) FX call option and short one unit OTM FX put option.[7] In other words, it is the cost of buying insurance against large foreign currency appreciation, financed by providing insurance against large foreign currency depreciation. By construction, the value of a risk reversal is equal to the implied volatility of an out-of-money call minus the implied volatility of an out-of-money put of the same "moneyness" and maturity. We follow Galati and Humpage (2006) with the following representation of a price of a European foreign exchange call option:

$$C(X,\sigma) = \frac{1}{(1+i)T}(F \cdot \Phi(d_1(X,\sigma)) - X \cdot \Phi(d_2(X,\sigma))) \tag{1}$$

[7] The delta of an FX option measures its sensitivity to the spot exchange rate. The strike price of a 25-delta option is far enough from the spot price such that the option premium exhibits only a 0.25 correlation with changes in the strike price.

where,

$$d_1 = \frac{\ln(F/X) + (\sigma^2/2)T}{\sigma\sqrt{T}}, d_2 = d_1 - \sigma\sqrt{T} \tag{2}$$

X is the strike price, $F=e^{(i-i^*)T}S$ represent the forward rate, i and i^* are domestic and foreign interest rates, S is the spot exchange rate and Φ is the cumulative distribution of a standard normal. An option's delta represents its sensitivity to the changes in the exercise price. Risk reversals are constructed from out-of-money options with only 25% sensitivity to changes in the strike price. Then the call price has the following property:

$$\frac{\partial C(X,\sigma)}{\partial X} = 0.25 \tag{3}$$

Finally, a 25-delta risk reversal is the difference in the implied volatility of a 25-delta call and put option:

$$RR25 = \sigma_c^{25\delta} - \sigma_p^{25\delta} \tag{4}$$

Under a symmetric risk-neutral distribution, the value of risk reversal should be zero since both OTM call and put will have the same probability of landing at-the-money by the expiration date. Therefore, risk reversals only take on non-zero values if the risk-neutral distribution of foreign exchange returns is skewed. Negative values of risk reversals imply that out-of-money dollar puts have a higher probability of being exercised than out-of-money dollar calls indicating a market hedge against large JPY appreciation (USD depreciation).

Jain and Stafford (2006) find that yen rallies, carry trade unwinding, and bouts of risk aversion are correlated. Hence, risk reversals may capture risk appetite of carry traders during the

times when insurance against JPY appreciation is costly. Whether risk reversals are forward looking is still uncertain. Jain and Stafford (2006) find that sharp movements in spot are usually followed by risk reversal overvaluation, as risk premium increases and implied skew in the following period is higher than the realized skewness. Examining data at daily frequency, Chaboud and Gagnon (2007) argue that during periods of high volatility movements in risk reversals postdate movements in exchange rates. At weekly frequency Carr and Wu (2007) find that JPY/USD and GBP/USD returns show positive correlations with changes in risk reversals. Farhi et al. (2009) find that monthly changes in nominal interest rates and risk reversals exhibit strong contemporaneous link. The same authors also find some evidence of exchange rate excess returns (relative to UIP) predictability with risk reversals – very high levels of risk reversals may predict currency appreciation.

Such mixed evidence on lead-lag relationship between risk reversals and spot prices may be because risk reversals only price extreme events.[8] Farhi and Gabaix (2008) formulate a general equilibrium model in which they show that under certain conditions risk reversals depict the difference in the resilience of the two country's export sector productivities to aggregate shocks.

Despite their potentially interesting information content, empirical academic literature on risk reversals is scarce. We are aware of two studies that have investigated the empirical links between risk reversals and official foreign exchange market intervention, using macroeconomic news in one case as control variables.[9] Galati et al. (2006) estimate the effect of Japanese foreign exchange market intervention on the value of JPY/USD risk reversals along with other measures

[8] Risk reversals are also used indirectly along with other option derivatives to derive higher moments of risk neutral distributions. Galati et al. (2005) and Morel and Teiletche (2008) study the relationship between official interventions in foreign exchange and market uncertainty. They use FX strangle and risk reversal prices to recover option implied higher moments of the risk-neutral FX return distribution.

[9] Several related studies including Beber and Brandt (2006), and Aijo (2008) investigate the impact of macroeconomic surprises on options implied higher moments, including option implied skewness, while Lahaye et al. (2011) study the effects macro announcements on jump components in realized volatility.

of dispersion in exchange rate expectations.[10] They consider daily data over January 1996 – November 2005 and find weak evidence that intervention operations impact risk reversals. Disyatat and Galati (2007) study the impact of official intervention on the value of risk reversals in the Czech Koruna – Euro, using daily data over September 2001 to September 2002. They also find that intervention has a limited impact on risk reversals, but that macroeconomic news is not significant. (They consider several measures of price, output and unemployment surprises for the Czech Republic and Germany). We obtain daily data on 1-month and 1-year 25-delta risk reversals from Bloomberg.

2.2. Macro news

A number of macroeconomic news can influence the risk perceptions of carry traders. Although there are various theoretical exchange rate models linking macro news surprises to exchange rate movements, there is no consensus in the literature over which drivers are most important in theory or empirical analysis. There are two broad exchange rate theoretical paradigms. *Flow models* emphasize the impact of economic drivers on exchange rate through the trade balance. The underlying mechanism rests fluctuations in the supply/demand of foreign currency from current payments/receipts of imports and exports of goods and services. *Stock models* emphasize the impact economic fundamentals on exchange rate through asset prices. These encompass portfolio balance models and monetary models of exchange rate determination. The academics generally prefer the asset-market approach, while practitioners frequently refer to the trade balance/exchange rate nexus as important in practice.[11] Complicating the inference,

[10] Galati et al. (2005) consider the effect of intervention and macroeconomic news on several measures of expectations regarding exchange rate movements, one of which (skewness) is derived from the value of risk reversals.

[11] A good summary of the literature of the asset market approach to exchange rate determination is given by Obstfeld and Rogoff (1996). Almost all basic textbooks describe the flow approach of exchange rate determination that emphasizes the trade balance and current account (e.g. Krugman et al., 2012). Academic work also supports the

many economic drivers may enter in either framework but with a different direction of causality. For example, in the asset-pricing framework, strong GDP growth may indicate stronger money demand (creating excess demand for the home relative to the foreign currency) and lead to a currency appreciation in the asset model. In contrast, according to the trade-balance exchange rate nexus higher demand for imports due to higher income would worsen the trade balance leading to a currency depreciation.

Unfortunately, the empirical literature is not able to fully distinguish which model explains exchange rate movements best in practice. We therefore cast the net widely and include array of macro news, guided partly by related empirical lietarture and partly by data availability. As discussed in the next section, it turns out that our results—in terms of the signs of the coefficients-- are most easily economically interpreted in the context of a trade-balance flow model of exchange rate determination: factors that tend to improve the Japanese (U.S.) trade balance appear to decrease the value of risk reversals, implying a rise in the expected likelihood of large JPY appreciation.

We begin by choosing Japanese news variables that are comparable to U.S. news variables found to be statistically in the Andersen et al. (2003).[12] The inclusion of most of these variables may be justified by both the flow and asset models of exchange rates. We also include several of the Bank of Japan's TANKAN survey measures. They are uniquely Japanese news items

flow approach in addition to the asset-market approach. Dornbusch (1980), for example, makes this point in summarizing his work: "The main lessons that emerge from the analysis concern the inadequacy of the monetary approach as a complete theory of exchange rate determination, the central role of the current account in influencing exchange rates…" (p. 144). Market commentary pointing to the role of the trade balance and current account include Investopedia "Six Factors that Influence Exchange Rates" (July 23, 2010).

[12] This selection criteria follows Fatum, Hutchison and Wu (2012). Japanese macro announcements are from Bloomberg News Service and are also available from the data banks of the Bank of Japan and the Japanese Cabinet Office. Andersen et al. (2003) consider U.S. and German macro news in their study of exchange rates, not Japanese news.

considered particularly important indicators for the strength of Japan's economy.[13] For the U.S., we add to the common set of news the consumer and producer price indices. These variables are especially important in the monetary approach to exchange rate determination. In total, the news data includes announcements and survey expectations regarding 15 types of Japanese macro news and 18 types of U.S. macro news. The Japanese news variables are GDP (quarterly), Industrial Production, Capacity Utilization, Construction Orders, Overall Spending, Large Retail Sales, Trade Balance, Current Account, Retail Trade, Consumer Price Index, Consumer Confidence Index, TANKAN Large Manufacturing Index, TANKAN Non-Manufacturing Index, Leading Economic Index, and Monetary Base. The U.S. news variables are GDP, Non-Farm Payroll Employment, Industrial Production, Capacity Utilization, Personal Income, Consumer Credit, Consumer Spending, New Home Sales, Durable Goods Orders, Factory Orders, Business Inventories, Trade Balance, Producer Price Index, Consumer Price Index, Consumer Confidence Index, NAPM Index, Housing Starts, and Index of Leading Indicators. For robustness, we also select as many news announcements on similar macroeconomic variables emanating from Switzerland and Australia (although data for these countries is much more limited). Table A.4 in the appendix list all the news announcement surprises under consideration.

Following recent literature we define news surprises as the difference between the actual announced value and the preceding survey expectations. The surprise components are then standardized to allow for a comparison across different types of news.[14]

[13] The Bank of Japan website at www.boj.or.jp/en/theme/research/stat/tk/index.htm provides details (in English) regarding the TANKAN survey variables.

[14] A standardized news surprise is given by the unexpected component of the macroeconomic announcement divided by the associated sample standard deviation. Let $A_{q,t}$ denote the value of a given macroeconomic fundamental q, announced at time (minute) t. Let $E_{q,t}$ refer to the median value of the preceding market expectations for the given fundamental at announcement time t, and let $\hat{\sigma}_q$ denote the sample standard deviation of all the surprise

2.3. Carry trade activity

Despite the well-documented profitability of carry trade activity, aggregate flow volumes are difficult to measure because of diverse carry trade strategies and data limitations. Following recent literature (e.g. Klitgaard and Weir (2004), Galati et al. (2007), Brunnermeier et al. (2009) and Anzuini and Fornari (2012)) we proxy for carry trade activity with net futures positions of non-commercial traders on the Chicago Mercantile Exchange (CME), which is the largest exchange for foreign exchange futures by volume (the empirical link between this proxy for carry trade volume and the relevant cost of hedging against funding currency appreciation is established in Section 4). The data is publicly available from the Commodity Futures Trading Commission (CFTC) through its Commitments of Traders report (COT). The CFTC position data has limitations because the classification of commercial and non-commercial traders according to traders' own survey filings. A substantial portion of traders also remains unclassified. In many cases, CFTC staff may reclassify the trader if they possess additional information on the trader's use of the forward markets. In particular, traders are classified as non-commercial if they do not reveal a foreign exchange exposure to hedge and therefore presumably trade to make profit.[15]

In addition, CFTC data do not capture a sizable portion of speculative activity in foreign exchange markets. For example, Brunnermeier et al. (2009) point out that much of the trading in

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components associated with fundamental q. The standardized surprise of macroeconomic fundamental q announced at time t is then defined as $S_{q,t} = \left(A_{q,t} - E_{q,t}\right)/\hat{\sigma}_q$.

[15] A trader is classified as "commercial" or "non-commercial" by filing the Statement of Reporting Trader (CFTC Form 40). The CFTC staff may re-classify the trader if they possess additional information about the trader's use of the futures market. Furthermore, each trader receives a separate classification for each commodity depending on the traders' use of each market. In 2009 the CFTC began published the Disaggregated COT with more detailed trader classifications. Its own historical comparison between the two reports finds that historically the "non-commercial" category included professional money managers (such as hedge funds and commodity trading advisers) and other "speculative" traders while the "commercial" category has included producers, merchants, processors, and swap dealers who use futures markets to offset risks incurred in over-the-counter markets. For further details see http://www.cftc.gov/MarketReports/CommitmentsofTraders/.

currency derivatives takes place in the over-the-counter forward markets. Furthermore, Hattori and Shin (2009) argue that carry trade can be accomplished through inter-office loans of multinational investment banks. CFTC classifies traders as non-commercial if they have no foreign exchange exposure to hedge and therefore presumably trade to make profit. These traders on average hold approximately 20 percent of total open interest positions in major currencies (Sun (2010)).

While CFTC net non-commercial futures data may be an imperfect proxy for the broader yen carry trade, Cecchetti et al. (2010) show that this metric exhibits a close association to a BIS measure of carry trade activity based on the BIS international banking statistics, foreign exchange swap data, and the stock of yen-denominated international bonds.

We obtain the weekly data that reflects positions at the close of every business Tuesday. Among other variables, the COT reports include weekly times-series of non-commercial trader long and short positions in yen as a percentage of total open interest. The CFTC defines open interest as the sum total of all futures contracts not yet offset by transaction, delivery or exercise. We construct the measure of CME net non-commercial short positions (NCMS) as a percentage of open interest (% O.I.) by subtracting non-commercial long from non-commercial short positions divided by total open interest in yen futures.

2.4. Spot prices and interest rates

The daily spot and forward rate data comes from Datastream, with Wirtschaftsförderung metropoleruhr (WMR) as the underlying source. In addition we construct a daily series of interest rate spread between U.S. and Japan as the difference between the effective federal funds rate and Japan's uncollateralized overnight call rate. Both are publicly avaiable from the Federal Reserve Bank of New York and Bank of Japan respectively.

We confine the sample to the tranquil period of active carry trade: after the last episode Japanese official interventions that ended in March 2004 and before the emergence of the financial crisis in the middle of 2007. In all, we end up with 715 daily observations excluding weekends from 03/18/2004 through 12/31/2006

3. Empirical results: Macro news and risk reversals

3.1. Preliminaries

The upper panel of Table 1 presents summary statistics for 1-year 25-delta risk reversal series in levels and first differences. The maximum and minimum are -0.725 and -2.75, indicating that both series have remained negative throughout the sample period consistent with market hedge against sharp yen appreciation. Augmented Dickey Fuller (ADF) unit root tests are shown in the lower panel of Table 1. The first row in the bottom panel shows the unit root test on the value of a one-year 25 delta risk reversal. The second row is the corresponding tests on first differences of the values. The test fails to reject the null hypothesis of a unit root in levels, but rejects the null in first differences by a large margin (greater than 99% level of confidence). We therefore proceed to estimate our empirical model with the dependent variable in first difference form.

3.2. Estimation results

Tables 2 and 3 report the results of macro "news" on the change in the value of risk reversals. We focus in our formal empirical analysis on one-year risk reversals, the longer maturity options, in order to capture the hedging horizons of carry traders.[17] Table 2 shows the baseline results where the regressions are estimated using OLS and all the macroeconomic surprises are included in the data set, i.e. we do not drop "small" surprises from the sample. Table 3 focuses on whether

[17] The one-month results are available upon request. These are generally weaker than the one-year results, consistent with the view that the carry trader horizon is for hedges of longer maturity.

"large" changes affect the value of risk reversals, as would be expected since risk reversals reflect the risk of very large exchange rate changes. We use two criteria to select "large" surprises. The first approach only considers surprises outside the "narrow bounds," i.e. exclude all surprises less than one standard deviation from the series specific mean value. The standard deviation is calculated based on all observations of the surprise variables, including days with no surprises. The second approach, denoted as "wide bounds," corresponds to stricter criteria, whereby the standard deviation is calculated on non-zero observations only, thus effectively making the exclusion bounds wider. The results reported in the two tables are similar and most of the discussion will focus on our preferred equation reported in Table 3. Only the significant coefficients are reported for brevity. Complete regression results are reported in the appendix tables.

The two panels of Table 2 include the same news surprises, while the right-hand-side panel also controls for the first difference of logarithm of exchange rate and the interest rate differential. The point estimates for those coefficient are significant and virtually identical in the two regressions. However, controlling for exchange rates and the interest rate differential (right panel) give substantially higher explanatory power (higher R^2) and a better fit based on AIC statistic. Two U.S. news surprises (GDP and Consumer Credit) and three Japanese news surprises are significant (Trade Balance, Consumer Confidence and Overall Household Spending).

How may the significant estimates be interpreted economically? The signs are consistent with the trade balance/flow model of exchange rate determination. Recall that the value of risk reversals remained negative throughout the carry trade sample we are investigating, indicating a market hedge against sharp yen appreciation. A negative (positive) coefficient indicates higher

(lower) risk of large yen appreciation. U.S. trade deficits are associated with higher GDP growth and stronger U.S. consumer credit, leading to a lower value of risk reversals—the perceived risk of sharp dollar depreciation against the yen rises. News of improvement in the Japanese trade balance reduce the value of risk reversals, increasing the perceived likelihood of sharp yen appreciation. In contrast, a rising Japanese Consumer Confidence Index and Overall Household Spending reduces the Japanese trade balance, hence it lower the risk of major yen appreciation. The relative importance of news related to GDP growth, consumer credit in the U.S. and trade balance, consumer confidence, and household spending of Japan is broadly in line with Anzuini and Fornari (2012), who find that demand shocks in particular have significant impact on carry trade profitability.

The value of including the exchange rate and interest rate differential is evident from the estimates in Table 2, so we include these variables in Table 3 where we focus on "large" news surprises. The left-hand-side panel is estimated using OLS and the right-hand-side is estimated using an ARMA(4,4) process, for both "large" surprise selection criteria. In particular, closer analysis of the errors of the initial estimation suggested both AR(4) and MA(4) terms were appropriate—based on a significant lag in the autocorrelation function and partial autocorrelation function, respectively—in the estimation. This model was chosen, relative to a simple OLS estimation, based on the Akaike information criteria.[18]

The right-hand-side panel of Table 3 shows that the same explanatory variables remain significant (U.S. GDP and Consumer Credit and Japan's Trade Balance, Consumer Confidence and Overall Household Spending) when only "large" surprises are considered. In addition, U.S. Personal Income and Japan's TANKAN Non-Manufacturing Index are highly significant under

[18] These results are omitted for brevity but are available from the authors upon request. Monday and Friday dummies were also included in the initial estimation but were not statistically significant. Various values of p,q in the ARMA (p,q) process were considered and the p=4 and q=4 were selected based on the AIC criteria.

the "wide bounds" selection criteria. In all, three U.S. macro news surprises and four Japanese macro news surprises have a statistically significant impact on the value of risk reversals during our sample period.

The standardization of the macro news surprises allows a comparison of the relative sizes of the coefficients. Consumer Credit has the highest coefficient in absolute value among U.S. surprises at -7.0 compared to -3.9 for U.S. GDP and 1.2 for Personal Income. Among the Japanese macro surprises Trade Balance has the highest coefficient in absolute value of -6.4 followed by Overall Household Spending with 4.8.

3.3. Conditional regressions

Next, we examine the possibility that surprise macroeconomic announcements may have a larger impact on risk reversals when the risk of a large yen appreciation is on the rise. Such dynamics are consistent with both the so-called leverage effect (see for example Engle and Ng (1993)) and loss-aversion (see seminal paper by Tversky and Kahneman (1991)). In both cases, endogenous responses by carry traders would amplify impact of news when the option implied probability of sustaining a loss is already high.

We construct an increasing-risk-dummy variable that takes on a value of 1 on day when risk reversals rise in absolute value and a value of 0 otherwise. Then we repeat the regression of LARGE macroeconomic surprise announcements using the ARMA (4, 4) specification interacting each news surprise with the lagged rising-risk dummy. Table 4 shows the results for both "narrow bounds" and "wide bounds" regressions. An estimate is missing (indicated with "–") if no LARGE surprise announcement for a particular news type was preceded by an increase in the absolute value of risk reversals during our sample period.

The regression results in Table 4 indicate that the set of significant macroeconomic surprises, when an announcement is preceded with an increase in the cost of hedging JPY appreciation risk, is not the same as the unconditional specification. Moreover, under the stricter "wide bounds" selection criteria for LARGE surprises, more types of macroeconomic news surprises have a statistically significant impact on risk reversals. The difference is especially stark for news emanating from the U.S. Both conditional regressions exhibit higher R-squared, Durbin-Watson, and Akaike information criterion than unconditional regressions reported in Table 2 and Table 3 indicating that most of the explanatory power of macroeconomic news surprises is higher during periods of increasing risk aversion.

Focusing on the "narrow bounds" regression (left panel of Table 4) first, different U.S. news surprises are significant when conditioning on periods of rising hedging costs against sharp JPY appreciation. A positive surprise to Capacity Utilization and Housing Starts tend to increase the value of risk reversals (reduce the perceived risk of JPY appreciation) in times when that risk is on the rise. In terms of the exchange rate/balance-of-payments nexus, a rise in these variables may indicate greater U.S. demand for domestic intermediate goods relative to Japanese imports. This would reduce trade surplus of Japan and may lower the risk of sharp yen appreciation.

Among Japanese macroeconomic news, large surprises to the Leading Economic Index, quarterly GDP, and Retail Trade exhibit significant negative coefficients while Overall Household Spending remains positive and significant as was also the case in the unconditional regressions.

Next we focus on the "wide bounds" regression (right panel of Table 4). Under this specification 8 U.S macro and 5 Japanese macro surprise announcements are statistically significant. Most notably, U.S. and Japanese Trade Balance surprises have the largest

coefficients in absolute value and are both statistically significant at the 1% level. Consistent with the exchange rate/balance-of-payment nexus interpretation, a surprise improvement in U.S. Trade Balance is associated with a reduction in the absolute value of risk reversals while the surprise improvement in Japan's Trade balance makes sharp yen appreciation more likely to increase risk reversals in absolute value.

Among other U.S. news, the coefficients on Capacity Utilization and Housing starts remain positive and the coefficient on Personal Income is positive and significant as was also the case in the unconditional regressions. On the other hand, higher values of Consumer Credit, Consumer Price Index, and Index of Leading Indicators increase the perceived risk of yen appreciation (reduce the value of risk reversals), with the latter two variables having an impact only under the current specification conditioning on the environment of rising risk aversion. As for the rest of the Japanese macroeconomic surprises, a positive surprise to TANKAN large manufacturing index and construction orders mitigate the perceived risk of JPY appreciation whereas large surprises to Japanese Retail Trade and Consumer Price Index are associated with a further increase in the absolute value of risk reversals.

3.4. Economic impact of macro surprises on risk reversals

We conduct a rough assessment of the cumulative impact of macroeconomic surprises on the value of risk reversals. In this section and the next, we focus on two subsamples of particularly dramatic changes in risk perceptions in the JPY/USD foreign exchange market. The first period, 01/07/2005 through 03/13/2006, corresponds to a substantive reduction in the absolute value of risk reversals from about -2.4 to -1.0. The second, 04/12/2006 through 05/17/2006, corresponds to a substantial increase in the absolute value of risk reversals from -1.0 to -2.0. The impact of

each type of macro news is calculated by multiplying the regression coefficient by the value of the standardized surprise.

Table 5 shows the results for the two subsamples. The first two columns show the cumulative impact from surprise macro announcements for the first subsample, using both the "narrow band" for upper bound and the "wide band" for the lower bound regressions from Table 3. The cumulative impact of macroeconomic surprises ranges from 0.32 to 0.37, accounting for 25-30% of the total change in the value of risk reversals over this episode. In particular, the net negative GDP and consumer credit news in the U.S., combined with negative trade balance news in Japan, led to a sharp reduction in the perceived risk of large yen appreciation. Recall that the R^2 in the baseline regression not controlling for exchange rate or interest rate was approximately 0.03 indicating that over the entire sample period surprise macro announcements explain approximately 3% of the variation in the value of risk reversals. However, focusing on a subsample of dramatic decline in the market value of risk we see that macro surprise announcements can account for over 30% of the cumulative change in the value of risk reversals.

The third and fourth columns of Table 5 report the cumulative impact for the second subsample when the perceived risk of major yen appreciation jumped markedly. The rise in absolute value of risk reversals (rise in perceived risk of large yen appreciation) during this episode is associated with several surprise announcements, namely a sharp unanticipated rise in the Japanese Trade Balance and fall in Japanese Household Spending. These announcements accounted for approximately 10% of the total rise in absolute value of risk reversals during this episode.

Figure 4 depicts the results graphically in terms of the volatility smile for the two subsamples: 01/07/2005 through 03/13/2006 (top panel) and 04/12/2006 through 05/172006

(bottom panel). The asymmetric "volatility smirk" indicates a thick left tail (negative skewness) of return distribution. The solid line is constructed based on option implied volatility (historical options data) while the two dashed line represent counterfactual volatility distribution based on the results reported in Table 5. During the first subsample, the impact of the negative growth and consumption data from the U.S. combined with negative trade balance news in Japan effectively reduced the negative skewness in the market expectation of JPY/USD returns. The opposite is true of the second subsample (bottom panel), where sudden rise in Japan's trade balance and fall in household spending made sharp yen appreciation more likely, thus raising implied volatility curve in the left tail area of returns distribution.

4. Link to carry trade activity

As detailed in Section 2, we proxy for carry trade activity using CME non-commercial futures positions. As a way to check the consistency of CME non-commercial short positions in yen with the broader carry trade Figure 5 plots the time series of non-commercial short positions and a simple rate of return to carry trade (following Hochradl and Wagner (2010)):

$$CR_{t+k} = (1+i_{k,t}^{US})S_{t+k}/S_t - (1+i_{k,t}^{JP}) \tag{5}$$

where $i_{k,t}$ denote the effective k-period deposit rates available in Japan and U.S. at a given Tuesday of the same week, t. We use 1-month deposit rates. This trend is consistent with the expected behavior of carry traders increasingly going short JPY and long USD during the period of rising ex-ante returns to carry trade.

Figure 6 shows the time-series of net non-commercial short positions (NCMS) as percentage of total open interest (% O.I) (left) against 1-year risk reversals (right), where the frequency of 1-year risk reversals has been converted from daily to weekly (Tuesdays of each week to conform

with NCMS data). The series exhibit co-movement indicating that as the value of risk reversals tends towards zero (lower cost of insurance against JPY appreciation) the speculative shorts in JPY tend to rise. The pair-wise correlations between the weekly changes in non-commercial futures and weekly changes in 1-month and 1-year risk reversals are 0.58 and 0.73, respectively. We conduct Granger-causality tests to examine whether risk reversals lead (predict) speculative futures positions or vice-versa:

$$\Delta NCM_t = \sum_{j=1}^{2} \alpha_j \Delta NCM_{t-j} + \sum_{j=1}^{2} \beta_{t-j} \Delta RR_{t-j} + \sum_{j=1}^{2} \delta_{t-j} \Delta r_{t-j} + \varepsilon_t \tag{6}$$

$$\Delta RR_t = \sum_{j=1}^{2} \alpha_j \Delta NCM_{t-j} + \sum_{j=1}^{2} \beta_{t-j} \Delta RR_{t-j} + \sum_{j=1}^{2} \delta_{t-j} \Delta r_{t-j} + \varepsilon_t \tag{7}$$

The Granger causality results, reported in Table 6, indicate that risk reversals lead (Granger-cause) net non-commercial yen short positions but that positions do not lead risk reversals. The results are robust to the inclusion of the lagged exchange rate as a control. This indicates that past values of risk reversals have informational content in excess of that of the lagged exchange rate returns. The cumulative effect (sum of the coefficients) of the 2-lag specification for 1-year risk reversals controlling for the exchange rate, is 30.38. A 100 basis point decrease in the absolute value of risk reversals over a two-week period is followed by a 30.4% increase in the net NCMS as a fraction of total open interest potions. In other words, a sharp reduction in the perceived risk of large yen appreciation leads to substantially more carry trade activity.

Overall, Granger-causality results indicate that risk reversals convey important information on currency risk in excess of the exchange rate itself that is taken into account by non-commercial traders when deciding to take on an open interest futures position. Our findings are consistent with Brunnermeier et al. (2009) who find that that skewness tends fall together with

carry trade activity when financial markets in the U.S. become unstable suggesting that it is mainly carry traders who rely on risk reversals to ensure their portfolios.

A simple "back of the envelope" calculation allow to gauge the impact of macroeconomic surprises emanating from U.S. and Japan on carry trade activity transmitted through fluctuations in hedging costs via risk reversals. As Figure 4 shows, the first episode (1/07/2005 through 03/13/2006), when perceived risk declined (-2.5 to -1.0), was accompanied by a switch from a 20% net long position to a 40% net short open position of non-commercial traders, indicating a sharp rise in carry trade activity. The second episode (04/12/2006 through 05/17/2006), when perceived risk increased sharply (-1.0 to -2.0), was accompanied by a large unwinding of short yen open positions—a switch form a 30% net short position to a 10% net long position for non-commercial traders.

The cumulative impact of news surprises on risk reversals is multiplied by the sum of the coefficients on ΔRR_{t-j} in the Granger-causality equation (6) in Table 6. Table 7 shows the results. The first column of each panel corresponds to the conservative estimate obtained by multiplying the cumulative impact of macro surprises in excess of "wide bands" by the coefficient on ΔRR_{t-j} in the specification of (6) with 1-lag. The second column yields a higher estimate by multiplying the cumulative impact of macro surprises in excess of "narrow bands" by the sum of the coefficients in the 2-lag Granger causality specification in equation (6).

Based on these calculations, during the first episode U.S. GDP and Consumer Credit surprises had the effect of increasing net NCMS share of total open interest by 2.9 and 6.0 percentage points, respectively, while Japan's Trade Balance surprises accounted for another 2.8 percentage point rise. In total, the estimates suggest that macroeconomic surprises account for 38% (11.2 percentage points) of the rise in NCMS positions as a share of total open interest in

the first episode. During the second episode, the fall in NCMS positions is mainly attributable to Japanese news. Japan's trade balance contributed about -1.7 percentage points to the reduction in speculative positions on CME, while Japan's Overall Household Spending and Japan's Consumer Confidence surprises contributed around -0.9 and -0.3 percentage points, respectively. Overall, macroeconomic surprises accounted for approximately 10% (-2.67 percentage points) of the fall in carry trade positions during this episode.

5. Robustness: CHF as funding currency and AUD as target currency

A number of other currencies served to fund carry trade during this period. In particular, the Swiss Franc (CHF) was a major funding currency and the Australian Dollar was a major target currency. As a robustness check for the first set of results, we extend the analysis of Section 3 to investigate the impact of macroeconomic "news" on changes in the JPY/AUD (JPY is the funding and AUD is the target currency) and CHF/USD (CHF is the funding and USD is the target currency).

The basic analysis is carried out in an analogous way to that in Section 3. Again, we focus on 1-year 25-delta reversals from Bloomberg and confine our sample to the tranquil period of active carry trade. Due to historical data availability of the series from Bloomberg, the time sample differs across currency pairs. The sample of daily observations for JPY/AUD risk reversals is 6/08/2006 to 12/29/2006 (147 observations after adjustments) and for CHF/USD risk reversals is 3/10/2005 to 12/29/2006 (409 observations after adjustments). Consistent with a market hedge against sharp CHF and JPY appreciation, risk reversals of target currencies vis-à-vis the funding currencies remained negative throughout the period. News of improvement of trade balance in both Switzerland and Japan reduce the value of risk reversals, increasing the perceived likelihood of sharp CHF and JPY appreciation against USD and AUD respectively.

Based on the limited availability of consistent news release and survey data, we are only able to investigate six macro news variables for Australia (GDP, CPI, Current account balance, Trade balance, Unemployment rate and Retail sales) and eight macro news variables for Switzerland (GDP, CPI, Current account balance, Trade balance, Unemployment rate, Employment, Industrial production, and PPI) that fall in the same category as news announcements for Japan and the U.S. Due to shorter time sample compared to JPY/USD series, especially in the case of JPY/AUD (only 147 observations), and because many macro news releases take place on the same day, several news announcement surprises had to be dropped from the estimation due to perfect multi-collinearity.

The results are summarized in Table 8 for CHF/USD risk reversals and Table 9 for JPY/AUD risk reversals. The first column of the results considers "all news" and the third column considers "narrow bounds." Both sets of results suggest that only macro news surprises emanating from funding currency countries, Switzerland in Table 8 and Japan in Table 9, systematically exhibit statistically significant impact on risk reversals. Among the significant news variables, trade balance is robust to 3 out of 4 specifications with a negative impact on CHF/USD and JPY/AUD risk reversals values—a finding consistent with our earlier JPY/USD results. Again, positive news on the trade balance in a funding currency (Japan or Switzerland) indicates greater (expected) risk of sharp funding-currency appreciation.

In sum, the robustness check using CHF/USD and JPY/AUD risk reversals and news announcement data support the importance of fundamentals concerning trade balance in exchange rate determination.

6. Conclusion

This paper investigates market perceptions "tail" risks in foreign exchange rates by using information gleaned from risk reversal contracts and macroeconomic news. We focus on the height of the carry trade period in Japan, when concerns about sharp yen appreciation were particularly likely to show up in the price of risk.

We find that macroeconomic news is an important determinant of currency risk assessment during periods of heavy carry trade volume. The results are best interpreted in the context of joint trade balance/exchange rate model, often cited by practitioners. Macro news from Japan (U.S.) that are associated with an improvement (a worsening) of Japan's (U.S.) trade balance raise the perceived risk of sharp yen appreciation against the U.S. dollar. Factors that lead to a worsening of Japan's trade balance have the opposite effect. The basic results concerning the importance bilateral balance of trade in market participants' assessment of currency risk are robust to considering other currency pairs (Australian dollar as investment currency and Swiss franc as alternative funding currency).

In addition, macro news have greater impact on implied skewness of exchange rate returns, as measured by risk reversals, when this measure is already on the rise. Since risk reversals proxy for carry traders' currency risk hedging costs, this suggests that foreign exchange speculators play an important role in the transmission of macro fundamentals to exchange rates.

Finally, we find a close link between risk reversals and speculative positions in yen futures and this link is borne out in Granger causality tests. Using this metric, we estimate that macroeconomic news surprises can account for more than one third of the total adjustment in actual carry trade positioning.

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Table 1
Summary statistics and unit root tests for risk reversal series

	USD/CHF	USD/JPY	AUD/JPY
Mean	-0.240	-1.312	-1.309
Median	-0.300	-1.200	-1.375
Maximum	0.300	-0.725	1.225
Minimum	-0.586	-2.325	-2.125
Std. Dev.	0.232	0.400	0.428
Skewness	0.429	-0.632	2.699
Kurtosis	1.851	2.357	17.732
Observations	425	649	577
	ADF unit root test results:		
Levels	0.417	0.360	0.327
1st differences	0.000	0.000	0.000

Note: The table shows summary statistics for 1-year 25 delta risk reversals for selected currency pairs. Augmented Dickey-Fuller (ADF) unit root test implemented using automatic lag length selection based on SIC: 0 to 3; p-values against H0 of unit root; 3/18/2004 to 12/29/2006 sample period.

Table 2
Regression results for significant macroeconomic announcement surprises on risk reversals

ALL Macro Surprises	Baseline(1)		Baseline(2)	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
GDP	-5.517 **	(2.653)	-4.259 **	(1.768)
Nonfarm payroll empoloyment	4.679 *	(2.468)	0.616	(2.314)
Consumer credit	-4.293 *	(2.550)	-4.858 *	(2.619)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	-5.553 *	(2.857)	-5.452 **	(2.796)
Consumer confidence index	3.660 **	(1.865)	3.517 *	(1.859)
Overall household spending	5.738 **	(2.485)	5.558 ***	(1.530)
Exchange rate			5.239 ***	(1.256)
Interest rate differential			-0.067 *	(0.041)
Lag dependent variable	0.008	(0.052)	0.003	(0.044)
R-squared	0.033		0.211	
Durbin-Watson	1.814		2.085	
Akaike info criterion	-2.402		-2.600	

Note: 3/18/2004 12/29/2006 sample, 715 observations. Standard errors in parentheses; *, **, and *** indicate coefficients significant at 10%, 5%, and 1% level respectively. Constant and day of the week omitted because of insignificant coefficient. Only coefficient on significant macroeconomic surprise announcements reported, for complete regression results see Table A1 in the appendix.

Table 3
Regression results of significant LARGE macroeconomic announcement surprises on risk reversals

LARGE Macro Surprises	Baseline(2)				ARMA(4,4)			
	Narrow Bounds		Wide Bounds		Narrow Bounds		Wide Bounds	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
GDP	-4.219 **	(1.747)	-3.557 *	(2.043)	-4.327 **	(1.841)	-3.959 **	(1.982)
Personal income	1.658	(1.293)	1.082 **	(0.421)	1.569	(1.168)	1.211 ***	(0.374)
Consumer credit	-4.873 *	(2.635)	-6.478 *	(3.441)	-5.518 **	(2.726)	-7.033 **	(3.567)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	-5.526 **	(2.793)	-6.396 *	(3.448)	-5.620 **	(2.788)	-6.436 *	(3.512)
Consumer confidence index	3.513 *	(1.855)	1.812	(1.569)	3.538 *	(1.939)	1.680	(1.765)
TANKAN non-manuf. index	-1.946	(3.904)	-3.702 *	(2.100)	-2.765	(3.764)	-3.017 *	(1.658)
Overall household spending	5.583 ***	(1.478)	4.389 ***	(0.928)	5.903 ***	(1.948)	4.794 ***	(1.573)
Exchange rate	5.237 ***	(1.256)	5.193 ***	(1.249)	4.593 ***	(0.705)	4.539 ***	(0.691)
Interest rate differential	-0.068 *	(0.041)	-0.065	(0.041)	-0.076 **	(0.037)	-0.074 **	(0.037)
Lag dependent variable	0.003	(0.044)	0.002	(0.045)				
AR(4)					-0.658 ***	(0.164)	-0.653 ***	(0.169)
MA(4)					0.726 ***	(0.148)	0.724 ***	(0.152)
R-squared	0.212		0.211		0.286		0.286	
Durbin-Watson	2.084		2.078		2.129		2.126	
Akaike info criterion	-2.600		-2.599		-2.696		-2.696	

Note: 3/18/2004 12/29/2006 sample, 715 observations. Standard errors in parentheses; *, **, and *** indicate coefficients significant at 10%, 5%, and 1% level respectively. Constant and day of the week omitted because of insignificant coefficient. Only coefficient on significant macroeconomic surprise announcements reported, for complete regression results see Table A2 in the appendix.

Table 4
Regression results of significant LARGE macroeconomic surprise announcements conditional on increasing risk of sharp yen appreciation

LARGE Macro Surprises	**ARMA(4,4)**			
	Narrow Bounds		**Wide Bounds**	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Capacity utilization	10.679 **	(5.199)	8.407 **	(3.549)
Personal income	1.126	(0.867)	1.046 ***	(0.349)
Consumer credit	-5.076	(10.597)	-26.313 ***	(2.157)
New home sales	-2.690	(1.903)	-1.290 *	(0.742)
Trade balance	5.558	(6.012)	11.443 ***	(2.736)
Consumer price index	2.762	(5.401)	-8.416 ***	(1.208)
Housing starts	7.819 **	(3.871)	9.241 **	(4.276)
Index of leading indicators	1.432	(10.992)	-10.328 **	(4.480)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	-8.472	(10.264)	-20.050 ***	(0.998)
Leading economic index	-9.856 *	(5.380)	-	-
TANKAN large manufacturing index	-3.593	(5.969)	3.060 **	(1.286)
GDP (quarterly)	-13.323 ***	(5.117)	-	-
Construction orders	3.788	(3.257)	6.030 ***	(1.224)
Retail trade	-12.474 ***	(3.797)	-9.351 ***	(0.776)
Consumer price index	-0.669	(4.440)	-10.530 *	(6.064)
Overall household spending	10.630 **	(5.148)	4.097	(4.127)
Exchange rate	4.479 ***	(0.659)	4.443 ***	(0.695)
Interest rate differential	-0.062 *	(0.034)	-0.065 *	(0.034)
AR(4)	-0.647 ***	(0.164)	-0.648 ***	(0.161)
MA(4)	0.728 ***	(0.144)	0.728 ***	(0.142)
R-squared	0.287		0.290	
Durbin-Watson	2.189		2.160	
Akaike info criterion	-2.701		-2.730	

Notes: All news announcement surprises have been interacted with a lagged dummy variable that takes on a value of 1 if the cost of hedging against sharp yen appreciation rose between day *t* and *t-1*. 3/18/2004 12/29/2006 sample period, 715 observations. Standard errors in parentheses; *, **, and *** indicate coefficients significant at 10%, 5%, and 1% level respectively. Constant and day of the week omitted because of insignificant coefficient. Only coefficient on significant macroeconomic surprise announcements reported, for complete regression results see Table A3 in the appendix.

Table 5
Impact of significant news surprises on the value of 1-year risk reversals

Subsample Period:	01/07/2005-03/13/2006		04/12/2006-05/17/2006	
Surprise Announcement	**Narrow Bands**	**Wide Bands**	**Narrow Bands**	**Wide Bands**
US GDP	0.096	0.070	0.000	0.000
US Personal income	0.000	0.014	0.000	0.000
US Consumer credit	0.198	0.143	0.009	0.000
JP Trade balance	0.091	0.106	-0.058	-0.058
JP Consumer confidence index	-0.012	0.000	-0.009	0.000
TANKAN non-manufacturing index	0.000	-0.016	0.000	0.000
JP Overall household spending	0.000	0.000	-0.029	-0.024
Total	0.373	0.317	-0.088	-0.081
% of Change in 1-Year Risk Reversal	29.84%	25.34%	9.24%	8.56%

Note: The impact is calculated by multiplying the standardized value of the news surprise component relative to the Bloomberg survey of market expectation by the regression coefficient. The bottom row reports the cumulative impact of news surprises during each subsample period as a percentage of change in the value of 1-year risk reversal during the same time period.

Table 6
Granger causality tests between risk-reversals and net non-commercial short positions (% O.I.)

	Baseline				Controlling for exhange rate			
	1-lag		2-lag		1-lag		2-lag	
	risk rersals cause positions	positions cause risk reversals	risk rersals cause positions	positions cause risk reversals	risk rersals cause positions	positions cause risk reversals	risk rersals cause positions	positions cause risk reversals
F-Statistic	9.023***	0.521	9.611***	2.570*	7.720***	0.022	6.924***	1.798
Probability	0.003	0.471	0.000	0.080	0.006	0.882	0.001	0.169
Coeff. Sum	14.491	0.001	29.964	-0.003	15.495	0.000	30.388	-0.005
Obs.	151		150		151		150	

Note: *, **, and *** indicate the null hypothesis of no Granger-causality is rejected at significant at 10%, 5%, and 1% level respectively.

Table 7
Approximate cumulative impact of macro surprises on CME net non-commercial futures short positions through Risk Reversal valuation.

Subsample Period:	01/07/2005-03/13/2006		04/12/2006-05/17/2006	
Calculation Method:	Wide Bounds 1-Lag Coeff.	Narrow Bounds 2-Lag Coeff.	Wide Bounds 1-Lag Coeff.	Narrow Bounds 2-Lag Coeff.
Surprise Announcement	**ΔNCMS (% O.I)**	**ΔNCMS (% O.I)**	**ΔNCMS (% O.I)**	**ΔNCMS (% O.I)**
US GDP	1.08	2.92	0.00	0.00
US Personal income	0.22	0.00	0.00	0.00
US Consumer credit	2.22	6.01	0.00	0.27
JP Trade balance	1.64	2.76	-0.89	-1.77
JP Consumer confidence index	0.00	-0.37	0.00	-0.28
TANKAN non-manufacturing index	-0.25	0.00	0.00	0.00
JP Overall household spending	0.00	0.00	-0.37	-0.89
Total	4.91	11.33	-1.26	-2.67
% of Total ΔNCMS(%O.I.)	16.47%	38.03%	4.79%	10.14%

Note: The table shows the estimated cumulative impact over the sample period of macroeconomic news surprises on net non-commercial short positions (NCMS) as a percentage of total open interest (% O.I.) on the Chicago Mercantile Exchange (CME). The impact is calculated by multiplying the cumulative impact of news surprises on risk-reversals by the Granger-causality coefficients of risk-reversals on NCMS (% O.I).

Table 8
Regression results for macroeconomic announcement surprises on CHF/USD risk reversals

All News	All news		Narrow bounds	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
US GDP	0.056	(1.260)	4.903	(5.257)
US Personal income	-3.425	(3.538)	0.758	(1.828)
US Consumer credit	0.034	(0.828)	-0.177	(0.939)
Swiss Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
GDP	0.011	(0.018)	0.005	(0.019)
Leading indicator survey	0.012 *	(0.006)	0.005	(0.005)
Trade balance	-0.025 **	(0.011)	-0.025 **	(0.010)
Unemployment rate	-0.008	(0.013)	0.007	(0.008)
Industrial production index	-0.004	(0.011)	0.002	(0.007)
Lag dependent variable	-0.293 ***	(0.075)	-0.293 ***	(0.073)
Exchange rate	1.137 *	(0.673)	1.054 *	(0.646)
Interest rate differential	1.292	(1.294)	1.259	(1.247)
R-squared	0.100		0.097	
Akaike info criterion	-2.501		-2.503	
Durbin-Watson stat	2.195		2.193	

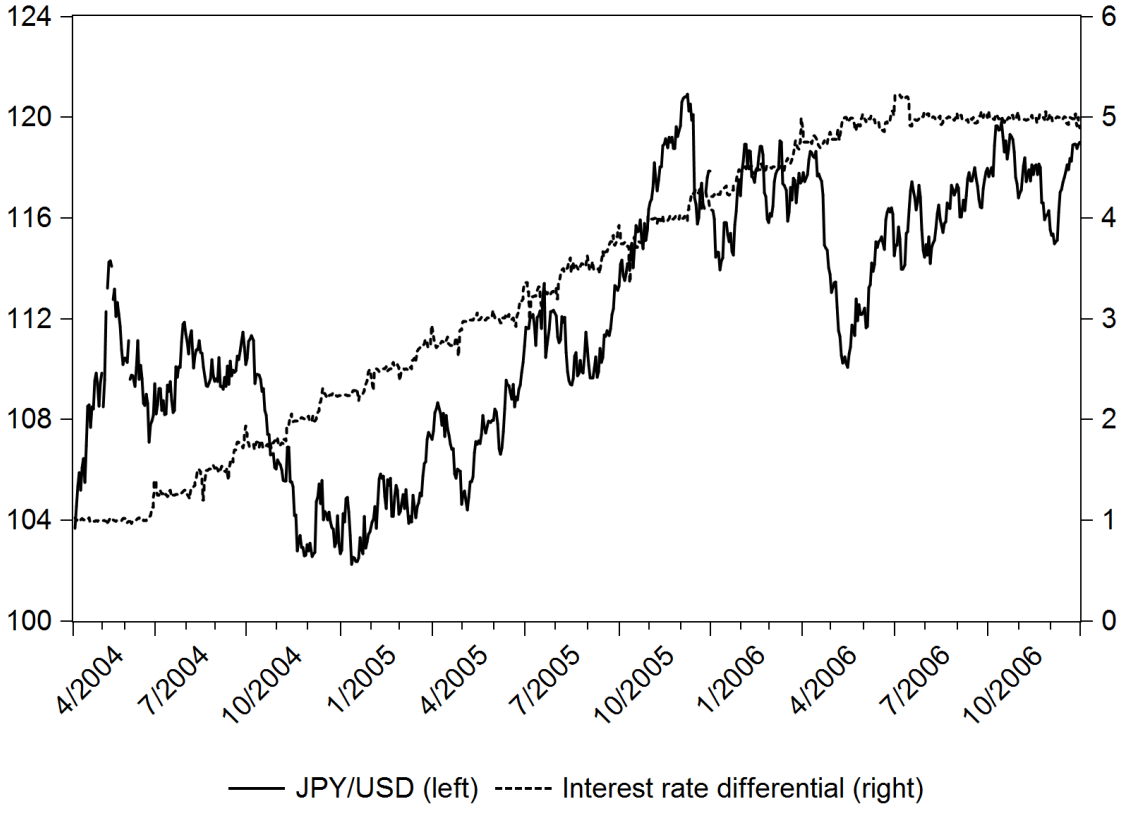
Notes: dependent variable is 1-year 25 delta CHF/USD risk reversal; time sample from 3/10/2005 to 12/29/2006 with 409 observations included after adjustments.

Table 9
Regression results for macroeconomic announcement surprises on JPY/AUD risk reversals

All News	All news		Narrow bounds	
Australian Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Current account balance	-0.021	(0.160)	0.132	(0.181)
Retail sales	-0.021	(0.051)	-0.009	(0.049)
Trade balance	0.064	(0.107)	-0.048	(0.115)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	7.560	(7.278)	-2.784 *	(1.947)
Consumer confidence index	11.139 *	(6.779)		
GDP	-55.397 **	(27.330)		
TANKAN non-manuf. index	-16.520 ***	(3.955)	-15.566 ***	(3.374)
Overall household spending	-15.896 ***	(5.944)		
Lag dependent variable	-0.412 ***	(0.066)	-0.423 ***	(0.059)
Exchange rate	3.336 *	(1.753)	3.984 **	(1.797)
Interest rate differential	0.189	(0.150)	0.220	(0.149)
R-squared	0.263		0.222	
Akaike info criterion	-1.746		-1.733	
Durbin-Watson stat	2.461		2.472	

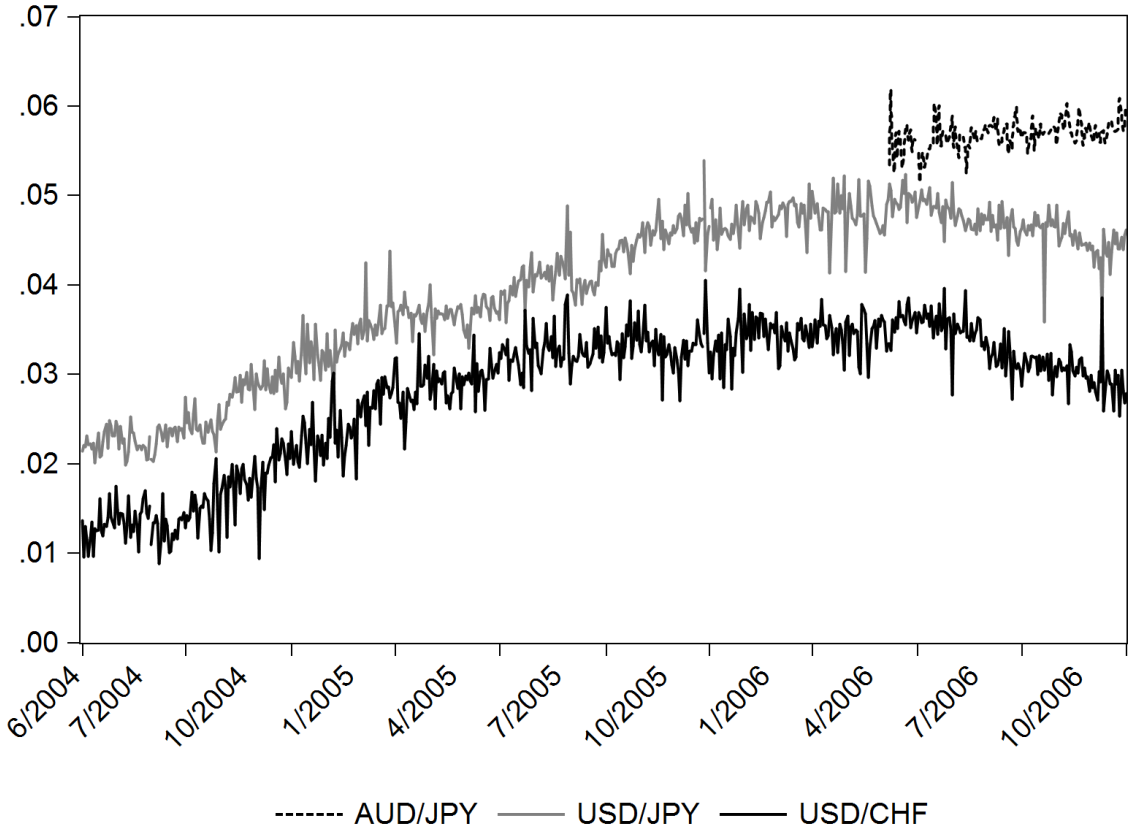
Notes: dependent variable is 1-year 25 delta JPY/AUD risk reversal; time sample from 6/08/2006 to 12/29/2006 with 147 observations included after adjustments.

Figure 1
U.S.-Japan interest rate differential and JPY/USD exchange rate.



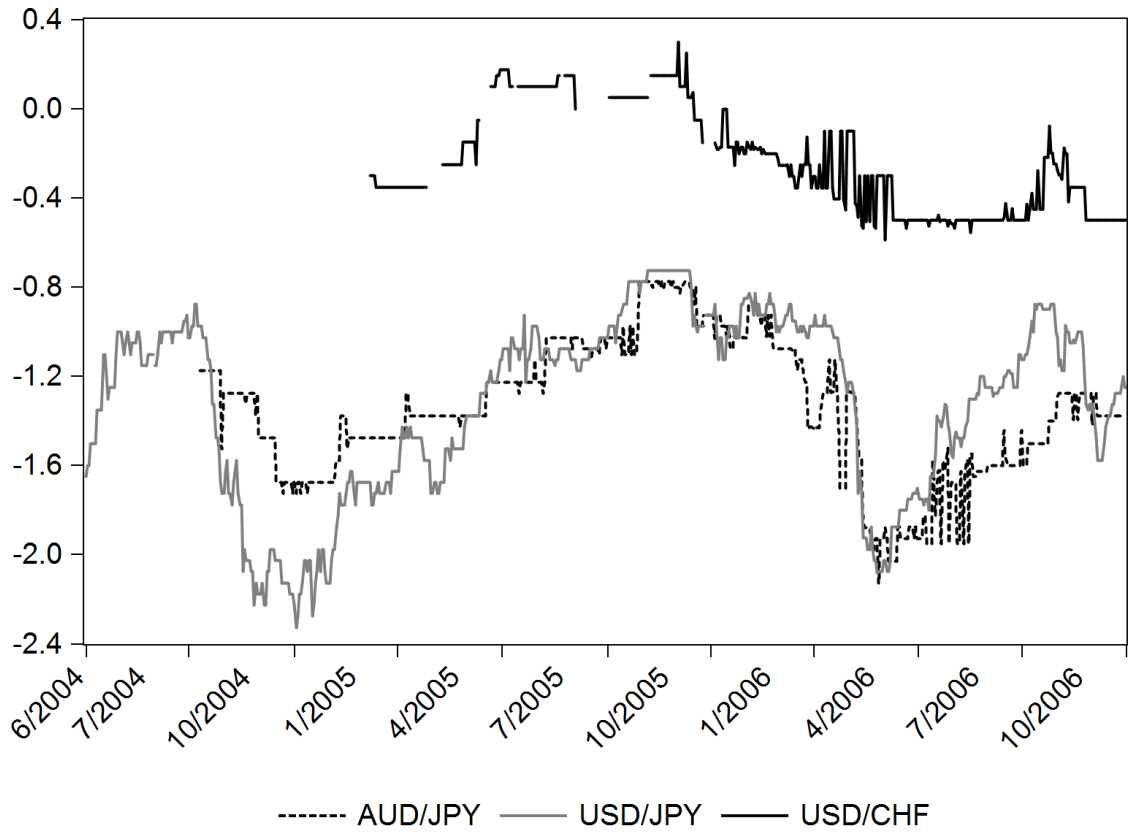
Note: An appreciation of the high yield currency is an example of the forward premium puzzle and the violation of the uncovered interest parity (UIP). The UIP regression coefficient has been estimated as low as -2.79 for the yen (Ichiue and Koyama , 2011).

Figure 2
Forward premiums for USD/JPY, USD/CHF and AUD/JPY exchange rates



Note: The figures shows the (f_t-s_t) differentials calculated using forward rates. Carry trade candidate currencies selected using the Menkoff et al (2011) forward premium ranking procedure, subject to risk-reversal data availability.

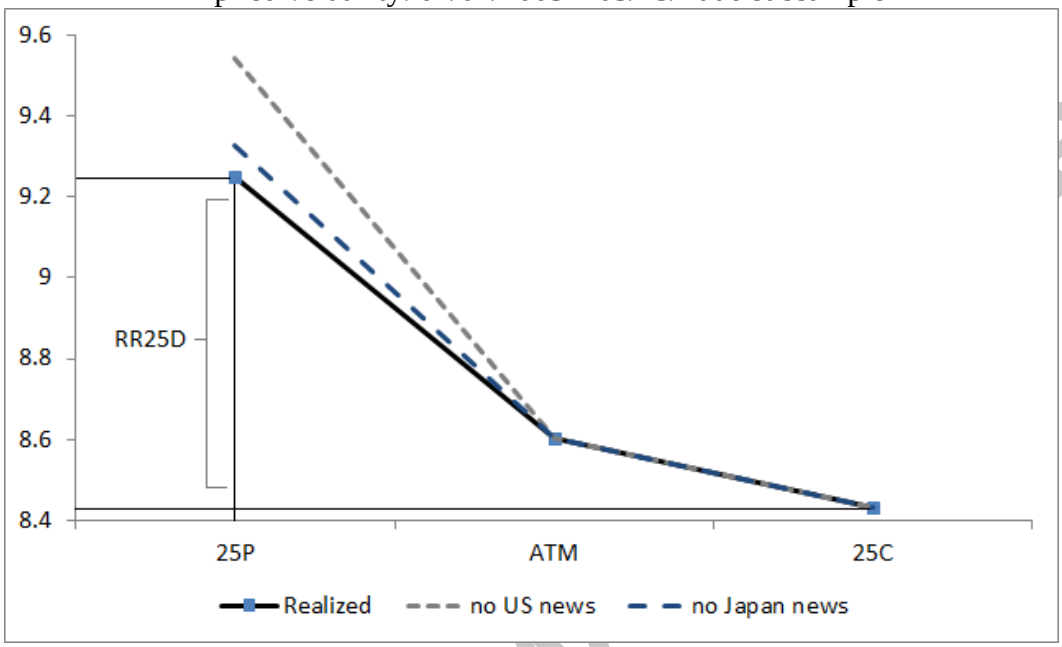
Figure 3
The cost of hedging against sharp depreciation (appreciation) of selected target (funding) currencies vis-à-vis the USD



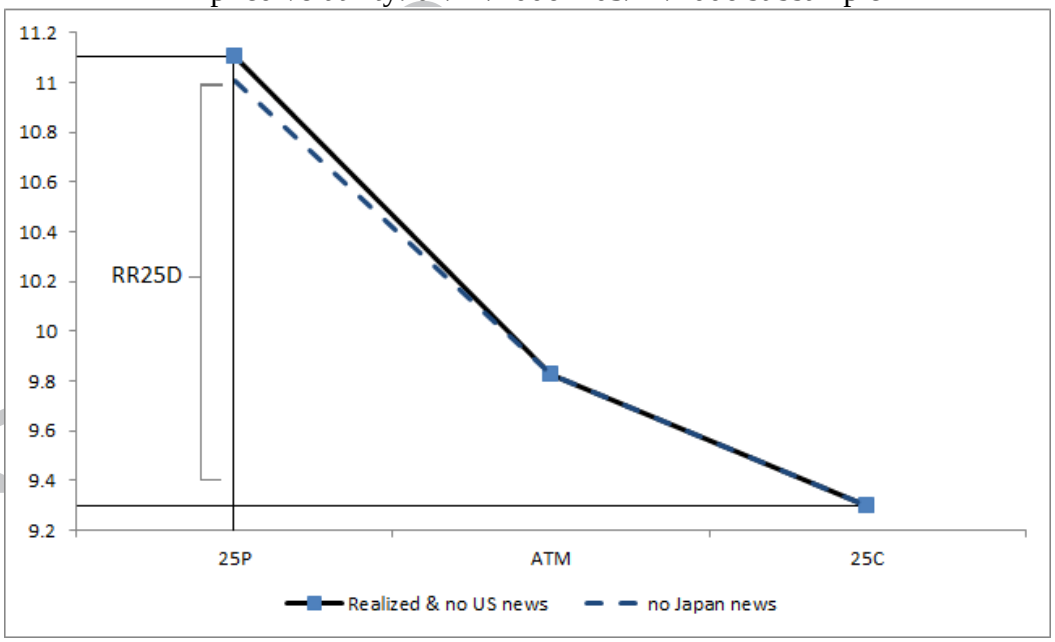
Note: The figures shows the (f_t-s_t) differentials calculated using forward rates. Carry trade candidate currencies selected using the Menkoff et al (2011) forward premium ranking procedure, subject to risk-reversal data availability.

Figure 4
Impact of macroeconomic surprises on JPY/USD implied volatility smirk.

Implied volatility: 01/07/2005 – 03/13/2006 subsample

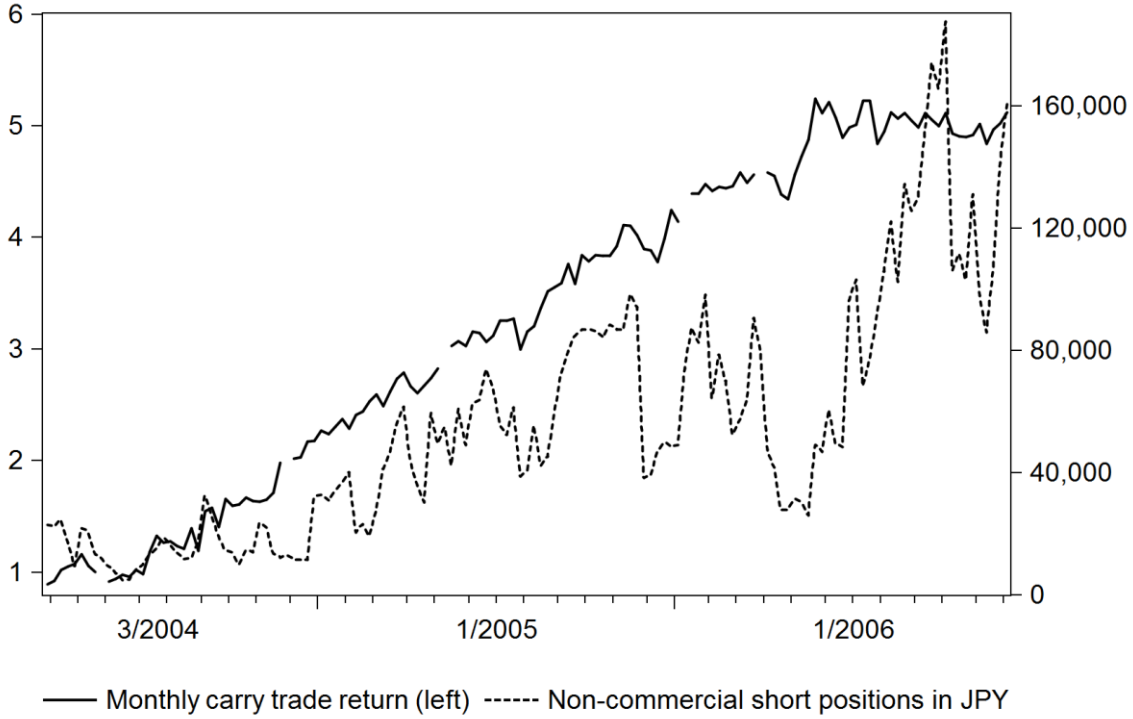


Implied volatility: 04/12/2006 – 05/17/2006 subsample



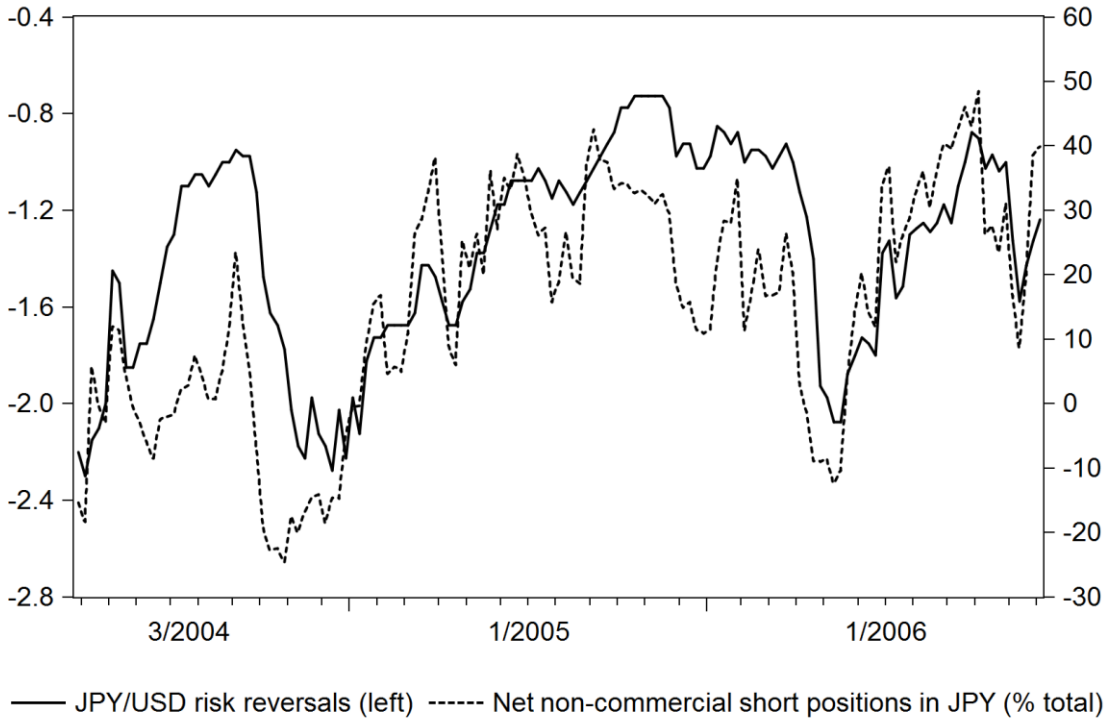
Notes: Implied volatility smirk means yen calls/dollar puts are more expensive. The vertical distance indicates the absolute value of 25-delta risk reversal: $RR^{25\delta} = \sigma_c^{25\delta} - \sigma_p^{25\delta}$. Estimates of the shift in the implied volatility curve are based on results in Table 5. (Source: Bloomberg, authors' calculations)

Figure 5
Carry trade return and total CME non-commercial short positions.



Note: We calculate carry trade return as $CR_{t+k} = (1+i_{k,t}^{US})S_{t+k}/S_t - (1+i_{k,t}^{JP})$ where *ik,t* denote the effective k-period deposit rates available in Japan and U.S. at time *t*. CFTC classifies traders as non-commercial if they have no foreign exchange exposure to hedge. A position corresponds to a contract value of 2.5 million yen (CFTC Explanatory Notes, http://www.cftc.gov/).

Figure 6
Risk reversals and CME net non-commercial Yen short futures positions



Notes: We construct the measure of CME net non-commercial short positions (NCMS) as a percentage of open interest (% O.I.) by subtracting non-commercial long from non-commercial short positions divided by total open interest in yen futures.

Appendix A. Complete coefficient vector – impact of macroeconomic surprises on risk reversals

Table A1

Regression results of ALL macroeconomic announcement surprises

ALL Macro Surprises	Baseline(1)		Baseline(2)	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
GDP	-5.517 **	(2.653)	-4.259 **	(1.768)
Nonfarm payroll employment	4.679 *	(2.468)	0.616	(2.314)
Industrial production	-2.341	(3.396)	-2.679	(3.154)
Capacity utilization	-0.970	(3.025)	-1.853	(3.034)
Personal income	0.766	(1.507)	1.661	(1.295)
Consumer credit	-4.293 *	(2.550)	-4.858 *	(2.619)
Consumer spending	-1.961	(3.582)	-2.553	(3.604)
New home sales	0.840	(2.728)	1.669	(2.473)
Durable goods orders	0.084	(2.387)	1.240	(2.567)
Factory orders	1.353	(1.650)	-1.471	(1.607)
Business inventories	3.646	(2.673)	1.781	(2.277)
Trade balance	0.175	(3.476)	-2.756	(2.406)
Producer price index	-2.826	(3.080)	-2.867	(2.720)
Consumer price index	-1.654	(4.822)	-0.687	(4.003)
Consumer confidence index	2.241	(3.747)	0.317	(3.788)
NAPM index	2.181	(1.975)	-0.096	(2.271)
Housing starts	-0.040	(2.218)	-0.703	(2.123)
Index of leading indicators	-2.248	(7.118)	-0.775	(4.959)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	-5.553 *	(2.857)	-5.452 **	(2.796)
Current account	-1.648	(1.782)	-0.632	(1.760)
Leading economic index	2.220	(1.982)	0.752	(1.626)
Consumer confidence index	3.660 **	(1.865)	3.517 *	(1.859)
TANKAN large manufacturing index	0.317	(3.915)	4.810	(3.647)
TANKAN non-manufacturing index	2.639	(5.011)	-2.026	(3.856)
Monetary base	-2.744	(4.125)	-2.265	(4.115)
Capacity utilization	-7.503	(13.797)	-5.090	(9.934)
GDP (quarterly)	-2.258	(3.118)	-3.249	(2.366)
Large retail sales	-5.532	(3.595)	-5.086	(3.388)
Construction orders	-0.019	(1.150)	1.326	(1.858)
Industrial production	0.434	(2.123)	1.683	(2.367)
Retail trade	0.386	(3.218)	0.097	(3.309)
Consumer price index	-3.304	(2.229)	0.158	(2.951)
Overall household spending	5.738 **	(2.485)	5.558 ***	(1.530)
Exchange rate			5.239 ***	(1.256)
Interest rate differential			-0.067 *	(0.041)
Lag dependent variable	0.008	(0.052)	0.003	(0.044)
R-squared	0.033		0.211	
Durbin-Watson	1.814		2.085	
Akaike info criterion	-2.402		-2.600	

Note: 3/18/2004 12/29/2006 sample, 715 observations. Standard errors in parentheses; *, **, and *** indicate coefficients significant at 10%, 5%, and 1% level respectively. Constant and day of the week omitted because of insignificant coefficient.

Table A2
Regression results of LARGE macroeconomic announcement surprises

LARGE Macro Surprises	Baseline(2)				ARMA(4,4)			
	Narrow Bounds		Wide Bounds		Narrow Bounds		Wide Bounds	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
GDP	-4.219 **	(1.747)	-3.557 *	(2.043)	-4.327 **	(1.841)	-3.959 **	(1.982)
Nonfarm payroll empl.	0.661	(2.317)	1.663	(2.388)	0.583	(2.110)	1.567	(2.214)
Industrial production	-2.744	(3.166)	0.354	(5.383)	-2.517	(3.244)	0.897	(5.315)
Capacity utilization	-1.784	(3.024)	-3.847	(5.701)	-1.289	(3.041)	-3.186	(5.544)
Personal income	1.658	(1.293)	1.082 **	(0.421)	1.569	(1.168)	1.211 ***	(0.374)
Consumer credit	-4.873 *	(2.635)	-6.478 *	(3.441)	-5.518 **	(2.726)	-7.033 **	(3.567)
Consumer spending	-2.522	(3.603)	-2.284	(4.088)	-2.289	(3.257)	-2.430	(3.688)
New home sales	1.620	(2.481)	2.850	(2.617)	0.666	(2.539)	2.717	(2.582)
Durable goods orders	1.190	(2.576)	1.221	(1.842)	0.788	(2.485)	1.511	(1.751)
Factory orders	-1.488	(1.612)	-1.512	(1.567)	-0.900	(1.509)	-0.762	(1.461)
Business inventories	1.786	(2.278)	1.949	(2.844)	1.613	(2.245)	1.781	(2.788)
Trade balance	-2.850	(2.396)	-1.254	(2.825)	-1.924	(2.379)	-0.069	(2.867)
Producer price index	-3.049	(2.771)	-0.751	(1.060)	-2.227	(2.164)	-0.659	(1.010)
Consumer price index	-0.717	(4.008)	1.308	(3.540)	-0.263	(4.031)	1.826	(3.593)
Consumer confidence index	0.406	(3.800)	1.052	(4.317)	1.149	(3.635)	0.139	(4.335)
NAPM index	-0.064	(2.263)	-0.456	(2.179)	0.163	(2.169)	-0.399	(2.067)
Housing starts	-0.612	(2.127)	0.602	(2.020)	-0.936	(2.262)	0.244	(2.179)
Index of leading indicators	-0.774	(4.958)	-4.849	(3.602)	-2.628	(3.934)	-5.116	(3.891)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	-5.526 **	(2.793)	-6.396 *	(3.448)	-5.620 **	(2.788)	-6.436 *	(3.512)
Current account	-0.622	(1.774)	-0.762	(1.951)	-0.696	(1.716)	-0.868	(1.916)
Leading economic index	0.758	(1.634)	0.393	(1.753)	0.303	(1.723)	-0.322	(1.762)
Consumer confidence index	3.513 *	(1.855)	1.812	(1.569)	3.538 *	(1.939)	1.680	(1.765)
TANKAN large manuf. index	4.823	(3.650)	4.440	(4.463)	3.874	(3.346)	3.640	(3.857)
TANKAN non-manuf. index	-1.946	(3.904)	-3.702 *	(2.100)	-2.765	(3.764)	-3.017 *	(1.658)
Monetary base	-2.209	(4.111)	-2.144	(4.271)	-1.551	(3.607)	-1.062	(3.776)
Capacity utilization	-4.751	(9.922)	-6.452	(8.678)	-7.923	(10.476)	-10.506	(9.524)
GDP (quarterly)	-3.205	(2.355)	-3.261	(2.410)	-2.948	(2.396)	-2.828	(2.480)
Large retail sales	-5.197	(3.399)	-5.197	(3.495)	-4.110	(3.578)	-4.798	(3.739)
Construction orders	1.365	(1.898)	0.736	(2.112)	1.321	(1.698)	1.007	(2.126)
Industrial production	1.565	(2.379)	0.987	(2.583)	0.726	(2.205)	0.648	(2.576)
Retail trade	0.064	(3.353)	1.833	(3.692)	-0.102	(3.277)	1.304	(3.672)
Consumer price index	0.114	(2.972)	2.747	(3.460)	0.644	(2.616)	2.765	(2.995)
Overall household spending	5.583 ***	(1.478)	4.389 ***	(0.928)	5.903 ***	(1.948)	4.794 ***	(1.573)
Exchange rate	5.237 ***	(1.256)	5.193 ***	(1.249)	4.593 ***	(0.705)	4.539 ***	(0.691)
Interest rate differential	-0.068 *	(0.041)	-0.065	(0.041)	-0.076 **	(0.037)	-0.074 **	(0.037)
Lag dependent variable	0.003	(0.044)	0.002	(0.045)				
AR(4)					-0.658 ***	(0.164)	-0.653 ***	(0.169)
MA(4)					0.726 ***	(0.148)	0.724 ***	(0.152)
R-squared	0.212		0.211		0.286		0.286	
Durbin-Watson	2.084		2.078		2.129		2.126	
Akaike info criterion	-2.600		-2.599		-2.696		-2.696	

Note: 3/18/2004 12/29/2006 sample, 715 observations. Standard errors in parentheses; *, **, and *** indicate coefficients significant at 10%, 5%, and 1% level respectively. Constant and day of the week omitted because of insignificant coefficient.

Table A3

Regression results of LARGE macroeconomic surprise announcements conditional on increasing risk of sharp yen appreciation

	ARMA(4,4)			
	Narrow Bounds		Wide Bounds	
U.S. Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
GDP	-1.829	(3.887)	-6.944	(4.935)
Nonfarm payroll empoloyment	-6.419	(8.050)	-	-
Industrial production	4.807	(3.080)	-	-
Capacity utilization	10.679 **	(5.199)	8.407 **	(3.549)
Personal income	1.126	(0.867)	1.046 ***	(0.349)
Consumer credit	-5.076	(10.597)	-26.313 ***	(2.157)
Consumer spending	9.139	(8.657)	-	-
New home sales	-2.690	(1.903)	-1.290 *	(0.742)
Durable goods orders	0.620	(2.836)	2.182	(3.035)
Factory orders	1.156	(3.350)	-0.596	(1.306)
Business inventories	5.263	(9.269)	-	-
Trade balance	5.558	(6.012)	11.443 ***	(2.736)
Producer price index	-5.381	(5.865)	-1.152	(1.263)
Consumer price index	2.762	(5.401)	-8.416 ***	(1.208)
Consumer confidence index	-4.303	(5.117)	-2.432	(7.176)
NAPM index	5.185	(6.617)	-2.551	(5.271)
Housing starts	7.819 **	(3.871)	9.241 **	(4.276)
Index of leading indicators	1.432	(10.992)	-10.328 **	(4.480)
Japanese Announcements	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Trade balance	-8.472	(10.264)	-20.050 ***	(0.998)
Current account	-6.551	(6.680)	-	-
Leading economic index	-9.856 *	(5.380)	-	-
Consumer confidence index	5.028	(5.800)	2.619	(3.428)
TANKAN large manufacturing index	-3.593	(5.969)	3.060 **	(1.286)
TANKAN non-manufacturing index	-4.587	(16.470)	-	-
Monetary base	30.400	(21.217)	-	-
Capacity utilization	-	-	-	-
GDP (quarterly)	-13.323 ***	(5.117)	-	-
Large retail sales	-8.823	(8.179)	-15.629	(13.881)
Construction orders	3.788	(3.257)	6.030 ***	(1.224)
Industrial production	-5.762	(5.312)	-6.696	(5.504)
Retail trade	-12.474 ***	(3.797)	-9.351 ***	(0.776)
Consumer price index	-0.669	(4.440)	-10.530 *	(6.064)
Overall household spending	10.630 **	(5.148)	4.097	(4.127)
Exchange rate	4.479 ***	(0.659)	4.443 ***	(0.695)
Interest rate differential	-0.062 *	(0.034)	-0.065 *	(0.034)
AR(4)	-0.647 ***	(0.164)	-0.648 ***	(0.161)
MA(4)	0.728 ***	(0.144)	0.728 ***	(0.142)
R-squared	0.287		0.290	
Durbin-Watson	2.189		2.160	
Akaike info criterion	-2.701		-2.730	

Notes: All news announcement surprises have been interacted with a lagged dummy variable that takes on a value of 1 if the cost of hedging against sharp yen appreciation rose between day *t* and *t-1*. 3/18/2004 12/29/2006 sample period, 715 observations. Standard errors in parentheses; *, **, and *** indicate coefficients significant at 10%, 5%, and 1% level respectively. Constant and day of the week omitted because of insignificant coefficients.

Table A4

List of macroeconomic news considered and the number of surprise announcements.

Funding currencies: JPY, CHF			Target currencies: AUD, USD		
Country	News item	# of surprises	Country	News item	# of surprises
Japan	Current account	22	Australia	GDP	12
	Leading economic index	8		CPI	12
	Consumer confidence index	12		Current account	12
	TANKAN large manuf. index	6		Trade balance	36
	TANKAN non-manuf. index	3		Unemployment rate	36
	Monetary base	18		Retail sales	36
	Capacity utilization	3	U.S.	GDP	18
	GDP	10		Nonfarm payroll empl.	17
	Large retail sales	15		Industrial production	18
	Construction orders	4		Capacity utilization	15
	Industrial production	23		Personal income	20
	Retail trade	16		Consumer credit	20
	Consumer price index	12		Consumer spending	14
	Overall household spending	1		New home sales	27
	GDP	12		Durable goods orders	26
Switzerland	CPI	36		Factory orders	22
	GDP	12		Business inventories	20
	Leading indicators	35		Trade balance	22
	Trade balance	10		Producer price index	23
	PPI & import prices	36		Consumer price index	12
	Unemployment rate	36		Consumer confidence index	24
	Employment	9		NAPM index	19
	Industrial production	12		Housing starts	21
				Index of leading indicators	7

Sources: Bloomberg, Bank of Japan.

Highlights

- Macroeconomic news impacts “tail risk” perceptions in JPY/USD.
- The results point to trade balance/flow model, often cited by practitioners.
- These results are robust to using CHF and AUD as alternative currencies.
- Speculators respond to currency risk hedging cost changes after macro releases.
- Macro news can translate in up to one third of yen speculative position changes.