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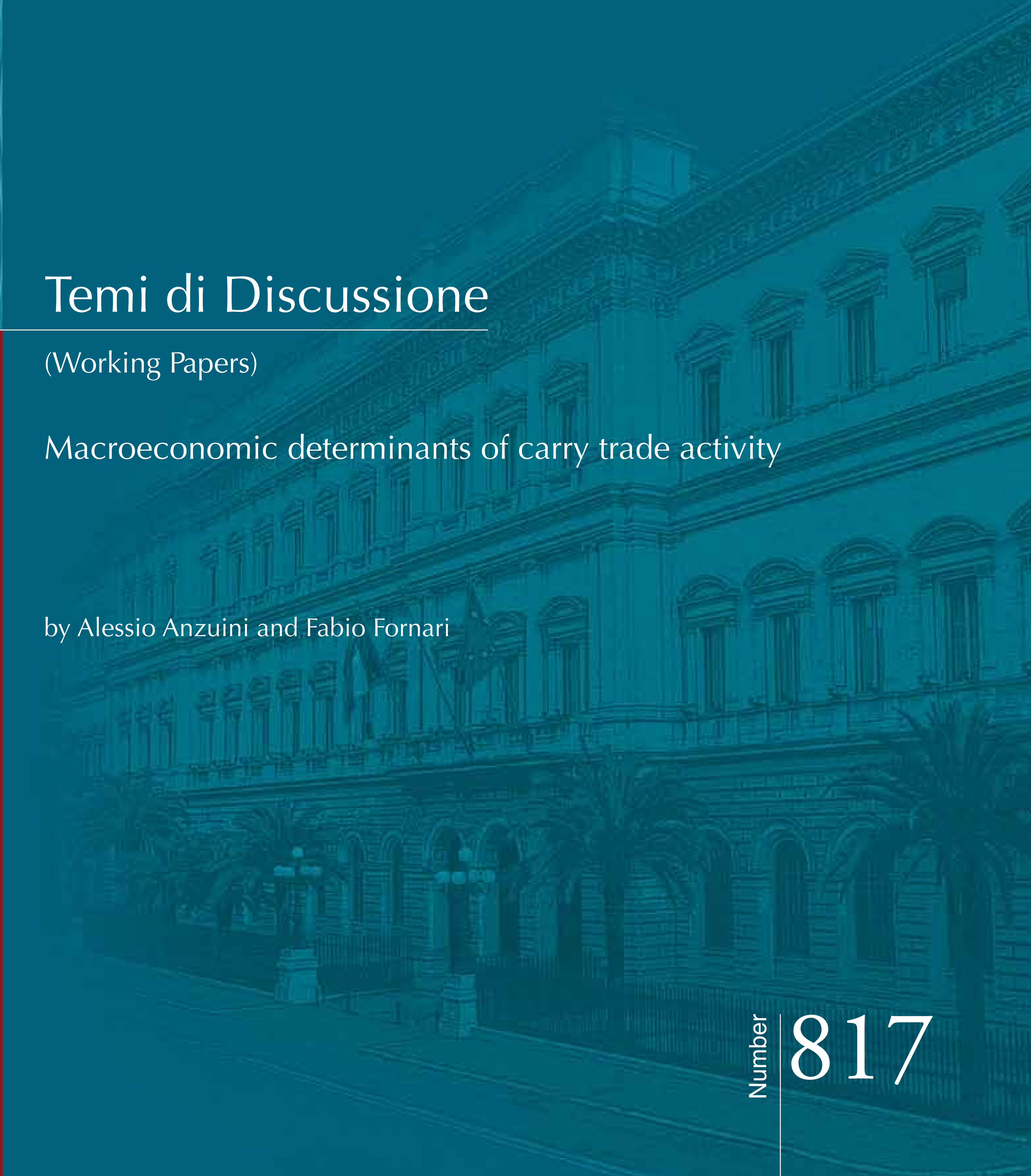

Temi di Discussione

(Working Papers)

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MACROECONOMIC DETERMINANTS OF CARRY TRADE ACTIVITY

by Alessio Anzuini* and Fabio Fornari**

Abstract

From a financial standpoint, the mechanics of the carry trade has been recently examined in Brunnermeier et al. (2009). They showed that shocks to interest rate differentials lead to carry trade activity and to significant reactions in the bilateral exchange rates vis-a-vis the US dollar that they analyse. Starting from their paper, we take a more macroeconomic standpoint and aim to identify what kind of structural shock can generate the implications of their interest rate differential shock. To this aim we add two macroeconomic variables and two indicators of confidence to the 4-variable financial VAR of Brunnermeier et al. (2009) and use sign restrictions on the impulse responses of the resulting larger VAR to identify four macroeconomic shocks. We evidence that demand shocks and confidence shocks are associated with longer-term gains from carry trade activity, relative to supply and monetary policy shocks. This finding also supports the widely reported idea that sentiment boosts position taking.

JEL Classification: G120, G130, G140.
Keywords: carry trade, speculative activity, sign restriction.

Contents

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* Bank of Italy, Economics, Research and International Relations. ** European Central Bank - Directorate General Economics.

1. Introduction

Carry trades are popular strategies in the foreign exchange market and they are set up by investing in (a set of) currencies yielding high interest rates the funds obtained from borrowing (a set of) currencies requiring the payment of low interest rates. Such positions are typically held as long as i) the two currency groups maintain on average a wide interest rate differential and/or ii) exchange rate risk remains low. When either or both conditions fail to hold positions are typically unwound, thereby triggering rapid exchange rate movements and rising volatility – also across other asset classes – with spillovers potentially reaching the real side of the economy. The deterioration in real activity, the turbulent financial market conditions worldwide and the large swings recorded by many currency pairs on account of the global deleveraging of international positions in the aftermath of the late-2008 tensions in the banking sector do certainly witness the potential effects that can originate from a global repositioning of investments across geographic areas.

Prior to the tensions ignited by the Lehman collapse, carry trades had been boosted by a combination of factors: subdued and falling exchange rate volatility, which minimized the risk of adverse exchange rate movements, historically low risk aversion (and/or low price of risk) and high interest rate differentials across currencies worldwide. Periods of low exchange rate volatility have been particularly conducive for carry trade activity, having historically coincided with appreciating high-yielding currencies against lower-yielding currencies – the opposite of what is predicted by the uncovered interest rate parity (henceforth UIP; see also Engel, 1996, Clarida et al., 2009, Baillie and Bollerslev, 2000, Jorda' and Taylor, 2009, for additional views on the topic) – so that the carry position provides positive profits also from the exchange rate side in addition to those achieved by locking in the positive interest rate differential. Menkhoff et al. (2009) as well as Christensen et al. (2009) - both papers being discussed in detail in the literature review in the next section - show that exchange rate volatility is a key factor behind the performance of carry trade positions. In line with this relationship, the heightened risk perceptions (and the collapsing interest rate differentials worldwide) that followed the Lehman collapse led to a sharp unwinding of outstanding positions, a phenomenon which is indirectly evidenced by the quick reversal in the amount of outstanding net speculative positions held in the foreign exchange futures market for all major currency pairs (see Figure 1 for a broad picture of such developments between 1986 and 2009; also Brunnermeier and Pedersen's (2009) model is evocative of these developments).[1]

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[1] Although there are no official statistics on the size of the carry trade phenomenon, the massive recourse to such a strategy in foreign exchange markets can be deduced by the presence of high correlation within the group of low-yielding currencies as well as within the group of high-yielding currencies in periods of low foreign exchange volatility. Other

This paper investigates beyond the conclusions reached by Brunnermeier et al. (2009) about the exchange rate appreciation stemming from an unexpected widening of the interest rate differential between two currencies. The authors measure how much a shock to the interest rate differential affects exchange rate returns in a way which is also consistent with developments in the factors that determine both the gains and the risks associated with carry trade activity – the interest rate differential, the skewness of exchange rate returns (a measure of exchange rate risks) as well as the carry trade intensity (proxied by the amount of net speculative positions held on the foreign exchange futures market). To anticipate, we explore whether the implicit conclusion of their analysis, i.e. that an unexpected change in the interest rate differential between two currencies leads to an appreciation of the higher yielding currency, holds irrespective of the external and the domestic macroeconomic environment, i.e. irrespective of the underlying shock which originated the unexpected movement in the interest rate differential. Put differently, do all interest rate movements have the same long-term impact on the foreign exchange rate and carry trading or is the initial (and possibly favourable) impact on carry trading amplified/dampened according to the different type of macroeconomic shock that originated the change in the interest rate differential? For example, some macroeconomic shocks could move the interest rate differential on impact but this initial gain for carry positions could subsequently revert possibly due to unfavorable developments in interest rates and foreign exchange rates induced by movements in a number of macroeconomic variables. Indirect evidence of the varied impact played by different shocks on the carry trade dynamics is implicit in the results obtained by Hutchison and Sushko (2010). They focus on periods of heightened carry activity (as measured by positioning in the foreign exchange futures market) namely i) between 7 January 2005 and 13 March 2006 and ii) between 12 April and 17 May 2006. While in the former period carry trade activity was significantly related to surprises for the US GDP, the US Consumer Credit and the US Trade Balance, in the second period it was especially Japanese surprises to account for a sizeable portion of the change in carry trade activity. Overall, the linkage between carry trading activity and specific types of macroeconomic surprises, also as a function of their geographical origin, would suggest that market participants engage in carry trading with an eye on the macroeconomic environment which surrounds financial developments.

The existence of differences in the responses of exchange rates and speculators' behaviour to different types of shocks is potentially interesting for monetary authorities as well as for market participants themselves. The former typically take interest decisions to the aim of achieving inflation or growth targets. These, in turn, are ultimately dependent also on an estimate of the cumulated appreciation/depreciation of the country's nominal foreign exchange rate vis-a-vis main trading partners over a given time span. Yet, it is not easy to forecast how the exchange rate will behave when market

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hints can be obtained by the amount of net non-commercial positions (often referred to as "speculative" position) taken on the foreign exchange futures market.

participants are hit by an unexpected interest rate change. Also depending on the degree of openness of the economy, the outcome of the official interest rate decisions may be blurred by a sudden and prolonged market reaction leading to an appreciation of the domestic currency which exacerbate the desired degree of tightening, with the reverse occurring when interest rates are unexpectedly decreased. Market participants should also be interested in knowing whether the macroeconomic shock behind what they perceive as an unexpected change in the interest rate differential may possibly have adverse and unexpected consequences for the longer-term returns on the carry trade positions that they are about to set up, despite the likely short-term gains that may be foreseeing.[2] Of course the duration of market participants' positioning plays a key role in determining the gains from carry trading, a topic which is nonetheless outside the aims of this paper.

We start with a monthly version of the 'financial' VAR in Brunnermeier et al. (2009) featuring (1) excess foreign exchange returns (z_{t+k}) [3], (2) the interest rate differential $(i_t - i_t^*)^{(k)}$, (3) a rolling measure of skewness of the bilateral exchange rate returns, which proxies for exchange rate risks ($s_t^{(k)}$) and (4) the amount of net (long minus short) positions in the futures foreign exchange market standardized by the open interest in the same market (pos_t), this latter variable representing the number of contracts open but not yet settled at a given point in time. We estimate the VAR for six bilateral pairs vis-a-vis the US dollar as well as pooling across the six currencies and compute the impulse responses to a (Choleski identified) interest rate differential shock. This impulse response measures the exchange rate pressure in response to a widening gap between the domestic and the US dollar short term rate.[4] In line with the findings of Brunnermeier et al. (2009), unexpected

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[2] The possibility that a reversal takes place in the carry trade gains some times after the interest rate shock can be also rationalised by making reference to the well-known and documented financial market reaction to 'economic surprises' in a high (daily) or low (monthly or quarterly) frequency context. At high frequencies (say intradaily), in fact, interest rates in a given country are likely to react to many news types, so that positions in the foreign exchange market should be adjusted almost continuously through the day (allowing for transaction costs) as long as macroeconomic releases or other events lead interest rate differentials to be wider/narrower than expected. However, when one looks at lower frequencies – so that the sign and the size of the underlying shocks can be more precisely identified – not all of the intraday positioning set up on the basis of the high frequency news will have generated positive returns, as some of these positions will turn out to have been wrongly placed, having failed to account for the relationship between the true underlying shock and the financial market variables.

[3] Measured by $z_{t+k} = s_{t+k} - s_t - (i_t^* - i_t)^{(k)}$.where s_t is the exchange rate and $(i_t^* - i_t)^{(k)}$ the foreign less domestic interest rate differential for the relevant maturity, k.

[4] While these data are described in the next section, let us point out here that the presence of risks in the foreign exchange markets is measured via the skewness of the bilateral foreign exchange returns rather than through their volatility, as volatility is a symmetric measure of risk, i.e. for a given change in the an exchange rate, volatility rises by the same amount independently on the sign of the change, while the skewness also keeps track of the direction of the exchange rate movement and 'informs' the model about the existence of risks for the carry trade return. This directional information, as pointed out by Brunnermeier et al. (2009), can be grasped by noticing that low-yielding currencies and high-yielding currencies have returns distributions which are very differently skewed. In particular, low-

developments in the interest rate gap lead the higher yielding currencies to record a persistently positive return (i.e. they appreciate), positions to cumulate in favour of the higher yielding currencies, the skewness of the foreign exchange rate returns vis-a-vis the US dollar to decrease as positioning in the futures foreign exchange market picks up (the last two developments highlight the growing risks that positions may be rapidly unwound). We then expand such 4-variable 'financial' VAR with two selected macroeconomic variables and two confidence indicators and identify four types of structural shocks – monetary policy, demand, supply, confidence – via sign-restrictions on selected impulse responses. The structural nature of such impulses allows us to draw conclusions about which of the four identified shocks plays a predominant role in explaining the developments in interest rate differentials, foreign exchange rates and carry trade activity that were identified in the impulse responses of the 'financial' VAR of Brunnermeier et al. (2009).

The paper is organized as follows. The next section reviews the relevant literature, the subsequent one describes the data and the methodology we adopt to identify the macroeconomic shocks, while section 4 presents the results. Section 5 deals with some robustness issues and aims to provide a quantification of the potential gain/losses experienced by market participants given the actual realization of the structural shocks and section 6 concludes.

2. Literature

Although the returns and the risks implicit in carry trade activity have been examined in a number of papers recently, we focus here almost exclusively on three works that more directly matter to our aims. Lustig and Verdelhan (2007) have shown that, from the standpoint of a US investors, the extra-returns per unit of risk offered by the carry trade relative to other investments (for example the equity market) can be reconciled with one specific risk factor, i.e. business cycle risk. Accordingly, it would then be rational to hold a low yielding currency (relative to the domestic one) because the former typically appreciates when the domestic economy enters a phase of recession and in this way it provides protection against the drop in domestic consumption. Seen from this angle, the high carry trade returns per unit of risk that some currency pairs offer would simply be compensating for their

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yielding currencies tend to exhibit negatively skewed returns, owing to episodes of large and rapid appreciation vis-à-vis the dollar, while high-yielding currencies have positively skewed returns, owing to episodes of large depreciation against the US currency (see Figure 1). The presence of a non-zero skewness in foreign exchange returns as well as its opposite sign across currency types (paying low or high interest rates) supports the idea that, as frequently put by commentators, currencies involved in carry trade activity tend to move "up with the ladder and down with the elevator", meaning that a prolonged and gradual trend appreciation/depreciation is followed by a sudden depreciation/appreciation when risks to the outstanding positioning become too large.

higher exposure to consumption risk, perhaps a finding little known to positions holders.[5] In a similar vein, Farhi et al. (2009) have attributed high carry trade returns to the possible realization of extreme events – i.e. to crash risk or disaster risk. They show that approximately 25% of the carry trade returns in advanced countries can derive from exposure to crash risks, a finding which however still leaves a significant proportion of such returns largely unexplained and casts doubts on the economic relevance of the explanation (see also Burnside et al., 2010, for a extreme event explanation of the carry trade returns, as well as Burnside et al., 2008).

Another subset of papers, among which Menkhoff et al. (2009) and Christensen et al. (2009), relate carry trade returns to asset price volatility. The latter authors model carry trade returns via a factor model - which comprises the S&P500 as well as the long term US T-bond yield - in which the factors are assumed to depend on the foreign exchange volatility level through a smooth transition function. The model can be represented simply as

$$\begin{aligned} z_t &= (1 - G(s_{t-1})) \cdot \beta_1' \cdot x_t + G(s_{t-1}) \cdot \beta_2' \cdot x_t \\ G(s_{t-1}) &= \frac{1}{1 + \exp(-\gamma(s_{t-1} - c)))} \end{aligned}$$

where z_t is the UIP residual (exchange rate change between t-1 and t plus the outstanding interest rate differential at t-1 scaled for the unit holding period), in other words the carry trade return, and s_{t-1} is the set of variables which determine the regime transition, in the paper assumed to be just the average volatility of a number of bilateral foreign exchange rates, $G(\cdot)$ is the logistic function and x_t collects the S&P500 return, its lag, the US Treasury note yield and its lag as well as the lag of the carry trade return and an intercept, i.e. $x_t = [SP_t, SP_{t-1}, TN_t, TN_{t-1}, z_{t-1}, 1]$. The parameter '$c$' in the logistic function regulates the point at which the nonlinearity is 'activated'. In this model the relationship between z_t and the factors will vary between β_1 for low volatility values, a state in which G is close to zero, and β_2 for high volatility values – when G approaches unity. Ultimately, it is possible to decompose z_t into three contributions for any quantile of the foreign exchange volatility: one stemming from the S&P500, one from the Treasury bond yield and finally one from the intercept (i.e. the pure volatility effect) jointly with the contribution arising from the presence of the lagged values of the factors. The key result is that in the top quantiles of the foreign exchange volatility distribution the S&P500 returns contribute to generate carry trade returns as low as -6% , the Treasury Note yield induces carry trade positions to lose 4% and the volatility together with the lags of the selected variables generates carry trade returns of approximately -18%. By contrast, the

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[5] The results in Lustig and Verdelhan (2008) have been shown to hold for a larger set of currencies in de Santis and Fornari (2009). See also Burnside (2007) for some alternative conclusions.

contributions of the two factors and especially the regime indicator (the volatility) are almost always positive in the lowest volatility percentiles, i.e. when market conditions are calm.

The analysis in Menkhoff et al. (2009) rests on the same set of forward rates for at most 48 currencies vis-a-vis the US dollar (the number of currencies increases through the sample) sampled monthly between 1983 and 2008 as in Lustig et al. (2011). The latter authors find that returns to carry trade positions – built as portfolios sorted according to the level of the interest rate differential vis-a-vis the US dollar – can be successfully explained by two factors: a level factor (so-called dollar factor, i.e. an average return computed across all the portfolios that they form) and a carry trade factor (i.e. the return differential between high-yielding and low-yielding portfolios of currencies relative to the dollar). Menkhoff et al. (2009) also support this two-factor structure for the cross sectional foreign exchange returns but also show that the model becomes more successful once the second factor – i.e. the carry trade factor of Lustig et al. (2011) – is replaced by an aggregate measure of foreign exchange rate volatility. According to their findings, foreign exchange volatility is a pervasive factor in the cross section of foreign exchange excess return and has the additional advantage - relative to the carry trade factor - of being an observable and identified factor, rather than an unidentified combination of returns themselves.

Finally Brunnermeier et al. (2009), the paper from which our contribution starts, look at the presence of crash risk in the currency market, conjecturing that sudden exchange rate movements unrelated to the release of news can derive from the unwinding of carry trade positions at times when speculators get near to their own funding constraints. In support of this conjecture they find that i) target currencies in carry trade operations are subject to crash risk, i.e. the distribution of their returns has positive skewness (quotes are expressed as units of currency per 1 dollar, so that positive skewness witness the higher odds of a sudden depreciation of the currency vis-a-vis the dollar), ii) that speculators' net positioning increases crash risk, iii) that rises in uncertainty, as measured by the equity volatility index VIX as computed by the Chicago Board Options Exchange (CBOE), coincide with reduction in speculators' positions and with higher returns to funding currencies (the low interest rate currencies). Another main conclusion of their work is that the existence of carry trading activity is not a destabilizing factor for the exchange rate market but rather that it helps driving the foreign exchange rate towards the level that UIP would predict to be reached on impact, i.e. immediately after the occurrence of the unexpected interest rate shock. On this respect, it is the presence of crash risk in the foreign exchange market that ultimately seems to keep speculators from taking positions large enough in the foreign exchange market to fully enforce the requirement of the UIP[6]. In this context, therefore, the empirical failure of the tests for the validity of the UIP would come from the presence of liquidity constraints so that capital arrives too slowly to the country

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[6] That is, that a country suddenly raising its interest rates should attract capital and record an immediate appreciation of its currency ahead of a gradual depreciation over the maturity spanned by the selected interest rate.

paying higher interest rates and the exchange rate appreciates only gradually. The question whether carry trades are a destabilizing phenomenon for the foreign exchange market has been also addressed in Brunnermeier et al. (2009) adding inflation differentials to the VAR. In fact, following a surprise increase in the interest rate differential:[7]

$$i_t^* - i_t - E_{t-1}[i_t^* - i_t] > 0$$

then the UIP implies:

$$z_t = \sum_{\tau=0}^{\infty} E_t \left([i_{t+\tau}^* - i_{t+\tau}] - E_{t-1}[i_{t+\tau}^* - i_{t+\tau}] \right) - (E_t[\overline{s}] - E_{t-1}[\overline{s}])$$

where $\overline{s}$ is the long-run level of the nominal exchange rate. Assuming stationarity of the log real exchange rate $s_t - p_t^* + p_t$, the total UIP-predicted movement in the nominal exchange rate amounts to

$$z_t = \sum_{\tau=0}^{\infty} E_t \left([i_{t+\tau}^* - i_{t+\tau}] - E_{t-1}[i_{t+\tau}^* - i_{t+\tau}] \right) - \left(E_t[\pi_{t+\tau+1}^* - \pi_{t+\tau+1}] - E_{t-1}[\pi_{t+\tau+1}^* - \pi_{t+\tau+1}] \right)$$

where $\pi_{t+\tau+1}^* - \pi_{t+\tau+1}$is the inflation rate differential. The comparison between the impulse response function of the excess foreign exchange return and the value of z_t predicted by the UIP will provide an indication of the potential destabilizing effects of the carry trade activity, i.e. its ability to lead the exchange rate away from the value consistent with its fundamental variables.

3. Data and methodology

3.1. Data and some preliminary evidence

We consider six currencies vis-a-vis the US dollar with long and continuous data for non-commercial positions in the foreign exchange futures market, i.e. Australian dollar (aud), Canadian dollar (cad), Swiss franc (chf), euro or German mark (eur), pound sterling (gbp) and Japanese yen (yen). Such data are available twice per month between January 1986 and September 1992 and thereafter weekly (on Tuesdays) from the website of the Commodity Futures Trading Commission (CFTC).[8] For the same set of currencies we compute daily measures of realised skewness (and also volatility and kurtosis) over overlapping windows of 63 working days, approximately 3 calendar months, and then we re-sample

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[7] In what follows we drow heavily on Brunnermeier et al. (2009).

[8] http://www.cftc.gov/

them at each month's end. Accordingly we also re-sample at a monthly frequency (as said, it is originally a weekly series) the positioning in the foreign exchange market, making sure that the end-of-month date for which the positions are sampled is equal or smaller than the date for which we have re-sampled the moments of the foreign exchange returns. While the foreign exchange rate moments are computed on returns achieved from holding the currencies for one day, the foreign exchange returns that are used throughout the paper, z_t, are, as said and consistently with Brunnermeier et al. (2009), the UIP residual, i.e. the exchange rate changes between time $t-1$ and t minus the one-month interest rate differential prevailing at $t-1$.

Figure 1 shows some features of the data, mainly the ingredients of our initial 4-variable 'financial' VAR. The low yielding currencies have been evidenced by dotted lines while high yielding currencies have solid lines with symbols. Especially as skewness is concerned, cross-country movements appear almost randomly scattered across time but they become extremely differentiated across currency groups around events which raise the global perception of risk, as the 1997 Asian crisis, the LTCM collapse in 1998 as well as the recent turbulences associated to the Lehman's default. It is worthwhile observing that exchange rate conditional volatility (not reported for brevity) does not exhibit such differentiated patterns despite the fact that Menkhoff et al. (2009) report movements in volatility to be good explanatory factor for the returns to currency portfolios ranked by their forward premium. Despite the 'pricing role' found in that paper, in fact, volatility has the drawback of being a symmetric indicator of risk while the skewness adds the information related to the expected direction of the subsequent exchange rate movements, similarly to what would be conveyed by the difference in the prices or in the implied volatilities of in-the money and out-of-the-money currency options (so-called risk reversal or implied skewness)[9]. The presence of an association between periods dominated by large changes in positions and large changes in returns' skewness is indicative at least of the existence of some correlation between the two measures, i.e. between market positioning and speculative activity. Indeed, beyond contemporaneous correlation, cross-correlations suggest that a rise in the exchange rate risks (as measured by the skewness of the currency returns) leads to a dismantling of net speculative positions over the subsequent four months (see Figure 2). For the Japanese yen and the Swiss franc, however, the reverse causality is also present. In addition, Granger causality tests (not reported for brevity) are also supportive of the presence of a two-sided causality between net speculative positions and exchange rate movements. From a more visual standpoint Figure 3 shows developments in the speculative positions (grey area) and in the bilateral rate vis-a-vis the dollar for two high yielding currencies (euro and pound) and two low yielding currencies (yen and swiss franc). The correlation between the relative developments looks indeed rather high.

Last, Figure 4 show the density functions, estimated through a gaussian kernel, of the foreign exchange 3-month returns (top panel) and the net positions (bottom panel), for two high yielding

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[9] See also footnote 4.

and two high yielding currencies. Again, consistently with the presence of carry trade and speculative activity, the low interest rate currencies tend to have positively skewed returns distributions (which points to the historical presence of sudden appreciations vis-a-vis the US dollar) as well as negatively skewed positions distributions (market participants tend to take more short rather than long positions in these currencies).

3.2. Methodology

How carry trade activity impacts foreign exchange returns following an interest rate shock is analysed in a VAR framework, based on monthly data, as in Brunnermeier et al. (2009). The VAR has four lags and includes (1) the short-term interest rate differential, (2) the exchange rate excess return (the 3-month interest rate differentials less the exchange rate changes over the subsequent 3 months), (3) the time-varying skewness of exchange rate returns (a proxy for exchange rate risks, computed at each month end as the skewness of the previous 63 daily returns) and (4) the net non-commercial positions on the futures market, scaled by the open interest.[10,11] All variables in the VAR are relative to the corresponding value in the United States or refer to the exchange rate of the domestic currency vis-a-vis the US dollar. The VAR is estimated for each of the six currencies for which a long history of futures positions vis-à-vis the US dollar are available, as said euro, Swiss franc, pound sterling, Australian dollar, Canadian dollar and Japanese yen, as well as pooling the currency together allowing for country fixed effects. In these VAR we adopt the simple structural identification provided by the Choleski decomposition of the covariance matrix such that interest rate differentials are first in the causal ordering, foreign exchange returns are second, skewness is third and positioning is last. The same assumption has been made in Brunnermeier et al. (2009) and it is well-justified assuming that underlying macroeconomic developments lead monetary policy to react, thereafter affecting exchange rates and their distribution, eventually leading market participants to position themselves in the foreign exchange market so as to profit (in expectation) from these developments.

As already explained in the Introduction, we then employ a larger VAR to examine whether the interest rate shock identified in the 4-variable 'financial' VAR and its consequences for the foreign exchange market can be reconciled with any of the interest rate and foreign exchange rate reactions that stem from one specific macroeconomic shock or if all four macroeconomic shocks lead to analogous reactions in the carry trade-related variables. In these larger VAR, the macroeconomic variables for

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[10] The open interest measures the positions opened but not yet closed; positions refer to the Tuesday immediately preceding the end of a given month; net positions are computed as the difference between long and short non-commercial position on the selected currencies vis-à-vis the US dollar.

[11] Even if we use monthly frequency in the data, we continue to use the three months horizon in the VAR variables as the three months contract is by far the most traded in the future market. Robust standard error procedure is used to control for the moving average process in the residuals.

a given country (i.e. the industrial production index and the consumer price index) enter in terms of differences with the corresponding US variables, so that the shocks are forced to be symmetric, i.e. we cannot distinguish neither the geographical origin of the shock nor the relative contribution of the two countries to the shock realization. For each currency pairs, the larger VAR includes the US confidence indicator, the US VIX index as well as inflation differentials and industrial production differentials vis-a-vis the United States, in addition to the four variables in the financial VAR, and structural shocks are identified through sign restrictions which, relative to traditional short- or long-run restrictions, are more flexible and do not impose overly tight conditioning on the response of the variables to the required shocks. Very briefly, given the reduced form $VAR(k)$ on the right hand side below

$$A_0 \cdot Y_t = c + \sum_{i=1}^{k} A_i Y_{t-i} + B \cdot \varepsilon_t \Longrightarrow Y_t = c + \sum_{i=1}^{k} \Gamma_i Y_{t-i} + \Theta \cdot \varepsilon_t$$

we identify the A_0 matrix of the corresponding structural VAR aiming to four structural shocks, a monetary policy shock, a supply shock, a demand shock and a confidence shock, through the sign restrictions reported in Table 1 below, i.e.

	$i_t - i_t^*$	$\pi_t - \pi_t^*$	$\frac{ip_t}{ip_{t-1}}$-$\frac{ip_t^*}{ip_{t-1}^*}$	$\sum_{i=1}^{k} fx_{t+i}$	skew	positions	confidence	VIX
MP shock	+	-	-	free	free	free	free	free
supply shock	free	-	+	free	free	free	free	free
demand shock	+	+	+	free	free	free	free	free
confidence shock	free	free	free	free	free	free	+	-

Table 1: sign-restrictions for the 4-shock VAR

We chose to impose the sign restrictions outlined above on the cumulated impulse response functions at the 4-th month after the impulse has been given (we experimented with some smaller and longer periods over which restrictions would apply, with no major changes). Overall we require in this way that the effects of the shocks start to fade at least four months after their occurrence. While the first three shocks are typical of macroeconomic analyses, the fourth one has been included as one of the recurring considerations of commentators in the financial press is that carry activity is significantly boosted by confidence/risk appetite among market participants, so that it seems to be worthwhile to disentangle a non-financial demand shock from a pure financial shock labeled 'confidence shock'. The importance of this special case of demand shocks for business cycle developments has been highlighted by the findings in Barsky and Sims (2010), namely that a confidence shock (in their paper a shock to a measure of forward confidence extracted by the US Michigan survey) generates persistent increases in consumption, output as well as in total factor productivity, while remaining orthogonal, in the very short term, to such variables. This suggests that while confidence shocks produce effects which are overall similar to those generated by demand shocks, they can be also seen as 'financial markets' or households anticipations of future increases in productivity, which are not yet manifest in actual data. The identification of the confidence shocks is entirely determined by the sentiment-related variables, i.e. the US consumer confidence indicator compiled by the Conference Board – and based on a sample of approximately 5000 US households – and the US stock market volatility index (VIX) computed by the CBOE, which is available for download from their website.[12] Overall the VAR that we consider has twice the size of the 'financial' VAR in Brunnermeier et al. (2009), i.e. 8 variables.

The sign restrictions needed to identify the 4 shocks are imposed in the following way. As $E(\varepsilon_t \varepsilon_t') = I$, the variance/covariance matrix of the VAR representation above is $\Omega = B' \cdot B$. For any possible orthogonal decomposition B we can find an infinite number of admissible decompositions of Ω, i.e.$\Omega = BQQ'B'$, where Q is any orthonormal matrix, i.e. $Q\prime Q = I$, the Choleski decomposition being a candidate for Q. Alternatively the eigenvalue-eigenvector decomposition can be used, i.e. $\Omega = PDP'$=$B \cdot B'$, where P is a matrix of eigenvectors and D a diagonal matrix with the eigenvalues on the main diagonal and $B = P \cdot D^{0.5}$. In both cases, for the $VAR(k)$ with coefficient vector and covariance matrix respectively (β, Ω), assuming a flat prior on β (which collects the parameters in the A_i matrices) the search of desired impulse responses (i.e. those satisfying the signs in the above Table) is performed sampling β from a normal distribution and Ω from an inverted Wishart distribution, whose joint use represents a conjugate prior, and achieving to obtain a reasonably high number of acceptances of such draws, say 1000, in which the generated impulses respect the required signs at the desired horizons. The impulse responses of the variables in the VAR to the desired shocks are then computed as the median of the accepted impulses and are typically presented alongside with 16% and 84% confidence bands. More specifically as concerns the identification scheme, the impulse responses come from orthogonal shocks generated via $B = chol(\Omega) * P$ where P is selected as $P = \Pi_{m,n} Q_{m,n}(\theta)$ with $Q_{m,n}(\theta)$ being rotation matrices of the form

$$Q_{m,n}(\theta) = \begin{pmatrix} 1 & ... & 0 & ... & 0 & ... & 0 \\ 0 & ... & ... & ... & ... & ... & ... \\ 0 & ... & \cos(\theta) & ... & \text{-}\sin(\theta) & ... & 0 \\ ... & ... & ... & 1 & ... & ... & ... \\ 0 & ... & \sin(\theta) & ... & \cos(\theta) & ... & 0 \\ ... & ... & ... & ... & ... & ... & ... \\ 0 & ... & 0 & ... & 0 & ... & 1 \end{pmatrix}.$$

For example, in our 8 variable VAR there would at most 28 bivariate rotations of the different

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[12] http://www.cboe.com/

elements of the VAR and the rotation angle θ is chosen randomly in the $[0, 2\pi]$ interval. The impulse responses are then generated through $R_{j,t+k} = A(L)^{-1} \cdot B_j \cdot \varepsilon_t$ and the sign restrictions are verified by checking that indeed $R_{j,t+k}$ is smaller or greater than zero, as required (see Table 1), at the desired number of steps after the initial shock.

One thing is worth mentioning as concerns the sign-restriction based identification of structural shocks. As put forward in Fry and Pagan (2010) the various rotation angles θ, according to which the Q matrices are generated and the impulses are identified, span the model space rather than the space related to the parameter uncertainty around a given model. Therefore the median impulse response and the median value of the $B = chol(\Omega) * P$ which led to accepted impulse responses cannot be used to perform tasks typical of the VAR analyses, as variance decomposition or historical decomposition. To this aim we therefore look for one specific B matrix among those which have generated accepted impulse responses, i.e. the one whose impulse responses (64 in our 8 variables VAR) minimise the distance from the respective median impulse responses computed over the models' space. In other words we aim to select the rotation B such that: $min_B \left[\sum_{k=1}^{nsteps} \left(IRF^{(i,j)}_{(B)}(k) - \overline{IRF}^{(i,j)}(k)\right)\right]^2$, where the horizontal bar symbol denotes the median impulse responses obtained from the accepted rotation matrices. Armed with this B matrix it becomes then a standard task that of computing the variance decomposition for the structural VAR.

4. Results

4.1. Financial VAR

As said, we begin our analysis by extending the results in Brunnermeir et al. (2009) to monthly data and a longer sample, through a VAR – one for each bilateral rate vis-a-vis the US dollar – which includes the interest rate differentials, excess currency returns (the UIP residual, i.e. the change in the bilateral foreign exchange rate between month $t-1$ and month t plus the interest rate differential prevailing at $t-1$), the exchange rate returns skewness and net (long-short) non-commercial positions scaled by the corresponding open interest. The data cover the period between January 1986 and September 2009. The Akaike information criterion suggests to use four lags.[13] Beyond these bilateral VAR we also consider a pooled estimation, stacking the four variables for all currency pairs, while allowing for a country specific intercept. We need to re-estimate this VAR over the longer sample and with monthly data so to be alble to compare the reults of the 'financial' VAR to those coming from the 'macro-financial' specification.

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[13] Adding more lags does not affect the main conclusion but it reduces the precision of the estimates.

Figure 5 shows the impulse response function for the panel estimation of the six currency VAR vis-a-vis the US dollar, i.e. yen, aud, cad, chf, gbp and eur to an interest rate differential shock. The coefficients of the lag matrices in the VAR are constrained to be the same across currencies but as just recalled each currency has its own intercept in the equations. The impulse response for the cumulated foreign exchange return is obtained by simply cumulating the response for the one-month foreign exchange return. Overall the impulses to an interest rate differential shock are rather precise and show that a 0.4 percentage points unexpected increase in the average interest rate differential against the dollar produces an average appreciation of these six currencies vis-a-vis the dollar that amounts to around 5% in the first year and to around 15% after four years. The impact on the crash risk, as measured by the skewness of the foreign exchange returns, also remains noticeably heightened for the first year and then peters out, while the impact on positions becomes statistically not significant after around one year of heightened speculative activity. Result from the VAR estimated at the currency-level (see Figure 6 and Figures A1-A4 in the Appendix) are in line with the panel-based results, although the impulse responses for the skewness and the speculative positions, possibly reflecting the smaller size of the sample when estimation does not rest on pooled data, are in some cases somewhat imprecise. By contrast, the cumulated foreign exchange appreciation continues to remain highly significant and overall ranges between 2.5% at the one-year horizon and 25% at a four-year horizon.

4.2. Macro-Financial VAR

Before getting to the structural VAR described in the previous section, it may be worth limiting the number of identified shocks at three, leaving aside the confidence shock. Having done so, we should then be able to improve our ability to understand the different implications of a non-financial demand shock and a shock that impacts the variables in the VAR pretty much like a demand shock but has its roots in an exogenous increase in confidence in a declining perception of financial risk. When the first 3 macroeconomic shocks only are identified, out of those in Table 1, Figure 7 reports the simple averages of the median impulse responses across the six currencies. While supply shocks do not exert any effects on the variables which are of interest for carry trading activity, demand and monetary policy shocks both lead to rising returns on the domestic currency vis-a-vis the US dollar. The size of the phenomenon is rather limited for monetary policy shocks, leading to an appreciation of the exchange rate as of around 5% over a four-year horizon, with effects which are not statistically significant on the variables that matter for speculative activity, i.e. the skewness of the foreign exchange returns and net positions. By contrast, demand shocks lead to increases in the foreign exchange return - in excess of 10% at the four year horizon - as well as to effects on the carry trade variables, i.e. significant and persistent decreases in the skewness and rising net positions in the foreign exchange futures market. Figure 8 shows that the pattern of the appreciation vis-a-vis the US dollar following a monetary policy or a demand shock is broadly similar across currencies, with demand shocks producing almost uniformly larger effects on the cumulated foreign exchange rate than the monetary policy shock. The cross-currencies effects of the monetary policy shock are also more scattered in terms of the foreign exchange rate appreciation, while demand shocks produce rather similar effects on the six bilateral pairs. The same is true for the cross-currency behavior of the skewness and the net positions.

Overall, demand shocks seem to play an important role in shaping the responses of the carry-related variables. This in turn would suggest that agents react significantly to endogenous developments in interest rate differentials. In other words, in order to prompt the market to engage in carry trade activity, the increase in the interest rate differential should be perceived to be persistent across time (as this boosts the expected returns from a progressive positioning vis-a-vis a given currency). Following a demand shock, in addition, the size of the equilibrium appreciation in the foreign exchange rate implied by the UIP is also larger. Both demand and monetary policy shocks produce effects on the cumulated appreciation of the foreign exchange rate that do not appear to be consistent with the view that carry trade activity can be destabilizing for the foreign exchange market. In fact, the movements of the bilateral exchange rates at the horizons spanned by the impulse response functions are overall consistent with their new long run equilibrium levels (see the dotted lines in the fourth row of Figure 7). As said, supply shocks do not play a major role on carry trade activity, as conditional on the occurrence of this type of shock the interest rate differential does not change significantly and - accordingly - the excess return on the foreign exchange rate also shows little variation. This last finding is in line with theoretical models of the new open macroeconomics where the response of the exchange rate to a technology shock is strongly dependent on the model parameterization (see Corsetti et al., 2008).

Bringing now also the confidence shock into the picture, so that non-financial demand shocks are separated from confidence shocks (the latter as said being a shock that increases the confidence indicator while decreasing the risk perception as measured by stock market volatility, and is of course orthogonal to the other three just discussed, see Table 1) produces the median impulse responses in Figure 9. Although not reported in order to save space, some of the confidence bands around these medians are rather wide, possibly also on account of the larger dimension of this VAR and the relatively small sample size. Among all currency pairs, however, it is especially interesting to focus on the responses of the Japanese variables to the four identified shocks (see Figure 10). In fact, following a confidence shock, Japanese industrial production and consumer prices (relative to the US counterparts) move in a way which is not very different from what seen for the supply shock. However, the financial variables related to carry trading react to a confidence shock very differently than to all other types of shocks. Overall, the rise in confidence leads market participants to strongly engage in carry trade activity, with massive yen short selling and a weakening of the Japanese currency, highlighting the often reported role of the yen as a funding currency. Also, the skewness of the yen/dollar returns becomes strongly and persistently positive, signalling the increased probability of a sudden yen appreciation as a consequence of the higher odds that an unwinding of foreign exchange positions takes place. Although we highlighted the case of the yen, as the effects of the confidence effects are more pronounced, the behaviour of the excess returns on the six currency pairs vis-a-vis the US dollar is overall broadly consistent with their different roles in the carry trade activity. In fact, following a confidence shock, the yen depreciation finds counterpart in the appreciation of the higher yielding currencies, which are typical carry trade targets, although such effects are not always extremely significantly. Figure A5 in the Appendix reports the corresponding impulse responses for the pound/dollar rate, which represented another case in which the confidence channel played a sizeable role. In this case, the Figure evidences rising foreign exchange rate returns and increasing long positioning on the pound, i.e. the opposite of what seen for the yen case, consistently with the role of target currency held on average by the pound in the sample analysed.

Overall, looking at the responses of the cumulated foreign exchange returns to the four identified shocks reported in Figure 9, demand shocks seem to be the key factor behind the reuurns reaction to the interest rate differential shock reported in Figure 5, almost uniformly across countries. The other three shocks have effects which are rather scattered across currency pairs and therefore their overall contribution to the interest rate differential - foreign exchange return relationship is more complex to assess, although confidence shocks are another main explanation for it beyond the demand shocks.

5. Additional issues

In this section we look at a number of issues which are either robustness analyses for the results presented so far or deeper investigations on ad-hoc selected topics.

Variance decomposition

In order to get a more quantitative assessment of the role of the shocks on the carry trade variables discussed at the end of the previous section, we report the percentage of the variance of three key variables in the carry trade, i.e. interest rate differentials, foreign exchange movements and net positioning, that can be explained by the identified shocks, i.e. the monetary policy, the demand, the supply and the confidence shock. As explained in Section 3 the identification of the VAR is based on sign restrictions on the impulse responses of selected variables stemming from rotations of the Choleski factorization of the covariance matrix. As our identification of the four shocks rests on 1000 such rotation matrices, we are inevitably faced with the task of choosing one of them to perform the variance decomposition. To this aim, following Fry and Pagan (2010), we select - out of the

1000 matrices - the rotation matrix that provides impulse responses of the 8 variables in the VAR to all 8 shocks (so 64 impulse responses as a whole) which are as close as possible to the median impulse responses based on the 1000 accepted rotations. Based on such identifications for the six VAR estimated at the currency level, Figure 11 reports the variance decomposition for the three variables to the four identified shocks at the 1-, 4-, 8-, 12- and 24-month horizons. Overall, with a good deal of commonality across currency pairs, interest rate differentials are significantly explained by monetary policy and demand shocks, with supply shocks and confidence shocks having almost no role. Looking at foreign exchange returns, monetary policy shocks play a negligible role, with the exception of Japan, and produce an effect which is almost constant over time. Demand shocks by contrast have an increasing importance over time and especially for the Canadian dollar, the euro and the Japanese yen they explain just over 8% of the foreign exchange rate variance (vis-a-vis the dollar) at the longer horizons, not a negligible role after all when one considers the almost random walk behaviour of exchange rates. Supply shocks play overall a very limited role in explaining the movements of the four variables. Interestingly, confidence shocks can explain a small part only of the movements in interest rate differentials when compared to monetary policy and demand shocks but, by contrast, they play a rather sizeable role in determining the movements in foreign exchange rate and positions for all currencies (with the exception of the canadian dollar) relative to the other two shocks. Overall, the variance decomposition provides additional evidence that demand shocks and confidence shocks can be seen as key drivers of speculative activity in the foreign exchange rate markets and that exogenous developments in risk-related attitudes can affect the foreign exchange market pretty much as non-financial demand shocks.

CONFIDENCE SHOCKS

As for the identification of the confidence shock, we concentrate on the yen/dollar case, the one in which the confidence channel has a more prominent role over what already accounted for by the demand shock. To check that the variables employed so far to identify confidence shocks are indeed picking the shock we aim to identify, we replace the US consumer confidence indicator with a more forward looking indicator of sentiment, i.e. the variable called E5Y and which is available in the Michigan consumer sentiment survey,[14] which has been employed in Barsky and Sims (2010) to identify confidence shocks. Also, we replace the US stock market volatility index VIX with either i) the simple average of the realised volatilities of the six foreign exchange rates vis-a-vis the dollar (as foreign exchange volatility may be a more appropriate way to identify the reaction of the carry-related variables to confidence shocks than the stock market volatility) or ii) the (negative of the) carry trade factor identified by Lustig et al. (2011), which is available from their website at a

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[14] It is basically built as the (net, i.e. the number of positive minus the number of negative outcomes) answer to the question whereby a survey of households is asked what is their business expectations at a 5-year-ahead horizon.

monthly frequency. These two additional identifications for the four structural shocks are carried out through the same sequence of random numbers used in the sign restrictions so that differences in the acceptance/rejection of the impulse response functions as a result of different variables chosen to approximate confidence is not likely driven by randomness. The results are reported in Figure 12, upper panel, for the yen/dollar case when the US VIX is replaced by the average foreign exchange rate volatility and when the consumer confidence is replaced by the E5Y variable. When the foreign exchange volatility is replaced by the carry trade factor results are instead in the lower panel of Figure 12. The two panels should be read against the findings in Figure 10, which are based on the VIX and the consumer confidence index. Although results do not change much, it is interesting to report that the reaction of the cumulated foreign exchange rate return to the confidence shock becomes less significant than it was in Figure 10 when the consumer confidence is replaced by E5Y and the VIX is replaced by the average foreign exchange rate realised volatility. Furthermore, when the carry trade factor takes the place of the VIX (lower panel) the reaction of the yen/dollar return is no longer significant which, being at odds with the two other indicators, may cast doubts about whether this variable is really and indicator of the risk intrinsic to carry trade operations.

Positioning and macroeconomic shocks

Is there a way to use the information that comes from the impulse response functions of the carry-related variables to the structural shocks to assess how market participants have fared over time in placing their positioning in the foreign exchange futures market, given the actual realization of the four identified shocks? One possibility on this respect is to estimate the dynamic relationships between the structural shocks and the net foreign exchange positioning. The resulting time varying covariances can help shed light about whether - conditional on the information available in each month of the sample - the change in net positioning has been consistent with the model-based assessment of the type of shock that occurred in that month. It is important to highlight that this conditional analysis provides a different information than the structural impulse responses of the VAR, which quantify in-sample relationships between the shocks and the carry-related variables.

The conditional analysis just described can be easily carried out through a simple multivariate Garch(1,1) model, a tool which has been widely recognised to provide simple and reliable estimates of the dynamic second order moments among a set of series. We estimate a multivariate Garch(1,1) for each of the six currencies vis-a-vis the US dollar based on five variables, i.e. the monthly change in net positioning and the four structural shocks. The conditional covariances between the change in net positioning and respectively i) the demand and ii) the confidence shock, those which were identified to be most influential on the carry trade-related variables, will be used to shed light on the way market participants positioned in the foreign exchange market for a given realization of these two shocks. The model is estimated on monthly data on a slightly smaller sample than was used for the VAR, due to the presence of lags and the need of initialising the covariance matrix and the BEKK specification (see Engle and Kroner, 1995) is employed, i.e.:

$$\begin{aligned} x_t &= \mu + \varepsilon_t \\ \varepsilon_{t(5 \cdot T)} &| I_{t-1} \tilde{} MN(0, H_t) \\ H_t &= C' \cdot C + A' \cdot \varepsilon_{t-1} \cdot \varepsilon_{t-1} \cdot A' + B \cdot H_{t-1} \cdot B \end{aligned}$$

where the vector x_t contains the change in net positions and the four structural shocks (monetary policy, demand, supply, confidence) and its demeaned values (i.e. ε_t) are distributed as a multivariate normal, conditionally on the information set I_{t-1}, with zero means and covariance matrix H_t. The covariance matrix evolves as a Garch(1,1) with C, A and B being real coefficients matrices. We do not need to introduce dynamics in the conditional mean equations of the vector x_t, as these series have very little autocorrelation. Estimation is carried out via maximum likelihood.

Having estimated H_t we then extract the time series of the elements in positions (1,2) and (1,4), i.e. the conditional covariance between the change in net positioning and the demand and the confidence shock respectively. If all positions had been done in accordance with the sign of the realised shocks and the indications stemming from the impulse responses in our structural VAR, then the conditional covariances should have well defined signs, i.e. i) changes in net positions should be positively correlated with demand shocks (demand shocks lead to appreciation of the currencies vis-a-vis the dollar, so that it would be rational to increase net positioning) and ii) changes in net positions should be positively correlated with confidence shocks for higher yielding currencies and negatively correlated with confidence shocks in the case of low yielding currencies (confidence shocks in fact lead to a depreciation of the low yielding currencies vis-a-vis the US dollar so that it would be rational to reduce the corresponding net positioning). To have an more consistent estimate of the success/failure of the carry trade activity the time series of the two conditional covariances can be also multiplied by the absolute value of the change in net positions, which has the effect of weighting the match or the mismatch in the correlation by the amount of foreign exchange risk assumed. In order to save space no information is provided on the results of the estimation beyond the time series of the conditional covariances discussed below.

Figure 13 shows the time series of the conditional covariances between changes in net positions and demand and confidence shocks for two high yielding (gbp, aud) and two low yielding currencies (yen, chf). Each conditional covariance series has been split into two components by multiplying them by an indicator variables which is one when the structural shock is positive and zero when it is negative (blue line in the Figure) and by another indicator variable which is its opposite (black line in the Figure). Having done so, we should always expect positive values for the two series as shocks and net positions should move in the same direction. For the Japanese yen - quite independently on the nature of shock - conditional covariances tended to move almost randomly above and below zero, so that most of this positions - if held for the number of periods to which our structural impulse responses in Section 4 are computed - must have resulted in losses rather than in expected gains. For the other currencies the situation is more mixed across time, as for the Bristish pound and the Swiss franc values have been almost always positive since 2005, similarly to what happens for the Australian dollar but with reference to the demand shock only. Figure 14 reports the same time series of conditional covariances but multiplied by the absolute value of the actual change in the net positions in each month, so to provide a weighed estimate of the potential losses incurred. Although the signs of these covariances are the same as in Figure 13, the relative weights of the theoretical profits and losses change somewhat, although the best accordance the actual between positioning and the expected outcome of such positioning (based on the estimated structural shocks and their effects on the carry trade variables) is found for the British pound/US dollar rate and the Swiss franc/US dollar rate. For the remaining two currencies pairs, the actual market positioning seems to have been done without considering the effects that the ongoing macroeconomic shock would have had on the variables underlying the gains and the losses of the outstanding positions.

6. Conclusions

This paper has provided a deeper examination of the results in Brunnermeier et al. (2009) placing particular emphasis on the role played by macroeconomic shocks. Within the 'financial' VAR of Brunnermeier et al. (2009) a shock to the interest rate differentials vis-a-vis the US dollar leads the exchange rate of the examined currencies to record a progressive appreciation, while speculators continue to intensify their demand for such currency and the exchange rate level becomes more exposed to the risk of recording a sudden reversal. We considered the extent in which such conclusions can be explained by given shock categories, i.e. demand, supply, monetary policy and confidence shocks. Overall, demand shock as well as confidence shocks are found to be powerful determinants of carry trade activity and can therefore be seen as the key 'underlying' developments behind the findings in Brunnermeier et al. (2009). Usign a multivariate conditional variance model to assess whether the actual positioning in the foreign exchange market has been consistent with the nature of the underlying shock, we found that for the British pound and the Swiss franc the answer is a positive one but for the Japanese yen and the Australian dollar actual positioning might have generated losses rather than gains as it was undertaken without a tight association with the realizations of the macroeconomic shocks, assuming positions have been held up to the horizons spanned in our analysis by the impulse response functions of the carry trade variables to the structural shocks.

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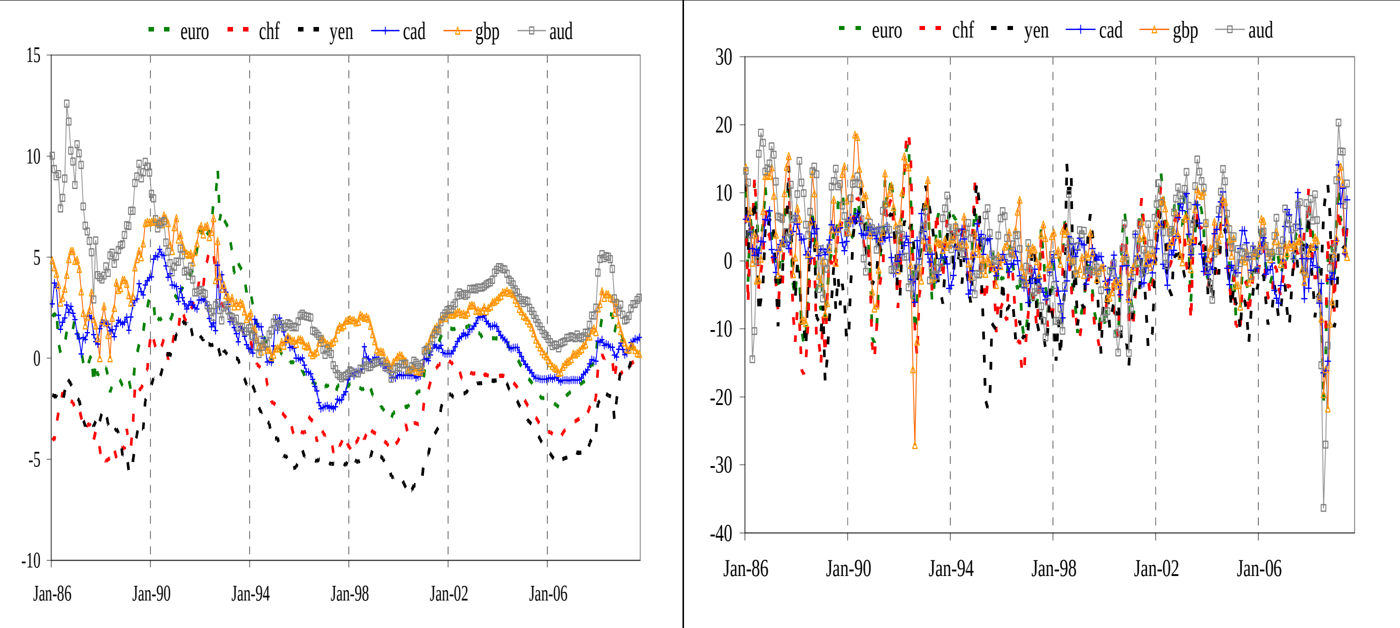
TABLES AND FIGURES:

Figure 1: Main features of the data

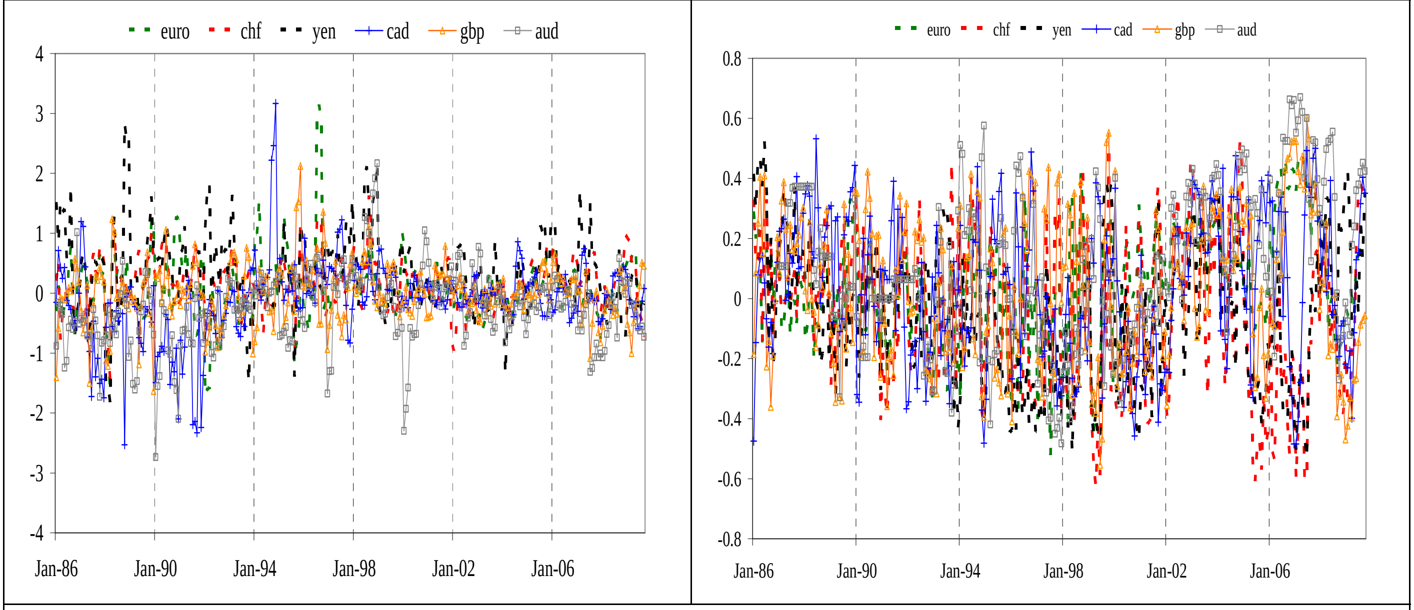
Interest rate differentials vis-à-vis the US dollar

Foreign exchange rate excess returns



Foreign exchange return skewness

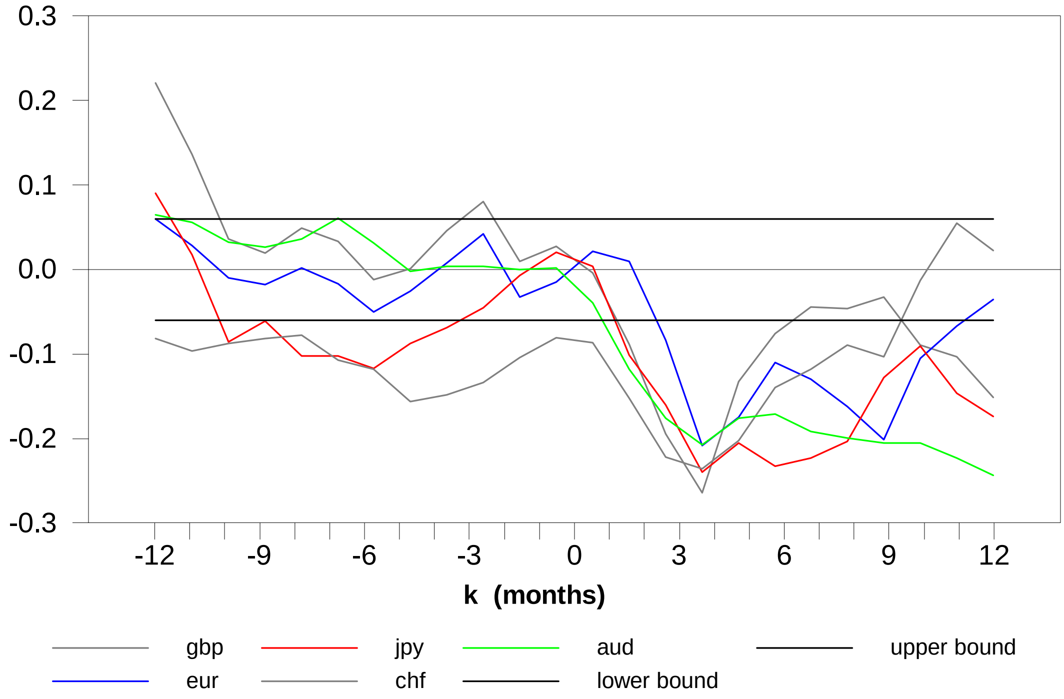
Net positions/open interest



Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Notes: Monthly data between January 1986 and September 2009. Interest rates are referred to the 3-month maturity. The foreign exchange return is computed as UIP residual, i.e. summing the 3-month interest rate differential (as of time t) and the subsequent 3-month change in the exchange rate (i.e. between t and t+3). The skewness is computed on daily foreign exchange returns, as the standard deviation of the 63 most recent daily returns. Exchange rates are all expressed as units of currency per US dollar. Low interest rate currencies (relative to the interest rate paid on the US dollar) are reported with dotted lines, while high interest rate currencies are displayed with continuous lines and symbols.

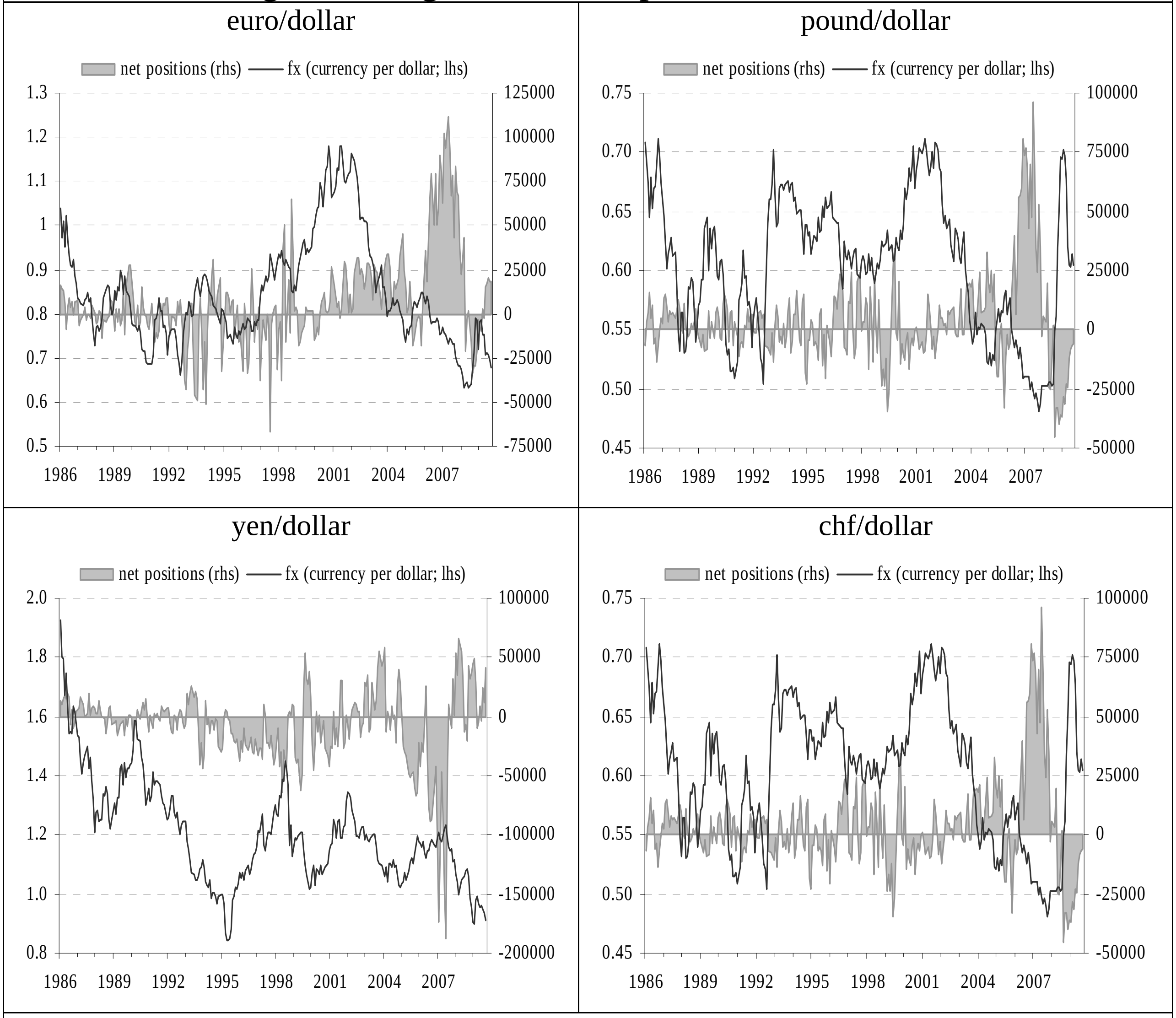
Figure 2: Cross-correlogram between the skewness of exchange rate returns (vis-à-vis the US dollar) and the amount of net positioning



Source: Calculations on data from Thomson Financial Datastream and Global Financial Data.

Notes: Monthly data. The figure reports the cross correlograms between the skewness of the foreign exchange returns vis-à-vis the US dollar and net currency positions at selected leads and lags (k). The horizontal lines are a pseudo confidence interval for the cross-correlations obtained as +/-1.96 times $1/T^{0.5}$ where T is the sample size.

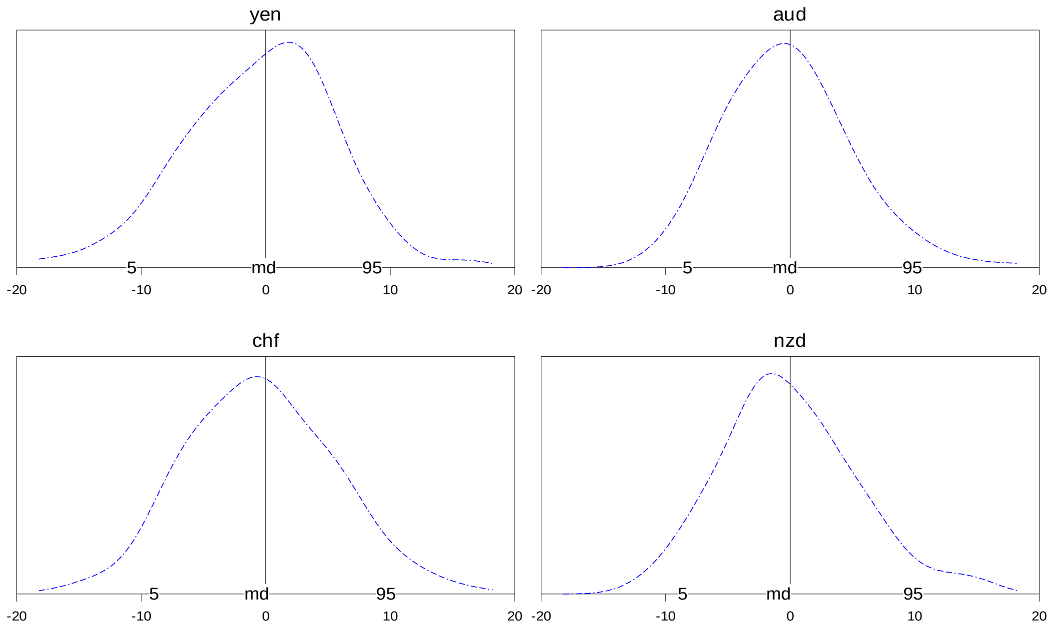
Figure 3: Net positions in the foreign exchange futures market and foreign exchange rate developments vis-à-vis the dollar



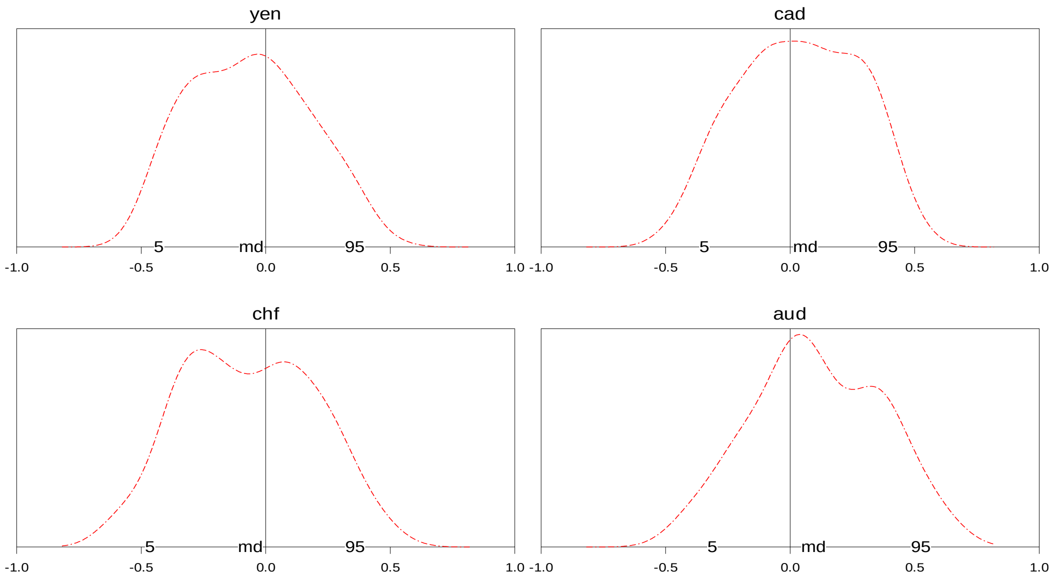
Source: Thomson Financial Datastream, Global Financial Data and CFTC.
Notes: Monthly data between January 1986 and September 2009. The yen is expressed as yen per 1/100 dollars.

Figure 4: Kernel density of net positions and currency returns

3-month currency returns (*)



Net positions (**)



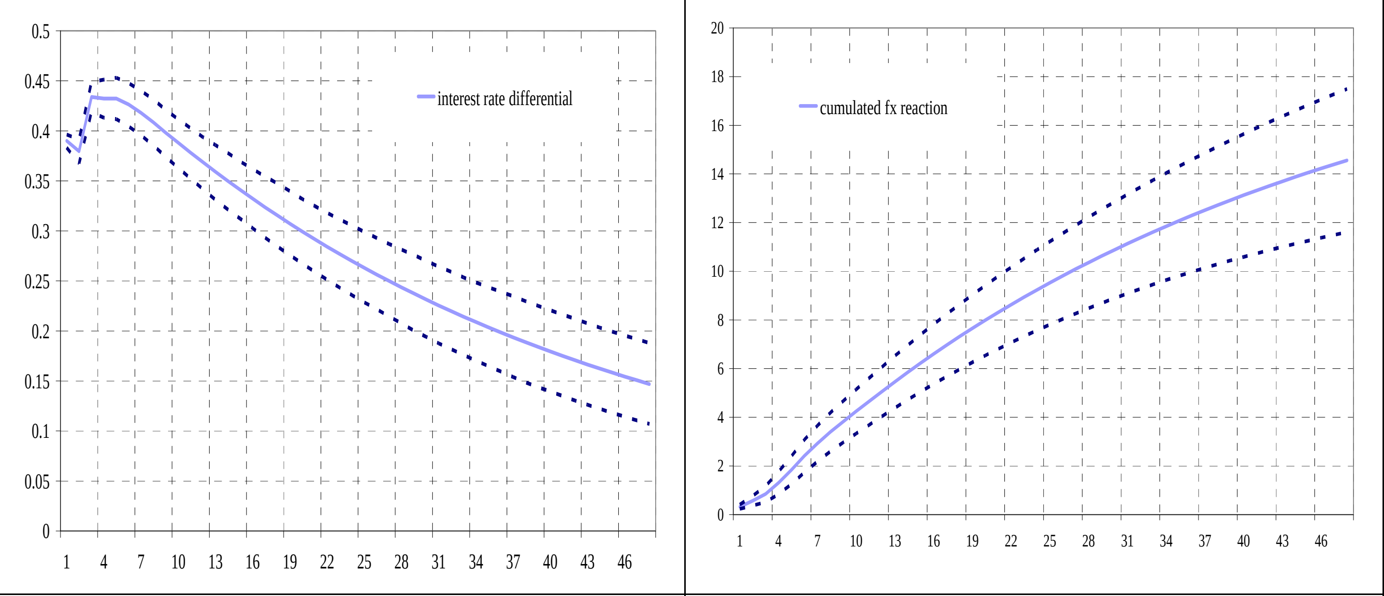
Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Notes: Monthly data. The upper panel reports the densities of 3-month currency returns vis-à-vis the US dollar, while the lower panel those of the net positions in the foreign exchange futures market. The symbols ‘5’, ‘md’ and ‘95’ on the x-asis of the charts evidence where the 5%-percentile, the median and the 95% percentiles are located. The kernel employed to compute the densities is a gaussian kernel.

Figure 5: Impulse response functions of the carry trade variables to an interest rate differential shock (VAR based on pooled estimation)

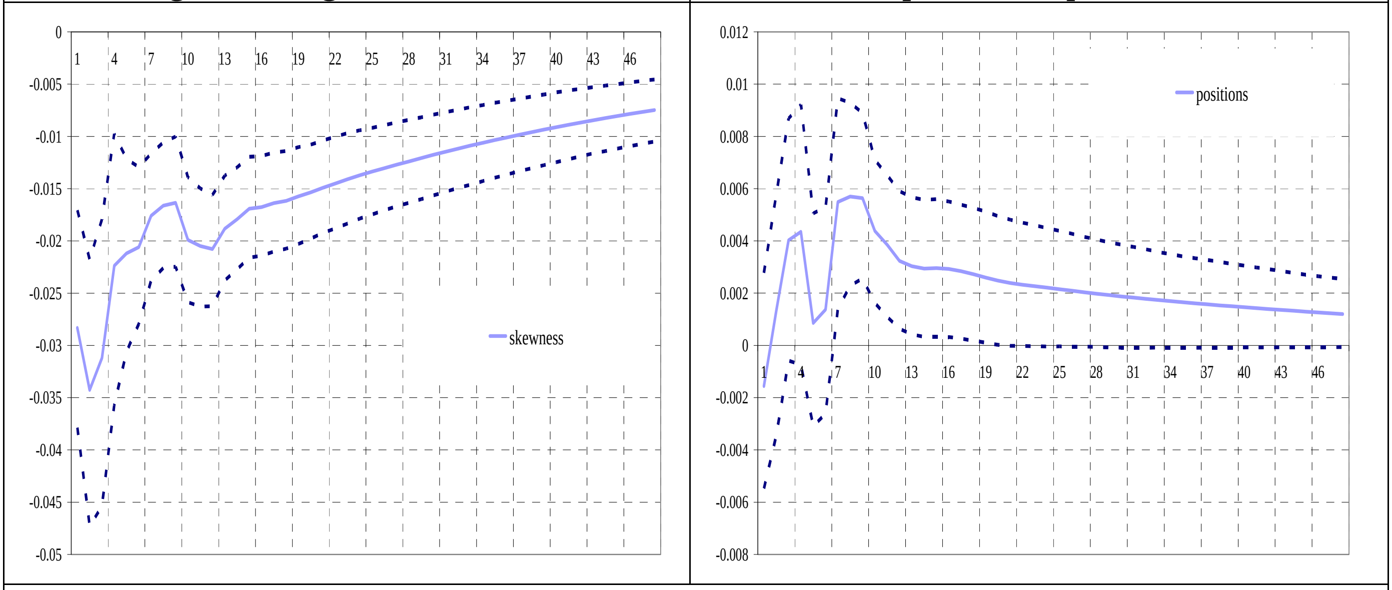
Interest rate differentials vis-à-vis the US dollar

Cumulated foreign exchange rate returns (vis-à-vis the dollar)



Foreign exchange return skewness

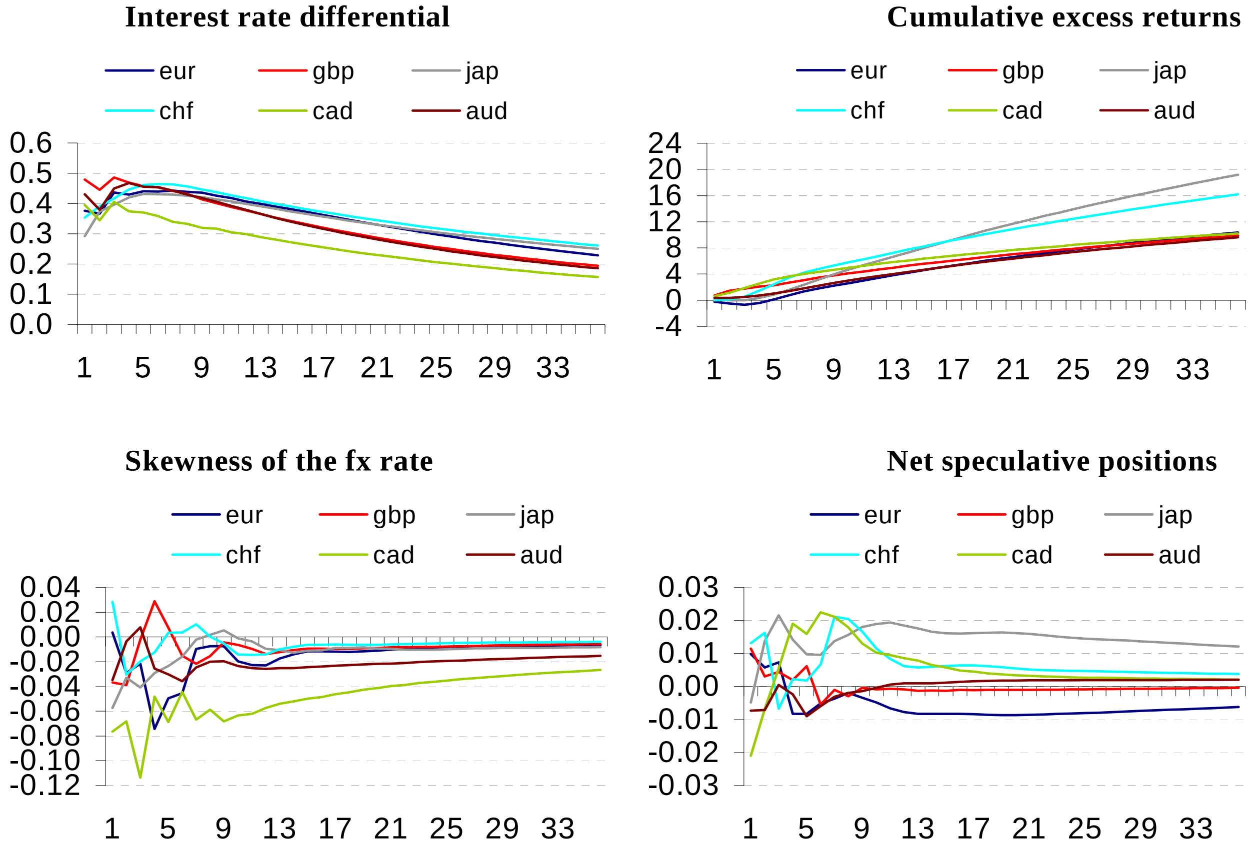
Net positions/open interest



Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Notes: Based on VAR estimates on monthly data between January 1986 and September 2009. The VAR is identified via Cholesky diagonalization of the covariance matrix with the following order: interest rate differential, foreign exchange return, skewness, positons. Interest rates are referred to the 3-month maturity. The foreign exchange return is computed as UIP residual, i.e. summing the interest rate differential and the subsequent 3-month rate of change in the exchange rate. The skewness is computed on daily foreign exchange returns, as the standard deviation of the 63 most recent observations. The x-axis is expressed as months after the impulse.

Figure 6: Median responses of the carry trade variables to an interest rate shock (VAR estimated for each bilateral pair)


Interest rate differential

Cumulative excess returns

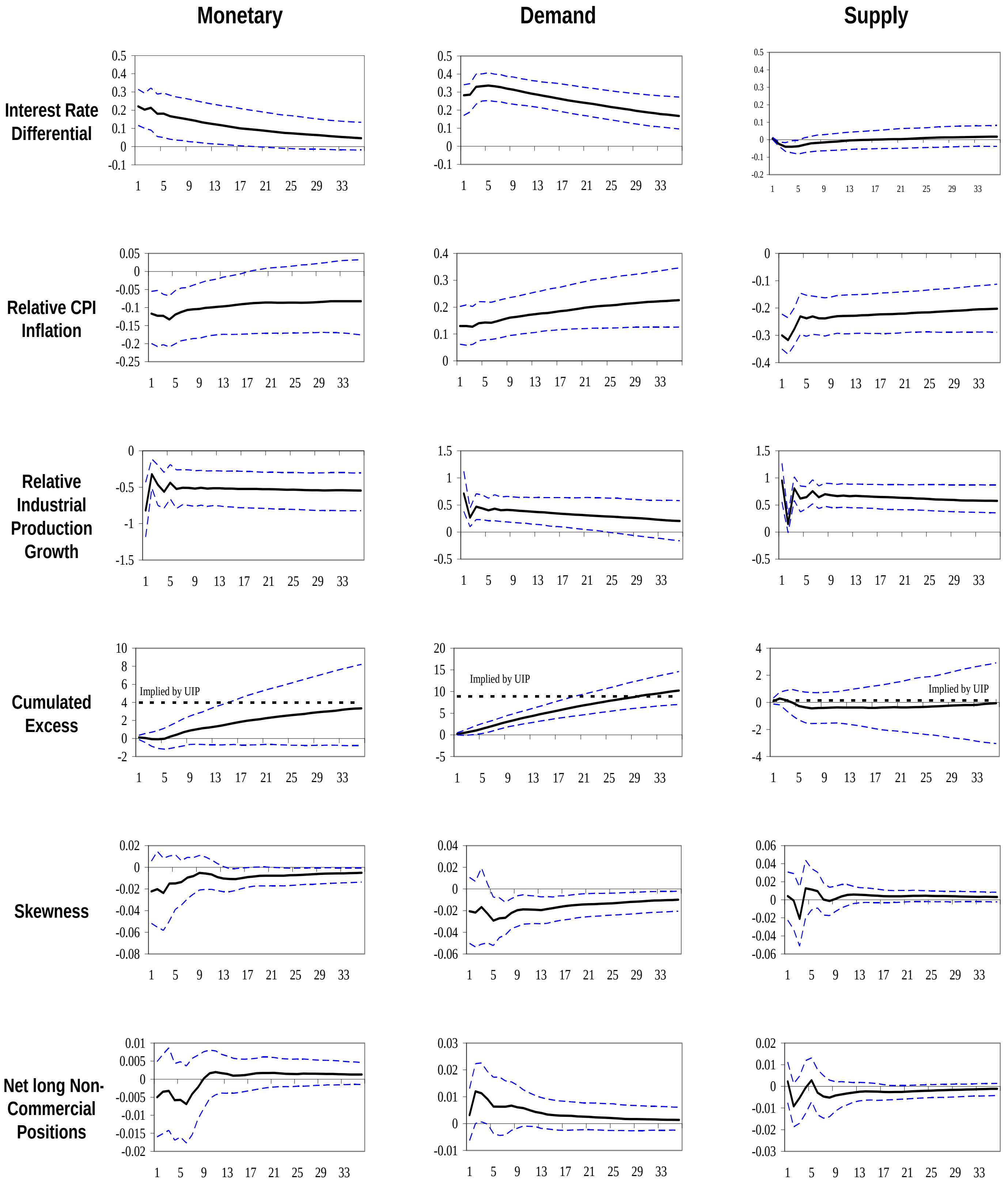
Skewness of the fx rate

Net speculative positions

Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Notes: The VAR is estimated on monthly data between January 1986 and September 2009. The x-axis is expressed in months after the shock. See also the Notes to Figure 5.

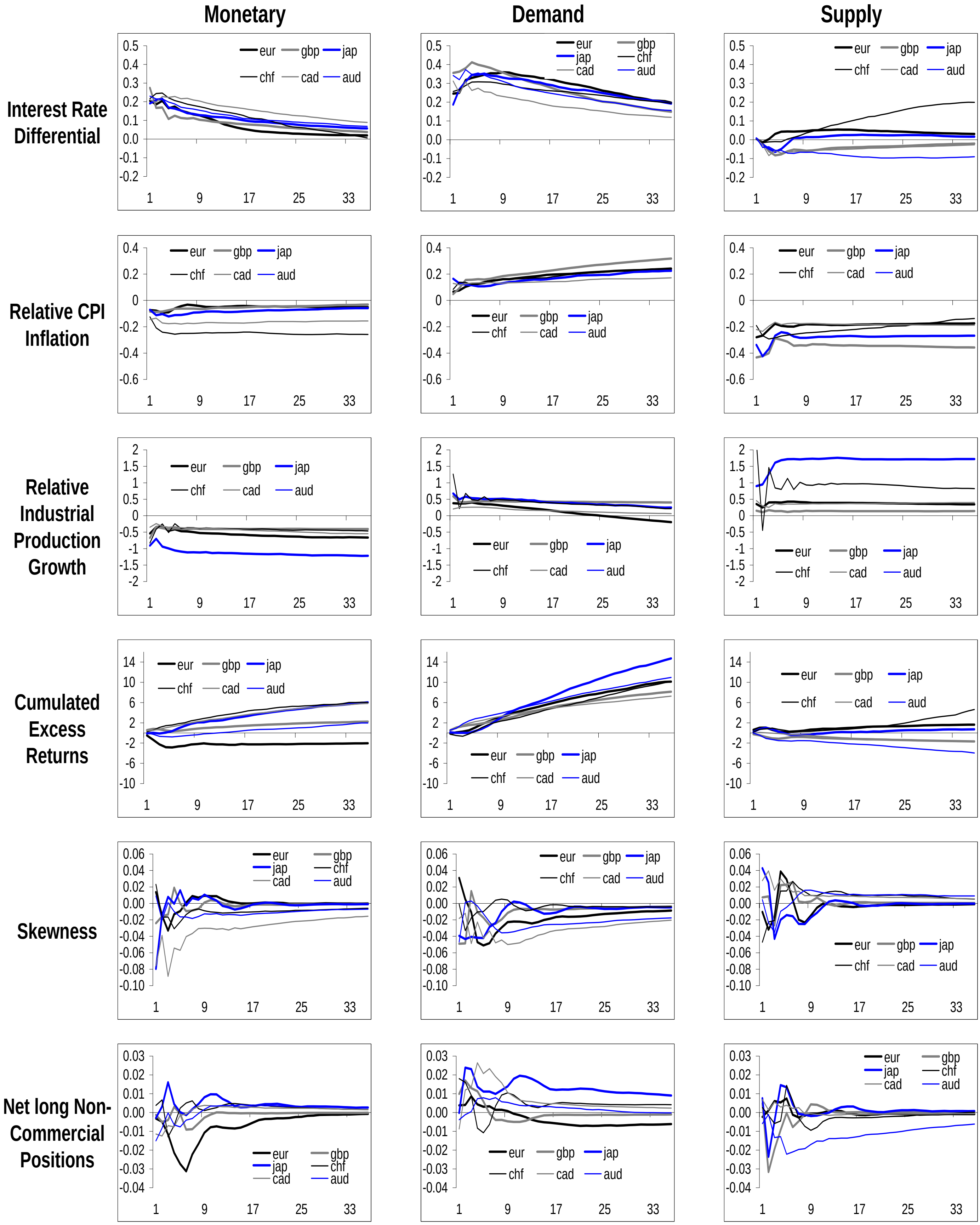
Figure 7: Average of the median responses from 3-shock VAR



Source: Calculations on data from Thomson Financial Datastream, Global Financial Data, CFTC and IMF IFS.

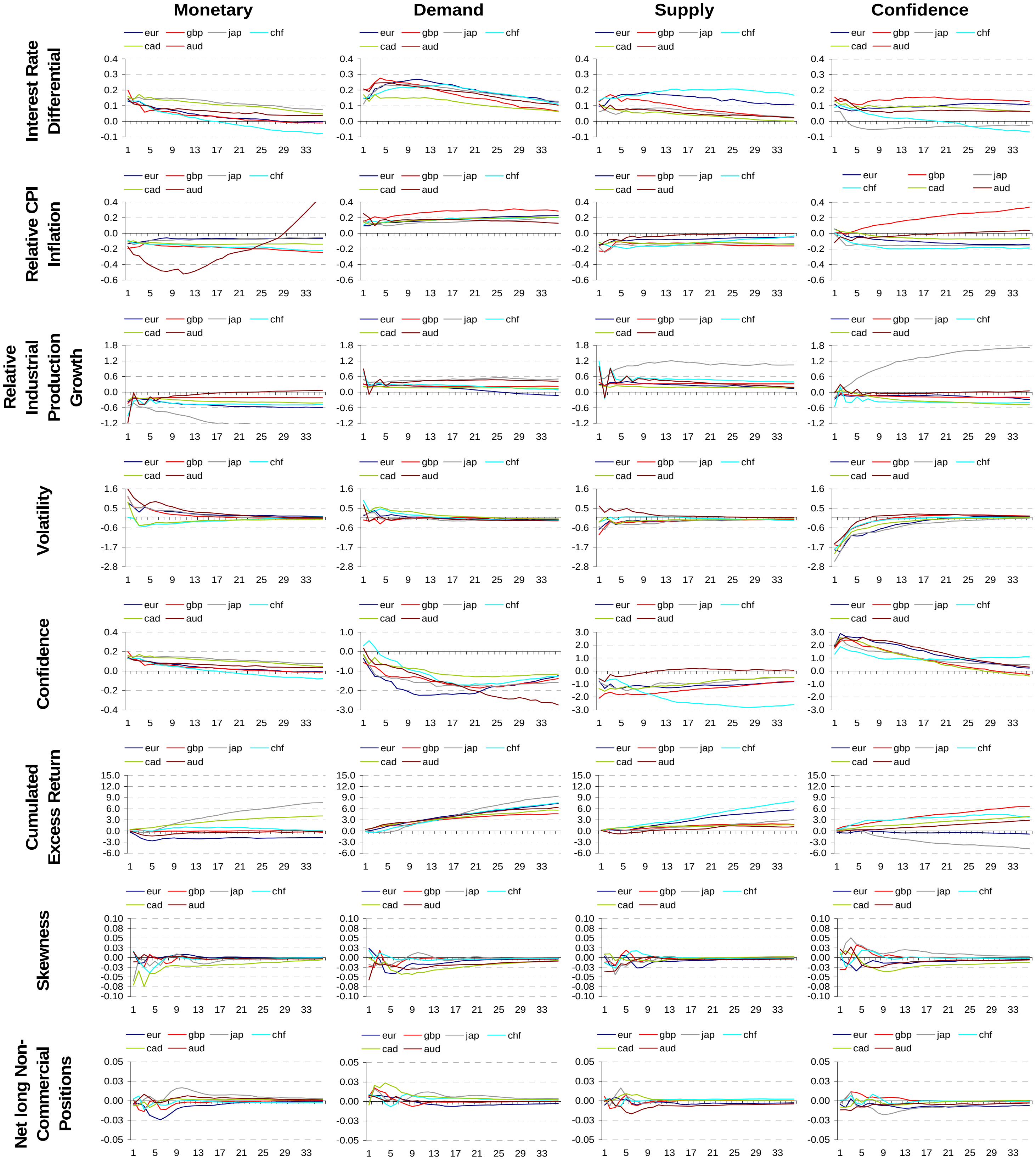
Notes: the VAR is estimated on monthly data between January 1986 and September 2009 and the three shocks are identified via sign restrictions. The x-axis is expressed in months after the impulse. See also notes to Chart 5.

Figure 8: median responses from 3-shock VAR



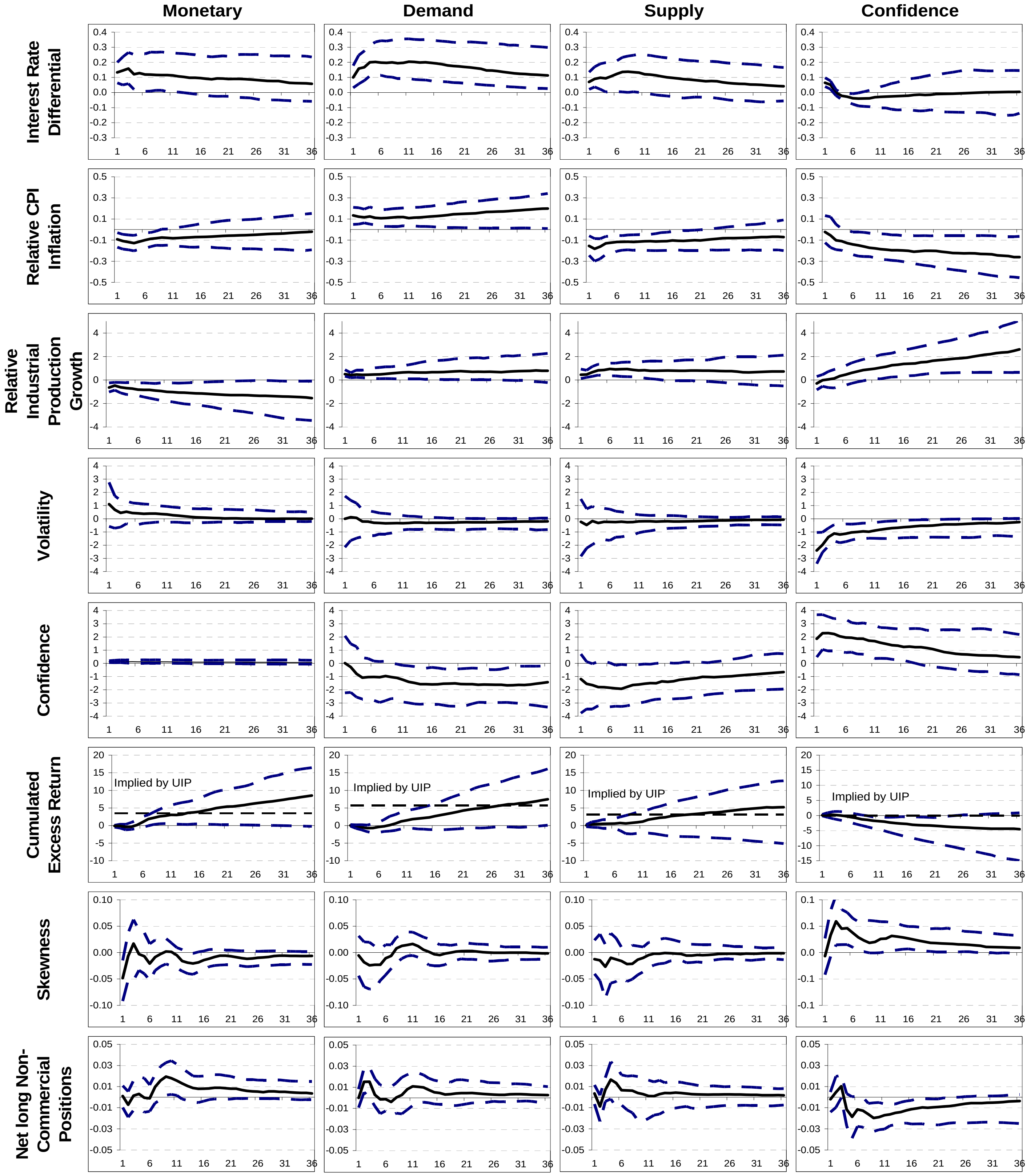
Source: Calculations on data from Thomson Financial Datastream, Global Financial Data, CFTC and IMF IFS.
Notes: see notes to Charts 5 and 8.

Figure 9: Median responses for the 4-shock VAR



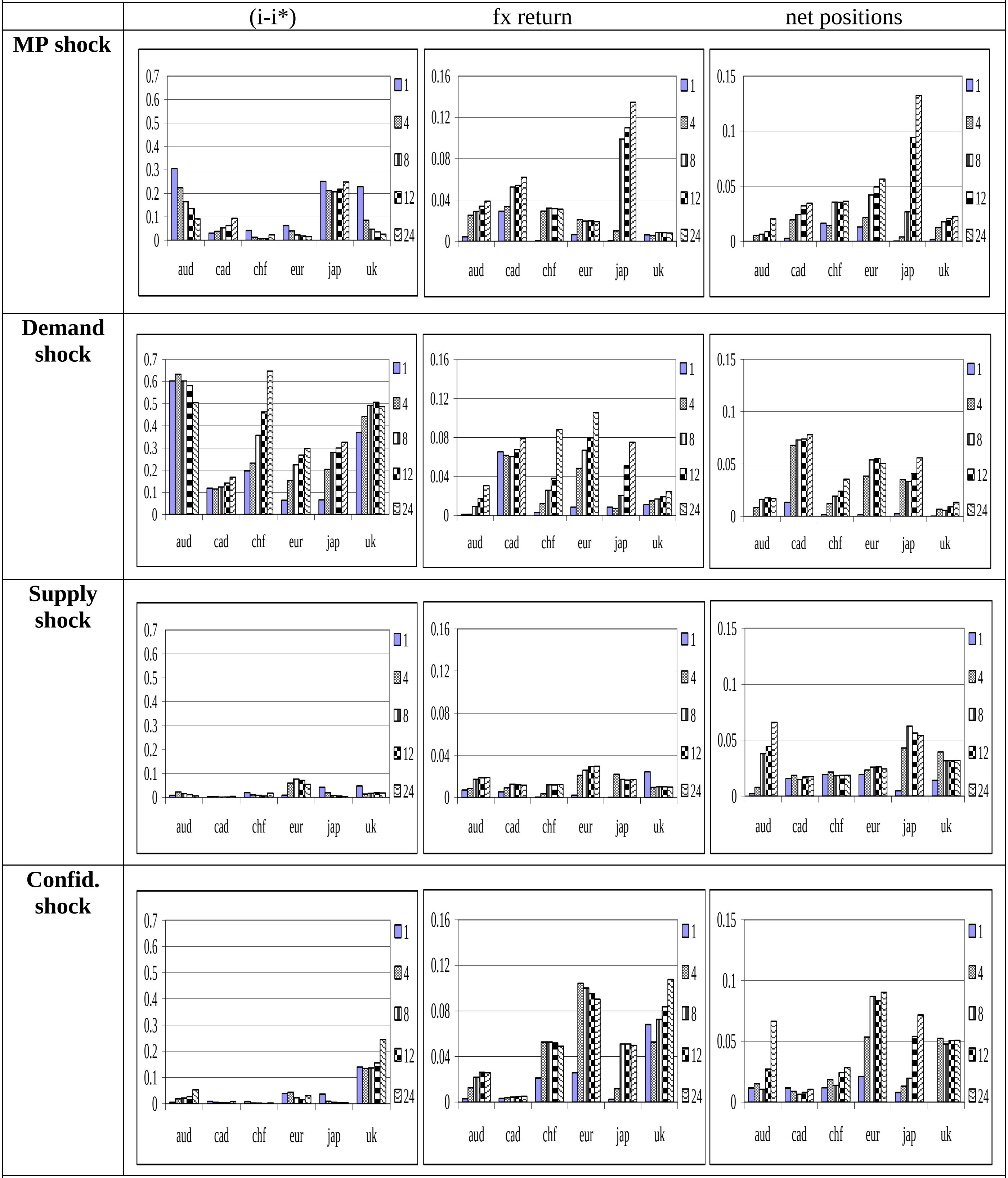
Source: Calculations on data from Thomson Financial Datastream, Global Financial Data, CFTC and IMF IFS.
Notes: See notes to Charts 5 and 8.

Figure 10: Responses for the jpy/usd case in the 4-shock VAR



Source: Calculations on data from Thomson Financial Datastream, Global Financial Data, CFTC and IMF IFS.
Notes: See notes to Charts 5 and 8.

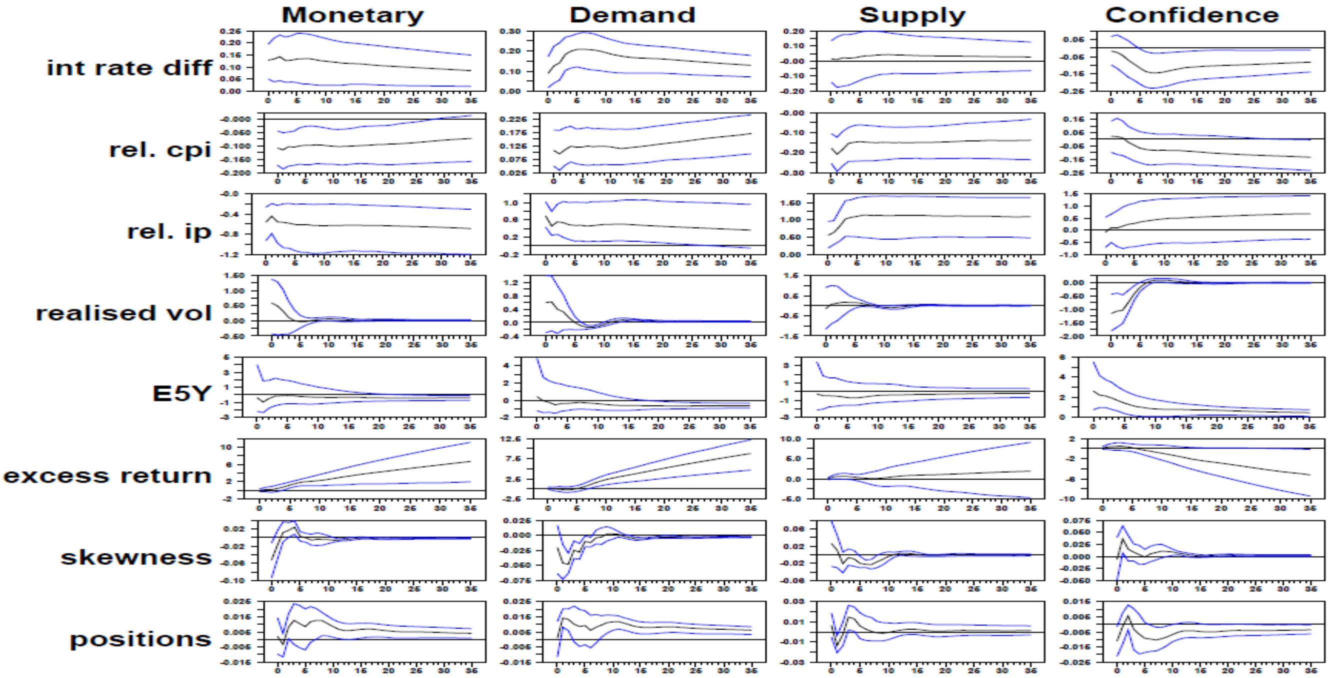
Figure 11: Variance decomposition for selected variables out of the 8 included in the VAR, at selected horizons



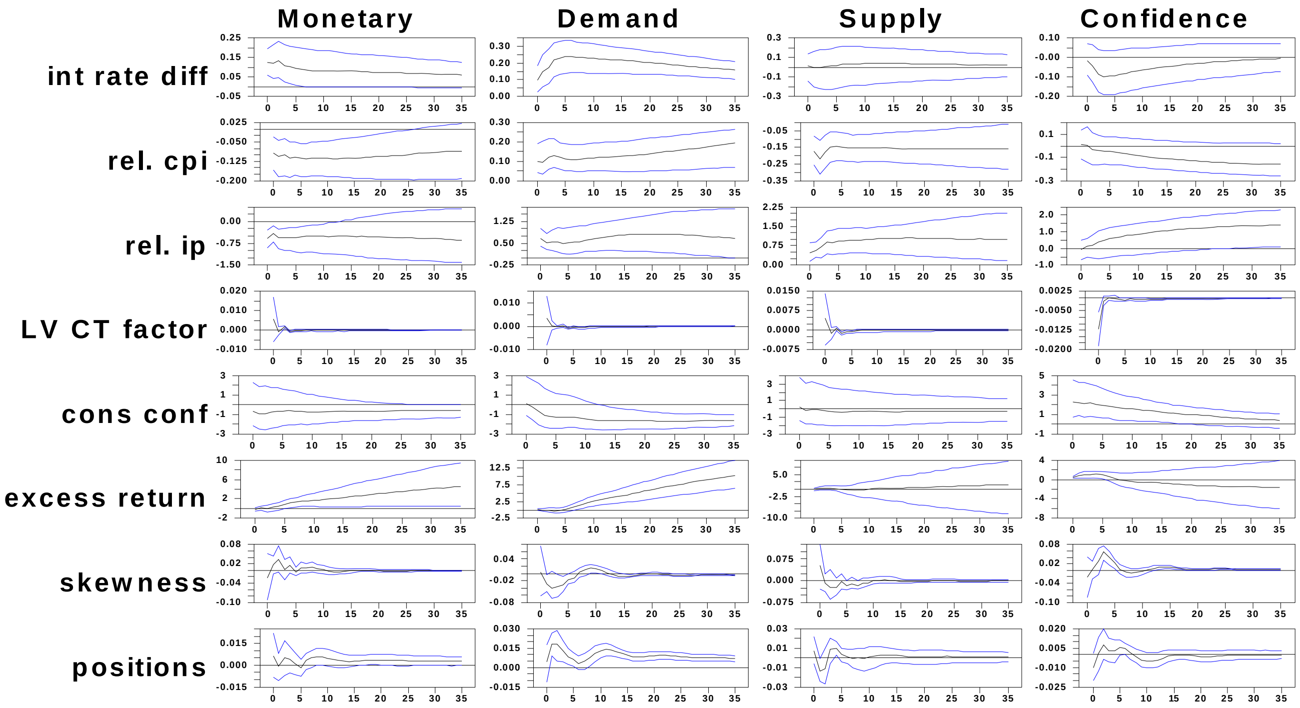
Note: The VAR is estimated on monthly data between January 1986 and September 2009 and the four shocks (monetary policy, demand, supply, confidence) are identified via sign restrictions. The variance decomposition is based on the rotation matrix which produced accepted impulse responses closest to the median impulses, see Section 5 for details. (i-i*) denotes the interest rate differential relative to the US dollar, fx return is the non-cumulative UIP residual, net positions are the amount of speculative positions in the foreign exchange futures market relative to the open interest.

Figure 12: Impulse responses to the four identified shocks with different confidence-related variables: yen/dollar case

With average realised volatility of the six currencies vis-à-vis the dollar and E5Y



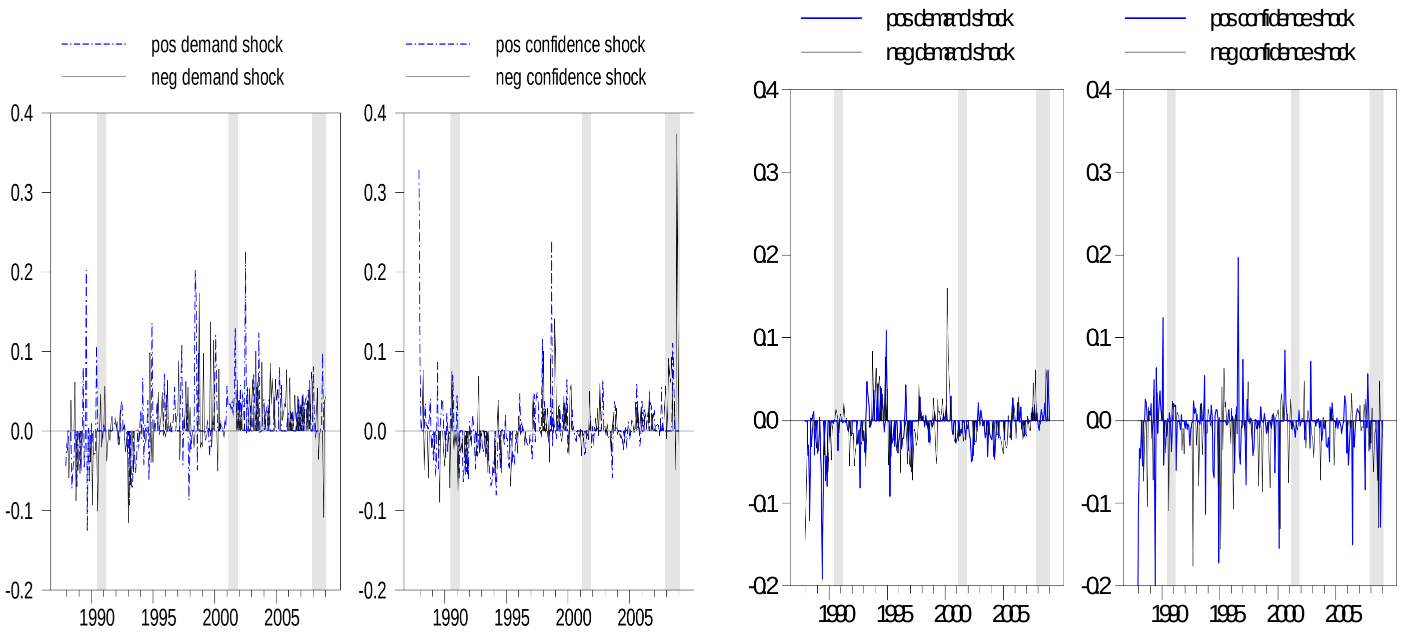
With Lustig et al. (2011) carry trade factor and consumer confidence



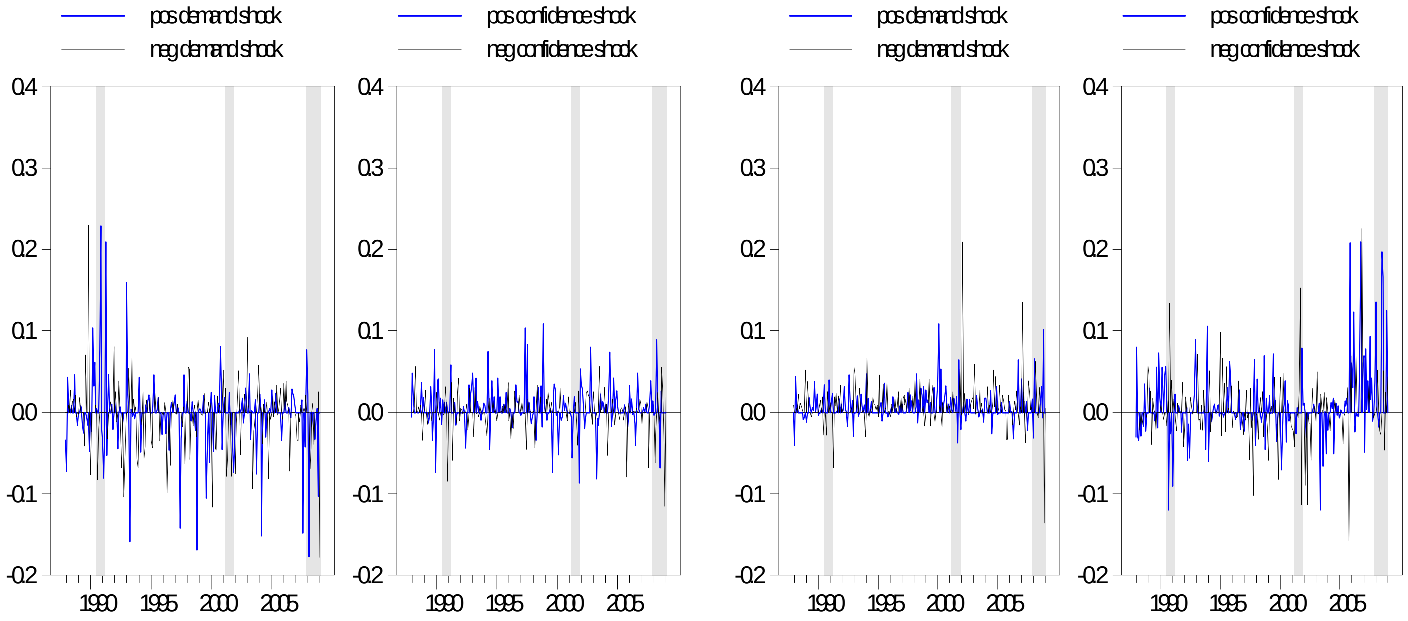
Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Note: the columns in the two panels (upper and lower) are the impulse responses of the 8 variables to the identified shocks, based on sign restrictions where the VAR is based on different variables than those in Figure 10. The variable E5Y is a forward measure of confidence based on the US Michigan Survey.

Figure 13: Conditional covariances between monthly changes in net positiong and demand and confidence shocks


British pound (a)

Australian dollar

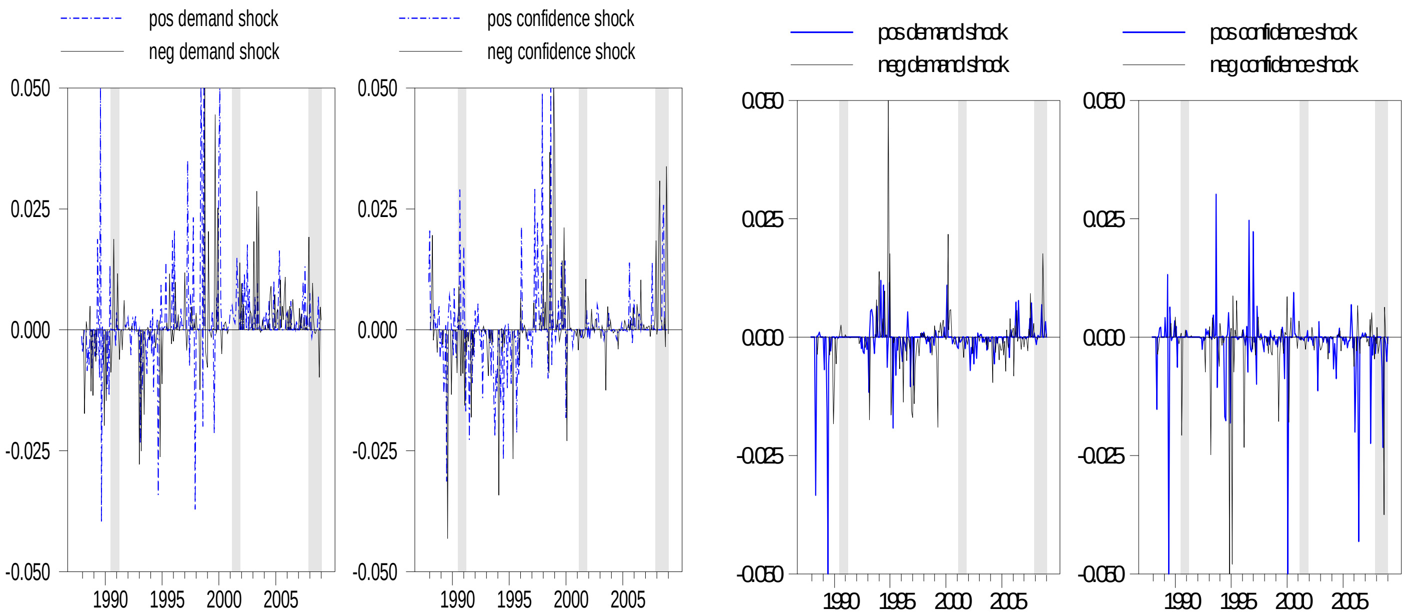

Japanese yen

Swiss franc

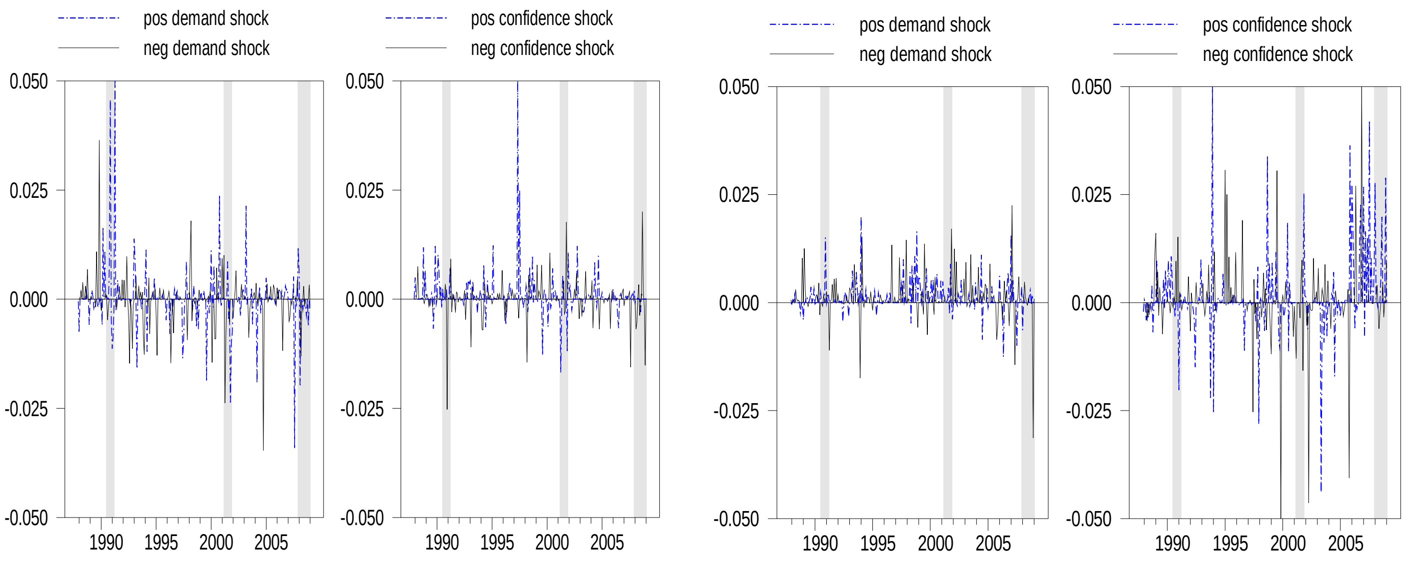
Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.
Note: this Figure reports the conditional covariances split according to the sign of the underlying shock in that month. Shaded areas are US NBER recession phases. The expected signs of the correlations are: for demand shocks, positive for all currencies; for confidence shocks: positive for British pond and Australian dollar, negative for the Japanese yen and the Swiss franc.

Figure 14: Conditional covariances between monthly changes in net positiong and demand and confidence shocks

British pound | Australian dollar



Japanese yen | Swiss franc



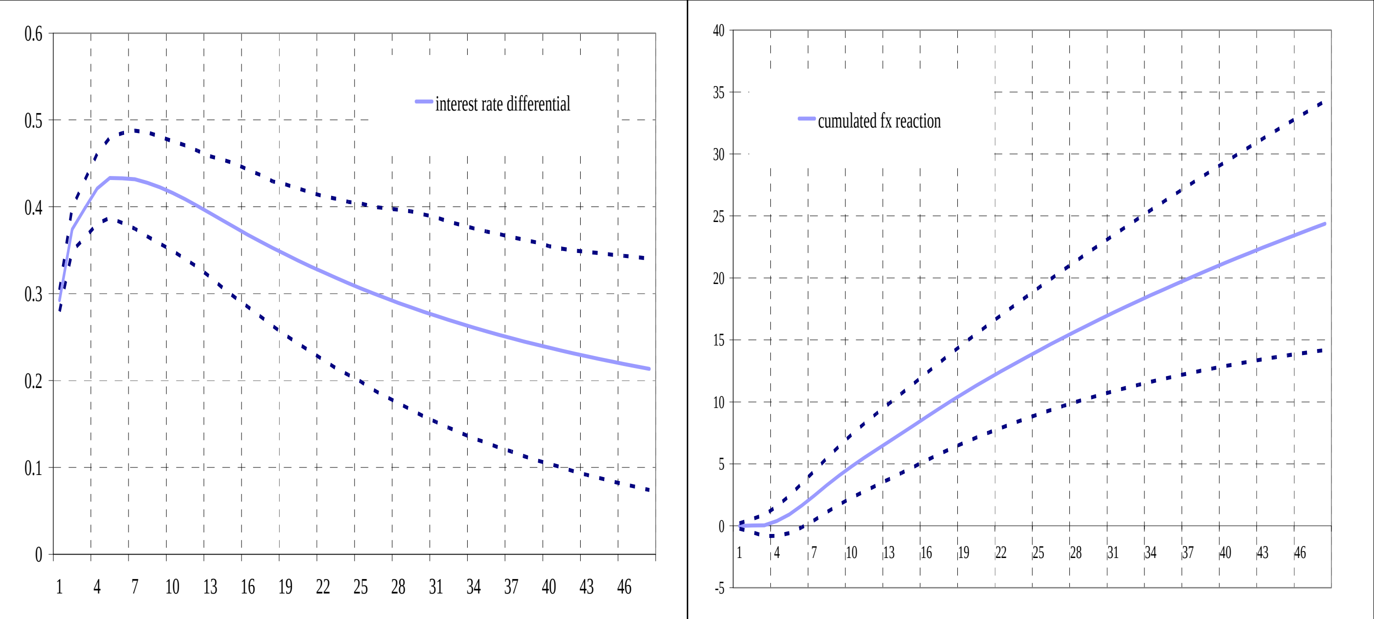
Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Note: this Figure reports the conditional covariances split according to the sign of the underlying shock in that month and multiplied by the absolute value of the actual change in net positions in that month. Shaded areas are US NBER recession phases. The expected signs of the correlations are: for demand shocks, positive for all currencies; for confidence shocks: positive for British pond and Australian dollar, negative for the Japanese yen and the Swiss franc.

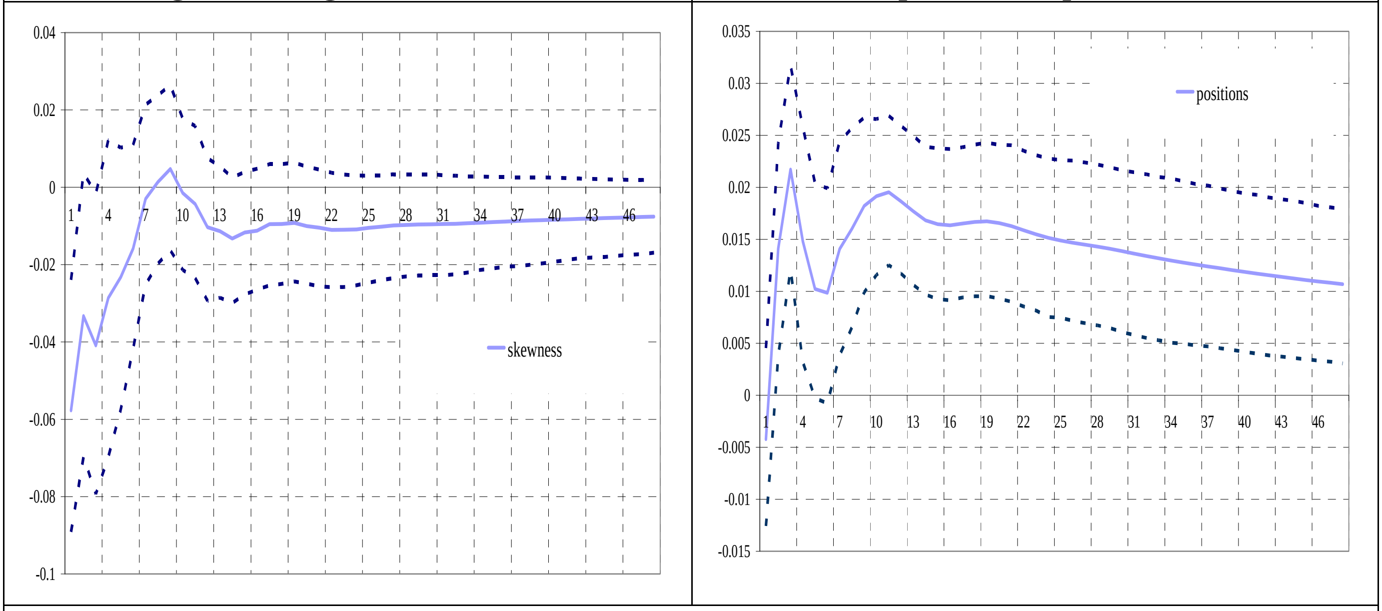
APPENDIX A:

Figure A1: yen/dollar estimation

Interest rate differentials vis-à-vis the US dollar | Foreign exchange rate excess returns



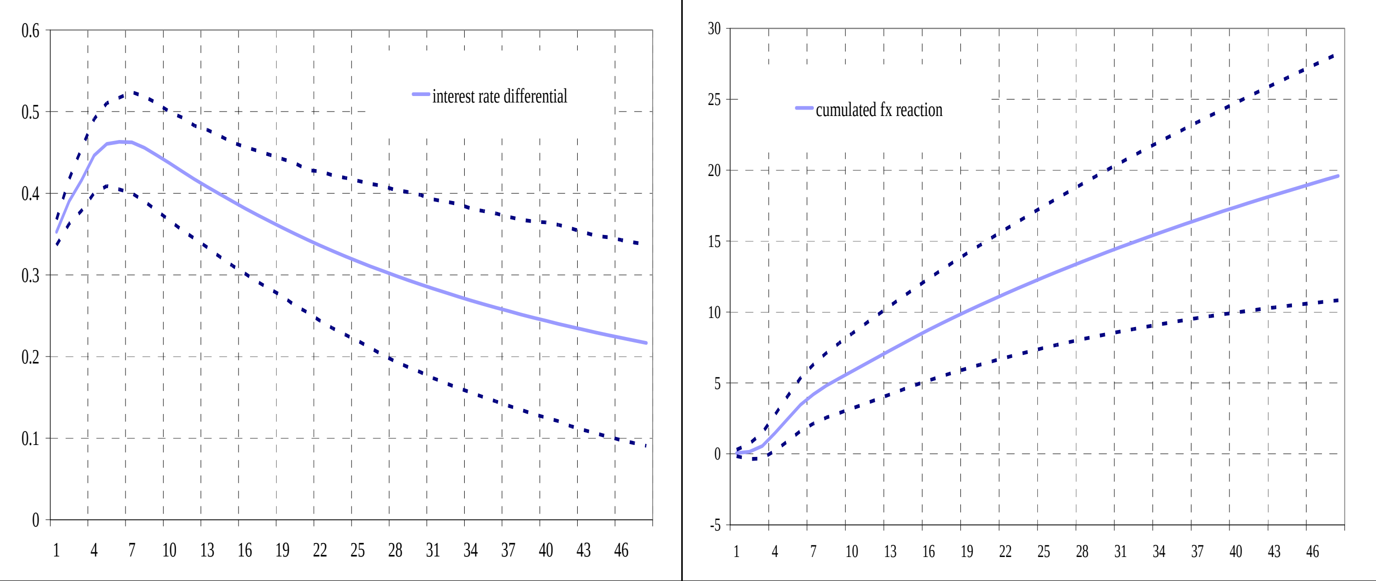
Foreign exchange return skewness | Net positions/open interest



Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

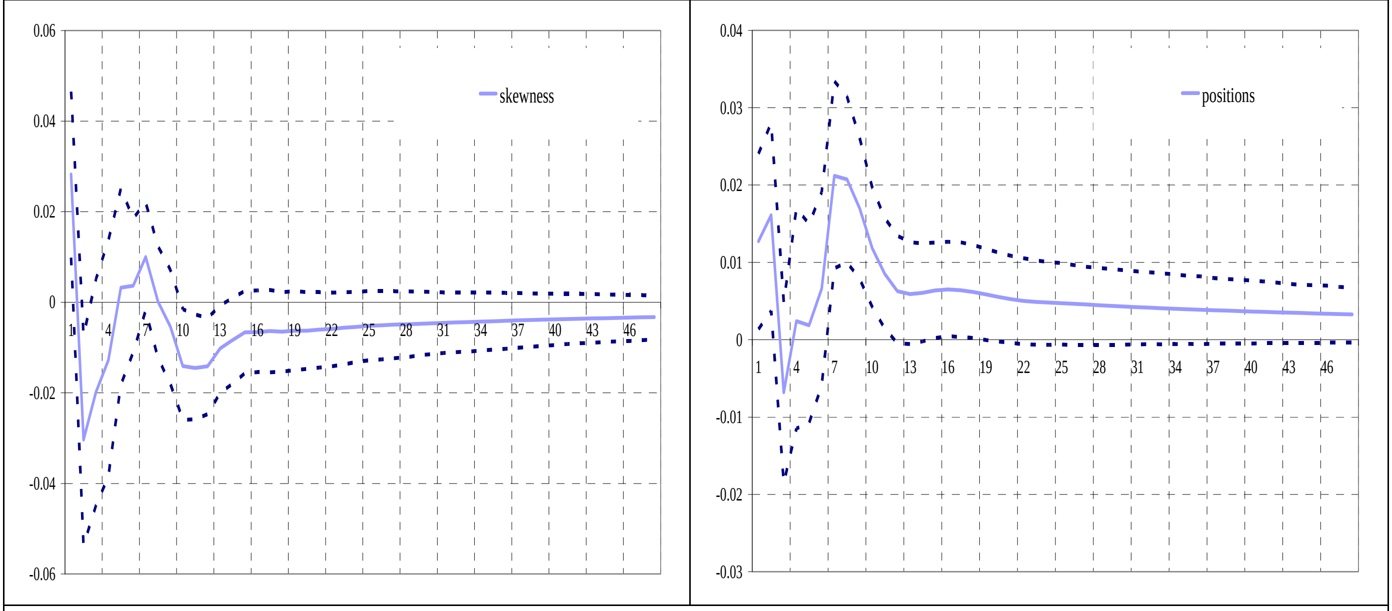
Notes: Monthly data. Interest rates are referred to the 3-month maturity. The foreign exchange return is computed as UIP residual, i.e. summing the interest rate differential and the 3-month rate of change in the exchange rate. The skewness is computed on daily foreign exchange returns, as the standard deviation of the 63 most recent data. The VAR is identified via Cholesky diagonalization with the following order: interest rate differential, foreign exchange return, skewness, positons.

Figure A2: chf/dollar estimation



Interest rate differentials vis-à-vis the US dollar

Foreign exchange rate excess returns



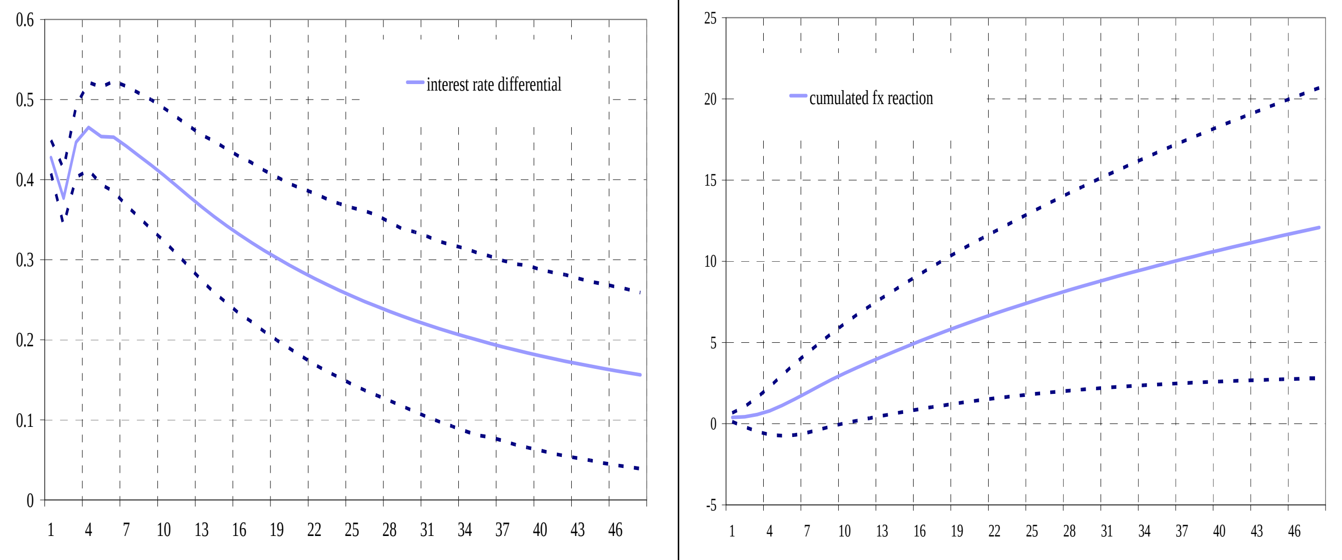
Foreign exchange return skewness

Net positions/open interest

Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

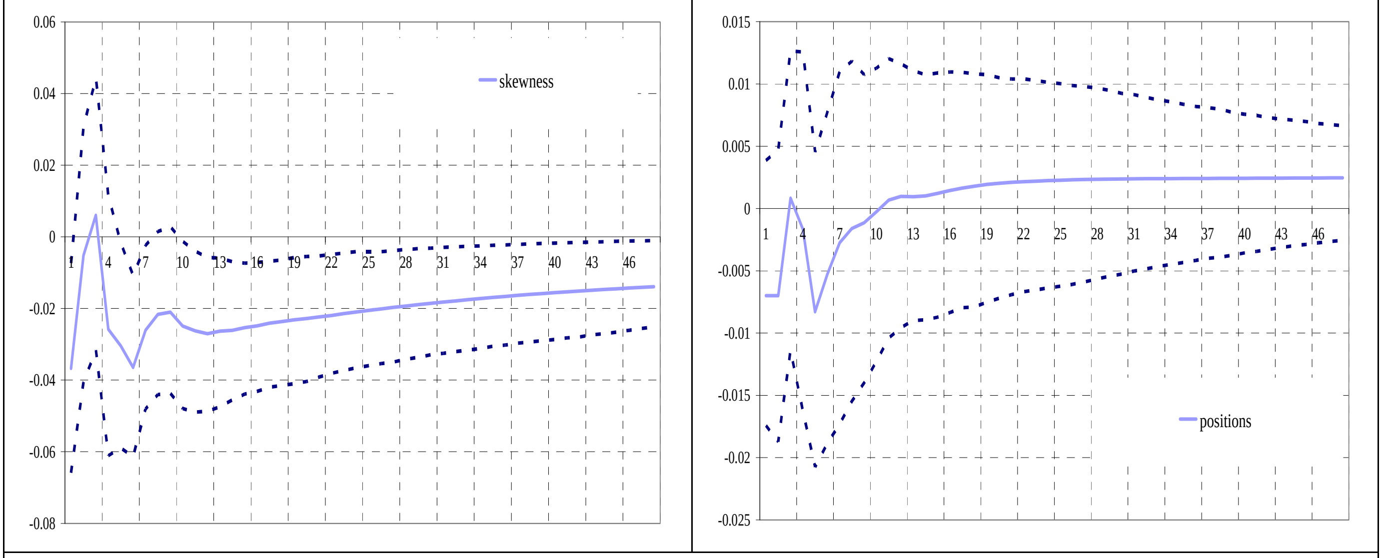
Notes: Monthly data. Interest rates are referred to the 3-month maturity. The foreign exchange return is computed as UIP residual, i.e. summing the interest rate differential and the 3-month rate of change in the exchange rate. The skewness is computed on daily foreign exchange returns, as the standard deviation of the 63 most recent data. The VAR is identified via Cholesky diagonalization with the following order: interest rate differential, foreign exchange return, skewness, positons.

Figure A3: aud/dollar estimation



Interest rate differentials vis-à-vis the US dollar

Foreign exchange rate excess returns



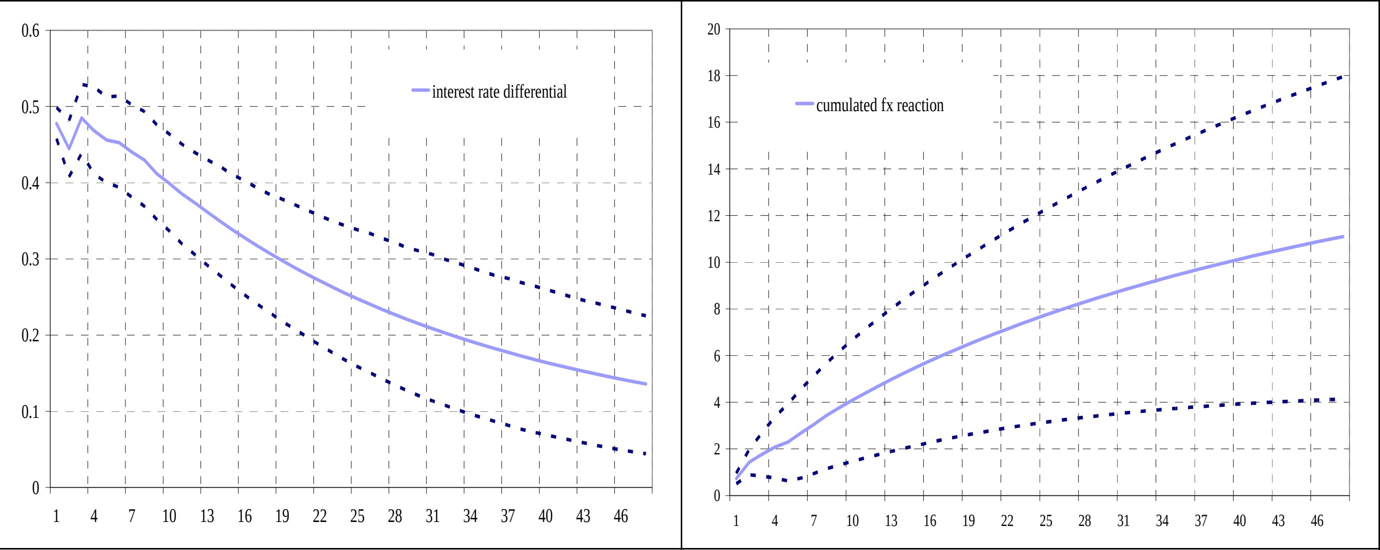
Foreign exchange return skewness

Net positions/open interest

Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

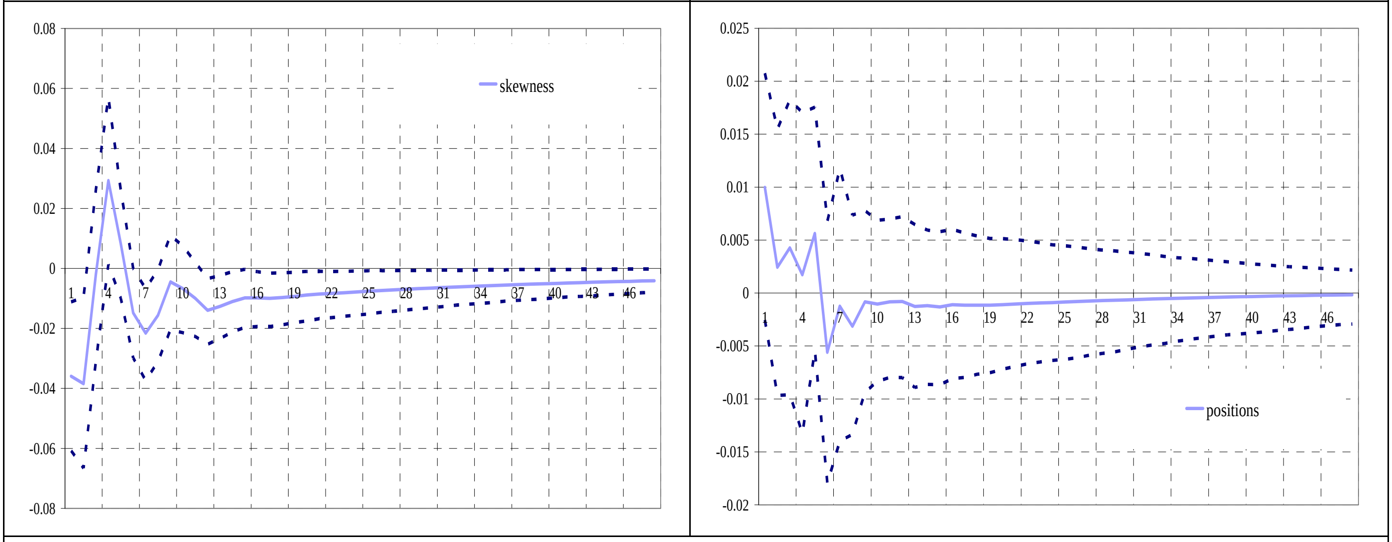
Notes: Monthly data. Interest rates are referred to the 3-month maturity. The foreign exchange return is computed as UIP residual, i.e. summing the interest rate differential and the 3-month rate of change in the exchange rate. The skewness is computed on daily foreign exchange returns, as the standard deviation of the 63 most recent data. The VAR is identified via Cholesky diagonalization with the following order: interest rate differential, foreign exchange return, skewness, positons.

Figure A4: gbp/dollar estimation



Interest rate differentials vis-à-vis the US dollar

Foreign exchange rate excess returns



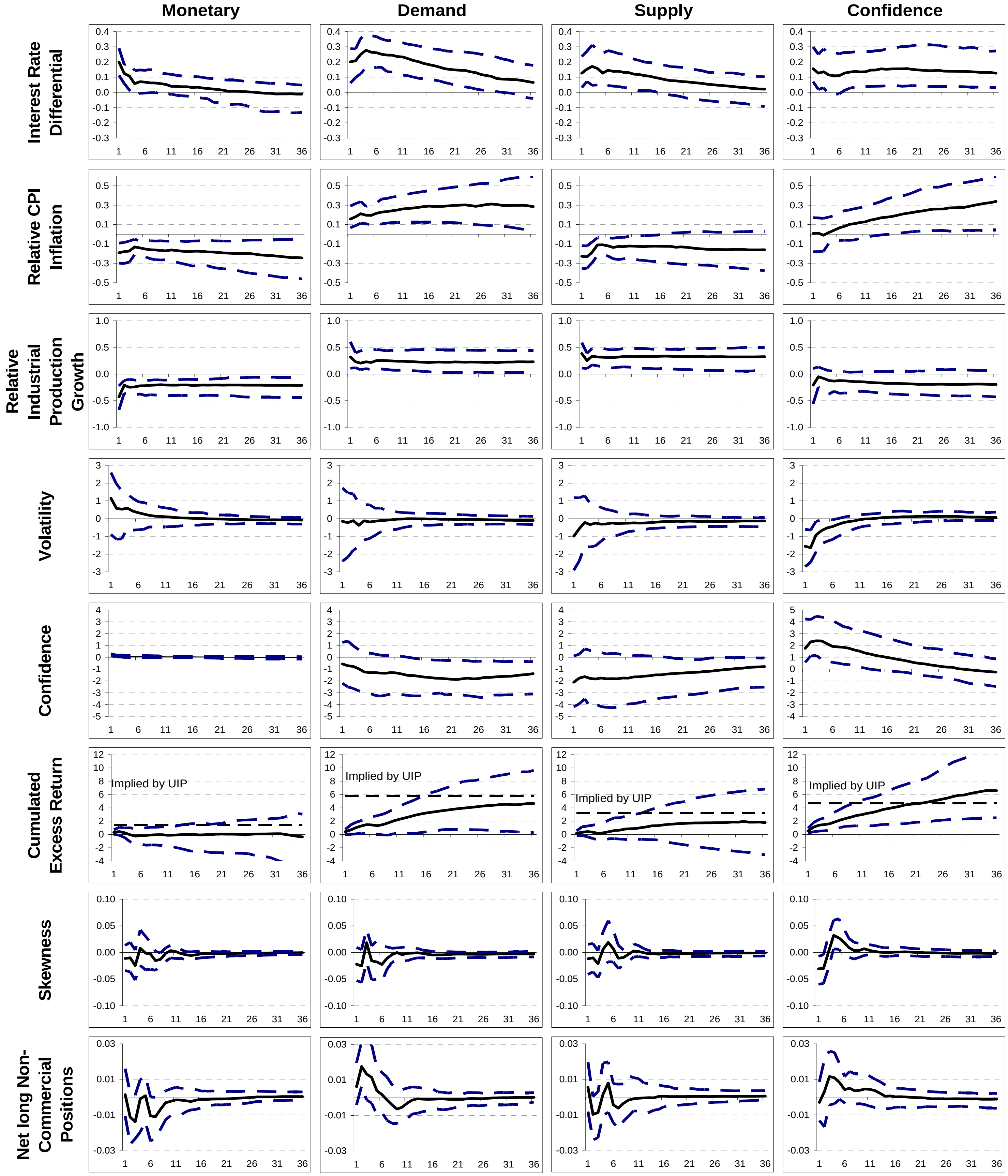
Foreign exchange return skewness

Net positions/open interest

Source: Calculations on data from Thomson Financial Datastream, Global Financial Data and CFTC.

Notes: Monthly data. Interest rates are referred to the 3-month maturity. The foreign exchange return is computed as UIP residual, i.e. summing the interest rate differential and the 3-month rate of change in the exchange rate. The skewness is computed on daily foreign exchange returns, as the standard deviation of the 63 most recent data. The VAR is identified via Cholesky diagonalization with the following order: interest rate differential, foreign exchange return, skewness, positons.

Figure A5: Responses for the gbp/usd case in the 4-shock VAR



Source: Calculations on data from Thomson Financial Datastream, Global Financial Data, CFTC and IMF IFS.

Notes: Monthly data. See also notes to Chart 1. The VAR is identified via sign-restrictions.

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