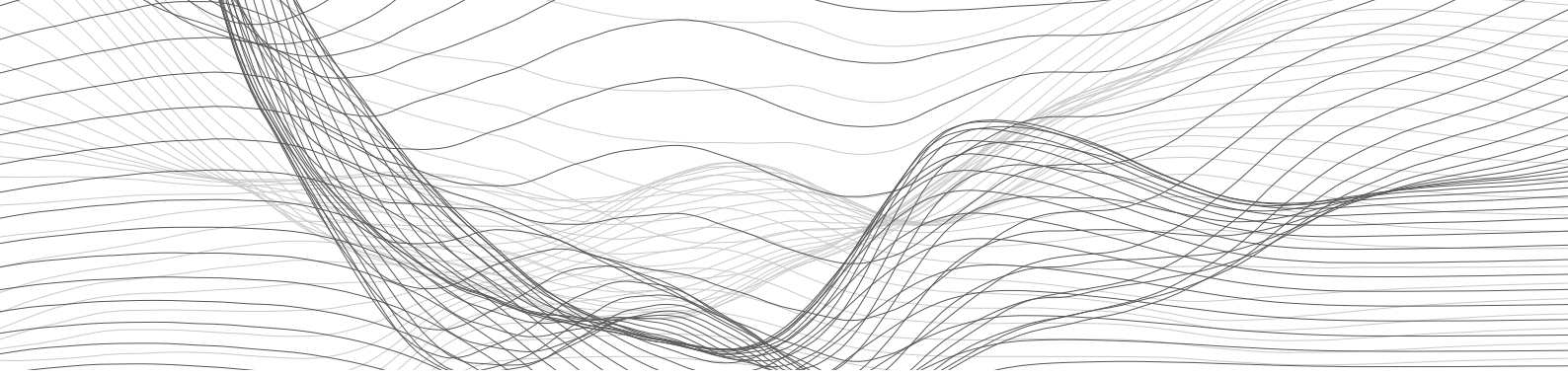

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Macroeconomic surprises, market environment and safe-haven currencies

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Abstract

In this paper, we study the reaction of the CHF and JPY to macroeconomic surprises and changes in the broader market environment before and during the crisis using high-frequency data. We show that both currencies are traditionally highly sensitive to macroeconomic surprises. This link, however, was significantly magnified during the crisis and effects persisted during times when monetary authorities implemented specific measures to limit the appreciation trend. We also find some evidence that, during the crisis, the CHF and JPY tended to respond more strongly to surprises generating an appreciation than to surprises leading to a depreciation. Both currencies also systematically respond to changes in the general market environment. This result is robust to the use of two measures of the market environment: VIX and on a novel index based on Bloomberg wires. Finally, our results suggest that negative macroeconomic surprises and deteriorations in the market environment are two distinct channels generating appreciation pressure on these two safe-haven currencies.

JEL Classification: F31, G12, G14.

Keywords: Safe-haven currencies, Swiss franc, yen, macroeconomic surprises, risk.

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1 Introduction

The Swiss franc and the Japanese yen are prominent safe-haven currencies. Their specific safe-haven status has been documented among others by Auer (2015), De Bock and De Carvalho Filho (2015), Botman et al. (2013) as well as Ranaldo and Söderlind (2010). In times of increased global risk aversion, these are the only currencies that appreciate against all other currencies, including the US dollar (USD).

The troubled times experienced by the world economy since the outburst of the subprime crises in August 2007 have brought about further evidence of the safe-haven status of these two currencies. With the intensification of the international crisis both the Swiss franc (CHF) and the Japanese yen (JPY) experienced waves of massive appreciation. Figure 1 displays the development of the nominal effective exchange rate for the two currencies.

The magnitude of the appreciation and its consequences in terms of deflationary pressures and output loss in the face of the zero-lower bound constraint forced monetary authorities in the two countries to adopt unconventional policies to limit the appreciation of their currencies in order to achieve their broader policy goals[1]. As depicted in Figure 2, this is reflected in the unique increase in the SNB and BoJ balance sheets. In this paper, we will summarize the adoption of these unconventional monetary policies under the term *regime change*. This is just for convenience. By that, we do not intend to suggest that this has corresponded to any fundamental change in the monetary policy strategy or institutional framework of either the SNB

[1] Between March 2009 and May 2010, the SNB intervened several times on the markets to contain the appreciation of the CHF (SNB, 2010 and 2011a). It also repeatedly made use of verbal interventions to manifest its discontent with the appreciation trend of the CHF and to signal that it stood ready to take further steps if needed. In September 2011, confronted with renewed strong appreciation pressures, the SNB introduced a formal exchange-rate floor vis-à-vis the EUR (SNB, 2011b). After lifting the exchange-rate floor in mid-January 2015, the SNB stated that it "will continue to take account of the exchange rate situation in formulating its monetary policy" and that "if necessary, it will therefore remain active in the foreign exchange market" (SNB, 2015). With respect to the Japanese currency, the stark appreciation that followed the Lehman Brothers events prompted the G7 to issue a statement expressing specific concern about the "recent excessive volatility in the exchange rate of the yen" (G7, 2008). The Bank of Japan (BoJ) started to intervene in September 2010 as the JPY hit a fifteen-year high against the USD. On March 18, 2011, the G7 countries jointly intervened to dampen the JPY strength. Various waves of BoJ interventions also occurred in the following months. However, as Figure 1 shows, the success of these measures was very limited. PM candidate Abe and the government that was appointed in December 2012 forcefully made the case for a further "unlimited" monetary policy easing to relaunch the economy and fight deflation. Indeed, the BoJ's easing stance became more resolute after the appointment of the new government. Markets clearly interpreted these signals as a game changer for the JPY (WSJ, 2012).

or the BoJ.

Fig. 1 here
Fig. 2 here

The safe-haven status of these currencies implies that the demand for CHF and JPY, and hence their market value, is crucially driven by shocks that impact the macroeconomic outlook and raise the general level of uncertainty on the international financial markets. Generally speaking, any piece of information that points to stable and balanced international growth will reduce markets' risk aversion and thus the demand for safe-haven assets. Conversely, news reflecting unanticipated economic weakness or instabilities of various sorts will spark risk aversion and foster the demand for safe assets. This principle, however, leaves a series of questions open. To which pieces of information do safe-haven currencies really react? How was this link influenced by the crisis? Does a stronger monetary policy focus on the exchange rate modify or even break the link? This paper investigates precisely these questions. Based on a sample of high-frequency data covering the period between January 2000 and December 2013, we study the effect of macroeconomic surprises, the general market environment and the monetary policy regime on the CHF and JPY exchange rates.

Narrowly defined macroeconomic surprises are a first likely source of safe-haven currency fluctuations. Several studies have investigated the connection between macroeconomic surprises – defined as the difference between the value released and the corresponding market expectation for a given macroeconomic indicator – and asset price adjustments. These studies have shown that some macroeconomic indicators, or more precisely their unexpected component, systematically generate significant and rapid reactions in asset prices.

However, the circle of factors that can potentially influence markets is obviously much wider and disparate than standard macroeconomic indicators. The general market environment, as we will call it, may be affected by factors like corporate news (such as earning announcements), economic policy news (such as budget numbers or structural reform announcements), political news and more. The trouble with these potential sources of uncertainty and market volatility is that they are less systematic and much harder to measure than standard macroeconomic surprises. That is why research traditionally takes an indirect approach: A popular proxy for general market uncertainty and risk aversion is the CBOE VIX index of implied volatility of the S&P 500 index options. In this paper we rely on the standard VIX measure as well as on a novel index based on the Bloomberg wires to capture market-environment conditions.

Our results allow us to make several points. First, we show that, in spite of their safe-haven status, CHF and JPY are not uniquely driven by foreign surprises. Some domestic variables matter in a very systematic and robust way. In fact, their role seems to be more stable across states of the economy than the one of foreign variables. Secondly, full sample regressions provide clear evidence that negative foreign surprises provoke an appreciation of the CHF and the JPY, while positive surprises lead to a depreciation. As such, this result simply confirms the outcome of various other investigations. We do, however, obtain relatively high R^2 for this kind of regression, signaling the specific relevance of macroeconomic surprises for safe-haven currencies. In particular, we find strong evidence that the sensitivity of the two currencies to macroeconomic surprises was magnified by the crisis. This observation is resilient to the changes in monetary policy regimes cited above: we find no evidence that the effects of macroeconomic surprises on the CHF and JPY were muted in any significant way. Also, we find some evidence of asymmetries: both currencies tend to display larger reactions when a surprise provokes an appreciation than when it causes a depreciation. Our results confirm the dominance of US macroeconomic indicators as both currencies are indeed strongly driven by US macroeconomic surprises. In addition, we test the importance of several euro area variables for both the CHF and the JPY. As questions on the fate of the European Monetary Union have taken center stage in the crisis and repeatedly rocked the markets, one might expect euro area macroeconomic surprises to have a strong impact on the CHF and JPY. Contrary to this assumption, while some German variables turn out to have a systematic influence, French, Italian and Spanish variables do not appear to be relevant, while aggregate euro area variables only have an unsystematic impact. Even when focusing specifically on the crisis period, macroeconomic surprises stemming from these economies do not gain in importance. Hence, the truly market-relevant news coming from these economies must have taken another channel to impact safe-haven currencies.

This other channel is possibly reflected in our market-environment variables. Indeed, according to our results, swings in the general market environment affect exchange rates *on top* of standard macroeconomic surprises. Market environment and macroeconomic surprises are thus complementary factors in explaining exchange rate movements.

The Bloomberg-based variable turns out to be strongly correlated with the VIX index. On the one hand, this further legitimizes the use of VIX as a proxy for market-environment conditions. On the other hand, however, our alternative market-environment measure displays various convenient features when compared to the VIX. First, it is not influenced by the macroeconomic surprise variables that we employ. Secondly, it is not bounded at zero and

can thus fluctuate in an untruncated manner. In doing so, it captures phases of strongly positive market sentiment better than VIX. Our results do indeed suggest that the Bloomberg-based variable is better positioned than VIX to capture the impact of extreme conditions on safe-haven currencies.

This paper is organized as follows. The next section summarizes the lessons learnt from the existing literature. Section 3 describes our dataset and defines our variables. Section 4 sketches our empirical approach and presents the results while section 5 concludes.

2 Relevant literature

A large body of literature has used high-frequency data to study the impact of macroeconomic surprises on asset prices: equities, exchange rates, treasury bills, bonds and forward rates. Generally speaking, there is broad-based evidence that macroeconomic surprises can produce significant changes in asset prices[2]. These changes tend to occur very rapidly after the surprise is observed (Pearce and Solakoglu (2007); Andersen et al. (2003); Dominguez (1999)). Not all assets are impacted equally. Goldberg and Leonard (2003) show that the effect of macroeconomic surprises are systematically stronger on the short end of the yield curve than on the long end. Bartolini, Goldberg and Sacany (2008) and Andersen et al. (2007) find that macroeconomic surprises have their strongest impact on interest rates while the impact is less pronounced for exchange rates and equity prices. The effects on interest rates and exchange rates appear to be longer-lasting than the effects on equity prices. Swanson and Williams (2013a) find that interest-rate reactions to macroeconomic surprises are less pronounced when the economy operates at the zero lower bound. Similarly, Goldberg and Grisse (2013) argue that the responsiveness of asset prices to macroeconomic surprises can vary over time with various states of the economy. A prominent feature of different studies is the dominance of US macroeconomic variables. Goldberg and Leonard (2003) show that while US macroeconomic surprises have a distinct impact on European yields, the evidence for a reverse influence is very limited. German yields appear to be more responsive to US surprises than to German or euro area surprises. Andersen et al. (2003) show that the impact of US surprises on the USD/DM exchange rate is much more substantial than the impact of German macroeconomic surprises.

The safe-haven status of the CHF and JPY has been documented by Ranaldo and Söderlind (2010), based on an analysis of all major currencies'

[2]See Neely and Dey (2010) for a broad survey of the literature on macroeconomic announcements and FX returns.

reactions to various financial market shocks over the period 1993-2008. CHF and JPY appreciate in a systematic way when risk peaks. In the most extreme instances, the appreciation of these two currencies is non-linear in the increase in risk. The measure of risk that appears to matter most is FX-market volatility, i.e. FX-specific risk rather than general measures of risk such as the VIX. In their effort to identify what characterizes a safe-haven currency, Habib and Stracca (2011) also fail to find a stable link between the VIX and the currencies of advanced economies. Instead they find that an increase in the VIX is systematically associated with depreciations of emerging market currencies. De Bock and de Carvalho Filho (2013) use spikes in the VIX to define risk-off episodes and show that in such periods returns on the CHF and JPY outperform those of all other currencies. Yeşin (2016) finds that the VIX displays stronger co-movements with the CHF real effective exchange rate than do capital flows to and from Switzerland. Thus the evidence on the usefulness of the VIX as a measure of global risk aversion to explain the behavior of safe-haven currencies is mixed.

3 Data sources and variables definition

3.1 Exchange rates

We work with a dataset covering the period from January 1, 2000 up to the end of 2013, at a five-minute frequency. All in all, the full sample includes 1,472,832 observations for each exchange rate cross. Nominal exchange rate data are taken from the Swiss National Bank database and originate from the EBS trading platform. We focus the on following exchange rate crosses: EURCHF, USDCHF, EURJPY, USDJPY. The notation of the currencies is such that a rising (falling) value in the quotes represents a depreciation (appreciation) of the safe-haven currency. For each point in time we dispose of bid and ask quotes as posted on EBS, and compute transaction prices as the average between the two. In the absence of formal quotes, the price at time t is computed on the basis of the latest quotes observed. We remove weekends from our data sample and focus on trades occurring between Sunday 11:00 pm and Friday 9:00 pm British Standard Time (BST). For simplicity's sake, all variables are matched to a continuous time vector (without summer time). Returns are computed as logarithmic differences:

$$\Delta fx_{t+1} = ln(FX_{t+1}) - ln(FX_t)$$

where the interval between t and $t+1$ in our baseline specification lasts five minutes.

3.2 Macroeconomic surprises

The database on macroeconomic news and market expectations is provided by Haver Analytics, which has taken over surveys that were originally conducted by Money Market Services. The database includes the precise time of the official data release, the number released and the corresponding market expectation. Expectations are defined as the median forecast over all market participants included in the survey. These data sources are the reference in the existing literature on macroeconomic news (Andersen et al. (2003), Gürkaynak et al. (2005), Swanson and Williams (2013a,b)). Our initial dataset groups together information for ten economies: Switzerland, US, euro area, Germany, France, Italy, Spain, Belgium, the UK, and Japan.

Following a well-established approach, we compute macroeconomic surprises at time t for any given macroeconomic indicator k as the difference between the released number (R_{kt}) and the value expected by market participants, E_{kt}. Also, in order to facilitate a comparison of the relevance of various surprises across macroeconomic indicators, surprise variables are standardized as in Balduzzi et al. (2001) by dividing the surprise by its sample standard deviation.

Hence, our surprise variables are defined as follows:

$$(1) \qquad S_{kt} = \frac{R_{kt} - E_{kt}}{\hat{\sigma}_{R_{kt} - E_{kt}}}$$

If the data released correspond precisely to the expected value, S_{kt} will be equal to zero. Note that, by construction, each time series S_{kt} is predominantly composed of missing values, as announcements for any variable k only occur once a month or once a quarter. Regressions below will focus only on exchange rate changes when surprises are available.

S_{kt} is a true surprise only under the assumption that E_{kt} actually incorporates all information available up the announcement time. In other words, if the amount of time elapsing between the market participants' survey and the actual announcement is large enough, surveys might provide an inappropriate proxy of rational expectations at time t as they do not incorporate information made available in between. This question has been investigated by Andersen et al. (2003) and Swanson and Williams (2013b), for example. Formal tests do not find any evidence that the reliability of surveys as rational expectation proxies should be questioned.

3.3 Market environment

Surprises stemming from standard macroeconomic indicators are not the only factors that move asset prices. Qualitative information often plays a crucial

role. Any unexpected piece of news that might impact the (future) performance of the economy can affect financial markets' mood – risk aversion and market expectations – and thus move asset prices. The spectrum of potentially relevant information is broad. It includes further macroeconomic news (such as growth projections, budget or public debt numbers), macroeconomic policy announcements (such as structural reforms), individual companies' information, and national or international political events. We summarize these elements under the term *market environment*.

A major problem naturally exists in the concrete measurement of the factors affecting the market environment. In order to incorporate this crucial aspect in our analysis we take two different routes. The first is an indirect route. We identify the market environment measure with the inverse of the CBOE VIX index of implied volatility of the S&P 500 index options, a proxy for general financial market uncertainty and risk aversion. This same approach is taken in an abundant number of contributions in the literature. We name this first market-environment variable, VIX_t.

The second and more novel approach is based on Bloomberg wires. A Bloomberg algorithm allows us to count stories as reported in the wires on a daily basis according to desired filtering criteria. Users have various options. They can create their own story counts by using key words or by selecting and combining specific topics. Alternatively, they can rely on pre-defined story counts as provided by Bloomberg itself. The algorithm distinguishes between positive and negative news according to their historical relevance for markets. Our second market-environment variable, BB_t, is derived as the simple difference between two very broad-based pre-defined topics, 'POSITIVE' and 'NEGATIVE', as computed by Bloomberg itself. Under the first topic the algorithm counts all 'potentially positive news'. Under the 'NEGATIVE' topic the algorithm records all stories which appear to be 'potentially negative news'. The definition of 'potentially positive' and 'potentially negative' is entirely empirical and rests with the Bloomberg algorithm. To provide the reader with a sense of which pieces of news are incorporated in this variable, Table A1 in the appendix lists the 38 top-ranked 'NEGATIVE' pieces of news taken into account in the computation of the story count on the day that BB_t reached its lowest absolute value in our sample (March 13, 2011). It is important to stress that BB_t does not contain macroeconomic data releases and thus does not overlap with our standard macroeconomic surprises.

BB_t is so defined that negative values correspond to days when negative news dominates. Figure 3 compares normalized versions of BB_t and the inverse of VIX (corresponding to our VIX_t), so that negative values correspond in both cases to a risk-averse environment. The two variables are highly correlated but not identical. At a daily frequency, BB_t is much more volatile.

In the 2003 to 2007 period – generally speaking a time of expansion and stability of the world economy – BB_t still displays repeated negative spikes while VIX_t does not. From 2011 onwards, the two variables diverge. While VIX_t goes back to the positive territory, in our logic pointing to a reduced demand for safe havens, BB_t remains mostly negative.

Figure 4 shows the daily changes in the two variables. Clearly, the second part of the sample displays a systemically higher volatility in market-environment conditions than the pre-crisis period. In this period it is not uncommon to observe fluctuations in BB_t in the order of magnitude of four standard deviations from one day to the next.

Fig. 3 here
Fig. 4 here

4 Empirical analysis

4.1 The role of macroeconomic surprises

A recurrent result in the existing literature is that US macroeconomic surprises often have a stronger impact on any country's asset prices than national surprises. Given their safe-haven function, one can expect the CHF and JPY to respond to a broader range of international macroeconomic surprises than other asset prices. Accordingly, beyond the domestic indicators, we included news originating from several other countries in our universe of potential explanatory variables: the US, the UK, Germany, France, Italy, Spain, Belgium, and the euro area as a whole. There are two reasons for including individual euro-area countries. First, some individual country data are released faster than the aggregated euro area data, and hence provide early signals for the area as a whole. Secondly, we want to be able to isolate the impact of macro-news stemming from specific countries that attracted significant market attention during the European debt crises.

In a first step, we estimate the following model:

$$\Delta fx^c_{t+1} = \alpha^c + \Delta fx^c_t + \sum_{k=1}^{K} \beta_k S_{k,t} + \varepsilon^c_t \quad . \tag{2}$$

where Δfx^c_{t+1} are the five-minute returns of the exchange rate cross c. β_k captures for each macroeconomic variable k the magnitude of the exchange rate reaction to any surprise S that occurs at time t. β_k coefficients can be interpreted as the percentage point changes in the exchange rate generated by a one-standard-deviation surprise. Coefficients estimates stem from OLS

regressions. t-statistics are computed using heteroskedasticity and serial correlation consistent (HAC) standard errors.

The number of explanatory variables initially considered is very large. We operate a first broad screening by regressing our four exchange rate crosses on the complete list of non-domestic S_k variables. We refer to the 10% significance level as the selection threshold. Regression results are not reported in this paper. They reveal a first clear verdict: macroeconomic news stemming from France, Italy, Spain, Belgium and the UK have no material relevance for the CHF and JPY. We thus remove them all from the set of explanatory variables. We will return later to the meaning of this outcome.

In a second step, EURCHF and USDCHF returns are regressed on all US, German and euro area macroeconomic surprises in addition to Swiss macroeconomic surprises. The same exercise is made with EURJPY and USDJPY, where Japanese surprises are used instead of the Swiss variables. Only a small number of variables appears to be consistently non-significant across all four regressions. Thus if we took significance in at least one regression as the selection criterion this would still leave us with a very large number of explanatory variables. Consequently, for each of the two currencies we selected only those variables that appear to be significant both in the EUR and USD regression. Applying this criterion leads to a choice of 22 variables for the CHF and 25 variables for the JPY. Table A2 in the appendix provides descriptive statistics for all these variables.

Tables 1 (for the CHF) and 2 (for the JPY) report detailed regression results using the explanatory variables we just selected. As the p-values show all coefficients appear to be highly significant. Generally speaking, as one might have expected, returns in both currencies are strongly affected by US macroeconomic surprises. However, the exposure to US macroeconomic surprises is more pronounced for the JPY than for the CHF: 19 US variables impact the JPY crosses, against 14 variables for the CHF. European news is more relevant for the CHF: four variables enter the CHF regressions, while only two are relevant for the JPY crosses. In the case of the CHF, only German variables have been selected, while in the case of the JPY, one euro-area-wide variable emerges. All in all, there thus seems to be surprisingly little systematic impact of non-German European variables on the two currencies.

A further interesting result concerns domestic indicators. Both currencies are significantly impacted by surprises in their domestic macroeconomic variables. Hence, movements in the CHF and the JPY are not driven only by international macroeconomic surprises. Unexpected domestic developments do matter.

All in all, the R^2 metric tells us that in this baseline specification our

regressions explain between 15% and 29% in the variation of 5 minutes returns for the CHF and between 11% and 35% for the JPY returns. As a comparison, the highest R^2 obtained by Ranaldo and Söderlind (2010) is 8% (for USDCHF). This suggests that macroeconomic surprises are important independent drivers of safe-haven currencies.

Table 1 here
Table 2 here

Looking at the EURCHF cross, all foreign variables display a positive sign. This corresponds to the expected result. It implies that positive surprises ($S_k > 0$) favor a depreciation of the CHF vs the EUR[3]. Conversely, negative surprises ($S_k < 0$) lead to an appreciation of the CHF. Domestic variables bear a negative sign. This is again the result we expected. Positive domestic surprises naturally tend to generate an appreciation pressure as they *ceteris paribus* imply a risk of a tighter monetary policy than previously projected. As far as the USDCHF regression is concerned, results are similar, with one prominent exception: all German variables are significant but bear the wrong sign. The explanation is to be found via the EURUSD cross. Positive German surprises cause an appreciation of the EUR against the USD and the CHF. The former being more pronounced than the latter, the Swiss currency appreciates against the USD. Results for the JPY are qualitatively very similar. Most β_k coefficients are highly significant and only one bears the wrong sign.

4.2 Impact of the crisis

Next, we want to check whether the crisis has impacted the link between macroeconomic surprises and CHF or JPY variations. The hypothesis is that, in periods of heightened uncertainty, safe-haven currencies react more to macroeconomic surprises. As a divide we take the outbreak of the subprime crisis in August 2007. Figure 1 shows that both currencies initiated an appreciation trend precisely around this time. Tables 3 and 4 show regression results. To make the main result easier to spot, coefficients of variables that are more relevant in the second period are in bold print.

In three out of four crosses, the number of coefficients that turns out to be significant is substantially larger in the second period. The exception is provided by the USDCHF cross. Interestingly, it is only in terms of foreign variables that a pattern emerges between the two subsamples. In other words,

[3] As far as US unemployment is concerned, we use the inverse of S_k, so that the positive sign also corresponds to what one would expect to observe.

there is no obvious evidence that the role of domestic variables varies in the two periods.

It is not just the number of significant coefficients for foreign variables that changes, but also the size of these coefficients. Typically, these are several orders of magnitude bigger during the crisis than in the pre-crisis period. For instance, whereas the reaction of EURCHF to surprises in the German Real GDP is twice as big and the reaction to surprises in the US Empire State Business Conditions Index or in the Consumer Confidence is some four times larger, the reaction to surprises in the US Non-Manufacturing ISM is no less than twenty times larger. In the case of the JPY, the change between the two periods is extremely impressive. Whereas domestic surprises tend to be significant (and bear the right sign) already in the pre-crisis period, most foreign variables turn significant only when the crisis occurs. This pattern is clearly visible in both the EURJPY and USDJPY exchange rates. The most extreme individual case is provided by surprises in the Nonfarm Payroll measure of employment: while in the pre-crisis period this variable bears the wrong sign, in the crisis a one standard deviation negative surprise generated a 0.27% JPY appreciation against the EUR and a 0.37% appreciation against the USD.

All in all, we thus find strong evidence of a much more pronounced impact of foreign macroeconomic surprises on our two safe-haven currencies during the recent crisis. The increased impact of macroeconomic surprises is also reflected in higher R^2 in the crisis. These results complement the evidence in Goldberg and Grisse (2013) on time-varying responses of asset prices to macroeconomic surprises.

Table 3 here
Table 4 here

In a separate set of regressions we look at whether macroeconomic surprises also have more persistent effects in the crisis, by using one to several hour windows instead of a five-minute window to compute the change in the exchange rates. We find no evidence of a change in patterns in this respect. This result stands in no contradiction to the increased intensity of reaction in five-minute windows, as of course the crisis is a time of much higher volatility in exchange rates.

4.3 Asymmetries

One open question is whether safe-haven currencies respond symmetrically to macroeconomic surprises. Evidence in this respect diverges. Fatum et

al. (2010) investigate this issue for the USDJPY over the 1999-2006 period. They conclude that negative US macroeconomic surprises have somewhat larger effects than positive surprises. Pearce and Solakoglu (2007) argue on the contrary that no evidence of asymmetric reactions can be found in the dollar-deutsche mark and the dollar-yen exchange rates. They use data spanning between 1986 and 1996 and surprises for a much smaller number of variables than we do here.

We collected all surprises that have the potential to generate an appreciation in an APP_S_t vector and all surprises potentially leading to a depreciation in a DEP_S_t vector. Hence, in the case of the EURCHF for instance, APP_S_t contains all negative foreign surprises as well as the domestic positive surprises, multiplied by –1. DEP_S_t contains all positive foreign surprises and all negative domestic surprises, again with the inverted sign. We then estimate the following regression for the pre-crisis and the crisis samples:

$$\Delta fx^c_{t+1} = \alpha^c + \Delta fx^c_t + \beta_a APP\_S_t + \beta_d DEP\_S_t + \varepsilon^c_t \quad (3)$$

We expect both β_a and β_d to have a positive sign. Asymmetry would request $\beta_a \neq \beta_d$. Table 5 displays the results.

In all but one case, coefficients bear the expected sign. Whereas in the pre-crisis sample no clear pattern emerges, in the crisis period the coefficient of APP_S_t is larger than the DEP_S_t coefficient in all four regressions. This suggests that macroeconomic surprises have a somewhat larger impact on both currencies when they induce an appreciation than when they have weakening effects. However, t-tests do not allow for a formal rejection of the the $\beta_a = \beta_d$ hypothesis. We should recall, however, that the crisis sample also contains extended periods in which monetary policy counteracted appreciation tendencies in the two currencies. Still, we interpret these results as a signal that to some degree asymmetric reactions might be at work, adding evidence to the findings of Fatum et al. (2010).

Note also, that this parsimonious specification confirms the qualitative results of tables 3 and 4: the surprise coefficients tend to be larger and the R^2 higher in the crisis period than in the pre-crisis period. The only exception is again the USDCHF cross.

Table 5 here

4.4 Non-linearity

Ranaldo and Söderlind suggest that safe-haven currencies may behave in a non-linear fashion. In particular, they seem to respond non-linearly to

varying levels of their preferred risk measure, observed volatility in the FX markets. In the following step we analyze whether evidence of non-linear responses to macroeconomic surprises can be found. We estimate the following regressions

$$\Delta fx^c_{t+1} = \alpha^c + \Delta fx^c_t + \beta_a APP\_S_t + \beta_{aa}(APP\_S_t)^2 + \varepsilon^c_t \quad (4)$$

$$\Delta fx^c_{t+1} = \alpha^c + \Delta fx^c_t + \beta_d DEP\_S_t + \beta_{dd}(DEP\_S_t)^2 + \varepsilon^c_t \quad (5)$$

The non-linearity hypothesis is confirmed if $\beta_{aa} < 0$ and $\beta_{dd} > 0$. As results in Table 6 show, we find no evidence at all of a non-linear impact of large surprises.

Table 6 here

4.5 Impact of the monetary policy regime

One might wonder to what extent the link between macroeconomic surprises and exchange rate reactions is affected by the attitude of monetary authorities. In a further step, we therefore investigate whether the sensitivity of the CHF and the JPY to macroeconomic surprises was modified by the change in the SNB and BoJ monetary policy regimes. The landmarks are provided by the adoption of the minimum-exchange-rate policy by the SNB in September 2011 and by the implementation of a more aggressive quantitative-easing policy by the BoJ as of December 2012.

Because of the reduced number of observations in the sample we refer again to the parsimonious specification (3). Results are displayed in table 7 and shall be compared to those in the lower panel of table 5.

If one is looking for nuances, then one might read estimates in table 7 as suggesting that the size of the APP_S_t coefficients declined after the new policy regimes were adopted, particularly in the case of EURCHF and EURJPY. Globally, however, coefficients remain highly significant, suggesting an unchanged relevance of macroeconomic surprises. We thus conclude that macroeconomic surprises maintained their impact on the CHF and JPY even under these two specific policy regimes.

Table 7 here

4.6 Role of the market environment

In a next step, we introduce the variables measuring general market conditions. They will operate as daily dummies in our regressions. We regress

our four exchange rate crosses on all variables of Tables 1 and 2 respectively plus our market-environment measures ME_t. ME_t is alternatively measured by VIX_t and BB_t (jointly and separately) and a one-day lag (corresponding to 288 five-minute spells) of the two as well as by (standardized) changes in VIX_t and BB_t. Table 8 provides summary statistics for these variables.

$$\Delta fx^c_{t+1} = \alpha^c + \Delta fx^c_t + \sum_{k=1}^{K} \beta_k S_{k,t} + \gamma_1 ME_t + \gamma_2 ME_{t-288} + \varepsilon^c_t \tag{6}$$

In order to better gauge the significance of our market-environment variables, regressions are based on 1.473 million observations, i.e. including the exchange-rate returns when no macroeconomic surprises are available. The VIX index is traded from 9:15 to 16:15 US East coast time. VIX_t denotes prior-day closing values. BB_t refers to news disseminated between 00:05 and 23:55 on the day preceding Δfx^c_{t+1}. Of course, VIX_t and BB_t are going to grow older (and possibly less relevant) as we refer to Δfx^c_{t+1} further into the next day.

Table 9 displays the results for the various versions of regression (6). For the sake of manageability, only the results for the market-environment variables are reported. Results for the surprise variables remain unchanged.

Table 9 here

We recall that positive values of VIX_t and BB_t are associated with a favorable environment, while negative values reflect times where negative news dominates, and thus risk is high. VIX_t and BB_t bear the right sign in all four regressions. An increase in these variables is associated with a depreciation of the CHF or JPY. When introduced separately, VIX_t and BB_t appear to be significant in three out of four regressions. The sign and size of the coefficient of VIX_{t-288} and BB_{t-288} clearly suggest that we refer to the changes in these two variables. Results for specifications including the changes only are in the fourth and fifth panel of table 9.

All in all, we interpret these results as clear evidence that returns in EURCHF, EURJPY and USDJPY are systematically influenced by changes in VIX_t and BB_t. Coefficients are small. We should recall, however, that we are regressing five-minute returns on daily variables. Hence a coefficient of 0.0002 for ΔBB_t in the EURCHF regression implies that a change in BB_t by one standard deviation moves the EURCHF exchange rate by 0.06% on a daily basis. Similarly, a one standard deviation change in VIX_t is associated with a 0.99% variation in the EURCHF. These are economically very substantial numbers.

The previous results suggest that market conditions have *on average* a significant impact on the CHF and JPY. Safe-haven currencies, however, are thought to respond in a particularly pronounced manner during times of extreme stress. Ranaldo and Söderlind (2010) find 'indicative' evidence of this phenomenon by using a dummy variable for 21 extreme events between 1993 and 2007, covering natural disasters, financial crises and acts of war or terror. We proceed by expanding regression (6) with dummy variables that reflect extreme values of our market-environment conditions. Concretely, we create a dummy for extreme negative values of BB_t and one for extreme positive values of BB_t by setting

$$EN\_BB_t = \begin{Bmatrix} -1 & if & BB_t < 2 * -\sigma_{BB_t} \\ 0 & & otherwise \end{Bmatrix}$$
$$EP\_BB_t = \begin{Bmatrix} 1 & if & BB_t > 2 * \sigma_{BBt} \\ 0 & & otherwise \end{Bmatrix}$$

EN_VIX_t is defined in a similar manner. EP_VIX_t is actually a vector composed of 0s only, as our standardized measure of VIX_t never gets higher than two standard deviations.

The two lower panels of table 9 show the results. Here again we also introduce one-day lagged dummies for extreme conditions. By construction, coefficients for our extreme market conditions variables are expected to be positive. As far as EN_VIX_t is concerned, coefficients are either insignificant (CHF crosses) or bear the wrong sign (JPY crosses). On the contrary, extreme market environment conditions as measured by our Bloomberg index provide significant results. Both the CHF and JPY respond with an appreciation to extreme negative conditions as measured by EN_BB_t. The response to extreme positive conditions instead is significant and makes sense only for the USDCHF exchange rate.

4.7 Do macroeconomic surprises and the market environment interact?

We next verify whether macroeconomic surprises and the market environment interact. One could in particular expect a larger impact of macroeconomic surprises on the CHF and JPY when the market environment is particularly positive or particularly negative.

$$\Delta fx^c_{t+1} = \alpha^c + \Delta fx^c_t + \sum_{k=1}^{K} \beta_k S_{k,t} + \lambda_k (S_{k,t} * ME_t) + \varepsilon^c_t \tag{7}$$

We run regression (7) using both levels and changes in VIX_t and BB_t as market environment measures. Across the board we find no convincing evidence that the market environment interacts with macroeconomic surprises. They thus appear to be two separate channels.

5 Conclusions

We use five-minute returns for the CHF and JPY over a thirteen-year period encompassing the post-2007 crisis to investigate the link between macroeconomic surprises, general market environment and monetary policy on the behavior of these two safe-haven currencies. We show that macroeconomic surprises and the general market environment are two distinct channels through which international factors can affect safe-haven currencies.

Both currencies are strongly affected by surprises in foreign macroeconomic data. US variables are the main drivers. However, German variables also play an important role, in particular for the CHF. The meaning of macroeconomic surprises for the two exchange rates is highly dependent on the state of the international economy. In particular, the impact of foreign surprises on CHF and JPY returns was strongly magnified by the crisis. Domestic surprises instead, maintain a relatively stable role across states of the economy. We also find some evidence that the impact of macroeconomic surprises can be asymmetric: surprises tend to produce somewhat larger appreciation movements than depreciation movements during the crisis.

Somewhat surprisingly, we find no significant relationship between our safe-haven currencies and macroeconomic surprises stemming from the countries that were at the heart of the European sovereign debt crisis. It must thus be the case that information originating in these countries affected safe-haven currencies via other channels. These other channels are most likely captured by our market-environment measures. Indeed, we show that safe-haven currencies react in a systematic way to measures of changes in the general market environment. This result is robust to the use of two distinct measures of the market environment: the VIX and a variable based on Bloomberg wires. We also show that the reaction of safe-haven currencies is particularly pronounced when the market environment turns extremely negative. This result, however, can only be identified when our Bloomberg measure of market conditions is used. This suggests that this variable displays a significant value added, compared to VIX, when it comes to understanding the behavior of safe-haven currencies.

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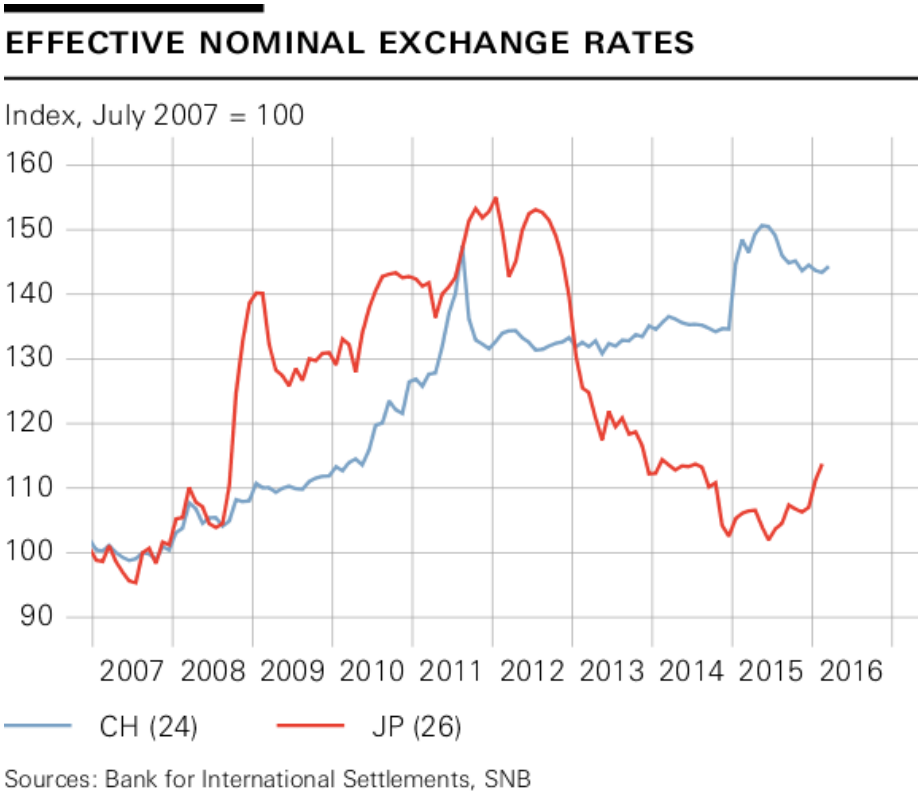
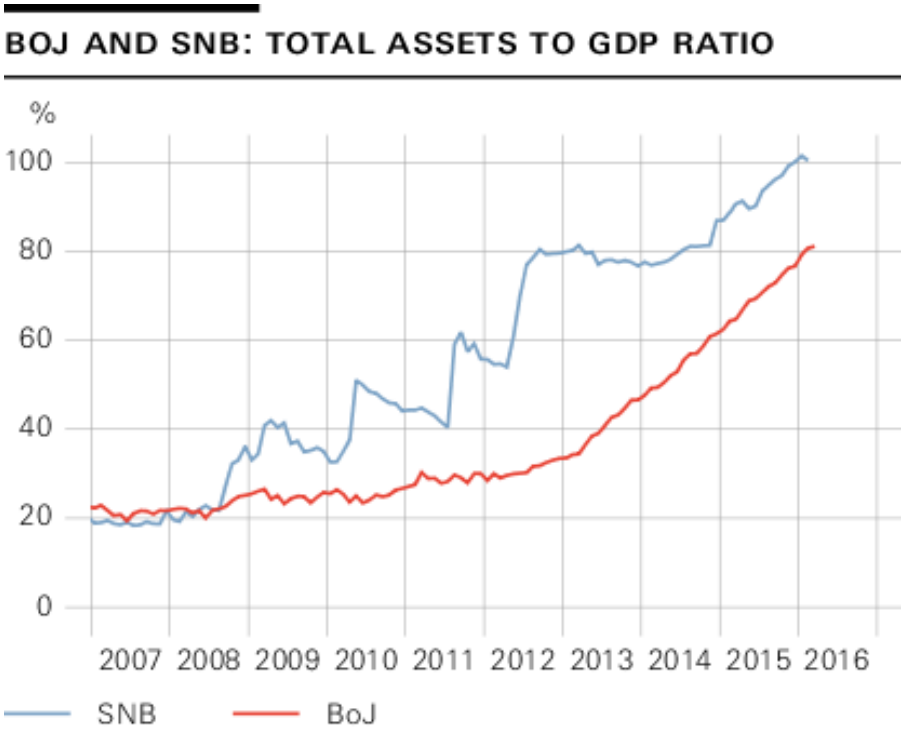
Figure 1:



Sources: Bank for International Settlements, SNB

Figure 2:



Sources: SNB, BIS

Figure 3: Bloomberg vs VIX

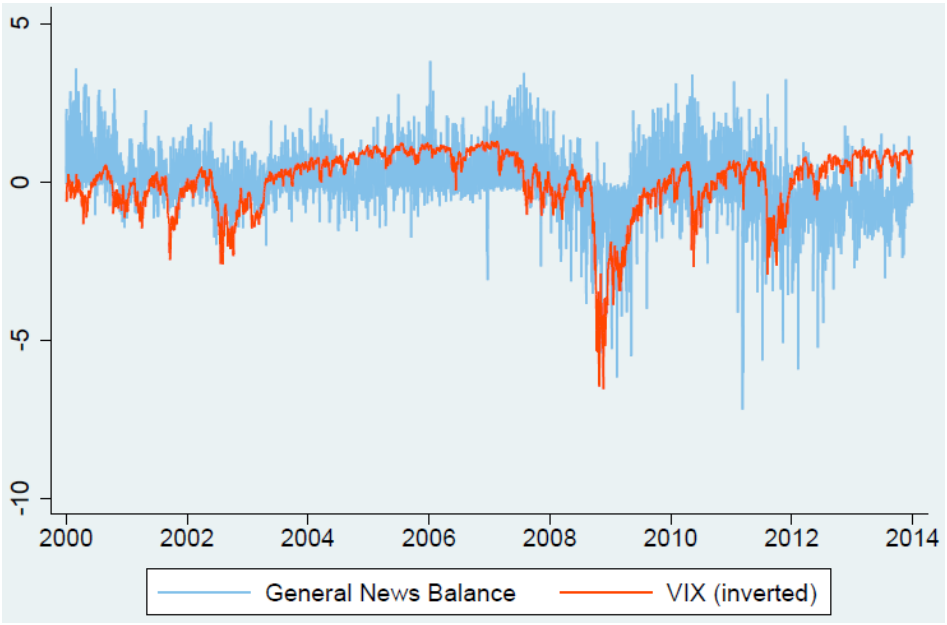


Figure 4: Daily changes in BB_t and VIX_t

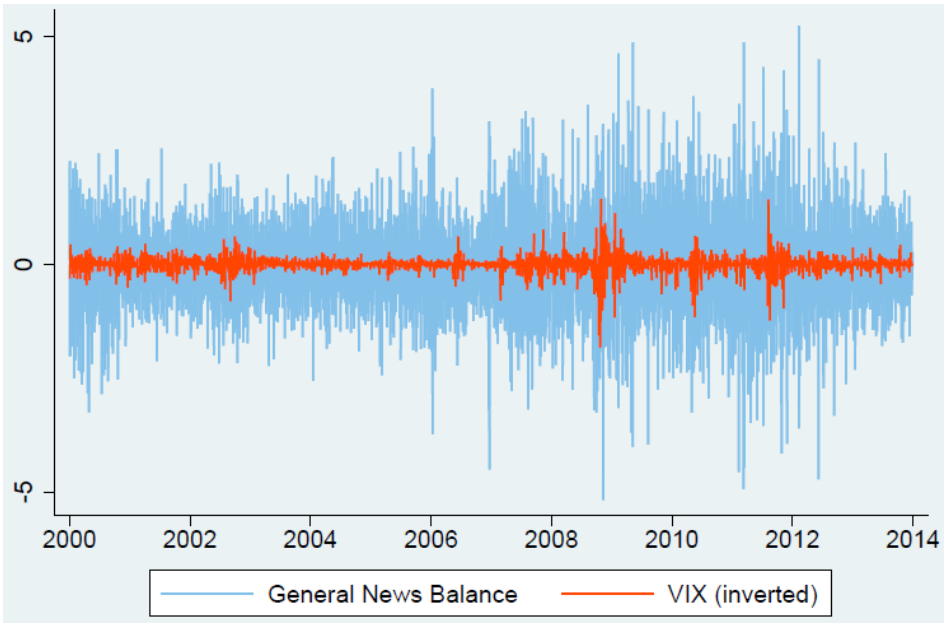


Table 1 – Full-sample estimates for the CHF

Sample: 1/01/2000 00:00 12/31/2013 23:55						
Dependent variable: Δfx_{t+1}^{c}	Observations: 2388 $c = EURCHF$			Observations: 2388 $c = USDCHF$		
	β_k	Std. Error	p-Value	β_k	Std. Error	p-Value
C	-0.002	0.001	0.215	-0.001	0.002	0.555
Δfx_t^c	-0.095	0.062	0.123	-0.347	0.091	0.000
Swiss Variables						
RETAIL SALES	-0.014	0.008	0.064	-0.021	0.009	0.025
KOF BAROMETER	-0.023	0.006	0.000	-0.030	0.008	0.000
PMI	-0.022	0.004	0.000	-0.020	0.006	0.001
REAL GDP	-0.030	0.011	0.004	-0.027	0.012	0.025
German Variables						
REAL GDP	0.021	0.005	0.000	-0.035	0.009	0.000
IFO BUSINESS CLIMATE	0.014	0.004	0.000	-0.063	0.011	0.000
RETAIL SALES	0.003	0.002	0.083	-0.018	0.008	0.020
ZEW INDICATOR	0.013	0.003	0.000	-0.032	0.007	0.000
US Variables						
AVG HOURLY EARNINGS ALL	0.054	0.032	0.092	0.089	0.037	0.018
EMP.ST. BUSIN. COND. INDEX	0.013	0.005	0.009	0.035	0.010	0.001
CONSUMER CONFIDENCE	0.021	0.004	0.000	0.036	0.011	0.001
PHIFED CURR. BUSIN. COND.	0.026	0.010	0.010	0.052	0.011	0.000
EMPLOYMENT NONFARM	0.052	0.015	0.001	0.241	0.039	0.000
HOUSING STARTS	0.012	0.003	0.000	0.020	0.010	0.051
INDUSTRIAL PRODUCTION	0.012	0.005	0.012	0.022	0.009	0.013
ISM NON-MANUF.	0.027	0.009	0.004	0.056	0.019	0.003
ISM MANUF.	0.045	0.015	0.003	0.083	0.015	0.000
NEW HOME SALES	0.013	0.004	0.001	0.041	0.009	0.000
NEW ORDERS DUR. GOODS	0.012	0.005	0.008	0.045	0.012	0.000
REAL GDP ADV	0.033	0.012	0.006	0.163	0.033	0.000
REAL GDP FINAL	0.014	0.006	0.021	0.028	0.016	0.070
UNEMPLOYMENT RATE	0.030	0.011	0.009	0.074	0.027	0.006
R-squared	0.152			0.291		
Adjusted R-squared	0.143			0.284		
Prob(F-stat)	0.000			0.000		

Table 2 – Full-sample estimates for the JPY

Sample: 1/01/2000 00:00 12/31/2013 23:55						
	Observations: 2239			Observations: 2239		
Dependent variable: Δfx_{t+1}^{c}	$c = EURJPY$			$c = USDJPY$		
	β_k	Std. Error	p-Value	β_k	Std. Error	p-Value
C	0.002	0.003	0.379	0.004	0.002	0.076
Δfx_t^c	-0.162	0.072	0.024	-0.285	0.069	0.000
Japanese variables						
MACHINERY ORDERS	-0.029	0.005	0.000	-0.031	0.005	0.000
RETAIL SALES	-0.008	0.005	0.097	-0.008	0.004	0.057
HOUSEHOLD EXPENDITURE	-0.009	0.004	0.021	-0.008	0.004	0.052
REAL GDP FINAL	0.022	0.006	0.000	0.020	0.005	0.000
Euro area variables						
BUSINESS CLIMATE	0.022	0.007	0.002	0.009	0.004	0.031
German variables						
RETAIL SALES	0.029	0.014	0.042	0.011	0.004	0.012
US variables						
AVG HOURLY EARNINGS PRO	0.048	0.028	0.092	0.080	0.035	0.024
EMP.ST. BUSIN. COND. INDEX	0.019	0.010	0.066	0.046	0.012	0.000
CONSUMER CONFINDENCE	0.049	0.016	0.002	0.067	0.011	0.000
PHIFED CURR. BUSIN. COND.	0.044	0.011	0.000	0.066	0.010	0.000
EMPLOYMENT NONFARM	0.095	0.037	0.010	0.286	0.031	0.000
EXISTING HOME SALES	0.029	0.014	0.034	0.041	0.010	0.000
HOUSING STARTS	0.016	0.006	0.004	0.024	0.010	0.011
IMPORTS GOODS & SERV.	0.030	0.012	0.017	-0.054	0.017	0.001
INDUSTRIAL PRODUCTION	0.016	0.006	0.012	0.026	0.006	0.000
ISM NON-MANUF.	0.044	0.017	0.009	0.073	0.018	0.000
ISM MANUF.	0.063	0.017	0.000	0.103	0.013	0.000
COMP.INDEX LEADING IND.	0.021	0.010	0.031	0.028	0.007	0.000
NEW ORDERS DUR. GOODS	0.017	0.009	0.064	0.052	0.011	0.000
PRODUCTIVITY	0.026	0.015	0.079	0.028	0.006	0.000
RETAIL SALES	0.060	0.016	0.000	0.090	0.014	0.000
REAL GDP FINAL	0.032	0.011	0.005	0.049	0.015	0.001
REAL GDP PRE	0.031	0.016	0.050	0.066	0.014	0.000
UNIT LABOR COSTS	0.041	0.021	0.052	0.025	0.004	0.000
UNEMPLOYMENT RATE	0.070	0.028	0.012	0.109	0.025	0.000
R-squared	0.107			0.345		
Adjusted R-squared	0.096			0.336		
Prob(F-stat)	0.000			0.000		

Table 3 – Crisis vs. Pre-Crisis for the CHF

Pre-Crisis Sample: 1/01/2000 to 7/31/2007; Crisis Sample: 8/01/2007 to 12/31/2013;								
Dependent variable: Δfx_{t+1}^{c}	Pre-Crisis Obs: 1051 $c = EURCHF$		Crisis Obs: 1337 $c = EURCHF$		Pre-Crisis Obs: 1051 $c = USDCHF$		Crisis Obs: 1337 $c = USDCHF$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	-0.001	0.100	-0.002	0.418	0.001	0.733	-0.003	0.364
Δfx_t^c	-0.155	0.008	-0.117	0.105	-0.484	0.001	-0.285	0.006
Swiss Variables								
RETAIL SALES	0.007	0.040	**-0.021**	0.016	-0.030	0.000	-0.018	0.095
KOF BAROMETER	-0.044	0.007	-0.010	0.056	-0.050	0.008	-0.015	0.061
PMI	-0.003	0.483	**-0.028**	0.000	-0.005	0.358	**-0.025**	0.001
REAL GDP	-0.060	0.000	-0.024	0.034	-0.063	0.000	-0.019	0.111
German Variables								
REAL GDP	0.009	0.034	**0.025**	0.000	-0.017	0.207	**-0.040**	0.000
IFO BUSINESS CLIMATE	0.010	0.000	**0.018**	0.003	-0.077	0.000	-0.054	0.000
RETAIL SALES	0.002	0.400	**0.007**	0.054	-0.022	0.045	-0.010	0.121
ZEW INDICATOR	0.005	0.035	**0.020**	0.001	-0.028	0.006	**-0.036**	0.000
US Variables								
AVG HOURLY EARNINGS ALL			0.052	0.090			0.092	0.021
EMP.ST. BUSIN. COND. INDEX	0.004	0.083	**0.017**	0.020	0.050	0.000	0.026	0.053
CONSUMER CONFIDENCE	0.007	0.023	**0.028**	0.000	0.094	0.000	0.007	0.521
PHIFED CURR. BUSIN.COND.	0.000	0.961	**0.035**	0.005	0.061	0.001	0.049	0.000
EMPLOYMENT NONFARM	0.016	0.025	**0.090**	0.001	0.292	0.000	0.188	0.000
HOUSING STARTS	0.004	0.028	**0.029**	0.001	0.012	0.226	0.035	0.180
INDUSTRIAL PRODUCTION	0.003	0.274	**0.016**	0.016	0.043	0.002	0.015	0.131
ISM NON-MANUF.			0.027	0.044			0.056	0.002
ISM MANUF.	0.005	0.046	**0.080**	0.002	0.074	0.000	**0.092**	0.000
NEW HOME SALES	0.011	0.000	**0.027**	0.094	0.037	0.000	0.038	0.248
NEW ORDERS DUR. GOODS	0.004	0.321	**0.019**	0.019	0.069	0.000	0.027	0.079
REAL GDP ADV	0.013	0.038	**0.050**	0.015	0.232	0.000	0.108	0.003
REAL GDP FINAL	-0.001	0.879	**0.019**	0.017	0.037	0.175	0.027	0.123
UNEMPLOYMENT RATE	0.005	0.490	**0.035**	0.013	0.099	0.046	0.067	0.034
R-squared	0.205		0.209		0.407		0.224	
Adjusted R-squared	0.188		0.194		0.394		0.209	
Prob(F-stat)	0.000		0.000		0.000		0.000	

Table 4 – Crisis vs. Pre-Crisis for the JPY

Pre-Crisis Sample: 1/01/2000 to 7/31/2007; Crisis Sample: 8/01/2007 to 12/31/2013;								
Dependent variable: Δfx_{t+1}^{c}	Pre-Crisis Obs: 991 $c = EURJPY$		Crisis Obs: 1248 $c = EURJPY$		Pre-Crisis Obs: 991 $c = USDJPY$		Crisis Obs: 1248 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	0.001	0.835	0.006	0.142	0.000	0.881	0.008	0.030
Δfx_t^c	-0.315	0.000	-0.203	0.016	-0.162	0.072	-0.349	0.000
Japanese variables								
MACHINERY ORDERS	-0.054	0.000	-0.018	0.003	-0.063	0.000	-0.018	0.000
RETAIL SALES	-0.023	0.049	-0.003	0.558	-0.029	0.028	-0.002	0.689
HOUSEHOLD EXPENDITURE	-0.008	0.208	**-0.010**	0.042	-0.013	0.151	-0.007	0.119
REAL GDP FINAL	-0.074	0.040	0.026	0.000	-0.073	0.000	0.024	0.000
Euro area variables								
BUSINESS CLIMATE	0.010	0.133	**0.032**	0.008	0.006	0.310	**0.012**	0.042
German variables								
RETAIL SALES	0.030	0.147	**0.032**	0.003	0.008	0.164	**0.015**	0.026
US variables								
AVG HOURLY EARNINGS PRO	0.017	0.461	0.097	0.242	0.063	0.060	0.082	0.358
EMP.ST. BUSIN. COND. INDEX	-0.019	0.009	**0.040**	0.008	0.031	0.012	**0.055**	0.001
CONSUMER CONFINDENCE	-0.035	0.000	**0.093**	0.000	0.053	0.001	**0.075**	0.000
PHIFED CURR. BUSIN. COND.	-0.032	0.014	**0.071**	0.000	0.024	0.011	**0.082**	0.000
EMPLOYMENT NONFARM	-0.077	0.006	**0.271**	0.000	0.199	0.000	**0.366**	0.000
EXISTING HOME SALES	0.003	0.651	**0.044**	0.063	0.029	0.020	**0.047**	0.001
HOUSING STARTS	0.002	0.732	**0.048**	0.002	0.010	0.239	**0.060**	0.049
IMPORTS GOODS & SERV.	0.035	0.008	0.020	0.411	-0.082	0.000	0.000	0.995
INDUSTRIAL PRODUCTION	-0.006	0.481	**0.024**	0.002	0.030	0.003	0.026	0.000
ISM NON-MANUF.			0.044	0.009			0.073	0.000
ISM MANUF.	-0.013	0.266	**0.130**	0.000	0.052	0.000	**0.147**	0.000
COMP.INDEX LEADING IND.	-0.003	0.569	**0.034**	0.012	0.006	0.286	**0.039**	0.000
NEW ORDERS DUR. GOODS	-0.015	0.013	**0.042**	0.004	0.049	0.000	**0.053**	0.004
PRODUCTIVITY	0.032	0.269	0.025	0.143	0.009	0.556	**0.033**	0.000
RETAIL SALES	-0.019	0.029	**0.105**	0.000	0.061	0.000	**0.107**	0.000
REAL GDP FINAL	-0.015	0.224	**0.046**	0.001	0.021	0.291	**0.061**	0.001
REAL GDP PRE	0.002	0.847	**0.042**	0.050	0.022	0.201	**0.084**	0.000
UNIT LABOR COSTS	-0.015	0.659	**0.045**	0.033	0.008	0.770	**0.028**	0.000
UNEMPLOYMENT RATE	0.007	0.806	**0.090**	0.010	0.109	0.003	**0.117**	0.000
R-squared	0.155		0.286		0.350		0.395	
Adjusted R-squared	0.131		0.269		0.332		0.381	
Prob(F-stat)	0.000		0.000		0.000		0.000	

Table 5 – Asymmetries

Pre-Crisis sample: 1/01/2000 to 07/31/2007								
Dependent variable: Δfx_{t+1}^{c}	Obs: 1051 $c = EURCHF$		Obs: 1051 $c = USDCHF$		Obs: 991 $c = EURJPY$		Obs: 991 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	-0.001	0.605	-0.007	0.178	0.002	0.653	0.005	0.283
Δfx_t^c	-0.141	0.009	-0.346	0.088	-0.262	0.002	-0.054	0.679
APP_S_t	0.008	0.000	0.056	0.000	-0.003	0.558	0.047	0.000
DEP_S_t	0.006	0.000	0.063	0.000	-0.003	0.699	0.030	0.000
R-squared	0.073		0.174		0.017		0.133	
Adjusted R-squared	0.071		0.171		0.014		0.130	
Crisis Sample: 8/01/2007 to 12/31/2013								
Dependent variable: Δfx_{t+1}^{c}	Obs: 1337 $c = EURCHF$		Obs: 1337 $c = USDCHF$		Obs: 1248 $c = EURJPY$		Obs: 1248 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	0.004	0.227	-0.001	0.906	0.009	0.228	0.009	0.182
Δfx_t^c	-0.108	0.131	-0.283	0.009	-0.172	0.059	-0.254	0.031
APP_S_t	0.034	0.000	0.048	0.000	0.053	0.000	0.060	0.000
DEP_S_t	0.021	0.000	0.039	0.000	0.044	0.000	0.055	0.000
R-squared	0.137		0.129		0.126		0.159	
Adjusted R-squared	0.135		0.128		0.124		0.157	

Table 6 – Non-linearity

Sample: 1/01/2000 to 07/31/2007								
Dependent variable: Δfx_{t+1}^{c}	Obs: 1173 $c = EURCHF$		Obs: 1163 $c = USDCHF$		Obs: 671 $c = EURJPY$		Obs: 669 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	0.001	0.631	-0.010	0.408	0.010	0.389	-0.019	0.165
Δfx_t^c	-0.060	0.409	0.044	0.833	-0.396	0.004	-0.199	0.509
APP_S_t	0.020	0.000	0.072	0.002	-0.001	0.945	0.003	0.860
SQR(APP_S_t)	0.005	0.000	0.010	0.143	0.001	0.629	-0.016	0.000
	Obs: 1087 $c = EURCHF$		Obs: 1097 $c = USDCHF$		Obs: 623 $c = EURJPY$		Obs: 618 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	0.001	0.555	-0.008	0.513	-0.002	0.834	-0.019	0.165
Δfx_t^c	-0.205	0.024	-0.698	0.023	-0.273	0.158	-0.377	0.072
DEP_S_t	0.008	0.068	0.081	0.000	-0.024	0.301	0.087	0.001
SQR(DEP_S_t)	-0.001	0.360	-0.009	0.203	0.007	0.563	-0.001	0.153
Crisis Sample: 8/01/2007 to 12/31/2013								
Dependent variable: Δfx_{t+1}^{c}	Obs: 682 $c = EURCHF$		Obs: 679 $c = USDCHF$		Obs: 397 $c = EURJPY$		Obs: 395 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	0.006	0.299	0.007	0.403	0.045	0.016	0.046	0.021
Δfx_t^c	-0.065	0.574	-0.340	0.041	-0.240	0.131	-0.440	0.028
APP_S_t	0.034	0.013	0.068	0.000	0.159	0.000	0.184	0.000
SQR(APP_S_t)	-0.000	0.928	0.007	0.251	0.030	0.003	0.035	0.000
	Obs: 611 $c = EURCHF$		Obs: 614 $c = USDCHF$		Obs: 357 $c = EURJPY$		Obs: 352 $c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
C	-0.007	0.103	-0.019	0.030	0.034	0.076	0.033	0.075
Δfx_t^c	-0.180	0.022	-0.270	0.060	-0.139	0.434	-0.215	0.346
DEP_S_t	0.043	0.000	0.087	0.000	0.015	0.618	0.044	0.143
SQR(DEP_S_t)	-0.007	0.029	-0.018	0.000	0.008	0.275	0.002	0.805

Table 7: Surprises and policy regime

Floor sample: 09/07/2011 to 12/31/2013				
Dependent variable: Δfx_{t+1}^{c}	Obs: 454 $c = EURCHF$		Obs: 454 $c = USDCHF$	
	β_k	p-value	β_k	p-value
C	-0.002	0.370	-0.013	0.086
Δfx_t^c	-0.091	0.361	-0.382	0.013
APP_S_t	0.009	0.011	0.033	0.006
DEP_S_t	0.016	0.000	0.061	0.000
R-squared	0.094		0.182	
Adjusted R-squared	0.088		0.176	
Abe sample: 12/01/2012 to 12/31/2013				
Dependent variable: Δfx_{t+1}^{c}	Obs: 205 $c = EURJPY$		Obs: 205 $c = USDJPY$	
	β_k	p-value	β_k	p-value
C	-0.006	0.529	-0.005	0.717
Δfx_t^c	-0.152	0.629	0.385	0.280
APP_S_t	0.032	0.022	0.070	0.002
DEP_S_t	0.040	0.009	0.057	0.005
R-squared	0.096		0.196	
Adjusted R-squared	0.082		0.184	

Table 8: Descriptive statistics for BB_t, VIX_t, ΔBB_t and ΔVIX_t

	Mean	Median	Max.	Min.	StDev.	Skew.	Obs.
BBt	0.00	-0.07	3.81	-7.19	1.00	-0.53	1472832
VIXt	0.00	0.21	1.27	-6.55	1.00	-1.95	1051776
ΔBBt	0.00	0.00	5.25	-5.17	0.06	0.46	1472831
ΔVIXt	0.00	0.00	1.44	-1.82	0.01	-15.07	1051045

Table 9: Role of the market environment

Sample: 1/01/2000 00:00 12/31/2013 23:55;
Obs: 1,472,832; 1,051,776 if VIX_t is included.

Dependent variable: Δfx_{t+1}^{c}	$c = EURCHF$		$c = USDCHF$		$c = EURJPY$		$c = USDJPY$	
	β_k	p-value	β_k	p-value	β_k	p-value	β_k	p-value
Market-environment measures								
VIX_t	0.0024	0.000	0.0000	0.924	0.0056	0.000	0.0034	0.000
VIX_{t-288}	-0.0024	0.000	-0.0001	0.772	-0.0055	0.000	-0.0033	0.000
BB_t	0.0001	0.001	0.0001	0.113	0.0001	0.484	0.0001	0.132
BB_{t-288}	-0.0000	0.272	0.0000	0.802	-0.0001	0.715	-0.0001	0.181
VIX_t	0.0025	0.000	0.0014	0.745	0.0057	0.000	0.0035	0.000
VIX_{t-288}	-0.0025	0.000	-0.0002	0.647	-0.0056	0.000	-0.0034	0.000
BB_t	0.0002	0.000	0.0001	0.130	0.0003	0.000	0.0002	0.000
BB_{t-288}	-0.0001	0.009	-0.0000	0.620	-0.0002	0.263	-0.0001	0.004
ΔVIX_t	0.0024	0.000	0.0001	0.757	0.0056	0.234	0.0033	0.000
ΔBB_t	0.0002	0.000	0.0001	0.140	0.0003	0.675	0.0002	0.000
VIX_t	0.0025	0.000	-0.0001	0.890	0.0060	0.000	0.0036	0.000
VIX_{t-288}	-0.0025	0.000	-0.0000	0.988	-0.0059	0.000	-0.0036	0.000
NE_VIX_t	0.0001	0.856	0.0013	0.177	-0.0022	0.024	-0.0012	0.054
NE_VIX_{t-288}	0.0000	0.990	-0.0012	0.205	0.0021	0.013	0.0010	0.091
BB_t	0.0002	0.000	0.0002	0.013	0.0001	0.183	0.0001	0.044
BB_{t-288}	-0.0001	0.006	-0.0002	0.039	-0.0002	0.543	-0.0002	0.001
NE_BB_t	0.0004	0.073	-0.0008	0.016	0.0020	0.001	0.0009	0.017
NE_BB_{t-288}	0.0001	0.820	0.0009	0.028	-0.0007	0.478	0.0001	0.758
PE_BB_t	-0.0002	0.075	-0.0001	0.725	0.0001	0.713	0.0003	0.227
PE_BB_{t-288}	0.0003	0.150	0.0007	0.030	0.0000	0.995	0.0004	0.105

Table A1 – Top-ranking negative news according to Bloomberg on March 13, 2011. (Source: Bloomberg Terminal)

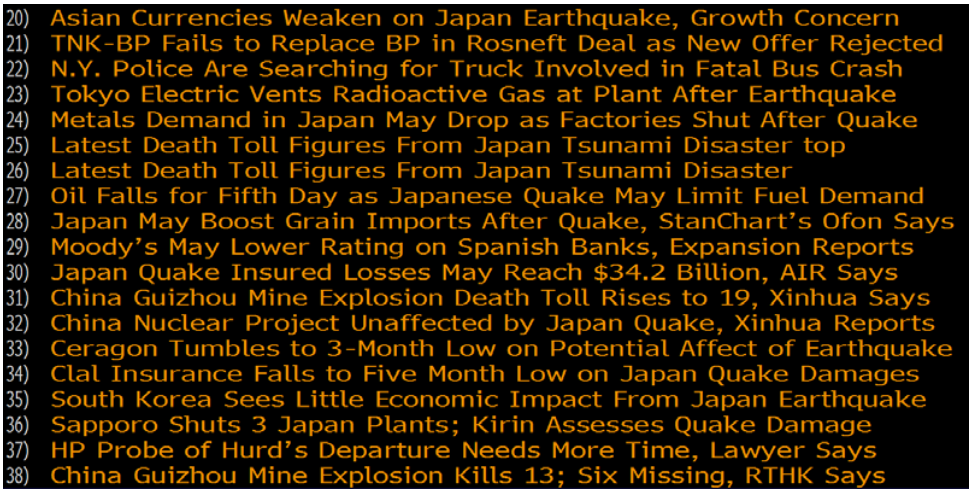


Table A2 – Descriptive statistics of selected variables

	Mean	Median	Max.	Min.	StDev.	Skew.	Obs.
SWISS VARIABLES							
RETAIL SALES YoY	-0.03	0.00	3.99	-4.35	1	-0.16	87
KOF BAROMETER	0.02	0.06	4.01	-2.71	1	0.57	117
MANUFACTURING PMI	0.07	0.14	2.75	-4.09	1	-0.40	118
REAL GDP QoQ	0.24	0.30	2.11	-2.72	1	-0.40	38
JAPANESE VARIABLES							
MACHINERY ORDERS MoM	0.00	-0.05	2.32	-1.95	1	0.15	110
RETAIL SALES YoY	0.09	0.18	2.46	-2.46	1	-0.34	108
HOUSEHOLD EXPENDITURE YoY	-0.02	-0.12	2.51	-2.45	1	0.28	115
REAL GDP FINAL QoQ	-0.23	-0.03	0.91	-5.53	1	-4.08	30
EURO AREA VARIABLES							
BUSINESS CLIMATE INDEX	0.09	0.16	2.83	-2.99	1	-0.10	119
GERMAN VARIABLES							
REAL GDP QoQ	0.09	0.00	3.08	-2.73	1	0.67	52
IFO BUSINESS CLIMATE	0.13	0.16	3.69	-2.41	1	0.02	166
RETAIL SALES MoM	-0.29	-0.30	3.72	-2.44	1	0.76	158
ZEW INDICATOR	0.04	0.01	3.17	-2.63	1	0.18	144
US VARIABLES							
AVG HOURLY EARNINGS ALL EMPLOYEES MoM	-0.40	0.00	1.34	-2.69	1	-0.02	47
AVG HOURLY EARNINGS PROD. WORKERS MoM	-0.09	0.00	3.01	-2.25	1	0.28	85
EMPIRE STATE BUSINESS CONDITION INDEX	-0.11	-0.03	2.09	-3.20	1	-0.37	119
CONSUMER CONFIDENCE	0.01	0.02	2.48	-2.50	1	-0.10	133
PHIL. FED CURRENT. BUSINESS CONDITIONS INDEX	-0.14	-0.09	1.96	-3.64	1	-0.40	132
COMP.INDEX LEADING INDICATORS MoM	0.06	0.00	2.91	-2.08	1	0.42	132
EXISTING HOME SALES	0.04	0.00	3.51	-3.72	1	-0.47	133
HOUSING STARTS	0.05	-0.02	3.07	-3.05	1	-0.15	129
INDUSTRIAL PRODUCTION MoM	-0.14	0.00	3.47	-4.85	1	-0.62	132
IMPORTS GOODS & SERV.	0.16	0.19	2.26	-2.29	1	-0.18	69
ISM NON-MANUFACTURING	0.01	0.05	2.07	-3.74	1	-0.81	71
ISM MANUFACTURING	0.14	0.19	3.46	-2.85	1	0.16	132
PRODUCTIVITY QoQ	0.10	0.00	2.86	-3.62	1	-0.64	44
NEW ORDERS DURABLE GOODS MoM	-0.12	-0.09	2.42	-3.80	1	-0.44	132
REAL GDP ADVANCED QoQ	-0.13	-0.32	2.06	-2.22	1	0.15	44
REAL GDP FINAL QoQ	-0.28	0.00	2.14	-2.49	1	-0.13	44
US_RETSALEX_MOM_S	-0.04	0.00	2.83	-3.64	1	-0.25	132
UNIT LABOR COSTS QoQ	0.06	-0.03	5.06	-2.82	1	2.35	44
UNEMPLOYMENT RATE	0.26	0.32	3.23	-2.59	1	-0.14	132

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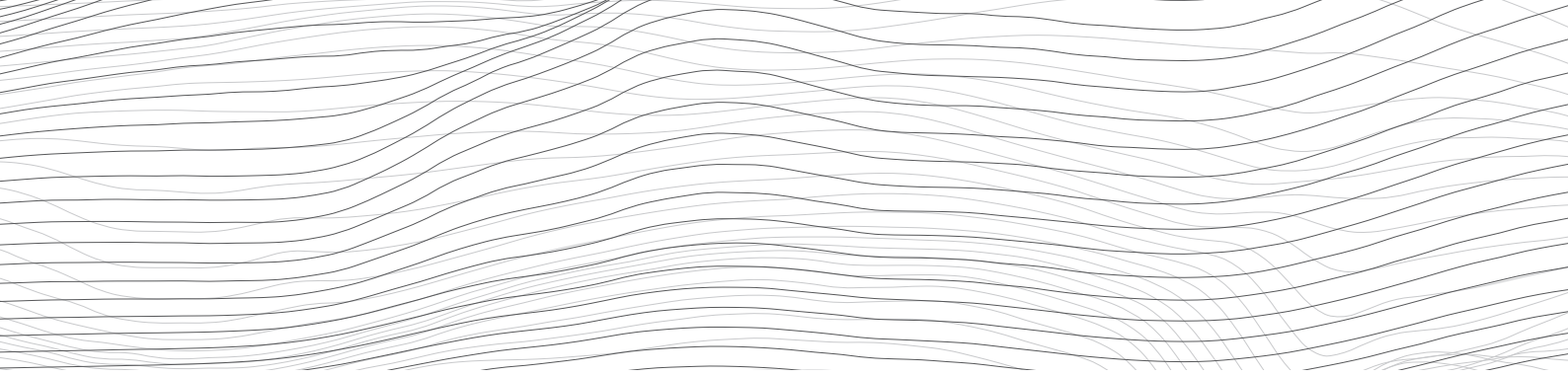

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