TWO SIGMA

Street View

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EXECUTIVE SUMMARY Market participants seemed to under-price the risk of the Swiss franc de-pegging from the euro by more than ten standard deviations. In fact, recent history suggests that the market systematically underestimates the volatility during "tail events" of pegged currencies more than it under-estimates the volatility of floating currencies. This might concern investors worried about the stability and embedded market risk from other pegged currencies, including the Greek "peg" to the euro.

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CURRENCY PEG RISKS

IN ONE OF THE FINAL SCENES of the original Star Wars film, Han Solo describes Luke Skywalker's coup de la mort of the Death Star as a "one in a million" shot (i.e., less than five standard deviations). By some measures, the recent appreciation of the Swiss Franc (CHF) appeared even less likely. The magnitude of the CHF move on January 15 doubled the magnitude of other developed market currency moves since 1990. The realized weekly volatility represented a ten standard deviation "shot."[1] Two possibilities exist that can explain the occurrence of such a statistically unlikely event: either the CHF move represented a fluke, or the market mispriced risk for a pegged exchange rate. This Street View argues for the latter explanation and wonders what other risks associated with currency regimes the market might also underestimate. The Greek "peg" to the euro springs to mind.

SWISS FRANC MOVE TWICE AS LARGE AS OTHER DEVELOPED MARKET CURRENCY CRISES

Currency pegs break. Gourinchas and Obstfeld (2012) count more than one hundred such currency crises since the end of the Bretton Woods era in 1972. Most currency crises afflict emerging markets, but even developed markets suffer on occasion. The recent de-pegging of the Swiss franc to the euro qualifies as such an event according to numerous criteria (e.g., Klein and Shambaugh, 2010),[2] even if the CHF crisis does not overly stress the Swiss banking sector or lead to a sharp contraction in GDP.[3]

Yet even against a backdrop of the ignominious history of currency crises, the breaking of the CHF peg on January 15 was unusual for a developed market. First, the Swiss National Bank abruptly renounced its pledge to maintain a ceiling of the franc against the euro. Then, the CHF appreciated by nearly 18 percent relative to the U.S. dollar (USD) and similar percentage relative to the euro in a single day (close-to-close). To put that move in perspective, Figure 1 plots the one day change of developed market currencies vis-à-vis the U.S. dollar during currency crises since 1990.[4] The figure plots absolute values of changes, because currency prices are by definition relative to an arbitrarily selected base.

According to this metric, on January 15, the Swiss franc moved more than twice as much as any other developed market currency crisis (e.g., Sweden and Spain in 1992) and more than 4.5 times more than the median change during currency crises. Even the infamous day in September 1992, when George Soros "broke the Bank of England," and the European Exchange Rate Mechanism failed to maintain a peg between the British pound and German deutschemark, pales in comparison to the recent CHF adjustment.

Fundamental economic differences across countries fail to account for the magnitude of the move. The horizontal axis of Figure 1 measures the absolute value of the deviation in purchasing price parity (PPP) of currencies during the calendar year prior to the currency crises. On a PPP basis, the CHF was less mispriced than Danish krone and Swedish krona during the Exchange Rate Mechanism crisis, yet the absolute change in its currency was two to nine times greater.

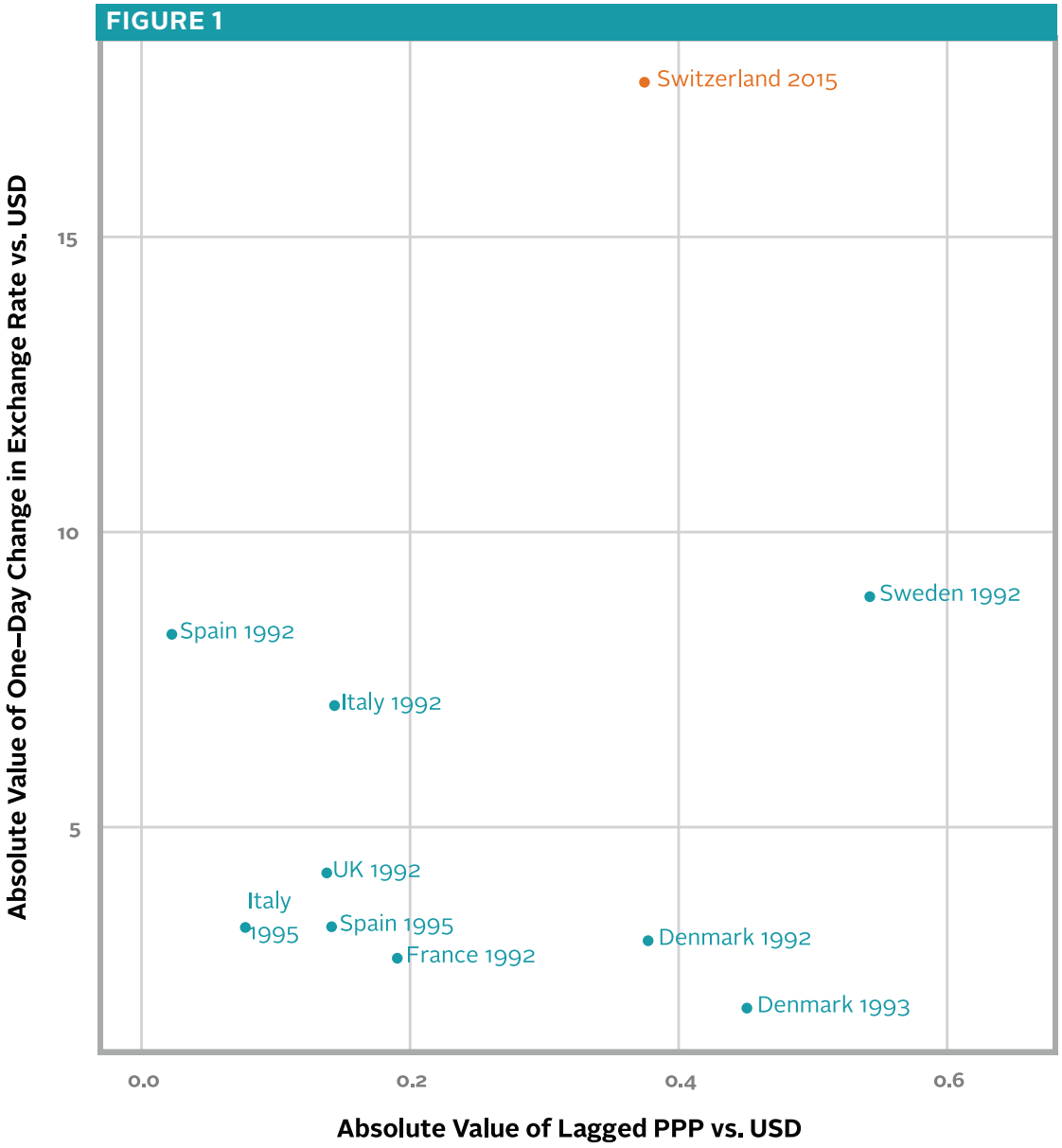
1 Weekly data on implied fx volatility was the highest frequency available. A weekly frequency for realized volatility was selected to match the implied volatility data. Andersen, Bollerslev, Diebold, and Labys (2001) argue that fx returns are non-normally distributed (in contrast to Coppes, 1995), making it difficult to translate a ten standard deviation change into a probability.

2 Strictly speaking, the CHF was not pegged to the euro but rather had a ceiling through which the Swiss National Bank vowed the currency would not appreciate. In practice, the difference between a traditional peg and the CHF ceiling was insignificant.

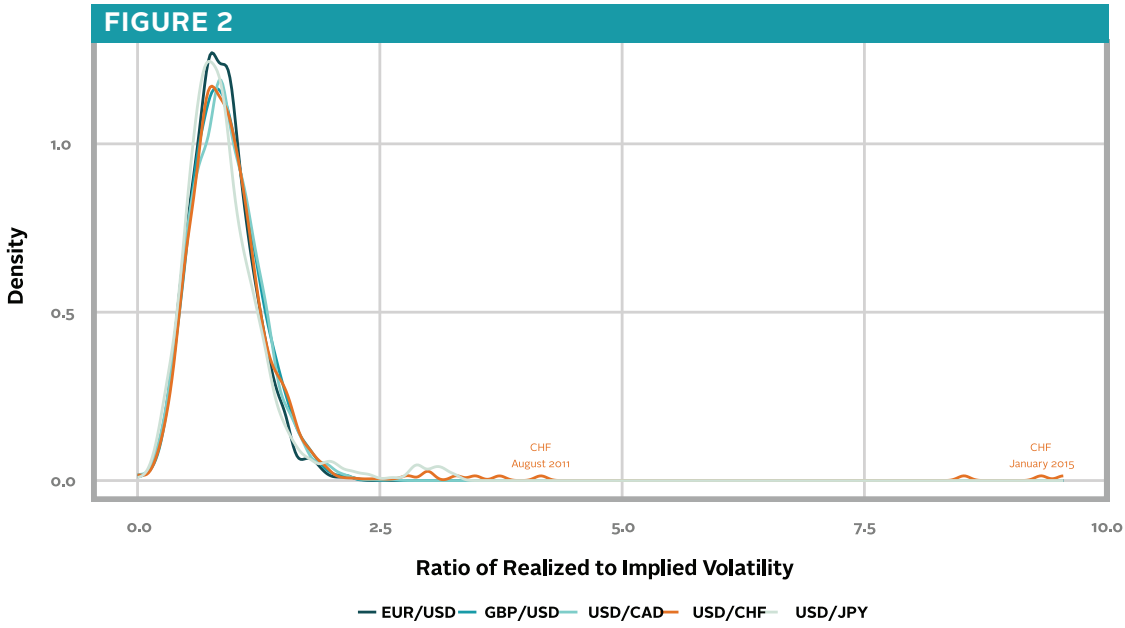
3 Reinhart and Rogoff (2014) list many currency crises that occurred without a simultaneous banking crisis or recession.

4 The years of currency crises based on Klein and Shambaugh (2010) with updated data (through 2012) downloaded from Shambaugh's website (www.gwu.edu/~iiep/about/faculty/jshambaugh/data.cfm). Within a crisis year, the figure plots the single largest currency change in absolute value relative to the USD. 2 U.S. Bureau of Labor Statistics, www.bls.gov/news.release/empsit.nr0.htm

FIGURE 1



NOTES
Daily data on the absolute value of a currency change (appreciate or depreciation) vs. the USD from Bloomberg. Purchase price parity data from the World Bank. Currency crisis dates based on Klein and Shambaugh (2010) and downloaded from (www.gwu.edu/~iiep/about/faculty/jshambaugh/data.cfm).



NOTES
Daily ratio of week-ahead realized to implied volatility for major currency exchange rates versus the U.S. dollar. Data from JP Morgan.

THE MARKET MISPRICED RISK ON THE SWISS FRANC

The market also underestimated the risk of a large movement in the Swiss franc. The implied one week volatility of the CHF prior to the Swiss central bank's announcement was 9.0, slightly below its mean of 9.6 since 2001.[5] Realized volatility following the Swiss National Bank's announcement peaked at 84, which is equivalent to 12.6 standard deviations above the mean. More plainly, the market expectation for volatility erred by a factor of nine, and this forecast error was more than twelve standard deviations worse than normal.

Figure 2 highlights the rarity of this forecast error. The figure plots the ratio of realized to implied one week volatility for five currency pairs – the U.S. dollar relative to the euro, Great Britain pound, Canadian dollar, and Japanese yen. A value of 1.0 would imply that the market was risk neutral and on average accurately forecasts realized volatility. As it turns out, the mean and median of the distributions fall closer to 0.9, which is consistent with risk averse investors willing to pay a premium to limit their exposure to currency volatility.

The recent CHF move stands as an extreme outlier. For all five currency pairs, the distribution of realized to implied volatility remains tightly distributed around their respective means. This implies that the market forecast (i.e., implied) volatility typically hovers closely to its actual value (i.e., realized volatility) after adjusting for an embedded risk premia. In contrast, the ratio of realized to implied volatility for the USD/CHF rate in January 2015 creates a long right tail. Empirically, the ratio was more than twenty standard deviations greater than the mean. The market "shock" when the CHF peg was first rumored in August 2011 was only four standard deviations above the mean. While it is theoretically possible that the recent CHF move was simply an unlikely event from an otherwise well understood return distribution, a more plausible explanation would suggest that the market significantly mispriced the risk associated with the CHF currency peg breaking.

WHAT OTHER CURRENCY PEG RISKS MIGHT BE MISPRICED (I.E., IMPLICATIONS FOR INVESTORS)

If the market mispriced the risk associated with the CHF peg, investors might wonder whether the market has mispriced the risks of other currency pegs failing as well. Recent history does not inspire much confidence. Table 1 applies the same metric of realized to implied volatility as Figure 2 over a wider range of currencies. Following Klein and Shambaugh (2010), each currency is divided

5 The time series for weekly data (highest frequency available) began in December 2001 for the USD/CHF exchange rate.

TABLE 1

	Percentile 50th	90th	99th	99.9th
Floating	0.79	1.35	2.08	3.38
Peg (Including Soft Peg)	0.60	1.32	2.43	7.89

into "floating" and "pegged" periods, where a currency peg may either be explicitly declared or implicitly managed by central banks within a narrow (usually two percent annual) band. Due to data limitations, a pegged "period" is an annual observation by currency.

For the median week, the ratio of realized to implied volatility for a floating currency is 0.79 while that for a pegged currency is only 0.60. In other words, investors demand a greater premium in order to protect themselves from exchange rate risk for pegged currencies than floating currencies. That remains consistent with economic theory given the risk that a central bank might suddenly change its mind about a peg. Even at the 90th percentile, the relative risk premium for pegged rates remains slightly higher than for floating currencies.

Market prices for volatility in a "tail" scenario tell a different story. When realized volatility is in the 99th percentile, the market forecasted volatility for a pegged currency is less than half (1/2.43) the realized level. The forecast error for floating exchange rates is smaller. At the 99.9th percentile, the market has only protected itself from approximately thirteen percent (1/7.89) of the realized volatility in a pegged currency. For a floating currency, the corresponding value is thirty percent. While this data covers only a short time frame (2001-2011) during which currency crises were relatively rare, the results are consistent with the hypothesis that the market systematically under-prices tail risks for pegged currencies.

Investors should not take comfort in the fact that the official number of pegged currencies, and therefore the number of potential "tail" events from currency de-pegging, has fallen since the 1990s. On the contrary, the IMF's most recent (2014) annual report on exchange rates counts more pegged (78) than floating (65) currencies. The IMF also lists 35 markets whose monetary authorities operate a hybrid form of currency flexibility. The People's Bank of China falls into this category, since it has restricted the yuan to trading within a narrow band relative to a basket of currencies for more than a decade.

Even more concerning for investors might be the set of countries that the IMF has not officially counted as operating a pegged currency, although this classification stems more from a literal definition than from an economic analysis. The seventeen individual members of the European Monetary Union (also known as the euro zone) have adopted a very rigid form of currency pegging despite operating under different fundamental economic conditions. For example, trends in German purchasing price parity and growth outlook appear very different than those in Southern Europe. Greece presents a particularly stark contrast to Germany, particularly because of its foreboding debt overhang. Since the economy of the euro zone is approximately twenty times larger than that of Switzerland, a currency crisis there has the potential to disrupt the global economy even more than the recent CHF move.

No form of currency peg - crawling like China, conventionally pegged like Switzerland, or more rigid like the euro zone - should be thought of as irreversible. Any currency regime that a central bank (or government) can create may also fail. A relevant question for investors is whether the market has appropriately priced the risks of a currency peg breaking. Recent evidence suggests it has not.

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