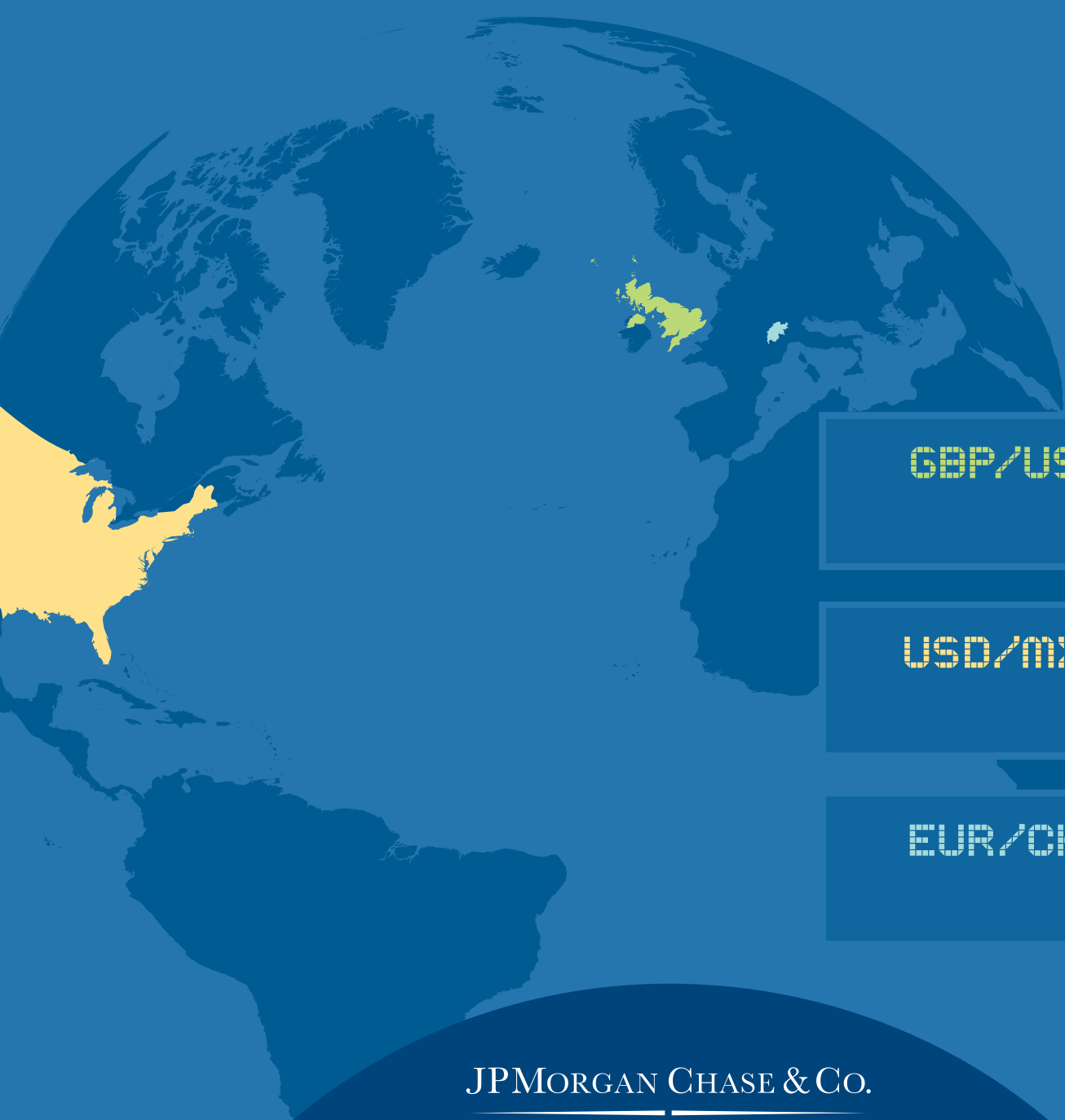


# FX Markets Move on Surprise News

Institutional Investor Trading Behavior around  
Brexit, the US Election, and the Swiss Franc Floor



GBP/USD

1.324

USD/MXN

19.620

EUR/CHF

1.053

# About the Institute

The global economy has never been more complex, more interconnected, or faster moving. Yet economists, businesses, nonprofit leaders, and policymakers have lacked access to real-time data and the analytic tools to provide a comprehensive perspective. The results—made painfully clear by the Global Financial Crisis and its aftermath—have been unrealized potential, inequitable growth, and preventable market failures.

The JPMorgan Chase Institute is harnessing the scale and scope of one of the world's leading firms to explain the global economy as it truly exists. Its mission is to help decision-makers—policymakers, businesses, and nonprofit leaders—appreciate the scale, granularity, diversity, and interconnectedness of the global economic system and use better facts, timely data, and thoughtful analysis to make smarter decisions to advance global prosperity. Drawing on JPMorgan Chase's unique proprietary data, expertise, and market access, the Institute develops analyses and insights on the inner workings of the global economy, frames critical problems, and convenes stakeholders and leading thinkers.

The JPMorgan Chase Institute is a global think tank dedicated to delivering data-rich analyses and expert insights for the public good.

## Acknowledgments

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## Contact

For more information about the JPMorgan Chase Institute or this report, please see our website [www.jpmorganchaseinstitute.com](http://www.jpmorganchaseinstitute.com) or e-mail [institute@jpmchase.com](mailto:institute@jpmchase.com).

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Institutional Investor Trading Behavior around  
Brexit, the US Election, and the Swiss Franc Floor

Diana Farrell  
Kanav Bhagat  
Chen Zhao

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# Executive Summary

In this inaugural JPMorgan Chase Institute report on financial markets, we examined three recent events that had major impacts on foreign exchange (FX) markets:

1. **The decision by the Swiss National Bank (SNB) to remove their floor on the Swiss Franc vs. Euro exchange rate (EUR/CHF):** on January 15, 2015, at 9:30 a.m. GMT, the SNB abandoned its floor on the EUR/CHF exchange rate via a surprise press release. The announcement shocked the FX market—EUR/CHF dropped 12.3 percent over the next few hours.
2. **The Brexit referendum:** on June 23, 2016, the United Kingdom (UK) held a referendum on whether the UK should remain a member of the European Union (EU). The “Leave” win led to an 11 percent drop in GBP/USD overnight.
3. **The 2016 US Presidential Election:** On November 8, 2016, the United States (US) held its Presidential Election. The unexpected Trump victory led to an 8.3 percent rise in USD/MXN overnight.

All three events shared one important quality—they had unexpected outcomes that led to the largest one-day moves in these three exchange rates in the last 20 years—that made them ideal candidates for research aimed at building a better understanding of institutional investor trading behavior. With this research objective in mind, we examined institutional investor trades in FX markets in the days and hours leading up to, during, and after each event. We analyzed total **trading volumes** (a measure of trading activity) and **net flows** (a measure of risk transferred) across all institutional investors in our sample, and then examined net flows at the investor sector and region level. Finally, we looked at transactions within each investor type to observe within-sector variation in trading behavior.

## Data

We constructed a unique, de-identified trade-level data asset that includes all available institutional investor transactions where the Markets Division of J.P. Morgan’s Corporate & Investment Bank acted as the market maker. This data asset allows for a highly detailed look at the behavior of institutional investors across all regions and in all asset classes, as our data are more granular, timely, and comprehensive than publicly available data. For this report we narrowed our focus to a sample of FX transactions that took place around three specific events.

### TRANSACTION DATA



**395 MILLION**  
TRADES



**44,000**  
INSTITUTIONAL INVESTORS

#### The data asset covers:

- All types of institutional investors
- All regions globally
- All asset classes: foreign exchange, equities, fixed income, and commodities
- Electronic and voice trades
- The post-financial crisis period (historical coverage varies by asset class)

### SAMPLING CRITERIA

- Spot or forward FX trades
- Relevant currency (SNB—CHF, Brexit—GBP, US Election—MXN) against any currency
- In a 24- (SNB) or 48- (Brexit & Election) hour period around each event
- Not cancelled
- Eliminated trades with: missing trade date/execution time, zero/missing buy or sell amount, missing investor sector, or outlier exchange rates

CHF

SNB 18,000 TRADES • 500 INSTITUTIONAL INVESTORS

GBP

Brexit 99,000 TRADES • 1,500 INSTITUTIONAL INVESTORS

MXN

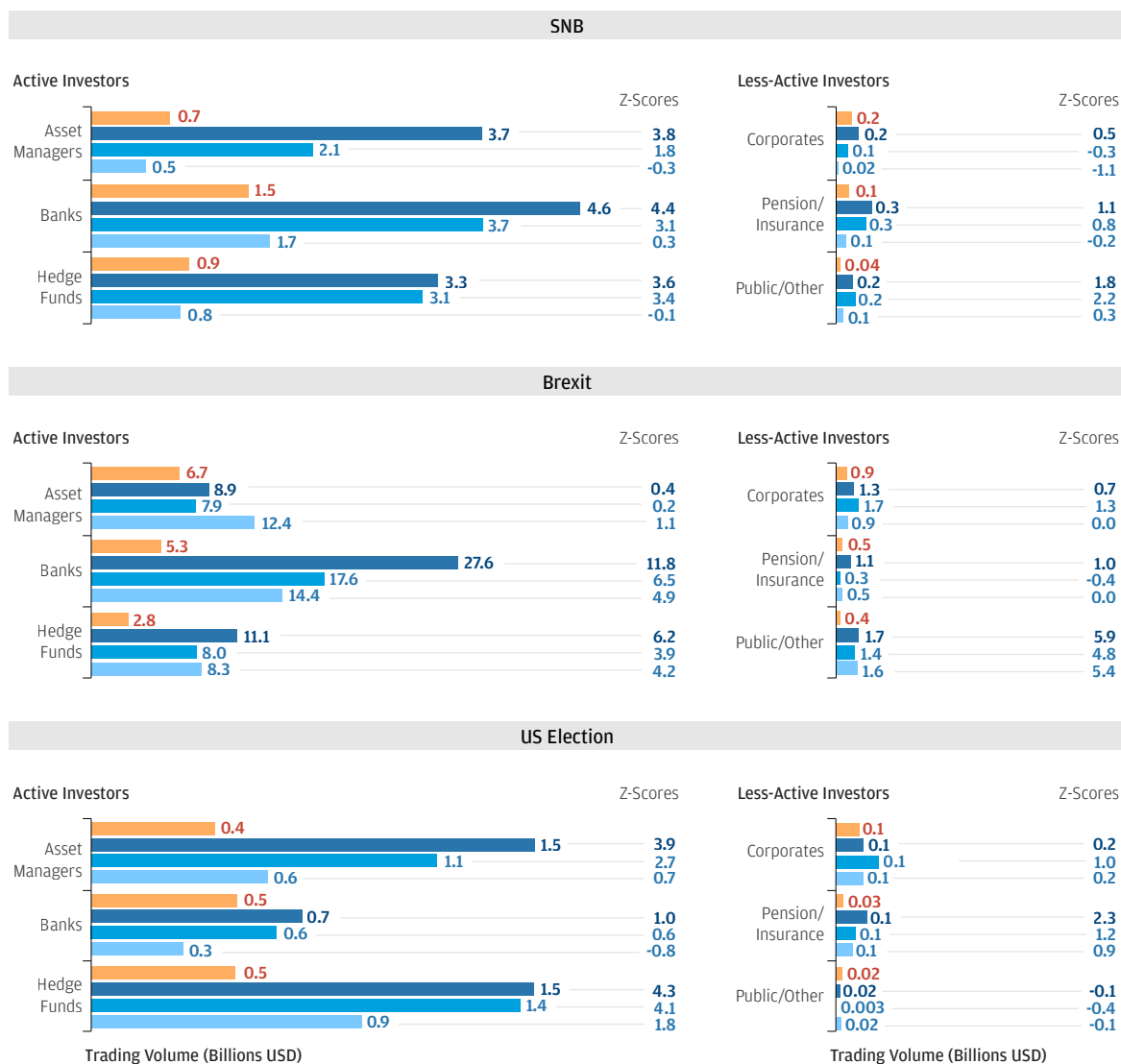
US Election 4,000 TRADES • 500 INSTITUTIONAL INVESTORS

**Finding One**

FX trading volumes for hedge funds, asset managers, and banks spiked during the three events. In contrast, volumes for the corporate, pension/insurance, and public/other investor sectors barely increased.

While overall FX trading volumes spiked, not all investor sectors increased their trading activity relative to their average daily volume. Trading volumes from hedge funds, asset managers, and banks (the active investor sectors) were particularly elevated on the event day itself. In contrast, corporate, pension/insurance, and public/other investors (the less-active investor sectors) showed little change in trading volumes on the three event days relative to their average daily volumes, despite the largest one-day moves in the relevant currencies in 20 years.

Trading Volume by Event and Investor Sector



● Average Daily Volume ● Event Day Volume ● Event Day +1 Volume ● Event Day +2 Volume

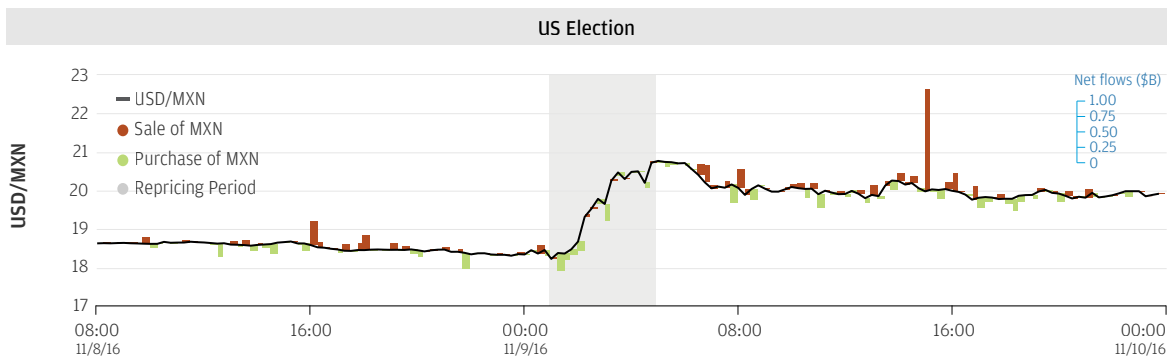
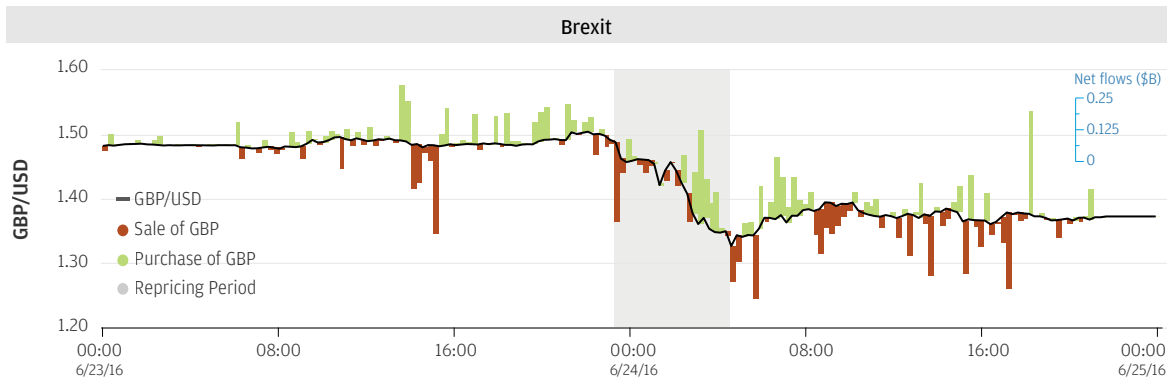
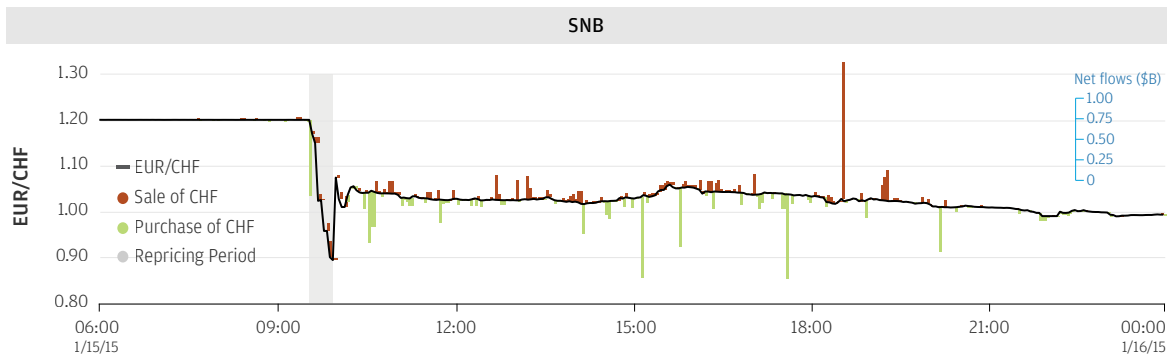
Source: JPMorgan Chase Institute

**Finding  
Two**

**Institutional investors traded significant amounts of FX risk during the events, but their net flows alone cannot explain the sharp exchange rate movements during the repricing periods.**

Our data show that net flows, or risk transferred, by institutional investors during each event was large. However, net flows coincident with the sharp moves in exchange rates were no larger than net flows that took place after exchange rates stabilized, indicating that the exchange rate moves just after the news broke were much larger than net flows alone would dictate. Market liquidity for the three currencies we examined was likely lower immediately after the news broke, and this may partially account for the disproportionate impact of net flows during the repricing periods.

Exchange Rates and Scaled Net Flows (Billions USD) During Each Event Day



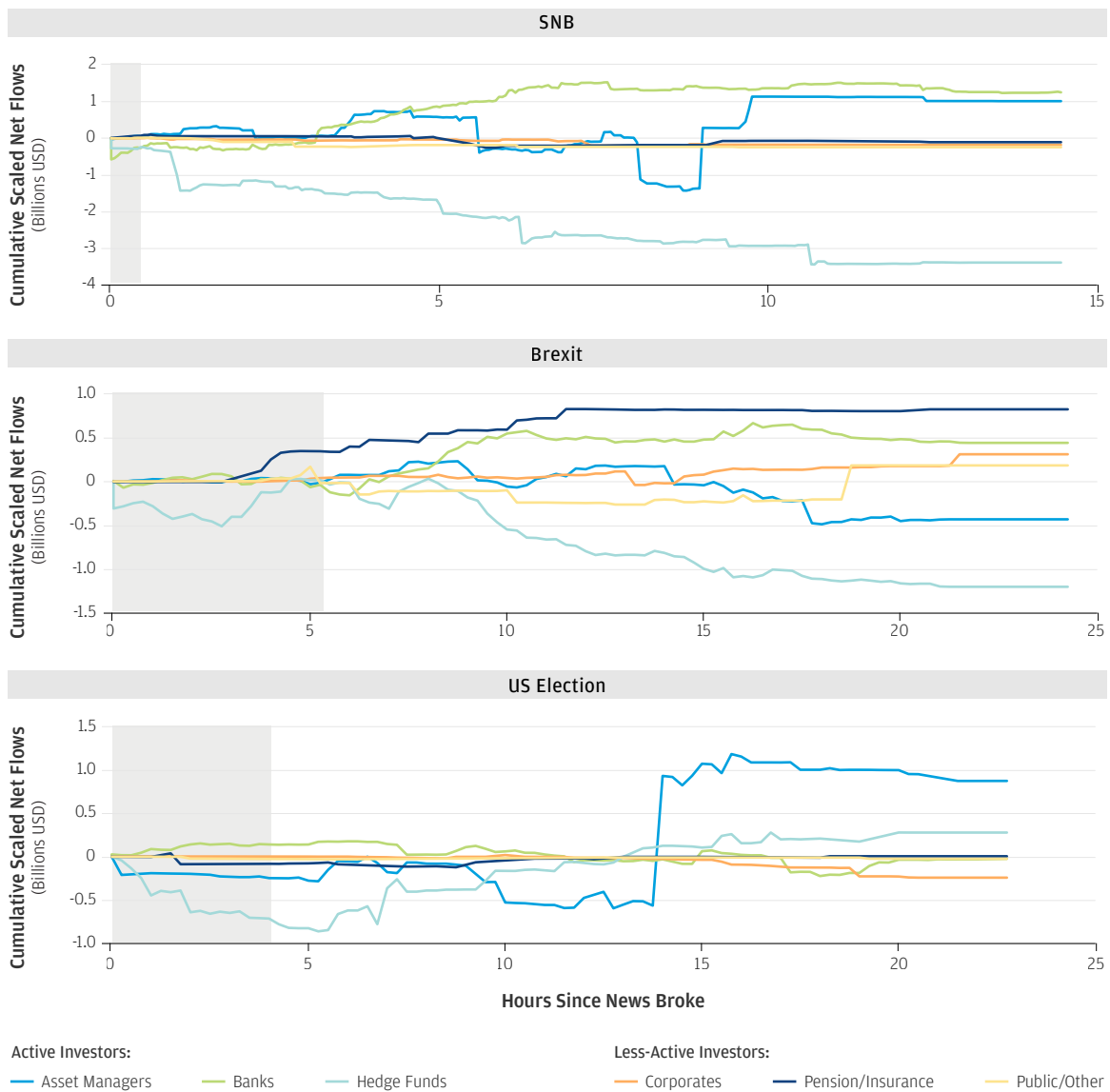
Source: JPMorgan Chase Institute; Thomson Reuters

**Finding Three**

**Only hedge funds consistently transferred risk immediately after news broke and as currencies repriced sharply. Other investors transferred risk but only after exchange rates stabilized.**

Hedge funds traded immediately after news broke and exchange rates began to reprice, transferring large amounts of risk during periods of high exchange rate volatility during all three events. In doing so, hedge funds participated in the establishment of the post-news equilibrium market price. Other investor sectors transferred risk only after market prices had stabilized. These results imply that market makers established a new equilibrium exchange rate without the benefit of net flow information from all the investor sectors and regions.

Cumulative Net Flows During the Repricing and Stabilization Periods, by Event and Investor Sector



Note: Shading denotes the repricing period.

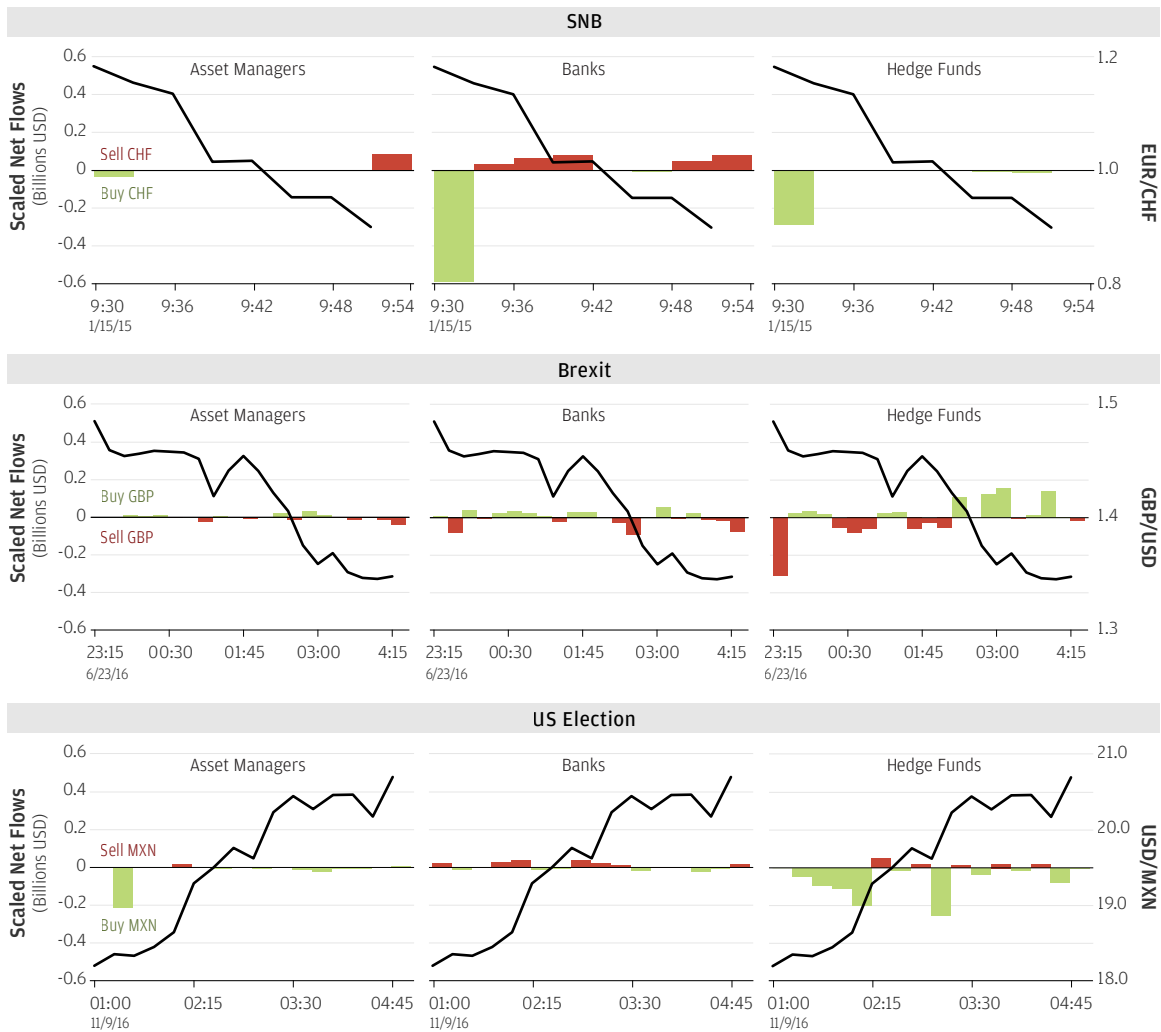
Source: JPMorgan Chase Institute

**Finding  
Four**

The active investor sectors played different roles in each event: During the SNB event, they all bought CHF, trading in the direction of the prevailing move in exchange rates; during the Brexit event their net flows were mixed; and during the US Election event they bought MXN, trading against the prevailing move in exchange rates.

Hedge funds, asset managers, and banks bought CHF as it appreciated sharply in the minutes after the minimum exchange rate policy was removed, leaving market makers as the only market participants selling CHF during this critical period. In contrast, the active investor sectors had a mixed reaction after Brexit, as their net flows reflected both buying and selling of GBP. During the US Election event, these three investor sectors were buying MXN as it depreciated, trading against the prevailing direction of the exchange rate. It is likely that the active investor sectors were all buying CHF after the SNB event because the surprise announcement did not allow them to prepare. While the outcomes were unexpected, the timing of the Brexit referendum and the US Election were well known, giving investors the opportunity to transact ahead of the events and prepare for all possible outcomes.

Net Flows Every 3 or 15 Minutes During the Repricing Period by Event and Investor Sector



Source: JPMorgan Chase Institute; Thomson Reuters

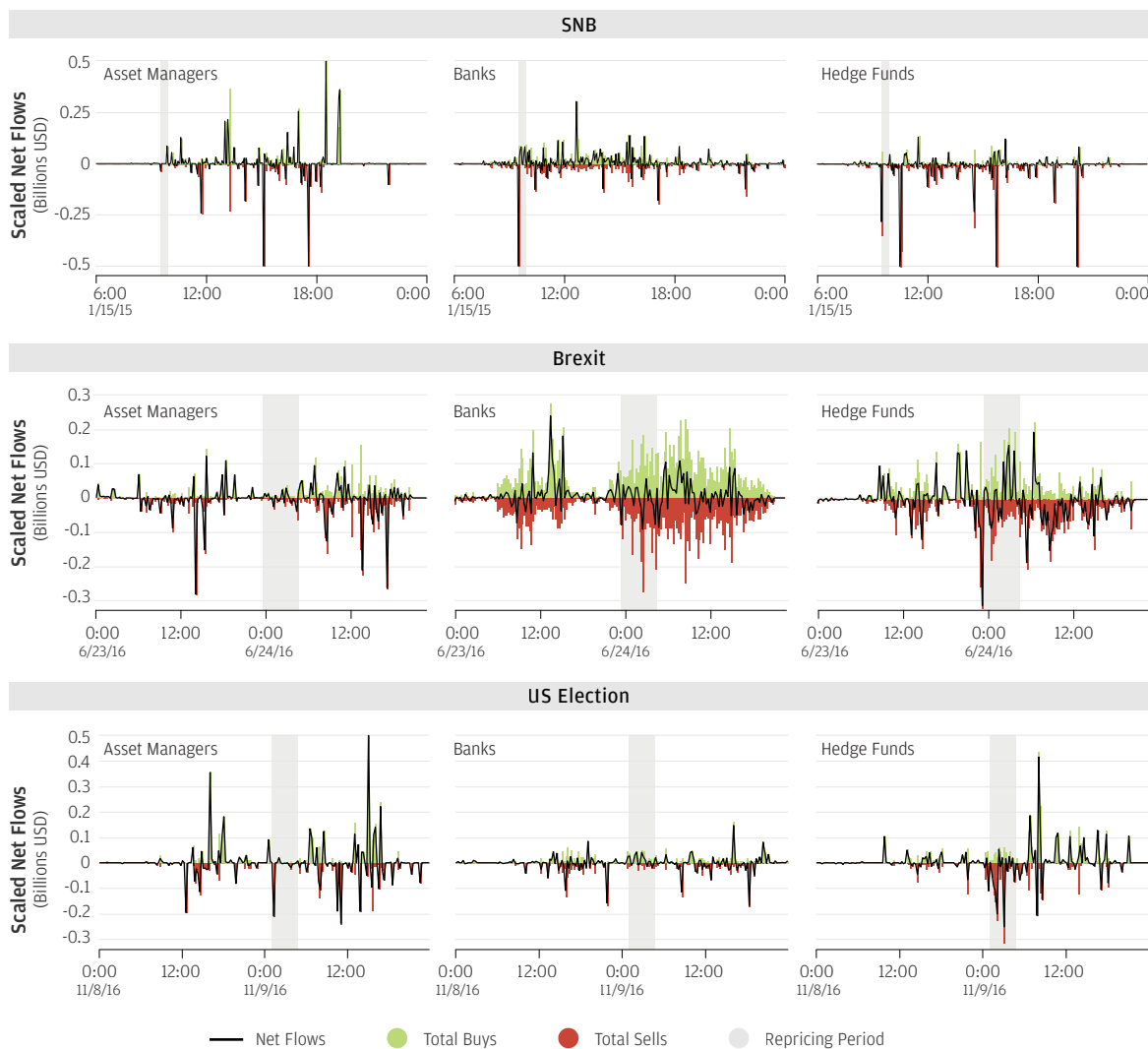


**Finding Five**

**Within each investor sector, there was considerable variation in trading behavior during each event.**

Regardless of the magnitude of the net flows at the sector level in a given time interval, there was actually a significant amount of risk being transferred in both directions by investors within that sector. This within-sector variation refutes the commonly held perception that all investors in a particular sector transacted in the same direction at the same time during these three events.

**Total Buys and Total Sells at the Investor Level During the Pre-Event, Repricing, and Stabilization Periods by Event and Investor Sector**



Note: Net flows, total buys, and total sells have been censored at 0.5 billion USD to better illustrate within-sector variation. The direction of the bars in these graphs are consistent with the other graphs in this report and the exchange rates that we show. This means that for Brexit, "Buys" refers to buys of GBP and "Sells" refers to sells of GBP, but for SNB and the US Election, "Buys" refers to buys of any other currency against CHF and MXN, respectively, and "Sells" refers to sells of any other currency (or buys of CHF and MXN, respectively).

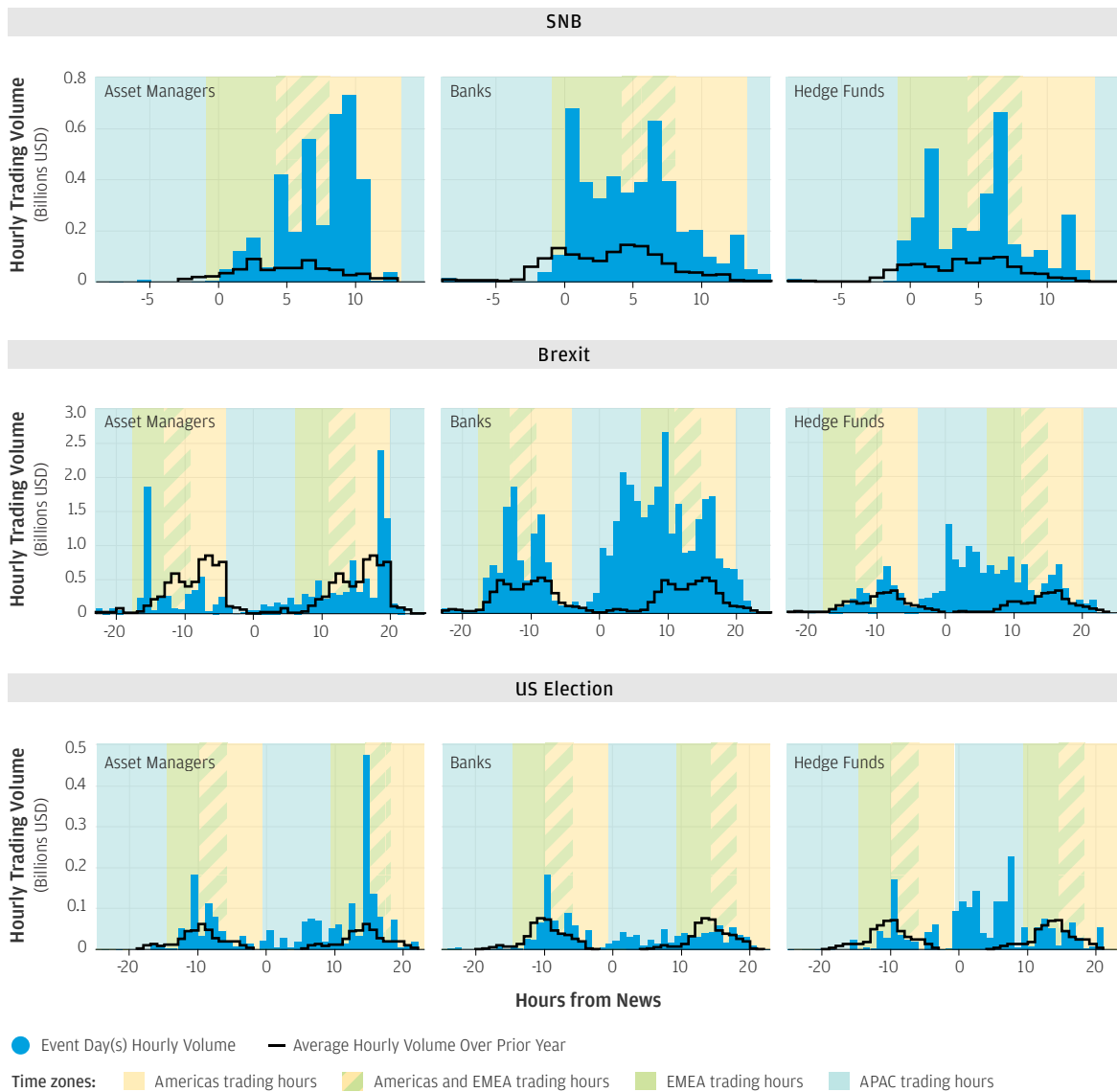
Source: JPMorgan Chase Institute

**Finding Six**

**Banks and hedge funds traded higher volumes outside of their normal business hours and outside of a currency’s local market; other investor sectors did not.**

Bank and hedge fund trading volumes spiked compared to average volumes during the overnight hours for both GBP and MXN, a marked change in trading behavior. These two investor sectors were also the most willing to trade outside of their normal business hours. Asset manager trading volumes only spiked during US trading hours, 10 to 20 hours after the news broke for both the Brexit referendum and the US Election.

Hourly Volume During Each Event vs. Average Hourly Volume for the Year Prior, by Event and Investor Sector



Source: JPMorgan Chase Institute

## Conclusion

In this report, we examined the trading behavior of institutional investors in the hours and days leading up to, during, and after three events that had major impacts on foreign exchange markets. Our results are informative along two dimensions: financial market stability and central bank communications.

Our analysis shows that the institutional investor reactions to major market events, as reflected in trading volumes and risk transferred, varied in pace and size across sectors. The slower risk transfer response of asset managers, corporates, pension/insurance companies, and public sector investors to the three news events that changed perceptions of the fundamental value of each currency suggests these four investor sectors did not participate in the price discovery process. Furthermore, these same four investor sectors did not transact against the prevailing move in exchange rates during the volatile repricing periods of these three events, contradicting the popularly held narrative that long-only investors with long-term investment horizons act as a stabilizing force during market dislocations.

Hedge funds and market makers played an especially significant role in the market ecosystem during these three events. Hedge funds transacted actively in FX markets just after each news event broke and during volatile conditions, participating in the establishment of a post-event market equilibrium. For all three events, market makers reconciled news about the fundamental value of the relevant currency with net flows, adjusted market liquidity, and established a post-event equilibrium exchange rate. When deliberating policies that limit the trading activity of market makers or hedge funds, policymakers can use our results regarding the differential roles institutional investors played in establishing a post-event market equilibrium exchange rate to weigh this factor against any other relevant considerations.

Company policies or regulations that limit the trading activity of institutional investors to their normal business hours or the local market of a currency may prevent these investors from accessing liquidity and mitigating their risk during market-moving events. Limitations to after-hours trading may also reduce market efficiency as markets might take longer to reach a new equilibrium price. With the appropriate safeguards, controls, and security in place, after-hours trading capabilities could be a useful addition for some institutional investors.

While a role for capital controls as a tool for enhancing financial stability in certain instances has gained popularity over the last 10 years, our results imply that strict controls on FX flows may act as a hindrance to market efficiency during times of instability and prevent domestic investors from accessing liquidity abroad.

Our results could be helpful to central banks as they pursue the appropriate balance between their increasing tendency toward transparency in communicating policy actions and other critical factors, such as maintaining their credibility. Enacting unexpected policy changes via a surprise announcement (like the SNB event) may not allow investors to adjust their risk in advance which in turn leads to directional net flows that could amplify price movements. When choosing the most appropriate method to communicate policy changes, policymakers can use these results to help weigh market expectations with respect to both the timing of announcements and the outcome in the context of other pertinent factors and their desired market impacts.

When deliberating unconventional policy measures that directly change the price of financial instruments, policymakers should carefully consider how they will unwind the policy. For example, policies such as the SNB's minimum exchange rate take pricing power away from the market and therefore can distort the incentives and, in turn, the behavior of market participants. To the extent that policymakers want to unwind such a policy and return pricing power to the market with minimal unintended market impacts, the behavior induced by the distorted incentives can become a complicating factor.

# Introduction

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In this inaugural JPMorgan Chase Institute financial markets report, we examined three recent events that had significant impacts on foreign exchange (FX) markets: the decision by the Swiss National Bank to end their minimum exchange rate policy on January 15, 2015, the Brexit referendum on June 23, 2016, and the US Presidential Election on November 8, 2016. All three events shared one important quality—they had unexpected outcomes that led to the largest one-day moves in the relevant exchange rates in the last 20 years—that made them ideal candidates for research aimed at building a better understanding of institutional investor trading behavior. With this research objective in mind, we examined institutional investor trades in FX markets in the days and hours leading up to, during, and after each event.

First implemented on September 6, 2011, the Swiss National Bank's (SNB) minimum exchange rate policy was designed to keep the Swiss Franc (CHF) from appreciating against the Euro (EUR) beyond 1.20 CHF per EUR. As such, the policy was described as a 1.20 floor on the EUR/CHF exchange rate. The SNB enforced this policy by intervening in the FX market—buying EUR and selling CHF, if and when the exchange rate approached the 1.20 floor—to keep EUR/CHF above 1.20. On January 15, 2015, at 9:30 a.m., the SNB abandoned the floor entirely via a surprise press release, rather than gradually or at a scheduled policy meeting. The announcement shocked the market—EUR/CHF moved from 1.201 to 0.895 (25.5 percent) over the next 24 minutes before retracing half of the initial move to settle at 1.053 (12.3 percent) at the end of the London trading day. This was the largest one-day repricing in EUR/CHF in over 20 years, nearly 27 standard deviations above the average. See Box 1 for further details about the SNB's minimum exchange rate policy.

On June 23, 2016, the United Kingdom (UK) held a referendum on whether the UK should remain a member of the European Union (EU). As the referendum date approached, polls suggested that “Remain” would defeat “Leave” by 2 percentage points, and betting markets had a 77 percent chance of “Remain” winning as voting began.<sup>1</sup> Economists predicted that a “Leave” result could cost Britain access to the single EU market, cause a significant

drop in investment in the UK, and potentially cost London its position as a financial center.<sup>2</sup> All of these outcomes would be negative for the British Pound (GBP), and with GBP/USD trading around 1.488 just before the referendum, J.P. Morgan's Corporate & Investment Bank (CIB) Research team predicted GBP/USD would be 1.32 on “Leave” and 1.51 on “Remain.”

In a surprising result, “Leave” won with 51.9 percent of the vote to 48.1 percent for “Remain”, on voter turnout of 71.8 percent (30 million people voted).<sup>3</sup> Figure 2 shows a timeline of how the Brexit referendum outcome unfolded. When the polls closed at 9 p.m. GMT, GBP/USD was around 1.488. As referendum results came in and it became evident that “Leave” would win, GBP depreciated sharply. About an hour after ITV and the BBC both called the referendum for Leave, GBP/USD reached 1.324, a loss of 11.0 percent. The unanticipated “Leave” result led to the largest one-day move in GBP/USD in over 20 years, 14 standard deviations above the average.



The three events we analyzed had unexpected outcomes that led to the largest one-day moves in these exchange rates in the last 20 years, making them ideal for research aimed at building a better understanding of institutional investor trading behavior.

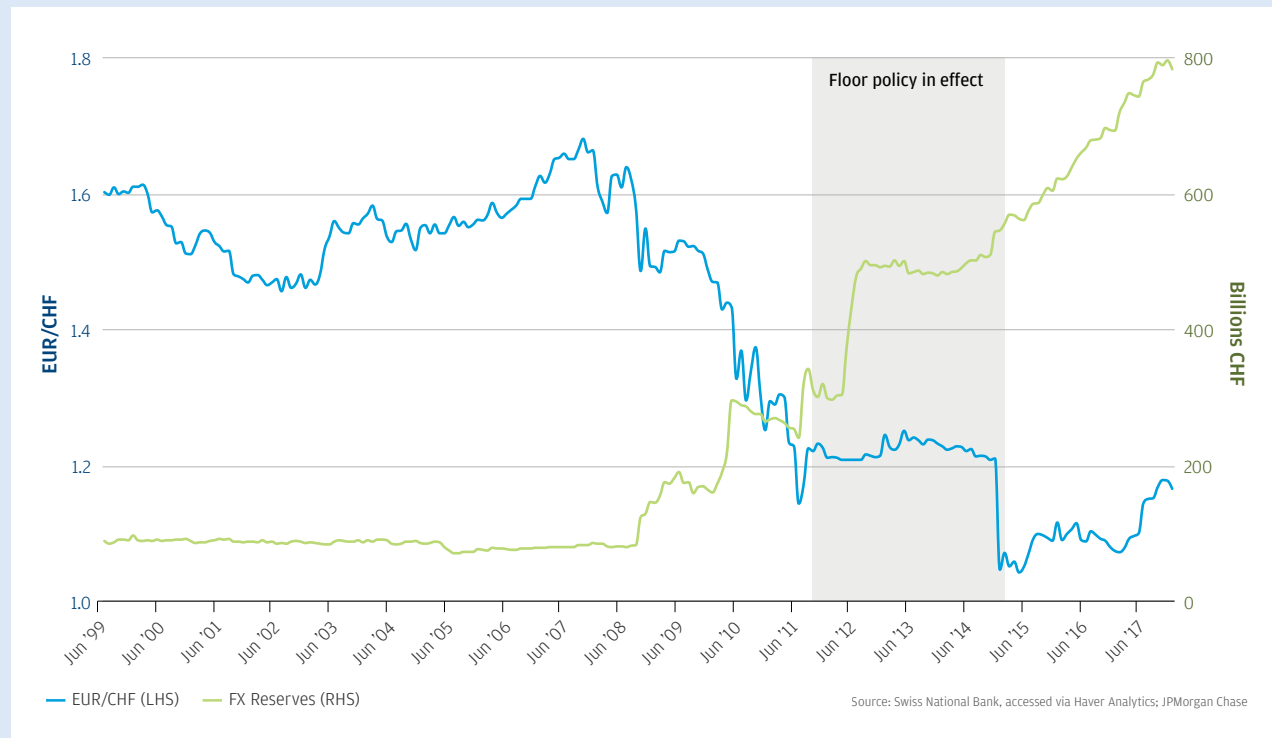
**Box 1: What conditions led to the implementation of the SNB’s Minimum Exchange Rate Policy and why was it removed?**

Between the adoption of the Euro as the Eurozone’s single common currency and 2011, CHF was a free-floating currency, varying in value between 1.032 and 1.679 CHF to one EUR. Figure 1 shows the history of the EUR/CHF exchange rate and the amount of foreign reserves held by the SNB.

Historically, market participants viewed CHF as a safe haven currency. During periods of global market turmoil (e.g., large drops in the stock market, increased market volatility, or increased global political uncertainty), CHF would appreciate against other currencies.<sup>4</sup> Beginning in late 2009, as economic conditions in the Eurozone deteriorated and the sovereign debt crisis gripped markets, CHF began to appreciate against the EUR. Between October 2009 and August 2, 2011, EUR/CHF moved from 1.514 to 1.097 (27.6 percent). Over the same period, the SNB’s foreign exchange reserves nearly doubled; from this we infer that the SNB “intervened” in FX markets (bought EUR and sold CHF) in an attempt to weaken CHF relative to EUR.<sup>5</sup> The SNB took a stand on August 3, 2011, saying a “massively overvalued” CHF posed a threat to Swiss economic growth and increased the risk of deflation, and proceeded with a series of policy actions:<sup>6</sup>

1. On August 3, 2011, in order to discourage investors from buying CHF, the SNB lowered the target range for CHF three-month LIBOR (their main interest rate policy tool) to 0.00–0.25%.<sup>7</sup> They also increased the supply of liquidity to the CHF money market by expanding the amount of bank deposits held at the SNB (known as sight deposits) from CHF30B to CHF80B and repurchasing outstanding SNB Bills.<sup>6, 8</sup>
2. On August 10, 2011, they further expanded banks’ sight deposits to CHF120B and began using foreign exchange swaps to create CHF liquidity.<sup>9</sup>
3. On August 17, 2011, the SNB again expanded banks’ sight deposits to CHF200B.<sup>10</sup>

**Figure 1: The EUR/CHF exchange rate (LHS) and SNB FX reserves (RHS).**



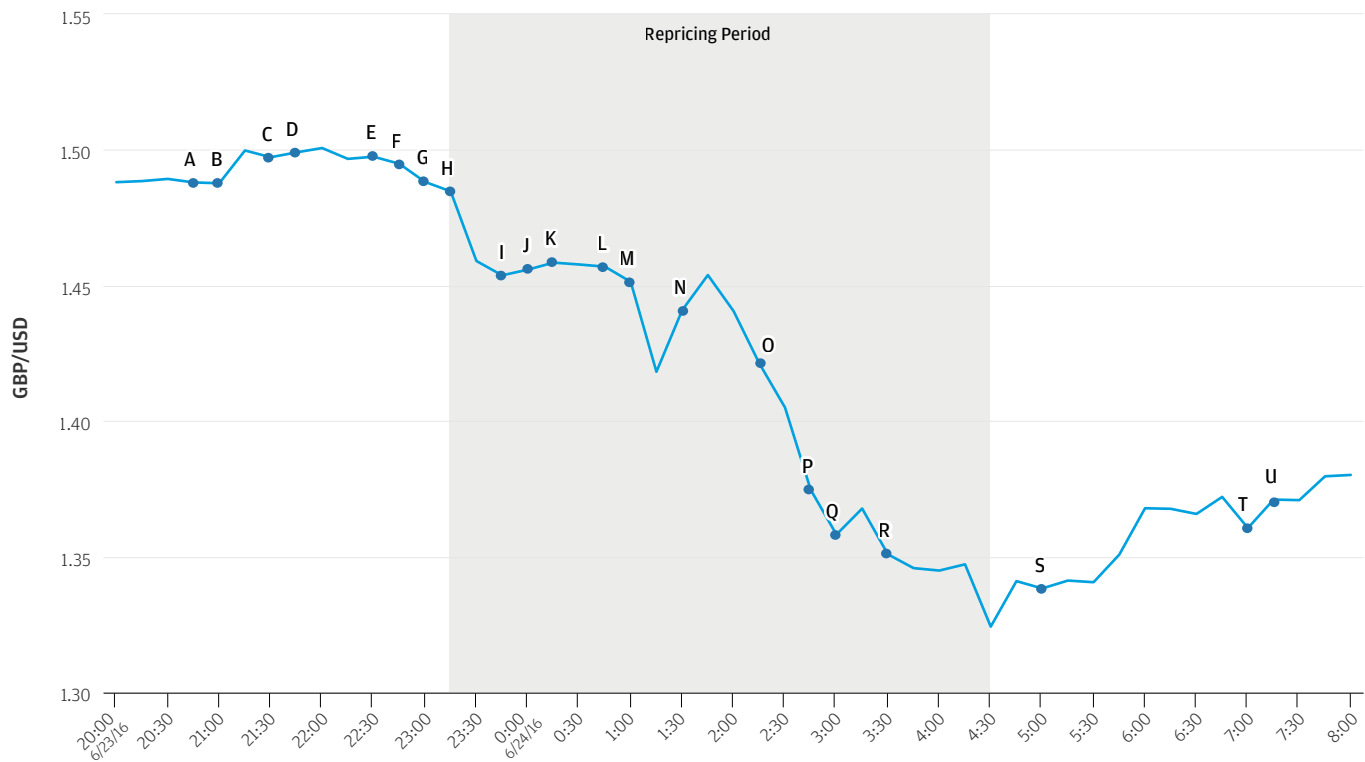
On September 6, 2011, noting that the “current massive overvaluation of the Swiss Franc poses an acute threat to the Swiss economy and carries the risk of a deflationary development,” the SNB surprised the market by announcing a minimum exchange rate policy. In order to weaken CHF in a sustainable and substantial manner, the SNB would “no longer tolerate” a EUR/CHF exchange rate below 1.20. To establish credibility for this policy, the SNB pledged to enforce it “with the utmost determination,” and to be “prepared to buy foreign currencies in unlimited quantities,” stating that “if the outlook and deflationary risks so require, the SNB will take further measures.”<sup>11</sup>

The minimum exchange rate policy had an immediate effect. After settling at 1.111 on September 5, EUR/CHF settled at 1.202 (8.2 percent) on September 6. The floor did in fact hold—between the initiation date and January 14, 2015, EUR/CHF settled between 1.201 and 1.261, as shown in the shaded section of Figure 1.

The SNB built up considerable foreign exchange reserves over the period that the floor was in place (Figure 1); we infer from this that they did in fact intervene in FX markets, selling CHF and buying EUR (and other currencies) when CHF appreciated towards the 1.20 minimum. As a consequence, from the inception of the minimum exchange rate policy in 2011 to the end of 2014, the SNB’s balance sheet had grown from CHF318 billion to CHF542 billion (71 percent), and from 51 percent to 83 percent of Swiss GDP.<sup>12</sup> Of the CHF542 billion total, 46 percent of the balance sheet was held in assets denominated in EUR.<sup>13</sup> As reserves increased, concern mounted that the pace of CHF sales would become unsustainable, because removing the floor would likely mean an immediate and sharp appreciation of CHF, leading to large losses on the SNB’s portfolio.<sup>14</sup>

On January 15, 2015, the SNB surprised the FX market by removing the EUR/CHF floor entirely in an announcement that was not part of a regularly scheduled meeting. EUR/CHF moved from 1.201 to 0.895 (25.5 percent) over the next 24 minutes before partially retracing to settle at 1.053 (12.3 percent) at the end of the London trading day. To support their decision, the SNB suggested that the Swiss economy had been “able to take advantage” of the policy, and because of the recent weakness of CHF against USD, maintaining the minimum exchange rate policy was no longer justified. The policy decision was accompanied by a 50 basis point cut in CHF three-month LIBOR, taking it further into negative territory (-1.25% to -0.25%).<sup>15</sup>

Figure 2: Timeline and GBP/USD exchange rate during the Brexit Event, from 8 p.m. GMT on June 23, 2016, to 8 a.m. GMT on June 24, 2016.



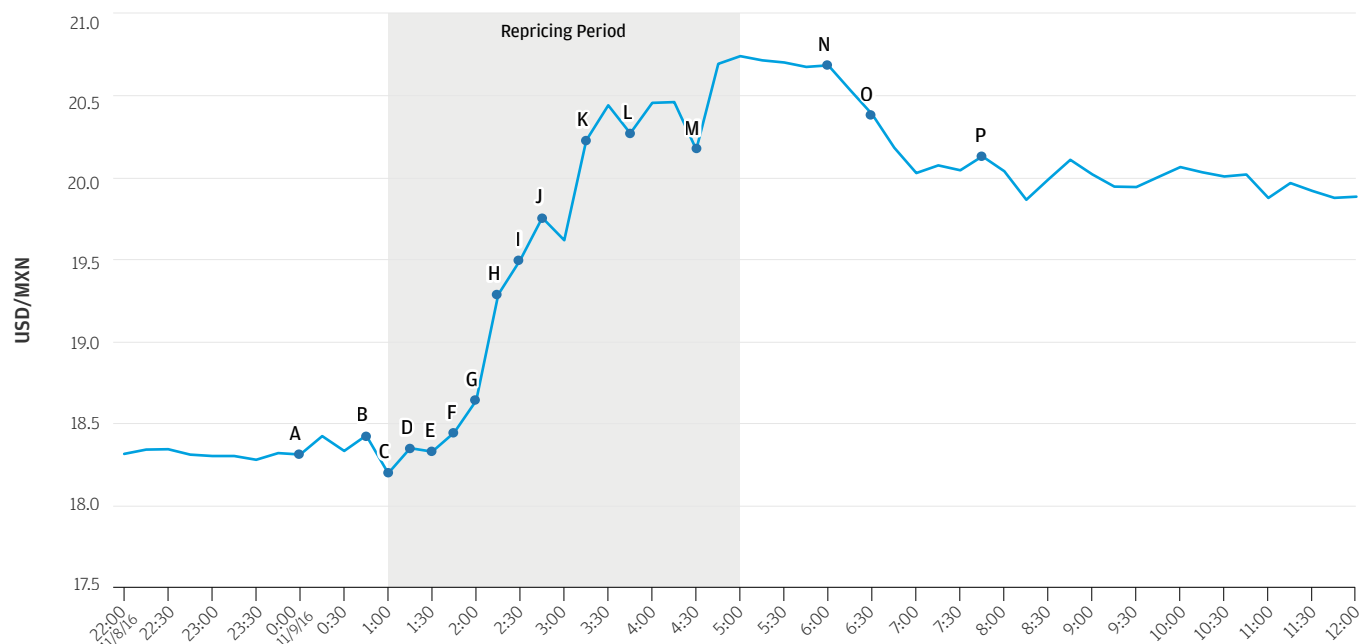
- (A) What UK Thinks poll of polls gives Remain 4-point win and Financial Times Brexit poll trackers give Remain 2-point win.
- (B) YouGov poll gives Remain a 4-point lead.
- (C) Nigel Farage says, "It looks like remain has edged it."
- (D) Guardian starts reporting that turnout was very high.
- (E) First results in: Gibraltar (expected to be pro-Remain) votes to Remain.
- (F) Guardian: Latest reports from Sunderland (seen as a bellweather) suggest, contrary to earlier claims, that Leave is heading for a big win.
- (G) Newcastle-upon-Tyne results: Remain wins by much smaller than expected margin.
- (H) Sunderland results in: Leave wins 61 percent to 39 percent, a much larger margin than expected.
- (I) Swindon results in: Leave wins by 9PP, a larger than expected margin.
- (J) Asian stock markets open; Voter turnout in London (strongly pro-Remain) is lower than expected due to rain while turnout elsewhere has been very high; Guardian: forecasters are predicting a narrow Leave win.
- (K) Kettering results: 61-39 for Leave (expected 59-41); Shetland Islands results: 56.5-43.5 for Remain (expected 63-37).
- (L) Hartlepool results: 70-30 for Leave (forecast 61-39).
- (M) First London results: London's financial district (City of London) more pro-Remain than expected but lower turnout.
- (N) Wandsworth results: 75-25 for Remain (larger than expected margin), the first really positive news for Remain.
- (O) Sheffield results: 51 percent for Leave, expected to go 52 percent for Remain.
- (P) ITV analysts predicting 80 percent chance of victory for Leave; ITV analysts predicting 80 percent chance of victory for Leave.
- (Q) Farage declares June 23 "our independence day."
- (R) ITV calls a win for Leave; BBC calls a win for Leave.
- (S) Leave campaign passes the winning post, the Press Association reports.
- (T) London stock markets open.
- (U) David Cameron remarks.

Source: The Guardian; Slate; CNN; Thomson Reuters

On November 8, 2016, the US held its Presidential Election, pitting Democratic presidential nominee Hillary Clinton against Republican presidential nominee Donald Trump. On election night, the FiveThirtyEight model based on polls suggested that Clinton had a 71 percent chance of winning, and betting markets placed the odds of a Clinton win at 84 percent.<sup>16</sup> The campaign rhetoric from Trump, for example regarding the renegotiation of the North American Free Trade Agreement and increased tariffs on Mexican imports, had foreign exchange market participants considering the impact of a Trump victory on the Mexican Peso (MXN).<sup>17</sup> With USD/MXN trading around 18.5 on Election Day, J.P. Morgan's CIB Research team predicted a move to 21.1 on a Trump victory and a move to 18.2 on a Clinton victory. In a surprising result, Trump won the election by carrying enough states to win 304 electors out of the total of 535 in the Electoral College.

Figure 3 shows a timeline for the US Election results. When the first polls closed at midnight GMT time (7 p.m. EST), USD/MXN was around 18.308. As early results came in and the odds of a Trump win increased, MXN began to depreciate. USD/MXN reached a peak of 20.741 (13.3 percent) around 5 a.m. GMT (midnight EST) after several swing states were either called for Trump or seemed well on their way to being called for Trump, and eventually stabilized around 19.828 (8.3 percent). The unexpected win for Trump led to the largest one-day move in USD/MXN over 20 years, nearly 12 standard deviations above the average.

Figure 3: Timeline and USD/MXN exchange rate for the US Election Event, from 10 p.m. GMT on November 8, 2016, to 12 p.m. GMT on November 9, 2016.



- (A) Polls start closing.
- (B) NYTimes projects that Clinton is slight favorite for Florida.
- (C) NYTimes reports that Clinton's lead in Florida was expected to be larger than early counts are indicating.
- (D) NYTimes reports that (1) late polls in Ohio indicated a better-than-expected Trump performance, and (2) that Trump is doing very well with white rural voters, which are plentiful in Pennsylvania and Michigan, states that Clinton counted on.
- (E) FiveThirtyEight reports that (1) Clinton may still win Virginia, but it's closer than expected, (2) betting markets and FiveThirtyEight now forecast Trump will win Florida, and (3) that the FiveThirtyEight model forecasts Trump will win Ohio.
- (F) NYTimes Upshot model lowers Clinton's chances of winning to 74 percent; NYTimes reports that (1) Clinton is not expected to win Michigan and Pennsylvania by wide margins, and (2) North Carolina and Florida are going to be extremely close even if Clinton wins.
- (G) FiveThirtyEight reports Betfair now places 25 percent chance on Trump winning; FiveThirtyEight model lowers probability of Clinton win to 73 percent from 78 percent.
- (H) Betting markets start to favor Trump; NYTimes reports that Trump could win Michigan, Minnesota, and Wisconsin; FiveThirtyEight reports that early returns in Michigan look bad for Clinton; NYTimes Upshot model lowers Clinton's chances of winning to 50 percent.
- (I) FiveThirtyEight reports that Upshot model has Michigan at a tossup; NYTimes Upshot model puts Trump's odds of winning at 51 percent.
- (J) Virginia called for Clinton (Fox).
- (K) Ohio called for Trump, first swing state (MSNBC).
- (L) North Carolina called for Trump (Fox); Florida called for Trump, a key battleground state (AP).
- (M) Wisconsin called for Trump (Fox).
- (N) Pennsylvania called for Trump, virtually guaranteeing him victory (AP).
- (O) Trump wins Wisconsin (CNN; NYTimes), putting him over 270 electoral votes; Clinton calls Trump to concede.
- (P) Trump gives victory speech.

Source: The Guardian; Business Insider; USElectionAtlas.org; New York Times; FiveThirtyEight; Thomson Reuters

Our main objective in studying these three recent events was to build a better understanding of institutional investor trading behavior. To do so, we examined trading in FX markets as each of these events transpired. We began with an analysis that spanned all institutional investors in our sample in the periods before, during, and after the three events unfolded, and then examined trading activity by investor sector and region. Finally, we looked at transactions within each investor type to observe within-sector variation in trading during these three events.

It is important to note that the three events we analyzed had to do with public news that affected the fundamental value of the three currencies in question, and therefore our findings and implications should be considered in this context. Furthermore, the three events we studied differ along many important dimensions, five of which we outline below. These five differences, among others, could account for the variation in trading behavior we observe across the three events. Therefore, when we compare trading behavior across the three events, we draw contrasts based on this framing.

First, the SNB event came in the form of a surprise announcement. In contrast, both the Brexit referendum and the US Election were highly anticipated events with known timing, but where the outcomes were different than consensus expectations. The fact that the SNB announcement came as a surprise is noteworthy in the context of the material increase in communication and transparency from developed market central banks. Over the last 25 years, as a matter of policy, central bankers have concluded that more transparency and open communication with the public would improve the effectiveness of monetary policy. For example, prior to 1994, the Federal Reserve did not explicitly announce changes in interest rate policy, whereas today, there are multiple Federal Reserve speeches and



testimonies before Congress, in addition to FOMC statements, press conferences, meeting minutes, full meeting transcripts, and a quarterly summary of the FOMC's projections for key economic variables and the federal funds rate for Fed watchers to consume.<sup>18</sup> The European Central Bank has taken many of the same measures and, in various speeches, the SNB has also acknowledged that transparency improves the effectiveness of monetary policy and taken similar steps to enhance communication.<sup>19</sup>

Second, the SNB decision was announced at 9:30 a.m. GMT through a widely disseminated press release, and the EUR/CHF exchange rate repriced in a matter of minutes. In contrast, the results of the Brexit referendum and the US Election unfolded over several hours as voting results were announced region by region, and both GBP and MXN depreciated over the course of four or five hours.

Third, the SNB event was a central bank policy decision and had direct implications for the EUR/CHF exchange rate. Both Brexit and the US Election events were based on voting outcomes, and the policy implications of a "Leave" result and a Trump victory on GBP/USD and USD/MXN, respectively, were indirect and subject to much more uncertainty that would be resolved over a much longer period.

Fourth, the three currencies we examined, CHF, GBP, and MXN, are associated with economies of different sizes and connections to the global economy. Two are developed market currencies, and one is a developing market currency, and each has different trading volumes and liquidity.<sup>20</sup> As a result, institutional investor exposure to and trading interest in each of the currencies in our analysis varies. For example, a hedge fund with global macroeconomic trading strategies will likely trade all three currencies, whereas a UK pension fund manager may only own assets denominated in GBP and USD and therefore only trade GBP/USD.

Fifth, the SNB event took place during local trading hours, while the results of the Brexit referendum and the US Election only became clear in the overnight hours for Europe and the US respectively. FX markets are generally considered to be open 24 hours per day (save for Saturday and Sunday morning GMT time) as most large market makers transfer their trading operations with daylight—from New York to Sydney to Tokyo to Singapore to London and then back to New York—but trading volumes and market liquidity for each currency vary from hour to hour.

## Our Analysis

To analyze these three events, we used our newly available transaction data set (described in more detail in the Data Asset section) that included all available spot and forward FX transactions where an institutional investor bought or sold CHF, GBP, and MXN against any other currency in the days and hours before and after each event. We did not capture interdealer transactions.<sup>21</sup> Our data included transactions executed over voice channels and electronic channels. For a more detailed description of the market microstructure of FX markets, see King, Osler, and Rime (2011).

For each transaction in our data set, a J.P. Morgan FX trading desk acted as **market maker**. Market makers provide liquidity to institutional investors by providing (1) a firm price at which they will buy or sell a financial instrument and (2) immediacy, standing ready to buy or sell despite near-term imbalances in supply and demand. To illustrate the role of a market maker, suppose an investor wanted to buy EUR100 million and sell CHF and asked J.P. Morgan (among other market makers) to price such a transaction. J.P. Morgan would propose the exchange rate for the transaction, for example at 1.205 CHF per EUR. If the exchange rate shown by J.P. Morgan was best among the market makers and accepted by the investor, then J.P. Morgan would sell the investor EUR100 million and buy from the investor CHF120.5 million. By executing this transaction, the investor has transferred risk to the market maker: J.P. Morgan is now shorter EUR100 million and longer CHF120.5 million relative to their positions prior to this trade, has provided liquidity to the investor, and put capital at risk. Examples of market makers in foreign exchange include banks, broker-dealers, and high-frequency trading firms. Institutional investors choose which market makers to transact with based on many factors, including price and relationship. For a more complete description of the role of market makers in setting prices, see Weill (2007).

It is important to note that our data only includes transactions, and does not contain any position information. As such, we could not discern whether an investor is long or short a particular currency. Furthermore, we could not see the currency exposure generated by other assets or enterprise-related risks. In this report, we limited our analysis to spot and forward FX transactions and did not include other types of financial instruments (e.g., FX options) that might create currency exposure for investors.

J.P. Morgan's market share as a market maker in spot and forward FX across all currencies varies from year to year between 10 percent and 15 percent. Broadly speaking, we believe that J.P. Morgan's overall market share is large enough that our transactions data was generally representative of the market activity of all types of institutional investors in the relevant markets we studied.

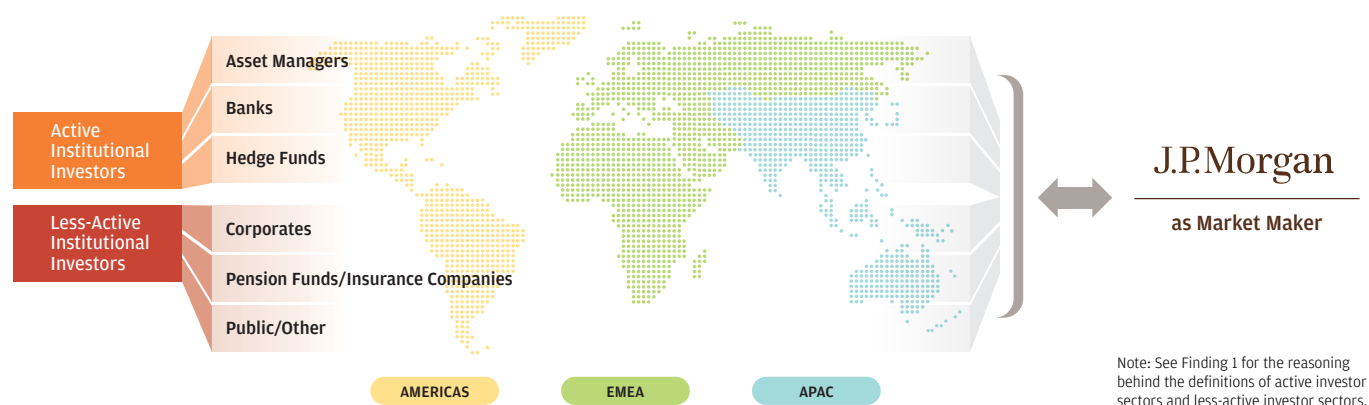
However, there is natural variation in J.P. Morgan’s market share across different currencies, investor sectors, regions, and time zones, and this is an important factor to consider when interpreting the results of our analysis. Of the three currencies we studied our market share was highest for GBP and lowest for MXN. For more information about our market share, see the Data Asset section of this report.

We grouped institutional investors by sector, region, and activity level, as shown in Figure 4. The six sectors are: hedge funds, asset managers, banks, corporates, pension funds/insurance companies, and public/other.<sup>22</sup> The bank category includes the Chief Investment Office and Treasury departments of banks, which might execute FX transactions to hedge their assets or liabilities. The bank category also includes broker dealers and the FX market-making operations of smaller banks that transact with J.P. Morgan for liquidity. The inclusion of the latter category likely accounts for much of the two-way net flows (both buying and selling) we see from this sector in the same or adjacent time intervals.

We grouped investors into three regions based on the location of the entity (and person) executing the transaction: Americas, Europe/Middle East/Africa/Other (EMEA), and Asia/Pacific (APAC).

We made the “active” and “less-active” investor sector distinctions based on analysis of trading volumes, which we describe in Finding 1. See the Data Asset section for a more detailed description of the institutional investors in our data.

Figure 4: Institutional investor classification scheme.



Note: See Finding 1 for the reasoning behind the definitions of active investor sectors and less-active investor sectors.

To measure trading activity, we calculated gross **trading volume** as the sum of the absolute value of the amount of the currency in question that was bought or sold in the set of transactions analyzed. Gross trading volume does not indicate the amount or direction of the risk transferred (i.e., whether the investors were buying or selling the currency in question).

To measure the amount and direction of risk transferred by investors, we used **net flows**. Net flows were calculated as the sum of the amount of the currency in question that was bought or sold in the set of transactions analyzed. Because we included the direction of the transaction (buys have the opposite sign as sells), net flows capture the directional risk transferred by the investor to the market maker. We aggregated net flows over short time intervals (three minutes for the SNB announcement and 15 minutes for Brexit and the US Election) in order to reduce noise and improve data visualization. For a full description of these calculations, see the Methodology section.

At times, we calculated cumulative trading volume or cumulative net flows over a 24- or 48-hour period. When interpreting those results, it is important to remember that while we believe our market share to be material and representative, the true cumulative change in position for an investor would include both their starting position and their trades with market makers other than J.P. Morgan.

To compare net flows across currencies, we made two adjustments. First, we converted net flows into their USD equivalent using tick data for USD/CHF, GBP/USD, and USD/MXN.<sup>23</sup> Second, because the risk of an equivalent amount of USD in each currency is not the same, we applied a scaling factor to normalize risk across currencies. For example, the risk to the investor of a \$50mm GBP transaction is not the same as the risk of a \$50mm MXN transaction, despite the fact that they both have the same USD equivalent. The average daily volume (ADV) for each currency is different, so trading \$50mm of each currency will consume a different proportion of the ADV for that currency. Furthermore, the volatility of each exchange rate is different, and therefore the amount by which the

value of each transaction can be expected to change over time will be different. Taking these two factors into consideration, we normalized net flows in USD equivalents using a measure of the volume-to-volatility ratio (VtV) for each currency.

The VtV ratio expresses how much volume is needed to generate one unit of volatility in price returns. A large VtV indicates that the currency exhibits little volatility even for large volumes, and therefore the currency is more liquid. A small VtV indicates that the currency exhibits more volatility for smaller volumes, and therefore is less liquid. By scaling our net flows using VtV, we aimed to account for the differences in risk described above and make net flows across currencies comparable. For a full description of these calculations, see the Methodology section.

Throughout this report, we performed analysis both at the daily level and at the intraday level, and all times are reported in GMT. For analysis at the daily level, we defined each event as covering a 24-hour period from 0:00 GMT to 23:59:59 GMT:

1. SNB event on 1/15/15
2. Brexit event on 6/24/16 (the day after the referendum)
3. US Election event on 11/9/16 (the day after the election)

For intraday analysis, we defined each event as covering the following periods:

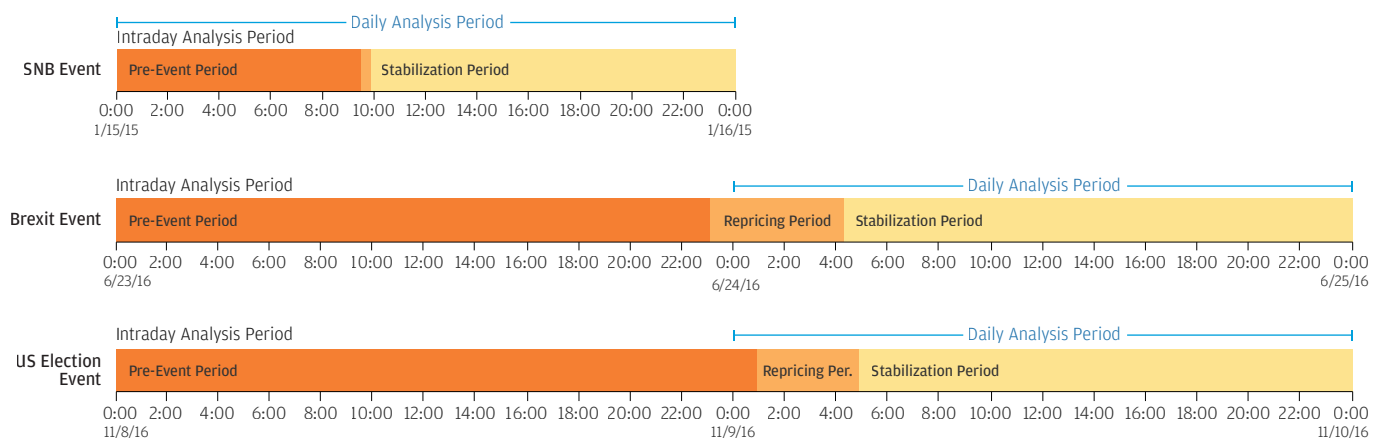
1. SNB event covers the 24-hour period from 1/15/15 0:00 GMT to 23:59:59 GMT (same as above)
2. Brexit event covers the 48-hour period from 6/23/16 0:00 GMT to 6/24/16 23:59:59 GMT (the day of the referendum and the day after)
3. US Election event covers the 48-hour period from 11/8/16 0:00 GMT to 11/9/16 23:59:59 GMT (the day of the election and the day after)

For intraday analysis, we further divided each event into three shorter periods:

1. A **pre-event period**, which covered the hours before the news broke, during which exchange rates were largely stable. For the SNB event, the pre-event period ended just before the 9:30 a.m. announcement. For Brexit and the US Election, the pre-event periods ended just as sentiment began to shift toward “Leave” and President Trump respectively.
2. A **repricing period**, that started just after the news broke or sentiment started to shift, during which exchange rates repriced rapidly. This period generally covered the peak to trough (or trough to peak) in the exchange rate and is shaded on the event time lines (Figures 2 and 3).
  - a. The SNB repricing period began at 9:30 a.m. GMT on 1/15/15 and ended at 9:54 a.m. GMT on 1/15/15
  - b. The Brexit repricing period began at 11:15 p.m. GMT on 6/23/16 and ended at 4:30 a.m. GMT on 6/24/16
  - c. The US Election repricing period began at 1 a.m. GMT 11/9/16 and ended at 5 a.m. GMT on 11/9/16
3. A **stabilization period**, which cover the hours after the repricing period, during which exchange rates partially retraced and eventually stabilized

Our periods of analysis are summarized in Figure 5.

Figure 5: Summary of analysis periods.



Source: JPMorgan Chase Institute

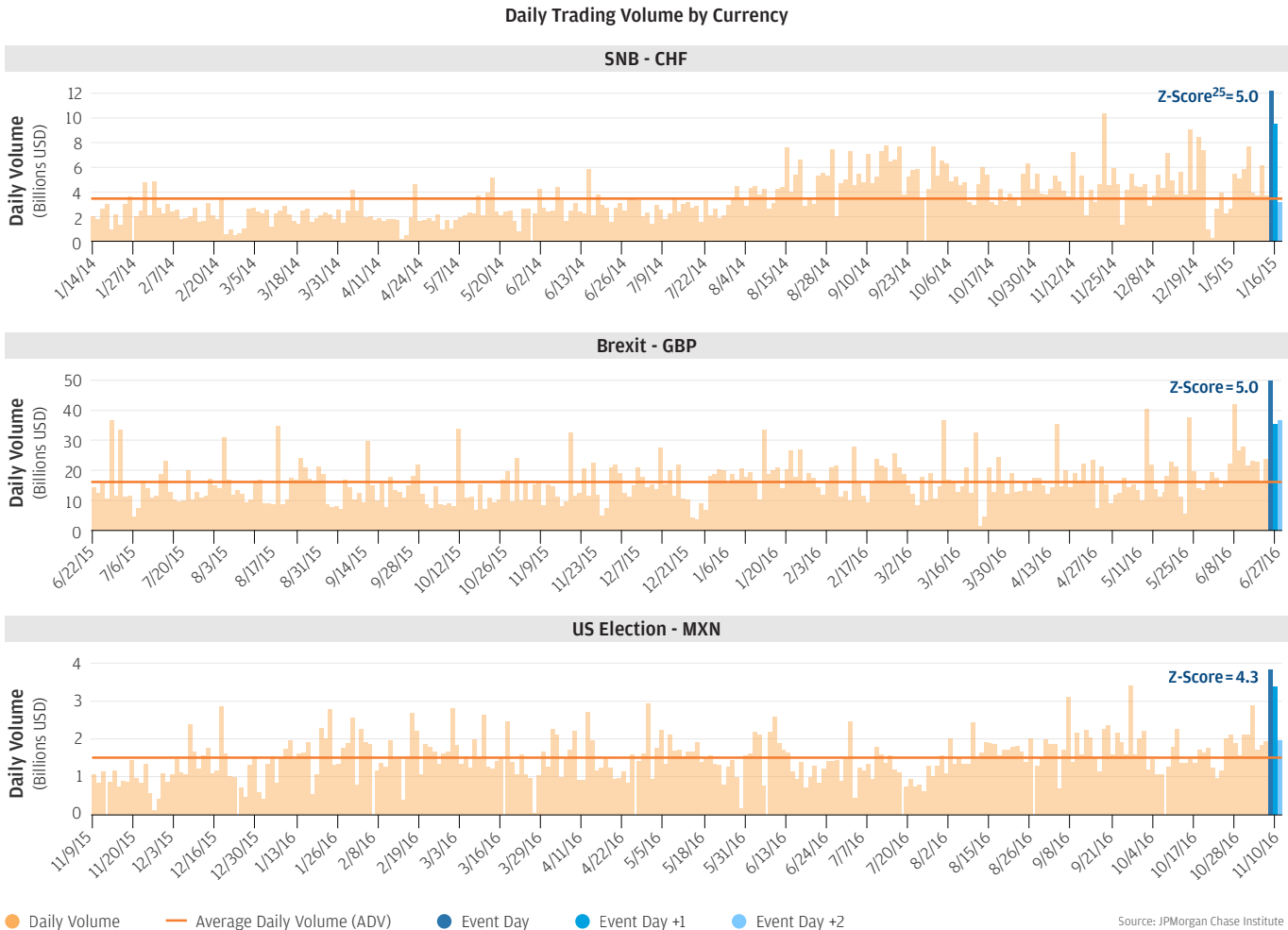
# Findings

## Finding One

FX trading volumes for hedge funds, asset managers, and banks spiked during the three events. In contrast, volumes for the corporate, pension/insurance, and public/other investor sectors barely increased.

Overall FX trading volumes spiked on the SNB, Brexit, and US Election event days. Figure 6 shows daily trading volumes for CHF, GBP, and MXN for the 12 months leading up to each event, the event day itself, and the two days after each event. While daily trading volumes show a fair amount of day-to-day variance, trading volumes on the three event days set the 12-month high for each currency and were between 4 and 5 standard deviations above the ADV for the year prior to the event.<sup>24</sup> However, the spike in trading volume was short-lived; two days after the event, volumes reverted closer to average levels.

Figure 6: Trading volume on the three event days set a 12-month high and was 4 to 5 standard deviations above the ADV in the year prior.

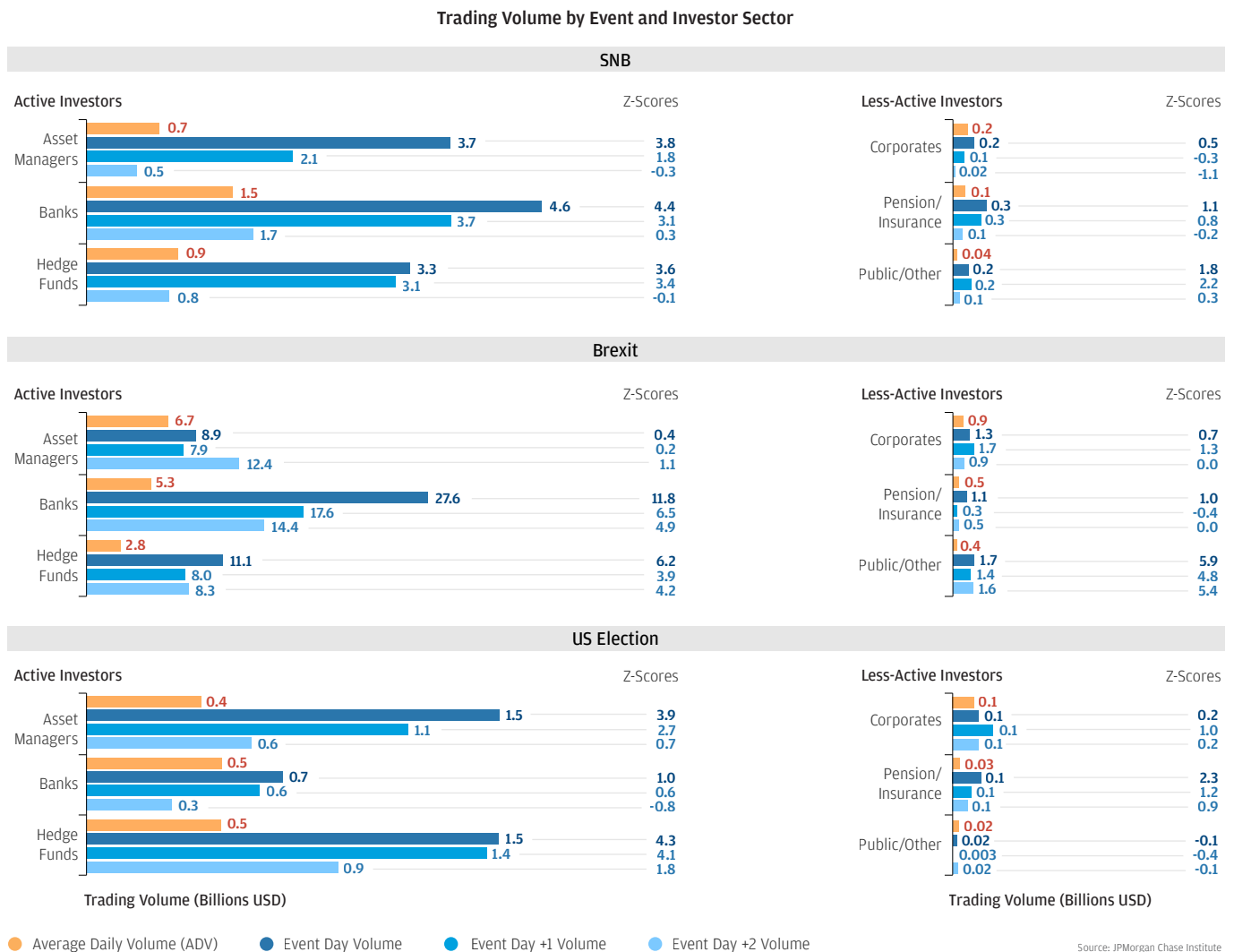


While overall trading volumes spiked, interestingly not all investor sectors increased their trading activity. This is illustrated in Figure 7, which shows trading volumes and one-year z-scores for each investor sector on the event day and the two subsequent trading days, along with the ADV for the previous 12-month period. Certain investor sectors showed a sharp increase in their trading activity during the event day, while others showed a more muted response, indicating that the reaction in trading volumes varied by investor sector.

Hedge fund, asset manager, and bank volumes were particularly elevated on each event day. Total volume for hedge funds was more than 3.5 standard deviations above the ADV across all three events. Asset managers traded nearly 4 standard deviations more than their ADV during the SNB event and the US Election. Bank trading volumes were well above average for the SNB event and nearly 12 standard deviations above the average for Brexit. Going forward, we will refer to this group (hedge funds, asset managers, and banks) as “Active Investors,” as their trading volumes fit this description.

In contrast, event day trading volumes for the corporate, pension/insurance company, and public/other investor sectors were not particularly high relative to their ADV. In seven of the nine less-active investor sector-event combinations shown on the right-hand side of Figure 7, event day volumes were less than 2 standard deviations above the ADV. Even including the two trading days after the event, volumes for these investor sectors were not particularly elevated despite the record size of the exchange rate moves.<sup>26</sup> We will refer to this set of investor sectors as “Less-Active Investors.” Their ADVs were low relative to the active investor sector, and their event day trading volumes were much less responsive to the three events in our study.

**Figure 7: Hedge fund, asset manager, and bank event day trading volumes were elevated, while the corporate, pension/insurance, and public/other investor sectors showed a more muted response.**



## Finding Two

**Institutional investors traded significant amounts of FX risk during the events, but their net flows alone cannot explain the sharp exchange rate movements during the repricing periods.**

After the news broke for each event, exchange rates repriced rapidly before eventually stabilizing at a post-event equilibrium. Institutional investors traded significant amounts of FX risk during the events, but net flows alone cannot explain the sharp exchange rate adjustments that took place during the repricing period.

Figure 8 provides an intraday look at each event, showing the evolution of each exchange rate and aggregated net flows over three-minute (for the SNB event) or 15-minute (for the Brexit and US Election events) intervals during the 24- or 48-hour event period. Net flows are represented by bars “hanging” from the exchange rate series, and the repricing period is shaded. The direction of the bars is consistent with the representation of the exchange rate: a bar above the exchange rate line represents selling of CHF against another currency for the SNB event, buying of GBP against another currency for the Brexit event, and selling of MXN against another currency for the US Election event.

In some instances, the direction of overall net flows is consistent with the prevailing changes in the FX rate, but not always. For example, in the three minutes following the SNB press release (Figure 8, top panel), we see buying of nearly \$1 billion scaled CHF against other currencies. The large purchases of CHF during this three-minute period coincide with a 2.5 percent appreciation of CHF vs. EUR. In contrast, we see net buying of MXN against other currencies at the start of the US Election repricing period (Figure 8, bottom panel), just as the odds tilt towards a Trump win and MXN depreciates. Therefore, there is evident variation in how much observed net flows impact market prices, and we explore this variation and potential explanations below.

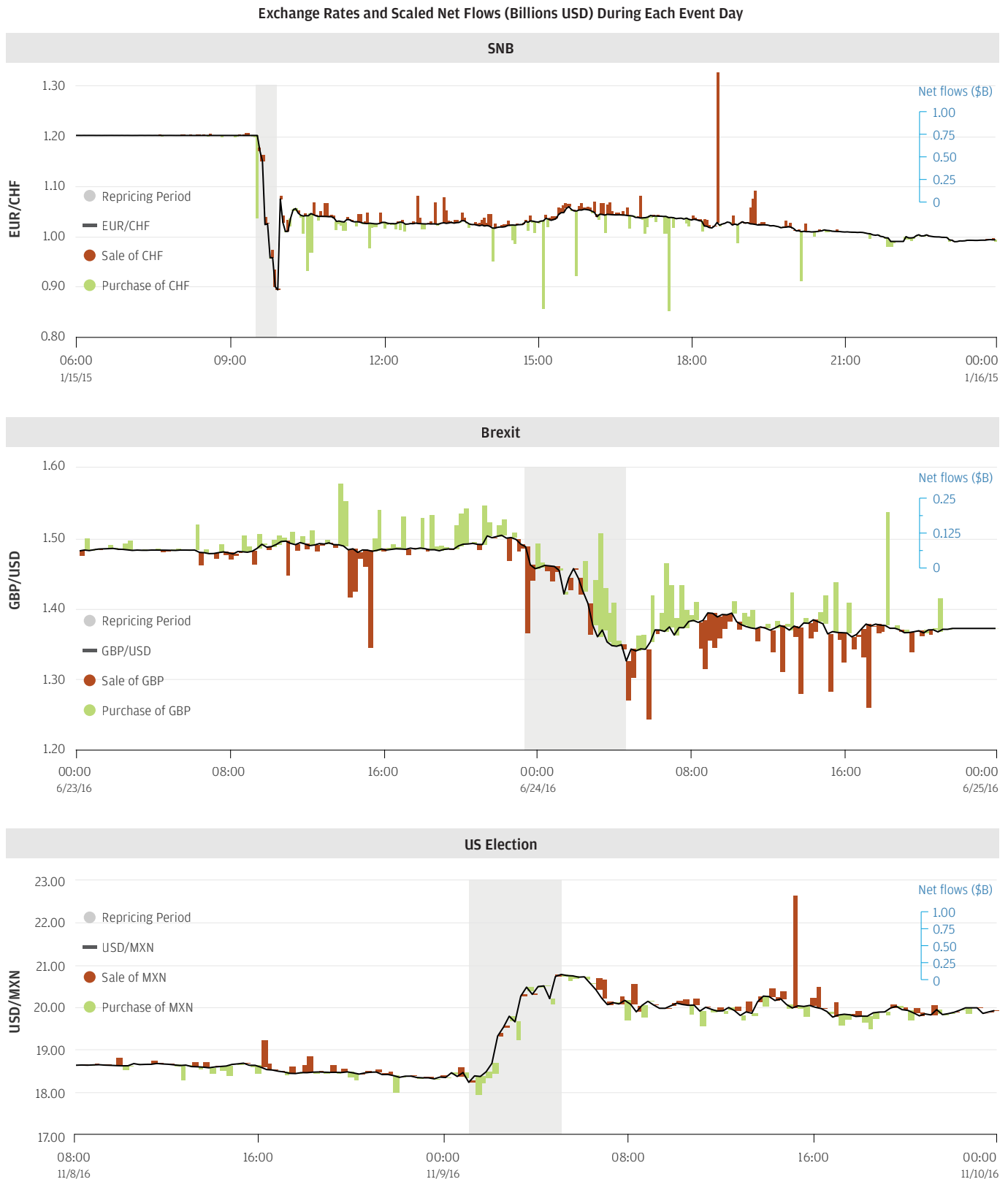
Pre-event positions held by market participants influence net flows after an event, and this may in part explain the variation in the relationship between net flows and exchange rates described above for the SNB event and the US Election. It is likely that the surprise nature of the SNB event did not allow for pre-event position adjustments, while the highly anticipated US Election event did. The lack of net flows in the SNB pre-event period relative to the pre-event periods for Brexit and the US Election highlighted in Figure 8 support this idea.

Furthermore, while the amount of risk transferred during the periods of sharp exchange rate repricing was large, it was not completely unprecedented relative to risk transferred during the stable periods that followed. The net flows during the volatile repricing period were not much larger in size than the net flows during the stabilization period, when exchange rates were steadier. Therefore, net flows alone cannot account for the sharp exchange rate changes. We see visual evidence of this in Figure 8—the relative sizes of the net flows do not correspond to the relative movement in exchange rates between the repricing and stabilization periods.

To provide further supporting evidence of the variation in the relationship between net flows and changes in exchange rates, we compared the absolute value of net flows and the speed of price changes from the repricing period to the stabilization period. Figure 9 presents the average size of net flows across each three- or 15-minute interval in the repricing and stabilization periods, as well as the average change in exchange rate over the same intervals. For this analysis, we were agnostic as to the direction of risk transferred across time intervals and therefore used the absolute value of both net flows and exchange rate changes. The data in Figure 9 indicate that the ratio of average risk transferred per three or 15 minutes between the two periods is much smaller than the ratio of average changes in exchange rates. Thus, the same amounts of net flows were occurring concurrently with a much larger exchange rate impact during the repricing period than during the stabilization period.

It is likely that the surprise nature of the SNB announcement did not allow institutional investors to make pre-event position adjustments, while the highly anticipated US Election did.

Figure 8: Institutional investors traded significant amounts of risk during each event, but net flows alone cannot explain the exchange rate moves during the repricing periods (shaded).

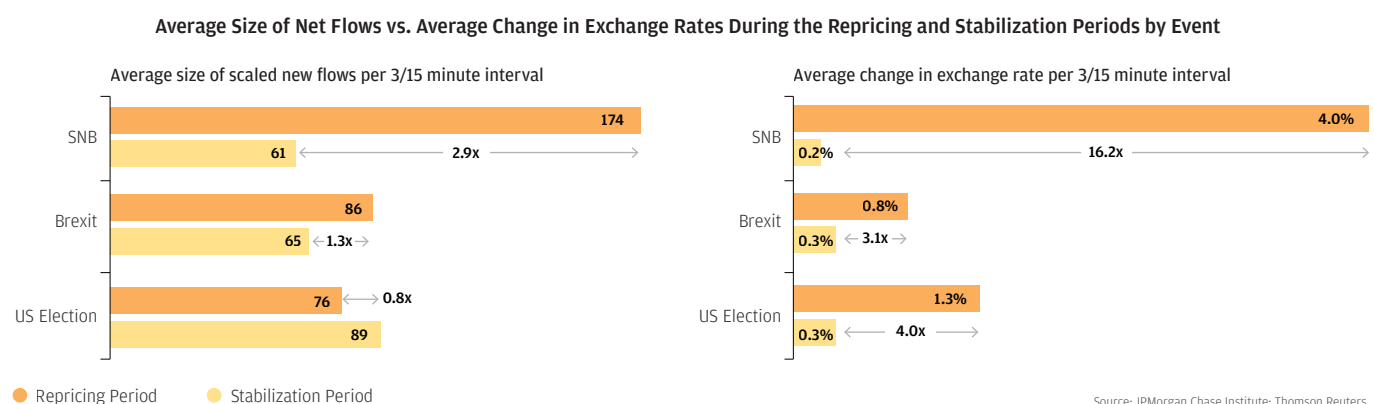


Source: JPMorgan Chase Institute; Thomson Reuters

For the SNB event, there was 2.9 times the average risk transferred every three minutes during the repricing period compared to the stabilization period, whereas the velocity of the exchange rate move in the repricing period was 16.2 times greater than in the stabilization period. For Brexit and the US Election, the risk transferred per 15 minutes was similar during the repricing and stabilization periods, however the velocity of the exchange rate moves in the repricing periods was 3 times to 4 times larger than in the stabilization period for both events.

Comparing the ratio of net flows and changes in the exchange rates in Figure 9 across events reveals some notable differences. For the SNB event, the ratio of net flows from the repricing period to the stabilization period is considerably larger than the ratio for the other two events. In addition, the ratio of the change in the exchange rate between the SNB repricing period and the SNB stabilization period is much higher than the ratio for the other two events. Among the many differences between these events, the slow unfolding of both the Brexit and the US Election results relative to the speedy CHF repricing during the SNB event likely contributed to this difference.

**Figure 9: The difference in the average size of the scaled net flows between the repricing and stabilization periods does not explain the difference in the magnitude of the exchange rate moves between the repricing and stabilization periods.**



Why did exchange rates move disproportionately or in the opposite direction relative to net flows during the repricing periods? Our data are consistent with a model of exchange rate dynamics where exchange rate changes are a function of three interrelated factors: (1) net flows, (2) news, and (3) overall market liquidity. Under this framework, when news arrives, market makers interpret the news, adjust liquidity accordingly, and absorb net flows to find a new equilibrium market price.

In this model, the arrival of news prompts net flows, which act as a transmission mechanism between the news and exchange rates, as described in Evans and Lyons (2007).<sup>27</sup> However, net flows are not the only determinant of the changes in exchange rates—both the news itself and overall market liquidity play an important role. The outcomes of each of the three events we studied (i.e. the news) led to changes in the fundamental value of each currency in question that were realized during the repricing periods. Given news regarding the fundamental value of an asset, market makers interpret that news directly; net flows are not required to re-price the asset. This was most clearly illustrated during the US Election repricing period—MXN depreciated despite net buying of MXN from institutional investors.<sup>28</sup>

Market liquidity refers to the collective willingness of all market makers to buy or sell an amount of a currency at a given price.<sup>29</sup> There is a natural relationship between liquidity and uncertainty—when uncertainty rises, liquidity falls, and vice versa, as discussed in Mancini et al. (2013). To the extent that events increase or decrease uncertainty, liquidity will change accordingly.<sup>30</sup> Given that the three events we analyzed had unexpected outcomes that changed perceptions regarding the fundamental values of CHF, GBP, and MXN, market liquidity for these currencies likely fell after the news broke and was lower during the repricing periods relative to the stabilization periods for all three events.<sup>31</sup>

While we don't measure market liquidity directly, the market liquidity component of the model of exchange rate dynamics may explain why net flows of the same size impact exchange rates more during the likely less liquid repricing period relative to the more liquid stabilization period. The same size net flow executed during the repricing period would result in a larger exchange rate move when compared to the stabilization period. For a more detailed evaluation of models of currency markets, see Evans (2011).



## Finding Three

**Only hedge funds consistently transferred risk immediately after news broke and as currencies repriced sharply. Other investors transferred risk but only after exchange rates stabilized.**

Next, we examined which investor sectors played a central role in establishing the new exchange rate equilibrium. We found that hedge funds traded immediately after news broke and the repricing periods began, transferring risk during episodes of high exchange rate volatility during all three events. In doing so, hedge funds participated in the establishment of the post-news equilibrium market price. A broader variety of institutional investors transferred risk only after market prices had stabilized; this was especially true for Brexit and the US Election, perhaps because both events did not take place during normal business hours for local investors or local trading hours for the currencies in question. Taken together, these results imply that market makers established a new equilibrium exchange rate without the benefit of net flow information from all investor sectors and regions.

Figure 10 shows, for the repricing and stabilization periods of each event, the cumulative trading volume (left panels) and cumulative net flows (right panels) for each investor sector. The shaded region marks the repricing period. Cumulative net flows convey the total amount of risk transferred over the period, while the change in cumulative net flows conveys net flows over time.

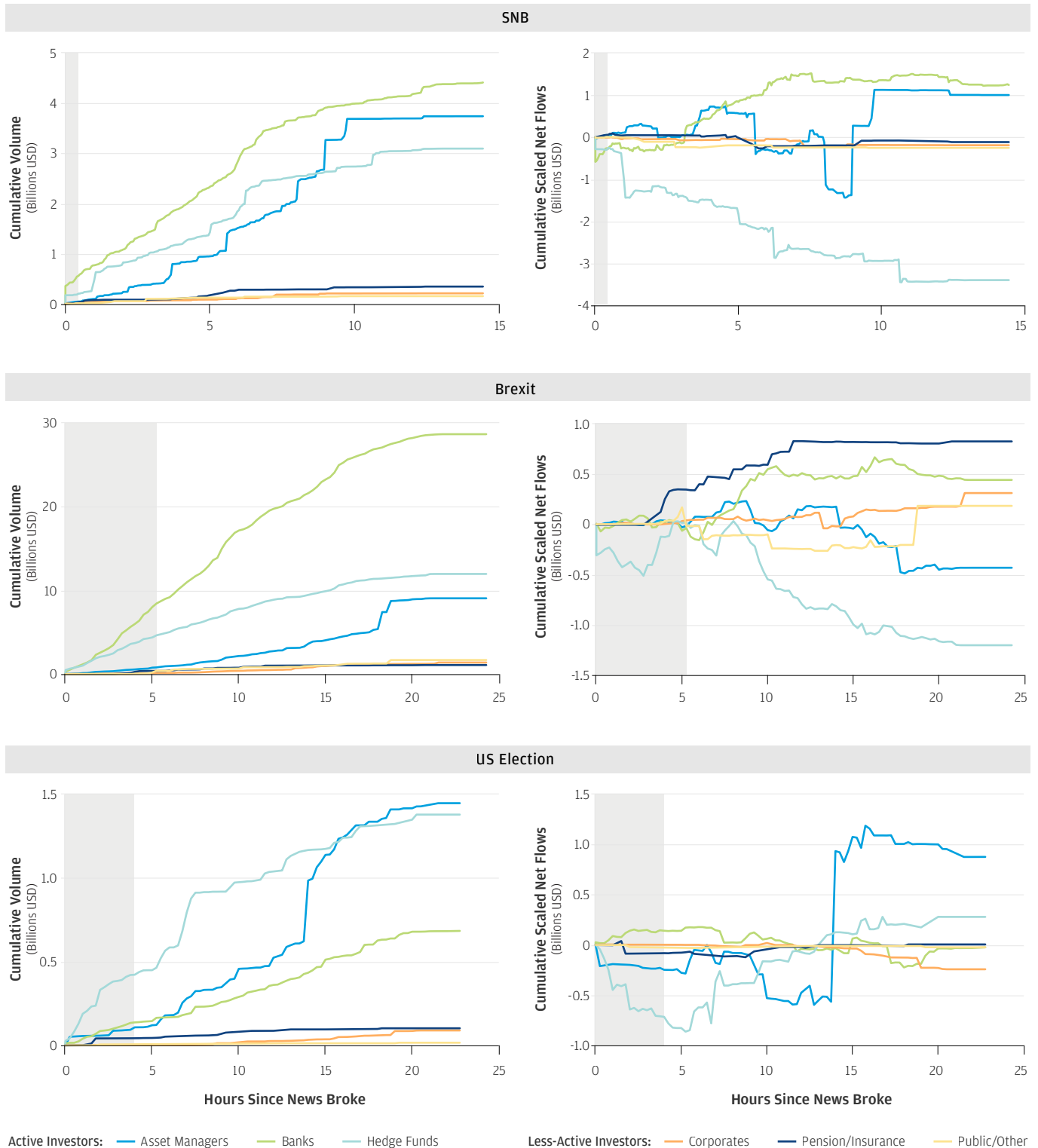
For all three events, banks and hedge funds were among the first investor sectors to react, trading a substantial amount of volume (Figure 10, left panels) just after the news broke and the repricing period began. Asset managers were somewhat slower to react, exhibiting low trading volumes during the repricing periods but considerably higher volumes during the stabilization periods. The three less-active investor sectors (corporates, pension/insurance, and public/other) were also slow to react and traded significantly less volume than the active investor sectors throughout the repricing and stabilization periods.

For all three events, hedge funds transferred the most risk during each repricing period and participated in the process of setting the new equilibrium exchange rate.

Of all the investor sectors, hedge funds transferred the most risk across all three of the repricing periods (Figure 10, right panels), and thus participated the most in the price discovery process. Hedge fund net flows provided information to market makers as they established a new market equilibrium exchange rate. Overall, banks did not transfer nearly as much risk as hedge funds because bank net flows were largely offsetting. The data for banks during the Brexit repricing period provide a good example (Figure 10, middle panel)—banks had the highest trading volumes in this period, but the activity generated very little net risk because banks were buying and selling in roughly equal amounts during each time interval in the period. Asset managers did not transfer significant risk during the repricing periods. In fact, the cumulative net flows for the asset manager sector did not become material until 3 to 6 hours after each repricing period ended. Among the less-active investor sectors, only the pension/insurance sector transferred material risk during one repricing period (Brexit).

Figure 10: While the active investor sectors increased their trading volumes after the news broke, only hedge funds consistently transferred risk during each repricing period. Other investor sectors transferred risk only after exchange rates stabilized.

Cumulative Volume and Cumulative Net Flows During the Repricing and Stabilization Periods, by Event and Investor Sector

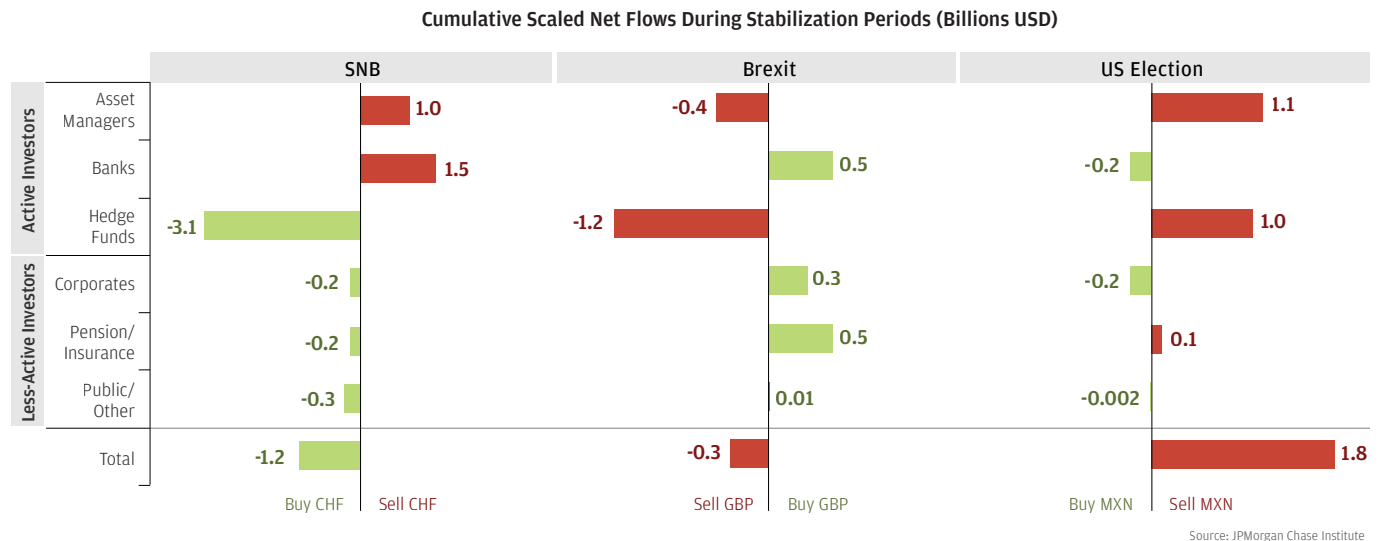


Note: Shading denotes the repricing period.

Source: JPMorgan Chase Institute

Once exchange rates stabilized, all investor sectors transferred some risk. Figure 11 reports total net flows by investor sector for the stabilization period of each event and indicates that risk transferred from each active investor sector was considerably larger than the risk transferred from each less-active investor sector for all three events. For the SNB event, cumulative net flows during the stabilization period were mixed across investor sectors—there were both buyers and sellers of CHF and all investor sectors participated. This is in stark contrast to the SNB repricing period, during which there were only buyers of CHF and net flows were dominated by banks and hedge funds, as noted above and in Figure 10. For Brexit and the US Election, cumulative net flows during the stabilization period are also mixed, with some sectors buying and some selling the currency in question, and all investor sectors transferring some risk.

**Figure 11: Cumulative scaled net flows during the stabilization period of each event were mixed, with some investor sectors buying and some investor sectors selling.**



We make two other observations from Figure 11. First, cumulative net flows for all three events do not sum to zero—this highlights the role of the market maker in putting capital at risk to absorb risk from institutional investors. Second, the cumulative net flows for each event during the stabilization period are consistent with the overall prevailing direction of the currency move over the entire 24- or 48-hour event window, even though these net flows occurred after the currencies had already repriced. Specifically, during the full SNB event period, CHF appreciated and cumulative net flows during the stabilization period show net buying of \$1.2 billion of CHF. Similarly, during the full Brexit event period, GBP depreciated and we see net selling of \$0.3 billion of GBP during the stabilization period. During the full US Election event period, MXN depreciated and we see net selling of \$1.8 billion of MXN during the stabilization period. While we did not investigate this directly, one interpretation of this relationship is that it is possible that in establishing the post-event equilibrium exchange rate during the repricing period, market makers and hedge funds were anticipating the net flows that would materialize in the stabilization period and valued each exchange rate taking into account their predictions.

To put the risk transferred by each investor sector into perspective, we also examined net flows for each investor sector and event day compared to the daily average over the 12 months prior to the event. Figure 12 shows the absolute value of net flows and z-score for each investor sector and event day, along with their average daily net flow.

All three of the active investor sectors transferred considerable net risk during the SNB event (Figure 12, left-hand side), about 3 standard deviations above the daily average. However, during the other two events, results were mixed. During the Brexit event, risk transferred by banks and hedge funds surged, but the increase in risk transferred by asset managers was modest. For the US Election, none of the active investor sectors transferred risk in an amount that was more than 2 standard deviations above average. In fact, bank and hedge fund net flows were below average.

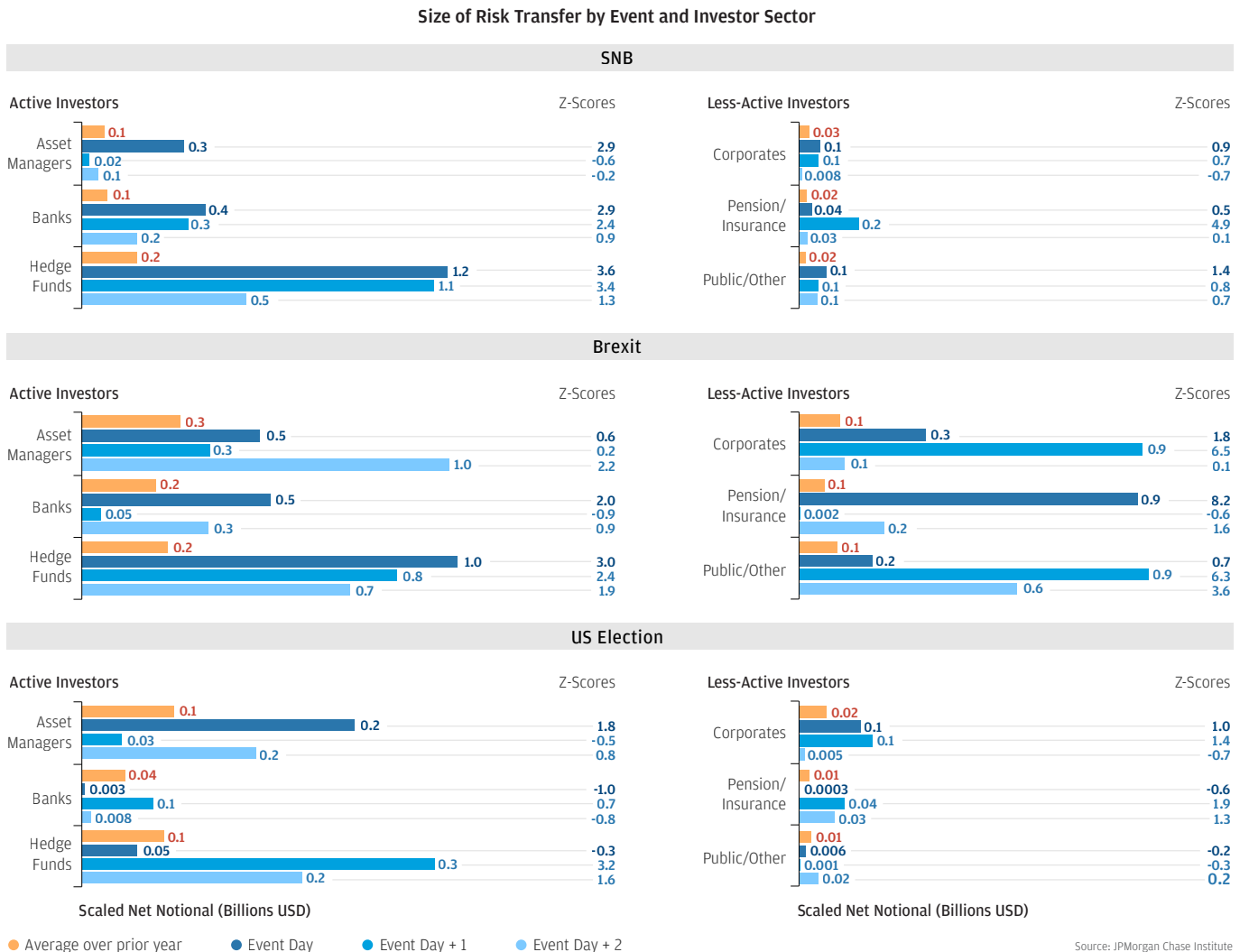
For eight of the nine less-active investor sector-event combinations shown on the right-hand side of Figure 12, net flows on the event day itself were unremarkable, within 2 standard deviations of their daily averages. The lone exception was Brexit, during which the pension/insurance investor sector was more than 8 standard deviations above average. In the two trading days that followed the event, net flows from less-active investor sectors increased, but not consistently.<sup>32</sup> The day after the SNB event, only the pension/

insurance investor sector transferred risk in an amount that was more than 2 standard deviations above average. The day after the Brexit event, corporates and the public/other investor sector transferred risk in an amount that was more than 2 standard deviations above average. In the two trading days that followed the US Election event, none of the less-active investor sectors transferred risk in an amount that was more than 2 standard deviations above average.

Given the above variation in the risk transferred by each investor sector across events, we draw two conclusions. First, even though all of the active investor sectors increased their trading volumes on the event day as described in Finding 1, the news and subsequent large exchange rate moves did not necessarily lead to an increase in risk transferred. Only in the case of the SNB event were net flows substantially above average for all three of the active investor sectors. Among the many reasons why the SNB event generated greater risk transfer by active investors, we hypothesize that the surprise nature of the announcement could be an important factor.

Second, for these three events, asset managers transferred risk only after exchange rates had stabilized and the reaction in risk transferred from investors in the less-active sectors was either delayed by a day or invariant to the news and ensuing large exchange rate moves. The absence of net flows from a variety of investor sectors after each event reduced the information about pre-event positioning that reached the market. Furthermore, the delayed or non-reaction of these investor sectors indicates that they may have played little role in the price discovery process that immediately followed the news in our three event studies, potentially making the process of finding an equilibrium price less efficient. We examine this further in the findings that follow.

**Figure 12: The active investor sectors increased risk transfer during the SNB event. For the other events and for the less-active investor sectors, the amount of risk transferred relative to average was mixed.**



## Finding Four

**The active investor sectors played different roles in each event: During the SNB event, they all bought CHF, trading in the direction of the prevailing move in exchange rates; during the Brexit event their net flows were mixed; and during the US Election event they bought MXN, trading against the prevailing move in exchange rates.**

Using the data discussed in Finding 2 and shown in Figure 8, we isolated net flows during the repricing period of each event and then analyzed net flows at the investor sector level. We found that the active investor sectors (banks, hedge funds, and asset managers) responded differently to each event. The active investor sectors bought CHF as it appreciated during the SNB event repricing period, trading with the prevailing move in exchange rates. During the Brexit repricing period, net flows from the active investor sector were mixed, with offsetting buys and sells. During the US Election repricing period, the active investor sectors bought MXN as it depreciated, trading against the prevailing move in exchange rates.

Figure 13, which displays net flows for each investor sector during the repricing period of each event with an exchange rate overlay, illustrates how investors responded differently during each event. The net flows during the 24-minute repricing period following the surprise announcement from the SNB indicate that net risk transferred was largely one way—all investor sectors were either buying CHF or absent. Net flows were consistent with the move in exchange rates—EUR/CHF dropped from 1.201 to 0.895 over the same period. After a large initial purchase of CHF, banks made some small sales, but on net were buyers of CHF over the full repricing period. Less-active investors (not shown) were largely absent during the repricing period. Because all of the active investor sectors were on net buying CHF as it appreciated, market makers were left as the only market participants selling CHF during this critical stage, and while we don't measure the connection directly, this may have amplified the move in EUR/CHF during the SNB repricing period.<sup>33</sup>

In contrast, net flows during the Brexit repricing period were mixed, showing both buying and selling of GBP (Figure 13, middle panel). Net flows from asset managers and banks were balanced throughout the repricing period. Hedge funds sold GBP during the first half of the repricing period but turned to buying in the second half even as the currency continued to depreciate. As such, the active investor sectors were trading both with and against the prevailing exchange rate trend over the course of the Brexit repricing period and likely had a smaller overall impact on the exchange rate. For example, hedge fund net flows could have amplified the initial drop in GBP but then helped GBP stabilize in the final hours of the repricing period. Notably, the Brexit repricing period was the only event where a less-active investor sector transferred risk—the pension/insurance sector purchased a material amount of GBP at the end of the repricing period after it had depreciated (not shown).

During the US Election repricing period, the active investor sectors' net flows were also directional rather than balanced, but in this case these investors were buying MXN as it depreciated and trading against the prevailing move in exchange rates (Figure 13, bottom panel). Among the less-active investor sectors, the pension/insurance investors also bought MXN (not shown). Taken together, these results suggest that institutional investors' net flows played a lesser role during the US Election repricing period.

While there may be many reasons why investors were more inclined to trade with the prevailing exchange rate trend during the surprise SNB event relative to the other two events, we consider two reasons here.

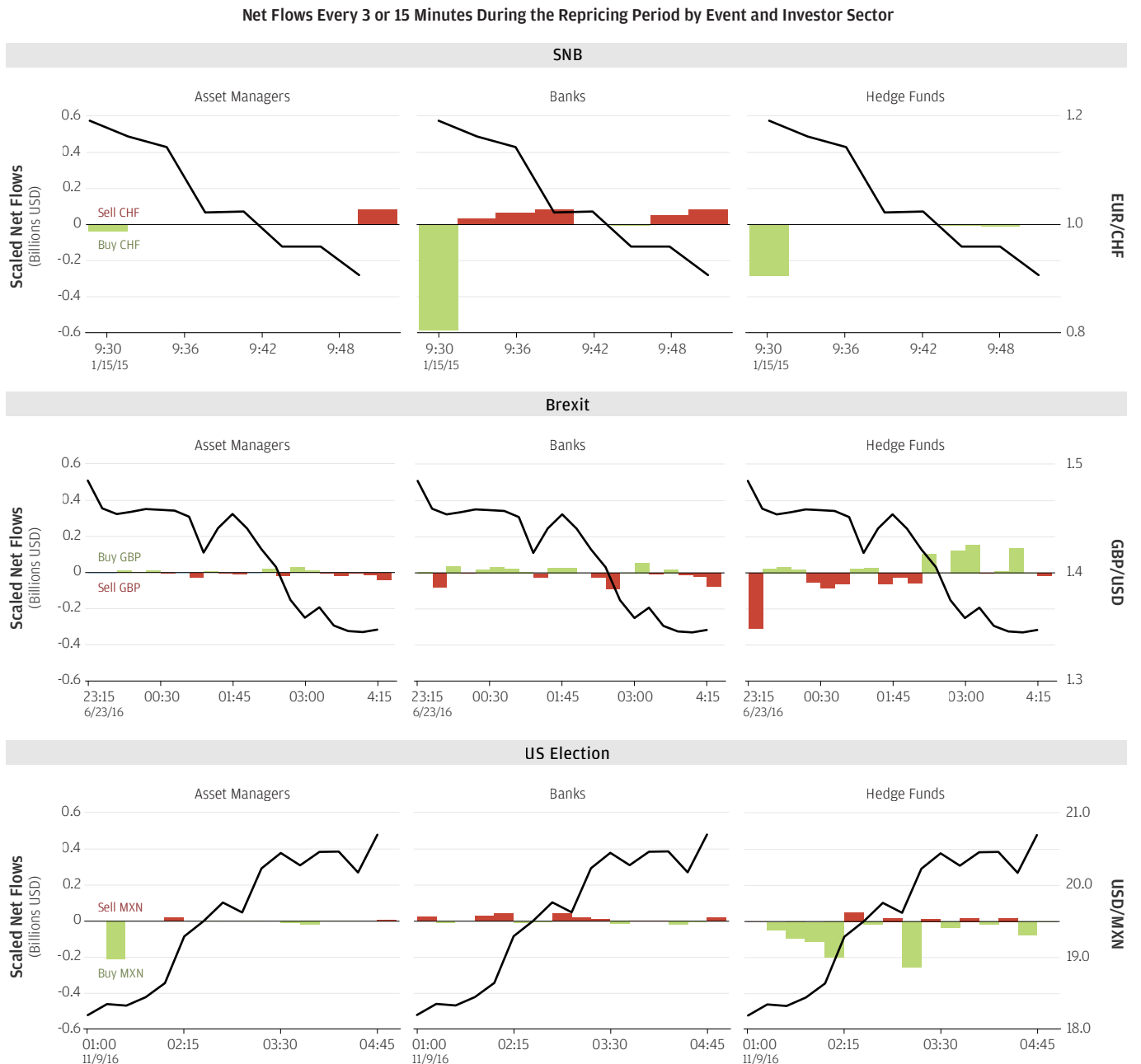
First, as might be expected, investors could better prepare for the latter two events. The timing of both the Brexit referendum and the US Election were well known, giving investors the opportunity to transact ahead of the events and account for all possible outcomes. The SNB decision to end the minimum exchange rate policy came as a surprise announcement, and therefore did not afford investors a similar opportunity to prepare. These patterns suggest an important interaction between preparation, resolution of uncertainty, and investor net flows.

Second, we see evidence in our data that, on balance, hedge funds transacted as if they expected the 1.20 EUR/CHF exchange rate floor to remain in place, as they were more likely to buy EUR vs. CHF when the exchange rate approached the 1.20 floor. This behavior may have contributed to their directional flows and the discontinuous nature of the exchange rate immediately after the SNB announcement. See Box 2 for a more detailed discussion. This observation is consistent with the net position data in CHF FX futures

contracts available in the Commodity Futures Trading Commission’s (CFTC) Commitments of Traders (COT) report.<sup>34</sup> Leveraged funds were net short nearly 24,000 CHF FX futures contracts as of January 13, 2015, but by January 20, 2015, had cut the short position to just under 11,000 contracts.<sup>35</sup> The GBP and MXN futures positions reports for leveraged funds showed much smaller changes over Brexit (2,205 GBP FX futures contracts) and the US Election events (641 MXN FX futures contracts).<sup>36</sup>

We drew the same conclusions about net flows for each event when we restricted our focus to the first few three- or 15-minute intervals in the repricing period, indicating that our finding was not driven simply by the duration or definition of the repricing period of each event. This further suggests an important interaction between preparation, resolution of uncertainty, and investor net flows and outcomes.

**Figure 13: Net flows from the active investor sectors during the repricing periods varied across events: they bought CHF during the SNB event, bought and sold GBP during the Brexit event, and bought MXN during the US Election event.**



Source: JPMorgan Chase Institute; Thomson Reuters

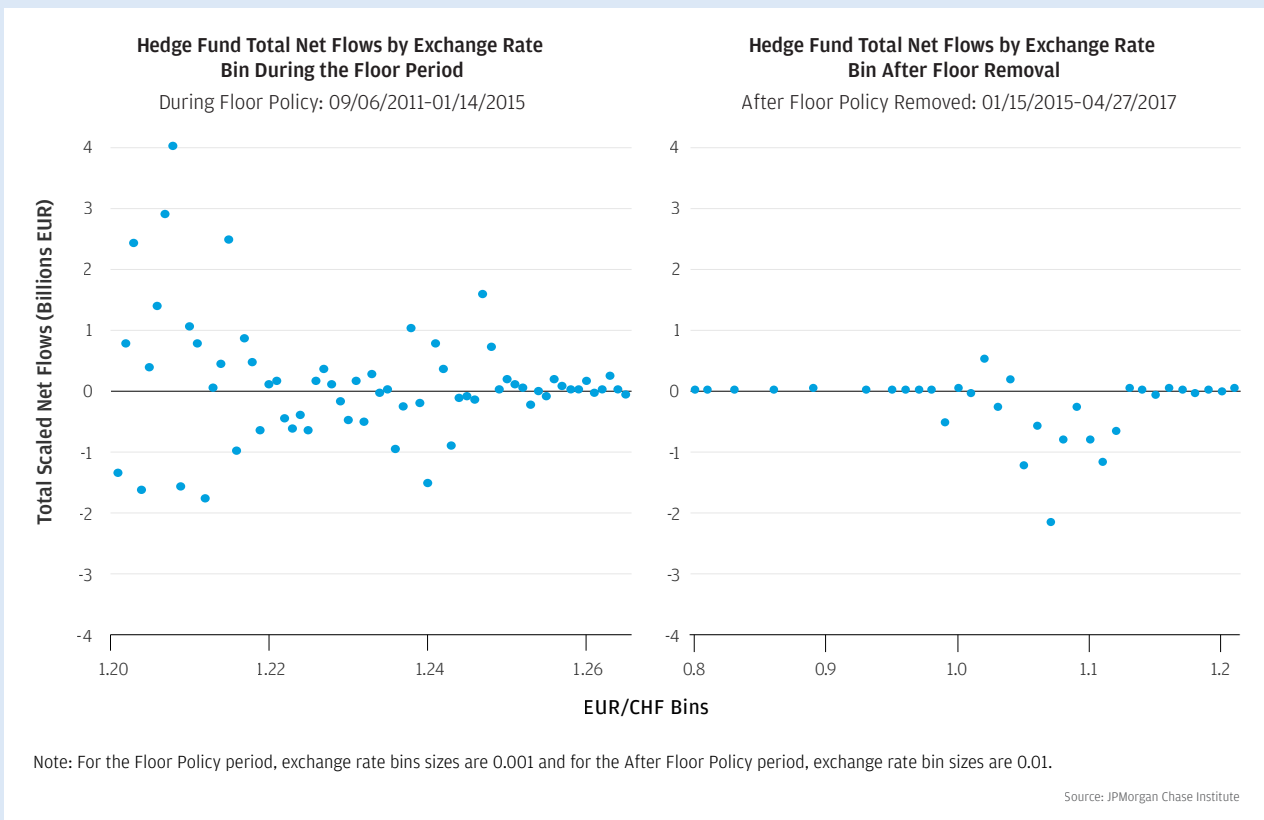
**Box 2: . Did hedge funds predicate their trading strategy on the belief that the SNB would maintain the EUR/CHF floor or did they anticipate the end of the policy?**

We see evidence that hedge funds transacted as if they expected the 1.20 EUR/CHF exchange rate floor to remain in place right up until the January 15, 2015, SNB announcement. Figure 14a shows the sum of hedge fund net flows from EUR/CHF spot transactions in each exchange rate bin during the period in which the minimum exchange rate policy was in place (left panel) and the period after the floor was removed (right panel). When the floor was in place, the sum of net flows was more positive for exchange rate bins close to the 1.20 EUR/CHF floor than for exchange rate bins further away from the floor. After the SNB removed the floor, there was no longer a relationship between hedge fund net flows and exchange rates. This suggests that hedge funds were more likely to buy EUR and sell CHF when the exchange rate was close to the 1.20 floor.

Assuming the SNB’s minimum exchange rate policy was credible, the risk/reward ratio of such a strategy was compelling. For example, if EUR/CHF were trading at 1.202, buying EUR and selling CHF at 1.202 would have a maximum downside of 0.002 because the SNB would buy EUR and sell CHF somewhere between 1.202 and 1.20, not letting EUR/CHF drop below 1.20. The upside could be unlimited, depending on how EUR/CHF evolved. Hedge funds could employ leverage to implement such a strategy, such that the capital behind these positions was only 5-10 percent of the amount at risk.<sup>37</sup>

We conducted a simulation to test the statistical significance of the relationship we identified for total net flows when EUR/CHF was close to the floor compared to when EUR/CHF was further from the floor during the period when the floor was in place versus the period after the floor was removed. Our simulation suggests our finding is statistically significant at the 95 percent confidence level. See the Methodology section of this report for more details.

**Figure 14a: Hedge funds were more likely to buy EUR and sell CHF when the EUR/CHF exchange rate approached the 1.20 floor (LHS). Once the floor was removed, this behavior ceased (RHS).**

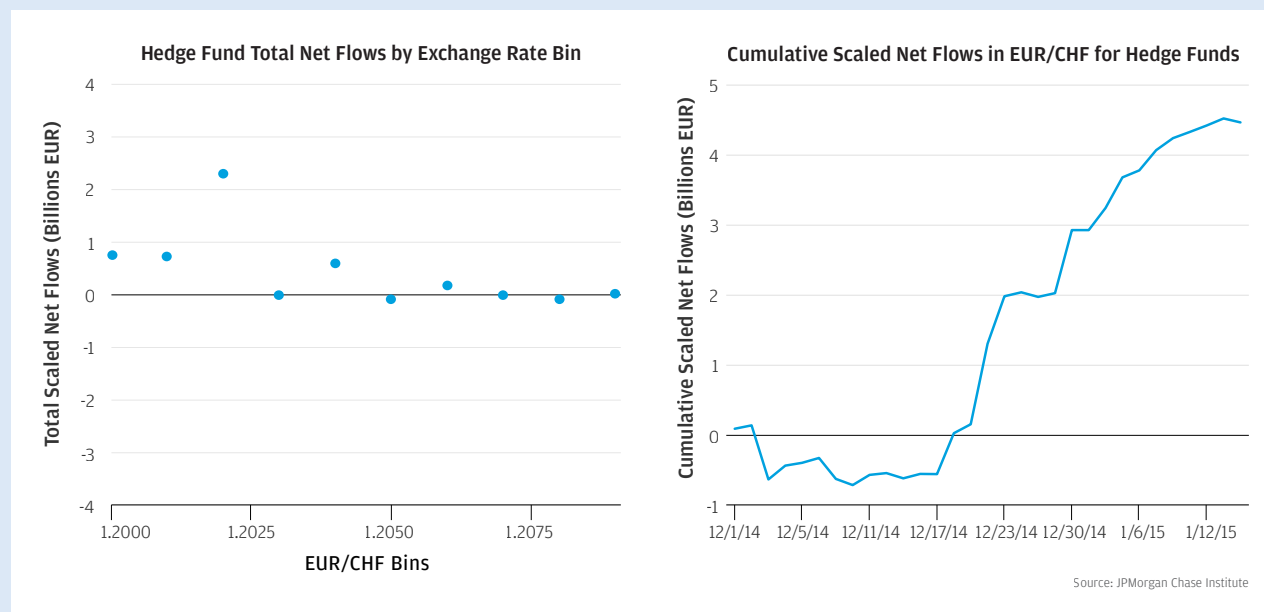


By executing this trading strategy, hedge funds were in effect supporting the minimum exchange rate policy on behalf of the SNB. The more these investors bought EUR and sold CHF when the exchange rate approached the 1.20 floor, the less intervention the SNB would have to conduct.

Did hedge funds anticipate the removal of the SNB's minimum exchange rate policy? Evidence suggests that hedge funds expected the floor to remain in place up until it was removed, as they continued to execute this trading strategy between December 1, 2014, and January 14, 2015. The left panel of Figure 14b is similar to the left panel of Figure 14a, but only includes trades from December 1, 2014, through January 14, 2015. The right panel of Figure 14b displays the cumulative net flows in EUR/CHF for the hedge fund investor sector over the same period. During this period, EUR/CHF settled between 1.201 and 1.204, providing attractive entry points for this trading strategy.

Figure 14b indicates that purchases of EUR vs. CHF increased after the SNB introduced negative interest rates and reaffirmed the minimum exchange rate policy on December 18, 2014.<sup>38</sup> The CFTC's COT report shows position data for leveraged funds in CHF FX futures that are consistent with the cumulative net flows shown in Figure 14b. Between December 16, 2014, and January 13, 2015, the COT shows leveraged funds increased their net short in CHF FX futures by over 24,000 contracts.<sup>39</sup> We hypothesize that this behavior, combined with the potential use of leverage in these trades, could in part explain why hedge funds were buying large quantities of CHF in the three-minute period after the policy was lifted, as described in Finding 4 and shown in Figure 13.

**Figure 14b: In the six weeks before the SNB removed the minimum exchange rate policy, hedge funds continued to buy EUR and sell CHF when the EUR/CHF exchange rate approached the 1.20 floor.**



Academic researchers have attempted to answer the question, "Did market participants anticipate the removal of the exchange rate floor?", with varied results. On the one hand, Hanke et al. (2017) suggests that market perceptions of the remaining life of the policy dropped considerably over 2014 and by the beginning of 2015 was less than six months, while Hetrich and Zimmerman (2017) suggests that by early 2015 the market-implied probability was over 50 percent that the floor would be lowered below 1.20. On the other hand, Jermann (2017) measures the probability that the floor would be lifted in early January 2015 as less than 20 percent, and Mirkov et al. (2017), finds that the SNB's credibility with respect to the policy was high up until the day it was removed.



## Finding Five

**Within each investor sector, there was considerable variation in trading behavior during each event.**

While sector level net flows were informative as to the overall impact of the sector, we explored one level deeper into our transaction data to understand behavior within each investor sector. We found that within each active sector, some investors were buying and some investors were selling during the same time interval. This within-sector variation refutes the commonly held perception that all investors in a particular sector transacted in the same direction at the same time during these three events.

Figure 15 shows purchases (green bars) and sales (red bars) aggregated separately at the investor level for each active investor sector, in each three-minute (SNB) or 15-minute (Brexit and the US Election) interval for each event. Net flows at the investor sector level (black line), which equals the sum of investor purchases and sales, are shown as an overlay. Regardless of the magnitude of the net flows at the sector level in a given time interval, within the sector some investors were buying while others were selling, both in considerable size.

Banks and hedge funds were active in transferring risk, and in the time intervals during which they were active, the buys and sells are considerably larger than the net flows for that period. When net flows were large, there was actually activity in both directions, rather than just in the direction that aligns with the net flow. Over the entire event, banks' net flows are more balanced than hedge fund flows. This may in part reflect the fact that in our investor classification scheme, the bank sector includes the market-making operations of smaller banks and broker-dealers. Asset managers were less active in transferring risk than banks and hedge funds, but in the periods when they were active, some asset managers were buying and some asset managers were selling. This behavior was particularly evident during the Brexit event, where risk transferred was more consistent over the full event timeline.

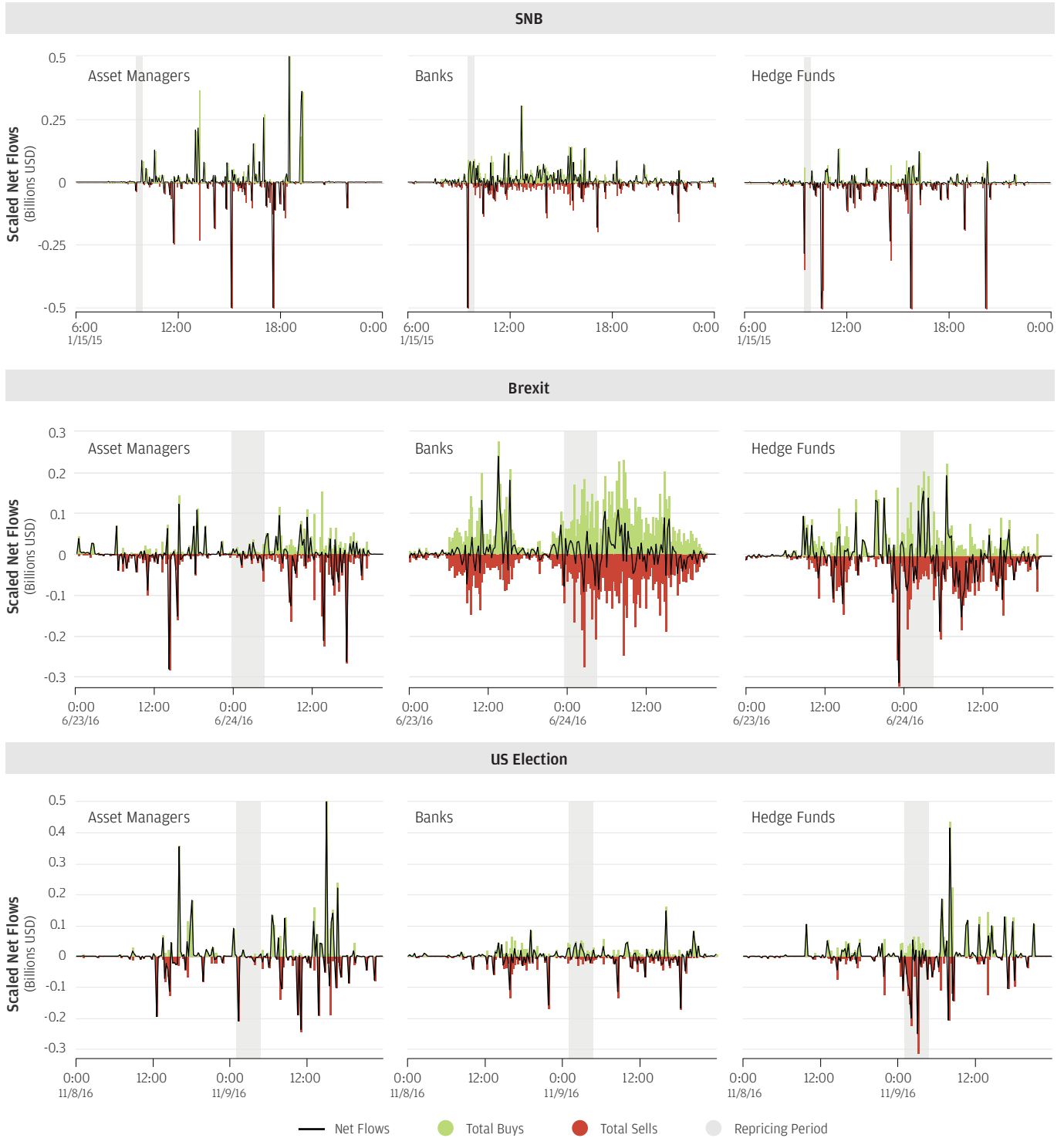
To further measure the variation in investor behavior within each sector, we examined the proportion of investors within each sector that were only buying, only selling, or doing both buying and selling during the repricing period of each event. These results are shown in Figure 16. For example, the first column of Figure 16 indicates that of the total number of asset managers that transacted during the repricing period of the SNB event, 42 percent were only buying CHF against other currencies, 5 percent both bought and sold CHF against other currencies, and 53 percent only sold CHF against other currencies.

The data in Figure 16 indicate that within the active investor sectors, there is a clear distinction between the SNB event and the other two events. For the SNB event, a much larger proportion of investors in the active sector were either buying or selling, but not both. In contrast, for Brexit and the US Election events, a larger proportion of banks and hedge funds both bought and sold over the repricing periods of those events. Thus, at the investor level, investors in the active sectors traded in a more directional manner in reaction to the SNB announcement.

The within-sector variation evident in our transaction data refutes the commonly held perception that all investors in a particular sector transacted in the same direction at the same time during these events.

**Figure 15: Within each active investor sector and for each event, some investors were buying and some investors were selling each currency regardless of the net flows at the sector level.**

**Total Buys and Total Sells at the Investor Level During the Pre-Event, Repricing, and Stabilization Periods by Event and Investor Sector**



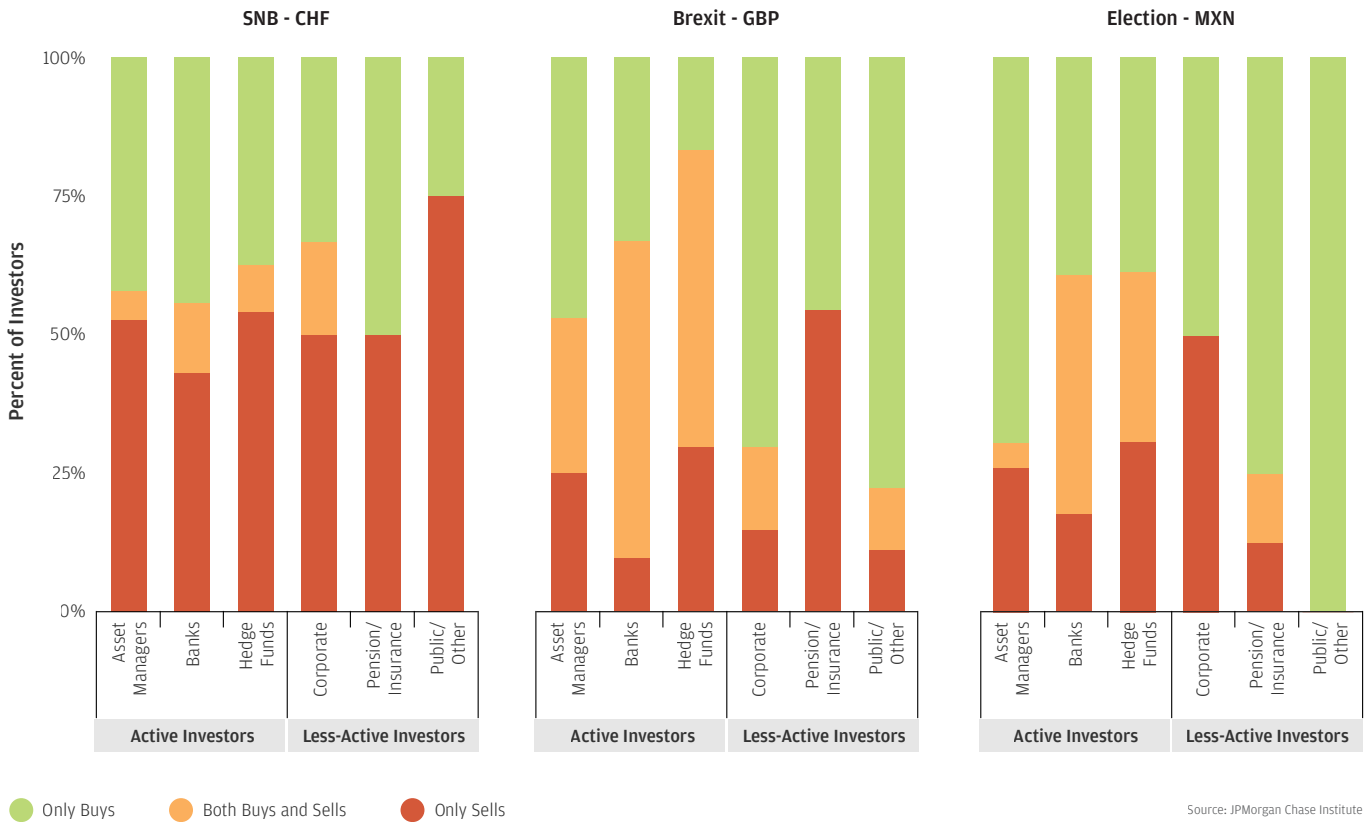
Note: Net flows, total buys, and total sells have been censored at 0.5 billion USD to better illustrate within-sector variation. The direction of the bars in these graphs are consistent with the other graphs in this report and the exchange rates that we show. This means that for Brexit, "Buys" refers to buys of GBP and "Sells" refers to sells of GBP, but for SNB and the US Election, "Buys" refers to buys of any other currency against CHF and MXN, respectively, and "Sells" refers to sells of any other currency (or buys of CHF and MXN, respectively).

Source: JPMorgan Chase Institute

To explain the more directional investor behavior in reaction to the SNB event, we return to the important interaction between preparation, resolution of uncertainty, and observed investor net flows. The SNB event was a surprise and did not allow investors to transact ahead of time in preparation for the announcement. Another contributing factor may have been that, relative to the other two events, the FX implications of the SNB announcement were clear and the CHF repricing happened very quickly.

Across all three events, investors in the less-active sectors were more likely to be either buying or selling, but not doing both. Only a small proportion of investors in the less-active sectors both bought and sold during any of the three events.

**Figure 16: Proportion of each investor sector buying, selling, or both buying and selling during the repricing period of each event.**



## Finding Six

### **Banks and hedge funds traded higher volumes outside of their normal business hours and outside of a currency's local market; other investor sectors did not.**

One important difference between the SNB event and the Brexit and US Election events is that the SNB event took place during “normal” trading hours for CHF, whereas the unexpected results of the Brexit referendum and the US Election only became clear during the overnight hours for EMEA and the US. For the SNB event, EMEA (the local market for CHF) was open, while for the other two events, the APAC markets were open but local markets were closed. This meant that investors who wanted to trade as the latter two events unfolded would have to trade GBP and MXN outside of the currency's local market.

The difference in timing for these three events allowed us to answer two questions: First, which investor sectors were willing to trade GBP and MXN outside of the currency's local market, when volumes in these two currencies are typically subdued, and which investor sectors waited for the currency's local hours to commence trading? And second, which investor sectors traded higher than average volumes outside their normal business hours on these event days, and which investor sectors waited until their normal business hours to transact?

To answer the first question, we analyzed the data depicted in Figure 17, which presents hourly trading volume on the event day for the active investor sectors (blue bars), superimposed on average hourly volume for the previous 12 months (black lines) for each event. The background shading indicates which market locations were open at that hour.<sup>40</sup> The average hourly volumes indicate that each of the three currencies we examined has a local market. As would be expected, most of the volume in CHF and GBP was traded during EMEA trading hours, while most of the volume in MXN was traded during Americas trading hours. Trading volumes outside of local market hours was muted.

A close examination of trading volumes during the Brexit and US Election events shows that bank and hedge fund trading volumes spiked compared to average volumes during APAC hours for both the Brexit and US Election events, a marked change in trading behavior. In contrast, asset managers were less inclined to trade currencies outside of the currency's home market, and their trading volumes only spiked during US trading hours, 10 to 20 hours after the news broke. This held true for the SNB event as well—despite the fact that the event took place during local trading hours for CHF, asset manager trading volumes were highest during Americas trading hours. While one might expect this result for asset managers based in the Americas, it is also true for asset managers based in EMEA—for all three events, asset managers based in EMEA traded their highest volumes during US trading hours.

We also note from Figure 17 that trading volumes in the pre-event hours were different across events. Before the SNB event hourly volumes were below the hourly average. In fact, they were nearly zero. For both Brexit and the US Election, pre-event hourly volumes were higher than average. The differences in pre-event volumes likely reflect that the SNB event was a surprise announcement. Both the Brexit referendum and the US Election were highly anticipated events and investors could transfer risk in advance to prepare for either outcome.

To answer the second question of which investor sectors were willing to trade higher volumes outside their normal business hours, we turn to the data depicted in Figure 18: hourly trading volume on the event day for each investor region (blue bars), superimposed on average hourly volume by investor region for the previous 12 months (black lines). Again, the background shading indicates which market locations were open at that hour.

We observe that, in the events we studied, investors changed their behavior and traded outside their normal business hours. To reach this conclusion, we focus on the five event-region combinations for which the event took place outside of the region's normal business hours or investors in the region did not typically trade the currency in question during the time when the event occurred as highlighted in Figure 18—SNB and APAC, Brexit and Americas, Brexit and EMEA, US Election and Americas, US Election and EMEA.

For these five event-region combinations, we see that investors transacted materially more volume outside of their normal business hours compared to the average hourly volume. A closer examination of the data underlying Figure 18 (not shown) revealed that once

again banks and hedge funds accounted for the significantly above-average volumes traded by investors outside of their normal business hours during these five event-region combinations.

After hours trading in the FX market would be enabled by mobile trading apps, and there is evidence of an upward trend in mobile FX trading. In a recent J.P. Morgan survey of over 400 traders at institutional investors, 61 percent of respondents said they were “extremely” or “somewhat” likely to use a mobile trading app in 2018, up from 31 percent the year prior. Half of the respondents cited their company policy as the main obstacle preventing mobile trading.<sup>41</sup> While we do not observe the type of application (desktop vs. mobile) investors used to execute the FX transactions in our sample, the combination of our finding and the results of the survey suggests that banks and hedge funds may have been earlier adopters of mobile trading apps for FX relative to other investor sectors.<sup>42</sup>

One additional observation from the data in Figure 18 is noteworthy. Investors in APAC had different reactions to the SNB event and the US Election. Investors based in APAC typically trade very little CHF or MXN regardless of time zone. During the SNB event, APAC investors changed their behavior and traded considerable CHF volume during European trading hours. However, during the US Election event, APAC investors traded very little MXN despite the unanticipated Trump victory and the large move in USD/MXN during their local trading hours.

**Figure 17: For the SNB event, hourly volumes for the active investor sectors spiked vs. average hourly volumes. Banks and hedge funds were most active in GBP and MXN during off-hours for these currencies.<sup>43</sup>**

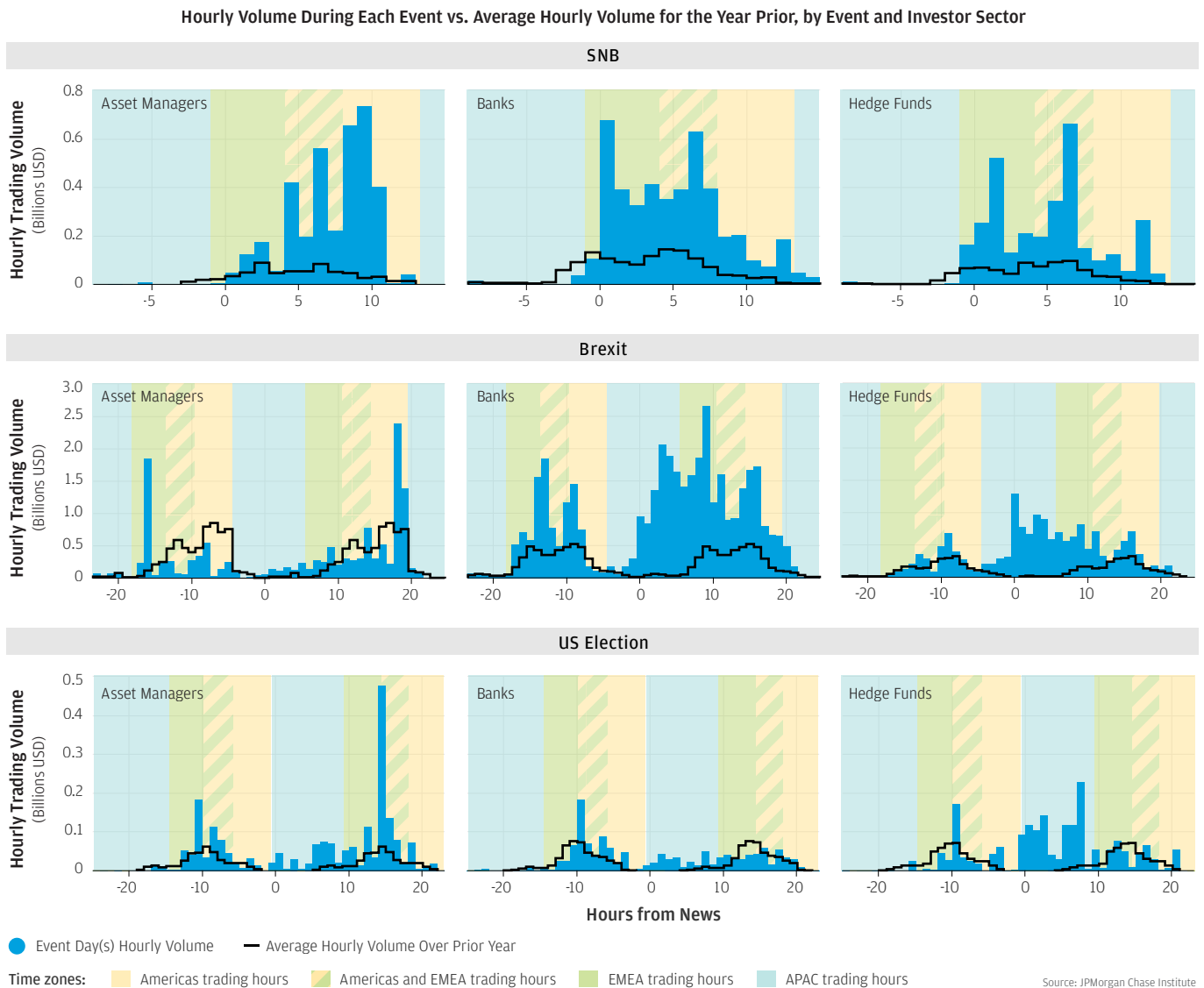
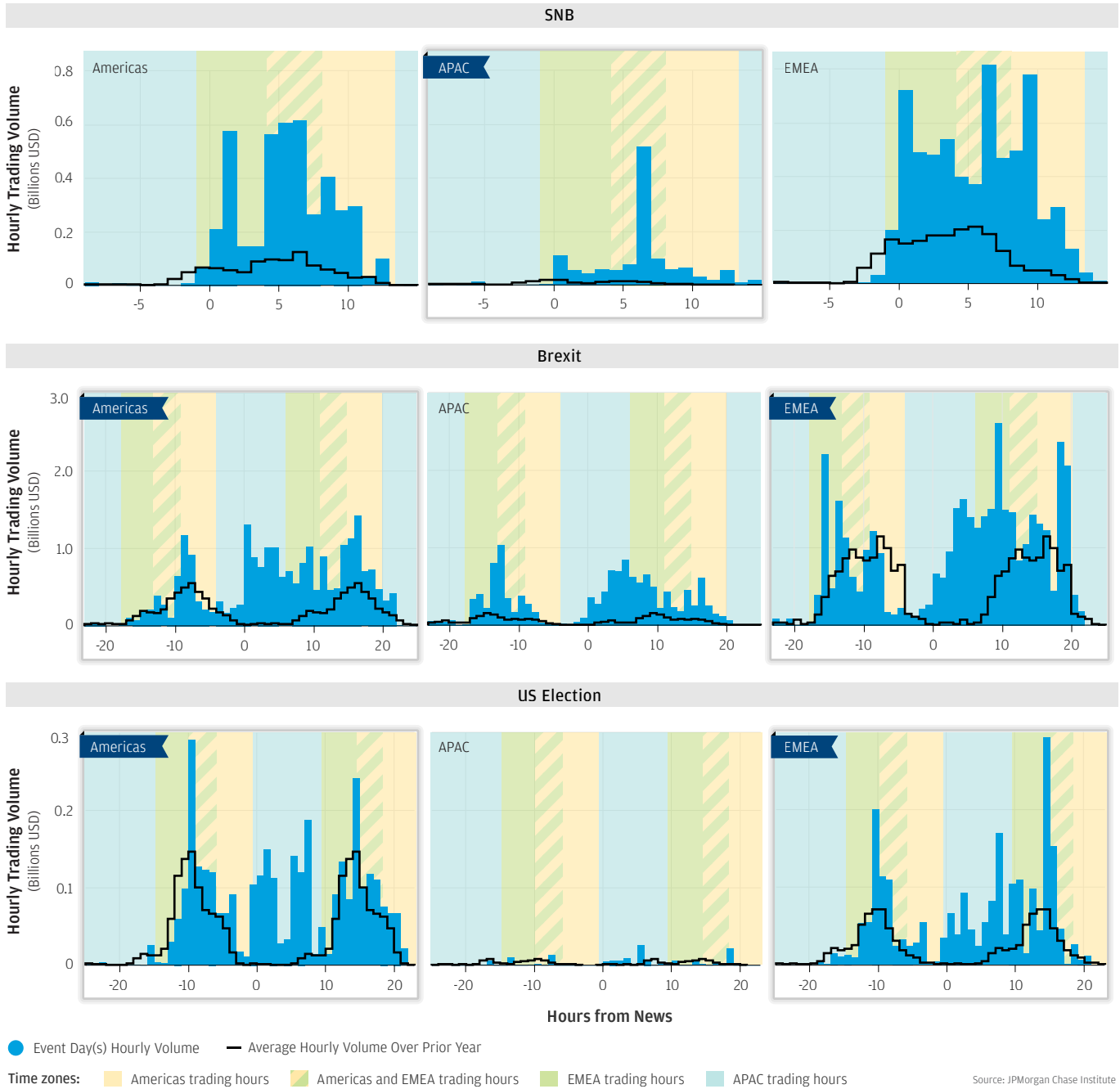


Figure 18: Investors in all regions were willing to trade outside of their normal business hours during all the events that took place outside of their local time zone.<sup>43</sup>

Hourly Volume During Each Event vs. Average Hourly Volume for the Year Prior, by Event and Region



Source: JPMorgan Chase Institute

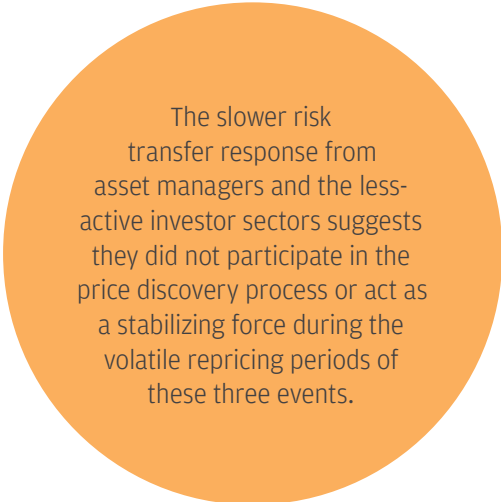
# Implications

The findings in this report are informative along two dimensions: financial market stability and central bank communications.

Our analysis shows that the institutional investor reactions to major market events, as reflected in trading volumes and risk transferred, varied in pace and size across sectors. During the three events we studied, banks and hedge funds increased their trading activity immediately, but only hedge funds transferred risk soon after news broke and as exchange rates were repricing rapidly. Asset managers increased their trading volumes and transferred risk, but only after exchange rates had stabilized. Investors in the corporate, pension/insurance, and public/other sectors waited for a day or two after the events to transfer risk. The slower risk transfer response of asset managers, corporates, pension/insurance companies, and public sector investors to the three news events that changed perceptions of the fundamental value of each currency suggests these four investor sectors did not participate in the price discovery process. Furthermore, these same four investor sectors did not transact against the prevailing move in exchange rates during the volatile repricing periods of these three events, contradicting the popularly held narrative that long-only investors with long-term investment horizons act as a stabilizing force during market dislocations.<sup>44</sup>

Hedge funds and market makers played an especially significant role in the market ecosystem during these three events. As discussed, hedge funds transacted actively in foreign exchange markets just after each news event broke and during volatile conditions, participating in the establishment of a post-event market equilibrium. For all three events, market makers reconciled

news about the fundamental value of the relevant currency with net flows, adjusted market liquidity, and established a post-event equilibrium exchange rate. During the repricing period of the surprise SNB event, our data suggest that market makers alone sold CHF during this critical stage—institutional investors' net flows were all consistent with the prevailing move in the exchange rate (buying CHF as it appreciated). When deliberating policies that limit the trading activity of market makers or hedge funds, policymakers can use our results regarding the differential roles institutional investors played in establishing a post-event market equilibrium exchange rate to weigh this factor against any other relevant considerations.



The slower risk transfer response from asset managers and the less-active investor sectors suggests they did not participate in the price discovery process or act as a stabilizing force during the volatile repricing periods of these three events.

Furthermore, our results suggest that company policies or regulations that limit the trading activity of institutional investor sectors to their normal business hours or the local market of a currency may prevent these investors from accessing liquidity and mitigating their risk during market-moving events. As described in Finding 6, in response to the Brexit and US Election events, asset managers based in the Americas and EMEA did not increase their trading volumes until the open of the US trading day, between 10 and 20 hours after the news broke and exchange rates first began to move. Limitations to after-hours trading may also reduce market efficiency as markets might take longer to reach a new equilibrium price. This is consistent with the model of exchange rate dynamics described in Finding 2, in which net flows transmit news and pre-event

positioning information to exchange rates. A broader set of investor sectors participating in after-hours trading could improve market liquidity, especially to the extent that there is variation in the direction of their trading. With the appropriate safeguards, controls, and security in place, after-hours trading capabilities could be a useful addition for some institutional investors.

Further analysis along this dimension may inform the use of cross-border capital regulations. While a role for capital controls as a tool for enhancing financial stability in certain instances has gained popularity over the last ten years (e.g., as described in IMF (2011)), our results imply that strict controls on FX flows may act as a hindrance to FX market efficiency during times of instability and prevent domestic investors from accessing liquidity abroad. This view is supported by the recent findings in Garcia (2017), which shows that capital controls can make exchange rates more sensitive to imbalances in net flows.

Our results could be helpful to central banks as they pursue the appropriate balance between their increasing tendency toward transparency in communicating policy actions and other critical factors, such as maintaining their credibility. Our data demonstrate the extent to which announcing unexpected policy changes at a previously scheduled event (i.e., similar to the Brexit referendum and the US Election) may allow investors to prepare for the range of possible outcomes and produce more balanced post-event flows, while enacting unexpected policy changes via a surprise announcement (like the SNB event) may not allow investors to adjust their risk in advance which in turn leads to directional net flows that could amplify price movements. When choosing the most appropriate method to communicate policy changes, policymakers can use our results to help weigh market expectations with respect to both the timing of announcements and the outcome in the context of other pertinent factors and their desired market impacts.

When deliberating unconventional policy measures that directly set the price of financial instruments, policymakers should carefully consider how they will unwind the policy. For example, policies such as the SNB's minimum exchange rate take pricing power away from the market and therefore can distort the incentives and, in turn, the behavior of market participants. We found direct evidence of this, as hedge funds traded in a manner consistent with the exchange rate floor and with the expectation that the policy would remain in place up until the SNB announced its removal. To the extent that policymakers want to unwind such a policy and return pricing power to the market with minimal unintended market impacts, the behavior induced by the distorted incentives can become a complicating factor.

Finally, this analysis demonstrates the potential for what we can learn from financial markets and macroeconomic research using microdata, much of which is proprietary administrative data that has historically been unavailable to researchers for publicly oriented research. These data are more granular, timely, and comprehensive than publicly available data, and we hope that our access to de-identified versions of these data will enhance our ability to understand the behavior of institutional investors and their impacts on financial markets and the global economy.



# Data Asset

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In this report, the JPMorgan Chase Institute introduced a novel data asset and made use of this data to inform our understanding of institutional investor behavior in financial markets. We have constructed a unique, de-identified trade-level data asset that includes all available institutional investor transactions where the Markets Division of J.P. Morgan's Corporate & Investment Bank (CIB) acted as the market maker.

This is the first data asset of its kind being used for publicly available policy-oriented research that allows for a highly granular and detailed look at the behavior of institutional investors across all regions and in all asset classes. This data asset includes nearly 395 million trades and over 44,000 unique institutional investors.

Our data asset covers:

1. All types of institutional investors, including asset managers, banks, broker-dealers, corporates, hedge funds, pension funds, insurance companies, public sector investors, and others.<sup>45</sup>
2. Institutional investors from all regions globally that for this report we broadly categorize into three regions: Americas, Asia/Pacific (APAC), and Europe/Middle East/Africa/Other (EMEA).
3. Trades in financial instruments in all asset classes: foreign exchange, equities, fixed income, and commodities.
4. Both electronic and voice trades

Our data cover the post-financial crisis period, though historical coverage varies by asset class.

Our de-identified data excludes the name of the institutional investor and other information that would allow us to identify the institutional investor associated with any particular trade. Each institutional investor is assigned a random identifier before we ingest the data, and this identifier allows us to allocate trades to a given institutional investor and track their transactions over time. We can also observe the institutional investor's sector and country. We are also able to identify transaction details such as the exact instrument traded, whether it was bought or sold by the institutional investor, the amount of each instrument transacted, and the price at which it was executed. Given these details, we can calculate a first-order measure of risk associated with each transaction. This is a critical distinction and advantage of our data, and allows us to comment not only on transaction volumes but also on the amounts of risk being transferred. Most publicly available data do not include or facilitate the calculation of a measure of risk.

As the first financial institution to use this type of data for the benefit of the public good, JPMorgan Chase puts strong guardrails and strict privacy policy protocols in place throughout the data asset building and analysis process to protect the privacy of the institutional investors who transact with the CIB.

## Data Privacy

The JPMorgan Chase Institute has adopted rigorous security protocols and checks and balances to ensure all customer data are kept confidential and secure. Our strict protocols are informed by statistical standards employed by government agencies and our work with technology, data privacy, and security experts who are helping us maintain industry-leading standards.

There are several key steps the Institute takes to ensure customer data are safe and secure:

- The Institute's policies and procedures require that data it receives and processes for research purposes do not identify specific individuals or institutions.
- The Institute has put in place privacy protocols for its researchers, including requiring them to undergo rigorous background checks and enter into strict confidentiality agreements. Researchers are contractually obligated to use the data solely for approved research and are contractually obligated not to re-identify any individual or institution represented in the data.
- The Institute does not allow the publication of any information about an individual consumer or business. Any data point included in any publication based on the Institute's data may only reflect aggregate and/or scaled information.
- The data are stored on a secure server and can be accessed only under strict security procedures. The data cannot be exported outside of JPMorgan Chase's systems. The data are stored on systems that prevent them from being exported to other drives or sent to outside email addresses. These systems comply with all JPMorgan Chase Information Technology Risk Management requirements for the monitoring and security of data.

The Institute provides valuable insights to policymakers, businesses, and nonprofit leaders. But these insights cannot come at the expense of customer privacy. We take precautions to ensure the confidence and security of our customers' private information.

## Constructing our Samples

For this analysis, in order to study the trading behavior of institutional investors in the foreign exchange market around our three events of interest, we identified a subset of transactions that met the following criteria:

1. Involved CHF (for the SNB event), GBP (for Brexit), or MXN (for the US Election) against any currency
2. Occurred anywhere from one year before the relevant event to two trading days after the event
3. Were spot or forward trades
4. Were not cancelled

We further cleaned the data to eliminate any trades that had a missing trade date and execution time, a buy or sell amount of zero or missing, a missing investor sector, or were associated with an exchange rate that was very different than the prevailing market exchange rate. The data cleaning process removed less than 1 percent of the transactions in our data.

For our intraday analysis, where we restricted our sample to trades in a 24- or 48-hour period around each event (as described in the Analysis section), we used three samples of the following approximate sizes:

- CHF: 18,000 trades involving over 500 institutional investors
- GBP: 100,000 trades involving 1,500 institutional investors
- MXN: 4,000 trades involving nearly 500 institutional investors

Broadly speaking, we believe that J.P. Morgan’s overall share of institutional investor trading is large enough for our data asset to be representative of market activity by all institutional investors in the relevant markets. For the analysis in this report, we believe our share of the total foreign exchange market to be among the largest of all market makers and large enough overall (roughly 10-15 percent of the total market) to be directionally representative of the entire market. However, given the natural variation in J.P. Morgan’s market share across different currencies, investor sectors, regions, and time zones, the degree to which the sample we are analyzing is representative of the broader market will vary. Specifically, for this report, we believe our market share to be lower for MXN and higher for GBP, with the expected relative impact on representativeness. Also, it is likely that our data would be most representative for investors in the Americas and least representative for investors in Asia/Pacific. This is an important factor to keep in mind when interpreting the results of our analysis. However, as shown in Table 1 below, we believe that our institutional investor coverage in all currencies, sectors, and regions to be large enough for our analysis across these dimensions to be informative and meaningful.

**Table 1: The approximate number of institutional investors in our sample that were active in each currency in the year before each event.**

		CHF	GBP	MXN
By Investor Type	Institutional	> 1,500	> 3,000	> 1,000
	Corporate	> 1,000	> 3,000	> 1,000
By Region	Americas	> 1,500	> 3,000	> 1,000
	APAC	> 150	> 500	> 150
	EMEA	> 1,000	> 1,500	> 500

# Methodology

## Gross and Net Flows

In our analysis, we measured two outcomes: trade volume and net flows. For each, we analyzed the raw data in each of the selected samples and did not attempt to process the data to adjust for any fixed effects, such as cyclical, seasonality, or the impact of other large events (e.g., central bank activity, economic data releases, weather, etc.).

For each trade, we observed in our data the amount of currency or notional amount (where the units were CHF, GBP, or MXN) being traded where a positive number represents a buy and a negative number represents a sell from the perspective of the institutional investor (not J.P. Morgan as market maker):

$$\text{Trade Notional}_{t,j} = \begin{cases} + \text{ amount of currency traded, if client is buying} \\ - \text{ amount of currency traded, if client is selling} \end{cases}$$

where  $t$  represents a particular time and  $j$  represents a particular investor. Trade volumes reflect the amount of activity in a given time period and were measured as the sum of the absolute value of the notional of all the trades in a particular period:

$$\text{Trade Volume}_{T,j} = \sum_{t \in T, j \in J} |\text{Trade Notional}_{t,j}|$$

where  $T$  is the time interval over which we aggregate (daily, three or 15 minutes) and  $J$  is a particular investor sector. By taking the absolute value, we ignore the direction of the trade (buy or sell).

Net flows represent a measure of risk and were measured as the sum of the amount of all the trades in a particular time interval where buys were represented as positive numbers and sells were represented as negative numbers. Net flows took into account the direction of each trade and therefore yield the net amount and direction traded in a given time interval for a set of investors.

$$\text{Net Flows}_{T,j} = \sum_{t \in T, j \in J} \text{Trade Notional}_{t,j}$$

In order to calculate z-scores for trade volume or absolute value of net flows, we calculated the mean and standard deviation of daily trade volume and daily net flows (specifically, the absolute value of net flows on a daily basis) for the one-year period before the event. For example, for trade volume, the formula would be:

$$\text{Z score}_{\text{trade volume}} = \frac{\text{Trade Volume}_{\text{Event Day}} - \text{Trade Volume}_{\text{Year Prior}}}{\sigma(\text{Trade Volume}_{\text{Year Prior}})}$$

While none of the events took place on a weekend, we removed Saturdays, Christmas, and New Year's Day from the one-year period prior to the event in order to avoid downward biasing the means. We also allocated any Sunday trades to Mondays. All times were converted to GMT, so Monday morning trading in Asia was represented as late on Sundays in GMT time.

For both volume and net flows, we converted from the local currency into USD using Thomson Reuters tick data for intraday USD/CHF, USD/MXN, and GBP/USD exchange rates in order to compare amounts across events.<sup>46</sup>

Furthermore, for net flows, we also converted the USD-equivalent amounts for each currency using a scaling factor that accounts for currency-specific volume and price volatility. This conversion allowed us to compare risk across currency pairs. The intuition for making this conversion is that holding identical USD-equivalent amounts of GBP, CHF, and MXN do not represent the same amount of risk to an investor. Currencies that are associated with greater average daily volume or less price volatility are less risky for an investor to hold. Therefore, we constructed a volume-to-volatility ratio for each currency as follows:

1. Average daily volume—using daily settlement data from CLS for spot and outright forward transactions as a proxy for daily trading volume, we calculated the average daily settlement amounts of each currency for the one-year period before the relevant event.<sup>47</sup> This volume calculation uses the most commonly traded currency pairs for each currency, which in each case accounts for more than 90 percent of the total amount of that currency that settled. Each currency pair's CLS volume is weighted by the currency pair's share in our transaction data to calculate the weighted average volume for each relevant currency

$$Average\ Daily\ Volume_c = \sum \omega_p \frac{\sum_{t,p} CLS\ Trade\ Volume_{t,p}}{T}$$

where  $\omega_p$  is the weight for a specific currency pair,  $c$  is a specific currency,  $p$  is a specific currency pair,  $t$  is a specific day in the one year prior to event period, and  $T$  is the number of trading days in the one year period prior to event period.

2. Price volatility—using J.P. Morgan's daily exchange rate data, we calculated the annualized standard deviation of close-to-close returns of USD/CHF, GBP/USD, and USD/MXN over the one year prior to each event. We doubled the price volatility of USD/CHF to reverse the volatility dampening effect of the SNB's minimum exchange rate policy and better reflect the risk of a policy removal.<sup>48</sup>

$$Price\ Volatility_c = \sqrt{251} * \sigma \left( \frac{Exchange\ Rate_t - Exchange\ Rate_{t-1}}{Exchange\ Rate_{t-1}} \right)$$

3. Volume-to-volatility ratio—the ratio of average daily volume divided by price volatility for each currency

$$Volume\ to\ volatility_c = \frac{Average\ Daily\ Volume_c}{Price\ Volatility_c}$$

Finally, the scaling factor for each currency was calculated as follows: (1) setting the scaling factor for one currency (chosen as the base) to a number close to one, and then (2) for the other two currencies, calculating the ratio of each currency's volume-to-volatility ratio divided by that for the base currency.

$$Scaling\ Factor_c = \frac{Volume\ to\ Volatility_c}{Volume\ to\ Volatility_{Base\ Currency}} * Scaling\ Factor_{Base\ Currency}$$

For each currency, we then divided the USD-equivalent net flows in each time interval by the scaling factor.

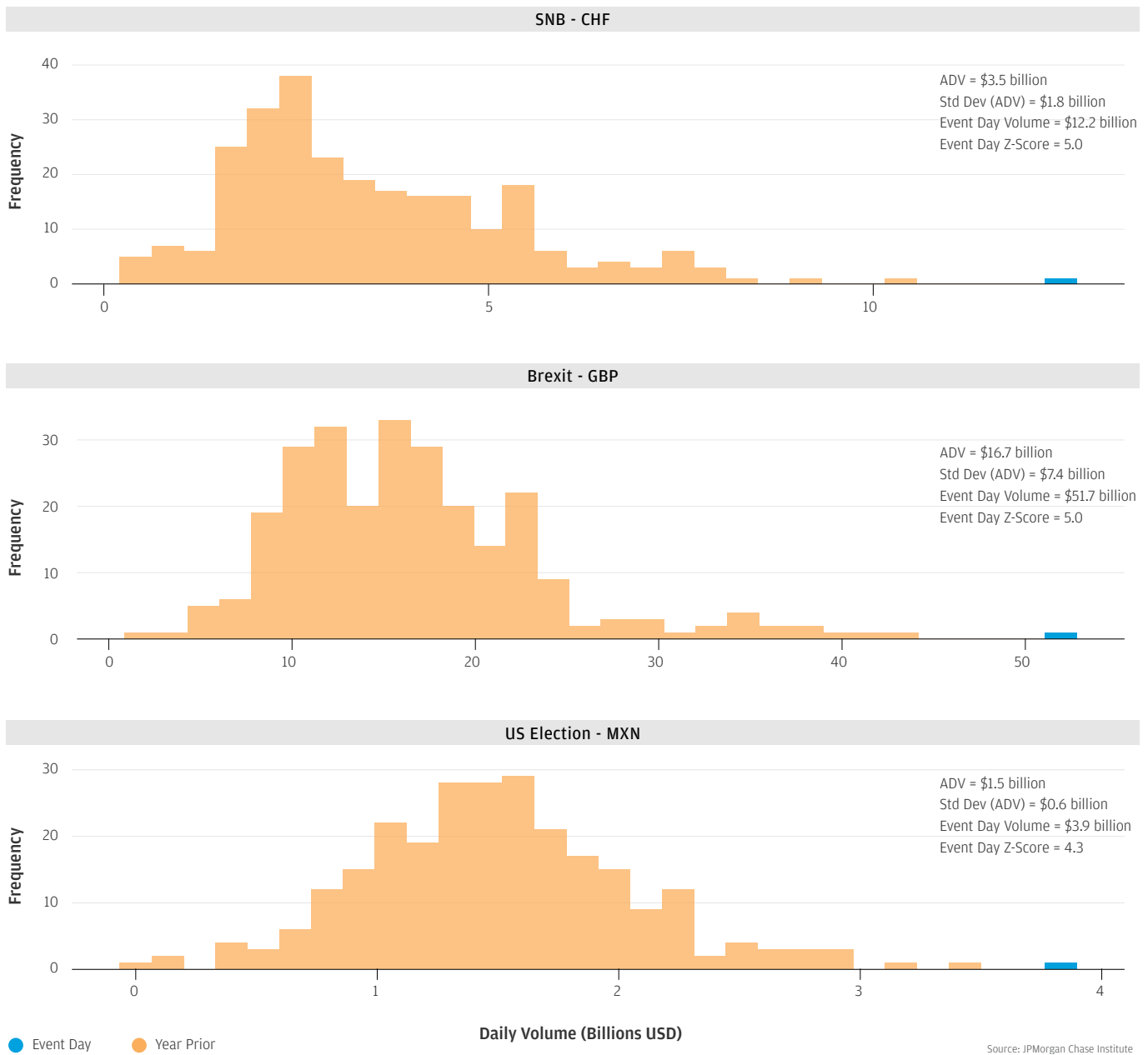
$$Scaled\ Net\ Flows\ USD_c = \frac{Net\ Flows\ USD_c}{Scaling\ Factor_c}$$

In order to create an intraday data series for exchange rates (both for converting volume and net flows into USD-equivalent amounts and to show in our figures), we used Thomson Reuters tick data.<sup>46</sup> First we calculated a mid-price as the average of each bid and offer at each tick. Then we created a minute-level data series from the tick data by taking the average of all ticks within five seconds before and after the end of the minute or if there were no such prices, we took the average of the three prices closest to the five seconds before the minute. Any minutes with missing data were imputed by carrying forward the last observation.

## Distribution of Daily Volume for Each Currency

In Finding 1 Figure 6, we looked at daily volume for each currency in the year leading up the relevant event as well as for the event day and the days immediately afterwards. We also showed the z-score of event day volume relative to the year before the event. In interpreting that z-score, it is important to keep in mind the distribution of the daily volume for each of the currencies. We show this in Figure 19 below using data for the one-year period leading up to each event. While the distribution for daily trading volumes in MXN looks approximately normally distributed, the distributions for CHF and GBP daily trading volumes are right-skewed (the mean is likely above the median), meaning the mass on either side of the mean are not equal.

Figure 19: Distribution of daily volume by event.



## Hedge Fund Flows During and the SNB's Minimum Exchange Rate Policy

In Finding 4 Box 2, we compared the relationship between hedge fund trades and the exchange rate while the EUR/CHF exchange rate floor was in place and after its removal. We found that for hedge funds, there were more bins with higher total net flows (signifying buying EUR vs. selling CHF) when the exchange rate was closer to the 1.20 floor than when the exchange rate was higher. Importantly, this was only true when the policy was in place. After the floor was removed, we do not see a relationship between exchange rate and net flows. To formally test the statistical significance of this finding, we randomly simulated this data 1,000 times and then counted how often we observed this same relationship. The specific steps were as follows:

1. Isolate all of the EUR/CHF spot trades done by hedge funds during both the floor and post-floor period (between September 6, 2011, to April 27, 2017).
2. Scramble the trade dates on these trades. In other words, randomly assign the dates to each trade (exchange rate and net flow pair).
3. Divide the scrambled trades into the floor period (September 6, 2011, to January 14, 2015) and post-floor period (January 15, 2015, to April 27, 2017). As we did for the finding, divide the trades into exchange rate bins (bin size = 0.001) and calculate total net flows for each bin.
4. Check if we see the same relationship as we do for our finding. Specifically, we define the rule as:
  - a. During the floor period, there are at least two bins in the band where the exchange rate is between 1.20 and 1.21 where the total net flow is at least 1.4 billion and there are less than two bins where the total net flow is at least 1.4 billion when the exchange rate is less than 1.20 or the exchange rate greater than 1.21
  - b. During the post-floor period, there are fewer than two bins in the 1.20-1.21 band and fewer than two bins outside of that band where the total net flow is at least 1.4 billion.
5. Repeat steps 2-4 1,000 times and count how many times the rule above is satisfied.

We found that the rule was satisfied 24 times out of 1,000 (2.4 percent), indicating that our finding was statistically significant at the 95 percent confidence level.

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# Endnotes

- 1 For results from an aggregate poll tracker, see <https://www.bloomberg.com/graphics/2016-brexit-watch/>. For betting market odds, see EU referendum chances on June 23, 2016, at 8 a.m. from <https://blogs.spectator.co.uk/2016/05/brexit-odds-live-updates-on-percentage-chance-of-uk-leaving-the-eu/>.
- 2 For a summary of the possible economic impacts of Brexit, see <https://www.lse.ac.uk/europeanInstitute/LSE-Commission/Hearing-11---The-impact-of-Brexit-on-jobs-and-economic-growth-summary.pdf>.
- 3 Source: <http://www.bbc.com/news/uk-politics-32810887>.
- 4 See Studer-Suter and Jannsen (2014) for a review of the academic literature on CHF as a safe-haven currency.
- 5 Source: Haver Analytics.
- 6 See [https://www.snb.ch/en/mmr/reference/pre\\_20110803/source/pre\\_20110803.en.pdf](https://www.snb.ch/en/mmr/reference/pre_20110803/source/pre_20110803.en.pdf).
- 7 See [https://snb.ch/en/iabout/monpol/id/qas\\_gp\\_ums#t2](https://snb.ch/en/iabout/monpol/id/qas_gp_ums#t2) for a description of SNB interest rate tools.
- 8 Sight deposits are deposits held by banks at the Swiss National Bank. For more details see [https://www.snb.ch/en/iabout/monpol/id/qas\\_gp\\_ums#t8](https://www.snb.ch/en/iabout/monpol/id/qas_gp_ums#t8).
- 9 See [https://www.snb.ch/en/mmr/reference/pre\\_20110810/source/pre\\_20110810.en.pdf](https://www.snb.ch/en/mmr/reference/pre_20110810/source/pre_20110810.en.pdf).
- 10 See [https://www.snb.ch/en/mmr/reference/pre\\_20110817/source/pre\\_20110817.en.pdf](https://www.snb.ch/en/mmr/reference/pre_20110817/source/pre_20110817.en.pdf).
- 11 See [https://www.snb.ch/en/mmr/reference/pre\\_20110906/source/pre\\_20110906.en.pdf](https://www.snb.ch/en/mmr/reference/pre_20110906/source/pre_20110906.en.pdf).
- 12 By the end of 2014, the SNB's balance sheet as a percentage of local GDP was considerably higher than other developed market central banks, such as the BoJ (58 percent), the Federal Reserve (26 percent), and the ECB (21 percent). Source: Haver Analytics.
- 13 Source: [https://web.archive.org/web/20150211234036/http://www.snb.ch:80/en/iabout/assets/id/assets\\_reserves](https://web.archive.org/web/20150211234036/http://www.snb.ch:80/en/iabout/assets/id/assets_reserves).
- 14 In theory, the SNB could have continued the minimum exchange rate policy indefinitely by printing CHF and then selling them to buy EUR, though this practice could lead to higher inflation and inflation expectations. In practice, the risks of large and increasing central bank balance sheets are still up for debate. Amador et al. (2016) address this topic, concluding that the fear of future, larger losses can lead a central bank that has built up large foreign exchange reserves to abandon a currency floor.
- 15 See [https://www.snb.ch/en/mmr/reference/pre\\_20150115/source/pre\\_20150115.en.pdf](https://www.snb.ch/en/mmr/reference/pre_20150115/source/pre_20150115.en.pdf).
- 16 For results from an aggregate US Election poll tracker, see <https://projects.fivethirtyeight.com/2016-election-forecast/>. For betting market odds, see [https://electionbettingodds.com/WIN\\_chart\\_maxim\\_lott\\_john\\_stossel.html](https://electionbettingodds.com/WIN_chart_maxim_lott_john_stossel.html).
- 17 See, for example, <http://money.cnn.com/2016/09/20/news/economy/donald-trump-mexico-peso/index.html>.
- 18 For a brief history of the evolution of Federal Reserve Communications see for example Swanson (2006) and the remarks by Ben Bernanke on 'Communications and Monetary Policy' from November 19, 2013, available at <https://www.federalreserve.gov/newsevents/speech/bernanke20131119a.htm>.
- 19 See [https://www.snb.ch/en/mmr/speeches/id/ref\\_20060624\\_tjn](https://www.snb.ch/en/mmr/speeches/id/ref_20060624_tjn) and [https://www.snb.ch/en/mmr/speeches/id/ref\\_20070524\\_tjn](https://www.snb.ch/en/mmr/speeches/id/ref_20070524_tjn).
- 20 In this context, the concept of liquidity for a currency is the relative ease at which an investor can buy or sell a large amount in a timely fashion without adversely affecting its exchange rate.
- 21 Interdealer transactions are those between two market-making dealers, and as such do not directly represent institutional investor transactions.
- 22 See the Data Asset section of this report for a more detailed description of our investor sectors.
- 23 Tick data refers to data from electronic trading platforms and captures each change, or tick, in the order book of the platform along with a timestamp. The order book is composed of the price and size of resting limit orders that are available for trading. Tick data also captures the price and size of completed trades.
- 24 See the Methodology section of this report for a discussion of the distribution of average daily volumes.
- 25 A z-score is a measure of how many standard deviations an observation is from the mean.
- 26 The sole exception is the public/other sector—trading volume for this group during Brexit was 5 to 6 standard deviations above ADV and remained so for the two days after the event—but even after the increase, their volume was still very small when compared to volumes from the active investor sectors.
- 27 We make a distinction between news and information—news is a specific type of information that is announced publicly. Information has a broader definition and includes not only public news but also private information such as imbalances in flows.
- 28 In foreign exchange trading, market makers put limit orders to buy or sell the currency into the limit order books of the various electronic trading platforms. These bids and offers are "firm," meaning that they can be traded on. We used the average of these bids and offers to construct the exchange rate time series shown in Figure 8. Importantly, this means market makers can move the exchange rate up or down as they see fit by increasing or decreasing their bids and offers—no transaction is required.
- 29 Market liquidity can be measured using a combination of transaction costs, the speed at which trades can be executed, the number and size of resting orders in the market (known as market depth), and the speed at which markets recover from order imbalances, as described in Lybek and Sarr (2002).

- 30 The relationship between event outcomes and uncertainty develops because market participants form expectations about the outcome of a pending, scheduled event in advance of the announcement. Once news is announced, uncertainty drops regardless of the outcome, simply because the event has passed and the news is public. If expectations are met, uncertainty drops further. If the outcome is away from expectations, uncertainty increases as a function of the difference between the outcome and expectations. If the outcome is far enough from expectations, then overall uncertainty will increase after the event.
- 31 Cielinska et al. (2017) documents the drop in liquidity for CHF during the SNB event. In addition, Cox and Griffith (2017) documents lower liquidity in equity markets just after the unexpected outcomes of the Brexit referendum and 2016 US Election became clear. Hautsch, Noe, and Zhang (2017) documents lower liquidity in the Bund futures market just after the unexpected outcome of the Brexit referendum.
- 32 Note that our definition of the SNB event includes the entirety of January, 15 2015, such that the day after the SNB event is January 16, 2015. Our definition of the Brexit event includes the entirety of June 24, 2016, the day after the referendum, such that the day after the Brexit event is June 25, 2016. Our definition of the US Election event includes the entirety of November 9, 2016, the day after the actual US Election, such that the day after the US Election event is November 10, 2016. For all three events, days are defined according to GMT time.
- 33 The SNB repricing period is a prime example of market makers' role as the supplier of immediacy to institutional investors—market makers stood ready to transact despite near-term imbalances in supply and demand and absorbed the market risk created by the asynchronous arrival of buyers and sellers. We do not make any quantitative or qualitative judgment as to the price at which liquidity was provided.
- 34 See <https://www.cftc.gov/MarketReports/CommitmentsofTraders/index.htm>.
- 35 Each CHF Futures contract equates to 125,000 Swiss Francs, as described here: [http://www.cmegroup.com/trading/fx/g10/swiss-franc\\_contract\\_specifications.html](http://www.cmegroup.com/trading/fx/g10/swiss-franc_contract_specifications.html). Commitment of Traders report data sourced from Haver Analytics.
- 36 Note that the Commitment of Traders reports only capture partial FX exposures, as they show positions in FX futures only (not FX spot, forward, or options positions) and because of their weekly frequency do not allow day-over-day position analysis.
- 37 In practice, investors would most likely implement such a trade through an FX forward contract, where the difference between the forward exchange rate and the spot exchange rate reflected the interest rate differential between the EUR deposit rate and the CHF deposit rate to the date of the forward contract. Over the period the floor was in place, the differential in one-month interest rates averaged about 28 basis points. To implement such a trade, a hedge fund would have to put up an independent amount (IA). The typical market maker or prime broker would require an IA of between 5 percent and 10 percent, which implies the investor could achieve leverage of 10 to 20 times.
- 38 See [https://www.snb.ch/en/mmr/reference/pre\\_20141218/source/pre\\_20141218.en.pdf](https://www.snb.ch/en/mmr/reference/pre_20141218/source/pre_20141218.en.pdf).
- 39 Source: Haver Analytics.
- 40 For the SNB and US Election events, EMEA trading hours run from 08:00 to 17:00 GMT, Americas trading hours run from 13:00 to 22:00 GMT, and APAC trading hours run from 22:00 to 08:00 GMT the next day. The Brexit event trading hours reflect daylight savings time: EMEA trading hours run from 07:00 to 16:00 GMT, Americas trading hours run from 12:00 to 21:00 GMT, and APAC trading hours run from 21:00 to 07:00 GMT the next day. Note that some of the trading sessions overlap.
- 41 See <https://www.bloomberg.com/news/articles/2018-01-22/fx-traders-do-100-million-deals-on-mobile-as-market-transforms>.
- 42 Trades that are “after hours” could also represent the execution of limit orders, stop orders, stop-limit orders, or good-till-cancelled orders left by institutional investors during their normal business hours and prior to the event in question. We do not observe order type, and therefore are unable to make this distinction.
- 43 For Brexit and the US Election, the event periods are 48 hours long, and as such we show the same average hourly volumes twice in these charts. For this analysis, we drop trades executed on a Sunday rather than allocating them to Monday.
- 44 For a further discussion of the belief that long-only investors with long-term investment horizons transact in a patient, countercyclical manner and how that belief is changing, see Acharya and Pedraza (2015), Shin (2013), and OECD (2013).
- 45 The public sector includes entities such as central banks, sovereign wealth funds, regional governments, and supranationals. The other category includes private equity investors and special purpose vehicles.
- 46 Source: <https://tickhistory.thomsonreuters.com/>.
- 47 Source: <https://www.quandl.com/databases/CLSRF/documentation/introduction>.
- 48 We doubled the price volatility for USD/CHF when calculating the scaling factor for USD/CHF because the SNB's minimum exchange rate policy reduced the volatility of USD/CHF significantly. In the year before the minimum exchange rate policy (September 5, 2010, to September 5, 2011), the price volatility of the USD/CHF exchange rate was 12.7%. In the final year that the minimum exchange rate policy was in place, the price volatility was 6.3%. If we were to use the 6.3% USD/CHF volatility figure in our volume-to-volatility calculation, we would be understating the risk of CHF transactions in the event that the SNB removed the floor. And in fact, in the year after the policy was removed, price volatility rose to 11.1%.

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