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Chapter 5

Implied Distributions from Risk-Reversals and Brexit/Trump Predictions

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In the 12 months from the middle of June 2016 to the middle of June 2017, a number of events occurred in a relatively short period of time, all of which either had, or had the potential to have, a considerably volatile impact upon financial markets.

The events referred to here are the Brexit referendum (23 June 2016), the US election (8 November 2016), the 2017 French elections (23 April and 7 May 2017) and the surprise 2017 UK parliamentary election (8 June 2017).

All of these events — the Brexit referendum and the Trump election in particular — were notable both for their impact upon financial markets after the event and the degree to which the markets failed to anticipate these events. A natural question to ask is whether these could have been predicted, given information freely available in the financial markets beforehand. In this paper, we focus on market expectations for price action around Brexit and the Trump election, based on information available in the traded foreign exchange options market.

Keywords: Brexit, Trump, foreign exchange options, implied distributions, forecasting, event risk.

1. Introduction

The year 2016 was notable for two major events in financial markets and world politics: Brexit and Trump. By these, we mean the UK referendum held on 23 June 2016 as to whether the UK should remain in the European

Union [EU] or leave it, and the US election on 8 November 2016 in which Donald Trump, once a relative outsider for the office of the President, won the election as Republican Party presidential nominee against the Democratic candidate Hillary Clinton.

These events share certain factors: they were both originally viewed as very unlikely from the viewpoint of mainstream political and economic commentary, but in the period of time before the UK referendum and the US election, both campaigns (for Brexit and for Trump) managed to marshal enough popular sentiment to achieve the result they sought.

After these two surprise results, commentators naturally turned their attention to two questions. Firstly, potentially using information available in financial markets or betting markets, could these results have been better predicted? Secondly, could similar techniques be used to assess the probability of similar unlikely but potentially very market-sensitive events occurring in 2017?

One natural possibility to analyse in the second quarter of 2017, as a potential consequence of the continuation of Brexit/Trump populism spreading to the Eurozone, was the possibility of the election of Marine Le Pen in the French elections held in two rounds on 23 April and 7 May 2017, which was won convincingly by Emmanuel Macron in the second round. A second and unexpected opportunity for modeling political event risk arose on 18 April 2017, when Theresa May (UK Prime Minister since 13 July 2016, following the Brexit referendum) announced that a UK general election would be held on 8 June 2017. It was generally felt beforehand that her position was unassailable, however the result was a net loss of thirteen seats for the Conservative Party, which was then no longer able to govern with an outright majority and needed to form a minority government supported by the Conservative-DUP agreement.

Our contribution to this volume seeks to empirically investigate the implied probability distributions around these event dates. We have already considered the case of Brexit [1] and we shall review our analysis herein, and then extend the analysis to Trump and the 2017 elections mentioned above.

2. Literature Review

We know from Breeden and Litzenberger [2] that if we know the price of European options on a tradable asset at all strikes, for a specific time

to expiry T , then we can infer the future risk-neutral probability distribution for that asset at the future time T . This is described with reference to foreign exchange [FX] markets in Malz [3]. An application of this principle is made by the same author [4] in connection with the specific example of the British pound/Deutsche Mark exchange rate in the European Exchange Rate Mechanism. More recently, in other works [5]–[8], the case of EURCHF is considered, which between 6 September 2011 to 15 January 2015 had an effective floor maintained at 1.20 Swiss francs per Euro due to Swiss National Bank policy and intervention in currency markets.

As well as our own work [1], Dupire [9] and Hanke *et al.* [10] use similar methods to model potential FX moves around the dates of the Brexit referendum and the 2016 US election (specifically considering the FX example of the Mexican peso quoted against the US dollar). Dupire [9] also discusses the 2017 French elections, with respect to equity markets, which have a traded market in volatility through the VIX [11].

It is therefore clear that there is a historical body of work that analyses the short-dated volatility skew in FX markets in order to construct implied distributions for currency exchange rates at various time horizons of interest, aligned with real world events subject to political event risk on those dates. This is the scope of this work.

3. Method

Historical spot and implied volatility quotes have been obtained from Bloomberg (www.bloomberg.com) for various currency pairs (EURUSD, GBPUSD, USDMXN) together with historical timeseries of bookmaker quotes from the Oddschecker web site (www.oddschecker.com) for bets on the event that the UK votes to leave the EU.

Spot market quotes are merely the price in units of domestic currency of one unit of foreign currency. Volatility quotes, however, are more complex. At-the-money straddles and 25-delta and 10-delta strangles and risk reversals with expiries corresponding to the overnight maturity, 1, 2 and 3 weeks, and at 1, 2, 3, 6 and 12 months.

For each expiry T_j , we have five market quotes from the volatility surface: σ_{ATM} , $\sigma_{25-d-SS}$, $\sigma_{10-d-SS}$, $\sigma_{25-d-RR}$ and $\sigma_{10-d-RR}$, where σ_{x-d-SS} denotes the x -delta smile strangle and σ_{x-d-RR} denotes the x -delta risk reversal, both expressed in units of volatility; see [12]. Consequently, we have five implied volatilities σ_{10-d-P} , σ_{25-d-P} , σ_{ATM} , σ_{25-d-C}

and σ_{10-d-C} satisfying

$$\sigma_{x-d-SS} = \frac{1}{2}[\sigma_{x-d-C} + \sigma_{x-d-P}] - \sigma_{ATM}, \quad (1a)$$

$$\sigma_{x-d-RR} = \sigma_{x-d-C} - \sigma_{x-d-P}, \quad (1b)$$

where $x \in \{25, 10\}$ and with the strikes K_{10-d-P} , K_{25-d-P} , K_{ATM} , K_{25-d-C} and K_{10-d-C} chosen such that

$$\sigma_{\text{imp}}(K_i) = \sigma_i, \quad (2a)$$

$$\Delta(-1, K_{x-d-P}, T, \sigma_{x-d-P}) = -x/100, \quad (2b)$$

$$\Delta(+1, K_{x-d-C}, T, \sigma_{x-d-C}) = x/100, \quad (2c)$$

$$\Delta(+1, K_{ATM}, T, \sigma_{ATM}) + \Delta(-1, K_{ATM}, T, \sigma_{ATM}) = 0, \quad (2d)$$

with $\omega = -1$ for a put and $\omega = +1$ for a call in

$$\Delta(\omega, K, T, \sigma) = \begin{cases} \omega N(\omega d_1), & \text{for GBPUSD,} \\ \omega \frac{K}{F_{0,T}} N(\omega d_2), & \text{for EURGBP.} \end{cases} \quad (3)$$

As we have five implied volatilities available for each maturity we have sufficiently many data points to interpolate between, or to calibrate a mixture model to the market.

Premium adjusted deltas are used for EURGBP and USDMXN but not for GBPUSD or EURUSD in (3), following usual FX market conventions [12]. In all cases we solve numerically for K_i to obtain a strike based representation for the volatility surface which we then extend to a full volatility surface $\sigma_{\text{imp}}(K, T)$ using flat forward volatility interpolation in the temporal dimension, and polynomial in delta interpolation in the moneyness dimension, to account for smile. For flat forward volatility interpolation in time, for interpolating volatility at time t in between two prespecified tenors t_1 and t_2 , we use

$$\sigma(t) = \sqrt{\frac{t_2(t-t_1)}{t(t_2-t_1)}\sigma^2(t_2) + \frac{t_1(t_2-t)}{t(t_2-t_1)}\sigma^2(t_1)}. \quad (4)$$

For polynomial in delta interpolation we use an expression of the form

$$\sigma_X(K) = \exp(f(\ln(F_{0,T}/K))) \quad (5a)$$

with

$$f(x) = \sum_{i=0}^4 c_i [\delta(x)]^i \quad (5b)$$

where $F_{0,T}$ is the T -forward, $\sigma_0 = \exp(c_0)$ and

$$\delta(x) = N(x/(\sigma_0\sqrt{T})). \quad (5c)$$

Note that we first interpolate in time, for each of the five points on the smile, and then we interpolate in strike, thereby obtaining a volatility surface $\sigma(K, T)$, which immediately gives call prices for all strikes K and tenors T

$$C(K, T) = S_0 e^{-r^f T} N(d_1) - K e^{-r^d T} N(d_2) \quad (6a)$$

using

$$d_{1,2} = \frac{\ln\left(\frac{F_{0,T}}{K}\right) \pm \frac{1}{2}[\sigma(K, T)]^2 T}{\sigma(K, T)\sqrt{T}}. \quad (6b)$$

Once we have this, we can employ Breeden-Litzenberger [2] to obtain the implied distribution for the terminal FX spot rate S_T in the (domestic) risk-neutral measure

$$f_{S_T}^d(K) = e^{r^d T} \frac{\partial^2 C(K, T)}{\partial K^2}. \quad (7)$$

Note that the risk-free rate r^d is determined separately for each maturity given the underlying yield curve, rather than being presumed constant.

As well as the empirical approach based around the Breeden-Litzenberger analysis above, we construct a mixture model, as described in [1] and references therein, which has a specific probability P_E of a **risk event** (such as a vote for Brexit, Trump, Le Pen or a vote against a Theresa May majority government) on the referendum/election date which we expect the market could well be sensitive to, and thereby associated with an event risk potentially likely to cause a jump in FX rates. We let T^* denote the time to that referendum/election date and use P_{NE} to denote the probability of no such risk event happening (clearly $P_E + P_{NE} = 1$).

In the case of a vote for a risk event (such as one of the above), we model this with a post-event exchange rate S_{T^*} by integrating the stochastic process $dS_t = \mu_E S_t dt + \sigma_E S_t dW_t$ from 0 to T^* , with drift and volatility terms μ_E and σ_E . If, however, the risk event does not come to pass, we model the distribution for S_{T^*} using Black-Scholes $dS_t = \mu_{NE} S_t dt + \sigma_{NE} S_t dW_t$ with a compensated drift μ_{NE} and a “no risk event” volatility σ_{NE} (both σ_E and σ_{NE} are annualized volatilities).

By risk-neutrality, we require

$$F_{0,T^*} = \mathbb{E}^d[S_{T^*}] = (1 - P_E)S_0 \exp(\mu_{NE}T^*) + P_E S_0 \exp(\mu_E T^*), \quad (8)$$

so the “no risk event” scenario has a terminal distribution for S_{T^*} equal to that of a Black-Scholes model with compensated risk-neutral drift term

$$\mu_{NE} = \frac{1}{T^*} \ln \left(\frac{F_{0,T^*} - P_E S_0 \exp(\mu_L T^*)}{S_0(1 - P_E)} \right). \quad (9)$$

We write the terminal distribution of the FX rate under the mixture model

$$S_{T^*} = \begin{cases} S_0 \exp \left((\mu_{NE} - \frac{1}{2} \sigma_{NE}^2) T^* + \sigma_{NE} W_{T^*} \right), & \text{with probability } 1 - P_E, \\ S_0 \exp \left((\mu_E - \frac{1}{2} \sigma_E^2) T^* + \sigma_E W_{T^*} \right), & \text{with probability } P_E. \end{cases} \quad (10)$$

Valuation of any European option with strike K is simply obtained by taking a weighted sum of the two Black-Scholes prices corresponding to integration of the payout function over the two density kernels.

Integrating the expression in the second case of (10) yields

$$S_{T^*,E} = S_E \exp \left(\left(\sigma_E \xi \sqrt{T^*} - \frac{1}{2} \sigma_E^2 T^* \right) \right), \quad (11)$$

where $S_E = S_0 \exp(\mu_E T^*)$ denotes the point estimate for the FX rate under the “risk event” scenario and $\xi \sim N(0, 1)$, i.e. ξ is normally distributed.

We use market volatility surfaces as described earlier to estimate risk event probabilities P_E based on the observed skew. Since we have five implied volatilities at each time slice, we conduct a least squares calibration of the parameter set $\{P_E, S_E, \sigma_E, \sigma_{NE}\}$ using Levenberg-Marquardt optimization.

4. Results

4.1. 2016 Brexit referendum

As already presented elsewhere in the literature [1], Figures 1 and 2 show implied densities for GBPUSD and EURGBP respectively from 1 May 2015 to 23 June 2016 for options expiring the day after the Brexit referendum date, and also the implied density as seen on Friday 24 June 2016 for the FX rate one business day later. These results suggest probability mass for GBPUSD between 1.10 and 1.30, and for EURGBP between 0.825 and 0.95 at the referendum date.

Nothing in the above provides directional support for making the claim that a “leave” vote in the Brexit referendum need be associated with the lower mode for the GBPUSD distribution, of course. In order to make a case for this, we have collected information from betting markets from the Oddschecker web site (www.oddschecker.com), an odds comparison web

site where prices for digital bets on certain political events are published (and tradable). The raw data, expressed as betting odds, is transformed into an implied probability for “leave”.

By considering the historical behavior of moves in FX spot relative to absolute changes in the betting market implied odds of a “leave” vote, displayed in Figure 3, we see that a 1% increase in the probability of a “leave” vote is correlated with a 0.16% decrease in GBPUSD. This we contend suggests that the probability mass for GBPUSD between 1.10 and 1.30 (and for EURGBP between 0.825 and 0.95) can be associated with the regime in which the actual Brexit vote is for “leave” on the referendum date.

In Tables 1 and 2 we see the parameters for the calibrated mixture model for each analysis date, where we show the implied probability P_E of a “leave” vote and the point estimate S_E for the FX spot price in the event of a Brexit “leave” vote, together with the expected GBP percentage appreciation $S_E/S_0 - 1$ (negative numbers, indicating devaluation in the event of a Brexit “leave” vote) and a 95% confidence interval for the realized post-referendum FX spot rate for GBPUSD in the event of a “leave vote”, together with “remain” and “leave” volatilities σ_{NE} and σ_E respectively (corresponding to no risk event and risk event respectively).

In Figure 4 we show the “leave” point estimate S_E and the “remain” point estimate S_{NE} together with the GBPUSD FX spot rate S_0 on each trading day, from 24 February to 22 June 2016, and in Figure 5 we show the mixture model implied “leave” probability P_E together with the two volatilities σ_E and σ_{NE} , also from 24 February to 22 June 2016.

We can see in these two figures that the implied “leave” probability varied between 15.3% and 45.3% during the period of analysis, with an average level of 30.6%, with a considerable amount of uncertainty from late April 2016 onwards (reflecting the market confusion during the approach to the referendum). From 25 June 2016 onwards, i.e. a month before the referendum date, we see a clear upward trend in both “leave” and “remain” volatilities σ_E and σ_{NE} , and an increasing separation between the point estimates S_E and S_{NE} for the “leave” and “remain” states. While there is some parameter uncertainty, perhaps not surprisingly given the uncertainty in the market, the average value of the estimate S_L over the two weeks (ten business days) before the referendum was 1.3727, very consistent indeed with the actual FX spot level decline from 1.4877 to 1.3622 which was realized after the announcement of the “leave” vote.

Fig. 1. GBPUSD implied densities for the Brexit referendum date from 1 May 2015 to 23 June 2016, sampled monthly from 1 May 2015 to 1 June 2016, then sampled daily, and for the next business day on 24 June 2016 (Source: [1]).

Fig. 2. EURGBP implied densities for the Brexit referendum date from 1 May 2015 to 23 June 2016, sampled monthly from 1 May 2015 to 1 June 2016, then sampled daily, and for the next business day on 24 June 2016 (Source: [1]).

Table 1. Calibrated mixture model parameters for GBPUSD from 24 February to 26 April 2016 (Source: [1]).

Date	S_0	P_E	S_E	$S_E/S_0 - 1$	95% CI for $S_{T^*,E}$		σ_{NE}	σ_E
24 Feb 2016	1.3927	30.8%	1.3250	-4.9%	1.0316	1.6184	8.8%	18.6%
25 Feb 2016	1.3962	31.5%	1.3319	-4.6%	1.0390	1.6247	8.4%	18.6%
26 Feb 2016	1.3871	32.0%	1.3252	-4.5%	1.0383	1.6120	8.3%	18.4%
29 Feb 2016	1.3917	32.6%	1.3340	-4.1%	1.0553	1.6128	8.2%	18.1%
01 Mar 2016	1.3952	32.5%	1.3378	-4.1%	1.0656	1.6100	8.1%	17.7%
02 Mar 2016	1.4078	32.4%	1.3541	-3.8%	1.0824	1.6258	7.9%	17.6%
03 Mar 2016	1.4178	33.4%	1.3666	-3.6%	1.0982	1.6349	7.9%	17.3%
04 Mar 2016	1.4229	33.0%	1.3711	-3.6%	1.1072	1.6351	7.7%	17.0%
07 Mar 2016	1.4265	33.5%	1.3773	-3.4%	1.1209	1.6337	7.7%	16.7%
08 Mar 2016	1.4215	33.3%	1.3737	-3.4%	1.1211	1.6262	7.6%	16.6%
09 Mar 2016	1.4217	33.5%	1.3753	-3.3%	1.1255	1.6252	7.5%	16.5%
10 Mar 2016	1.4281	33.7%	1.3830	-3.2%	1.1322	1.6339	7.6%	16.6%
11 Mar 2016	1.4382	32.7%	1.3936	-3.1%	1.1534	1.6337	7.1%	15.8%
14 Mar 2016	1.4302	33.5%	1.3885	-2.9%	1.1602	1.6167	7.0%	15.4%
15 Mar 2016	1.4151	33.5%	1.3701	-3.2%	1.1405	1.5998	7.3%	15.7%
16 Mar 2016	1.4259	34.1%	1.3800	-3.2%	1.1483	1.6117	7.4%	15.8%
17 Mar 2016	1.4482	33.9%	1.4011	-3.3%	1.1691	1.6331	7.5%	15.7%
18 Mar 2016	1.4476	34.5%	1.4015	-3.2%	1.1702	1.6328	7.6%	15.7%
21 Mar 2016	1.4369	34.7%	1.3902	-3.3%	1.1690	1.6113	7.7%	15.4%
22 Mar 2016	1.4208	35.6%	1.3751	-3.2%	1.1413	1.6089	8.2%	16.5%
23 Mar 2016	1.4117	27.9%	1.3189	-6.6%	1.0065	1.6314	9.5%	22.3%
24 Mar 2016	1.4153	27.4%	1.3159	-7.0%	1.0107	1.6210	9.5%	21.9%
25 Mar 2016	1.4132	27.7%	1.3156	-6.9%	1.0099	1.6212	9.6%	22.0%
28 Mar 2016	1.4254	30.6%	1.3471	-5.5%	1.0402	1.6540	9.6%	22.3%
29 Mar 2016	1.4384	27.2%	1.3403	-6.8%	1.0542	1.6264	9.4%	20.7%
30 Mar 2016	1.4378	26.6%	1.3394	-6.8%	1.0519	1.6269	9.4%	21.0%
31 Mar 2016	1.4360	27.9%	1.3453	-6.3%	1.0555	1.6350	9.5%	21.3%
01 Apr 2016	1.4227	27.8%	1.3326	-6.3%	1.0490	1.6161	9.5%	21.1%
04 Apr 2016	1.4264	27.6%	1.3383	-6.2%	1.0718	1.6048	9.2%	20.2%
05 Apr 2016	1.4161	28.5%	1.3349	-5.7%	1.0632	1.6067	9.5%	20.8%
06 Apr 2016	1.4123	27.8%	1.3246	-6.2%	1.0629	1.5864	9.8%	20.3%
07 Apr 2016	1.4056	28.8%	1.3222	-5.9%	1.0596	1.5849	9.9%	20.6%
08 Apr 2016	1.4128	30.4%	1.3377	-5.3%	1.0779	1.5975	9.6%	20.4%
11 Apr 2016	1.4239	30.2%	1.3520	-5.1%	1.1070	1.5970	9.4%	19.4%
12 Apr 2016	1.4275	31.3%	1.3611	-4.7%	1.1158	1.6064	9.4%	19.5%
13 Apr 2016	1.4204	31.1%	1.3552	-4.6%	1.1200	1.5904	9.4%	19.0%
14 Apr 2016	1.4155	32.4%	1.3566	-4.2%	1.1203	1.5929	9.5%	19.2%
15 Apr 2016	1.4202	30.6%	1.3590	-4.3%	1.1322	1.5858	9.4%	18.5%
18 Apr 2016	1.4278	33.0%	1.3801	-3.3%	1.1684	1.5918	9.0%	17.6%
19 Apr 2016	1.4398	37.5%	1.4026	-2.6%	1.2009	1.6043	8.4%	16.7%
20 Apr 2016	1.4332	37.7%	1.3991	-2.4%	1.2071	1.5911	8.1%	16.1%
21 Apr 2016	1.4323	37.8%	1.3993	-2.3%	1.2120	1.5866	8.1%	15.9%
22 Apr 2016	1.4403	39.5%	1.4118	-2.0%	1.2282	1.5955	7.9%	15.6%
25 Apr 2016	1.4482	42.8%	1.4305	-1.2%	1.2643	1.5968	7.6%	14.4%
26 Apr 2016	1.4582	22.6%	1.3546	-7.1%	1.1698	1.5394	9.3%	16.0%

Fig. 3. Percentage change in GBPUSD FX spot rates [y-axis] vs. the change in the leave probability from betting markets [x-axis] (12 January to 23 June 2016).

4.2. 2016 US election – Trump

Figure 6 shows implied distributions for USDMXN (the Mexican peso equivalent of one US dollar) based on FX options expiring on Wednesday 9 November 2016, i.e. the day after the 2016 US election. We see a notable skew in the distribution, suggesting the possibility of a devaluation in the Mexican peso in accordance with a move in USDMXN to above 20, in the event of a Trump victory — a move in FX which indeed came to pass after the election result became known.

Calibrating the mixture model to the observed FX volatility surfaces for USDMXN, we obtain the results shown in Table 3, which similarly suggest a “risk event” move upwards in USDMXN of around 5% from prevailing FX spot levels below 19.5 up towards the region of 20, which indeed happened after the Trump victory. We also see a mixture model implied probability of a Trump victory between 23.7% and 55.0% during the period shown in Table 3, with an average level of 38.6% — while these parameters seem unstable, it is worth remembering that many different factors were influencing the markets at this time, so we would not expect too much stability.

Fig. 4. Mixture model implied point estimates for S_E and S_{NE} (corresponding to “leave” and “remain” states of the world resp.) together with FX spot S_0 (24 February to 22 June 2016).

4.3. 2017 French elections

In Figures 7 and 8 we apply the same technique to obtain implied distributions for EURUSD for the day after the first round and second round respectively. We see downside risk for the Euro, though not as extreme an FX risk as for the Brexit and Trump events of 2016, with potential decline in the Euro to around 1.05, which we would expect to be associated with a victory for Marine Le Pen. However, this sequence of events did not happen thanks to Emmanuel Macron’s success in the election. We note for the first round of the French election, that the probability of very large downside moves in EURUSD is higher, compared with the second round, presumably reflecting the greater uncertainty at the first round stage.

We attempted to calibrate the mixture model to FX EURUSD volatilities but found that the calibration scheme experienced numerical problems when detecting any bimodality, perhaps not surprisingly given the relatively small levels of FX skew compared with the earlier levels seen for Brexit and Trump scenarios. This manifests as degeneracy in the parameter set (due to $S_E \approx S_{NE}$) and parameter instability. It would be interesting to conduct an analysis of the skew dependency of the mixture model, with

Fig. 5. Mixture model implied “leave” probability P_E together with σ_E and σ_{NE} for Brexit under “leave” and “remain” states of the world (24 February to 22 June 2016).

a view to improving the small skew behavior. This is an area we hope to revisit.

4.4. 2017 UK general election

A final and unexpected opportunity to investigate empirically implied FX distributions in relation to contemporary political events arose on 18 April 2017, and we can therefore present implied distributions for the GBPUSD currency pair for Friday 9 June 2017, the day on which the election results would be known. We see in Figure 9 some probability mass in the range 1.25 to 1.275, which we would have expected to be realized if Theresa May had unexpectedly lost the election or proceeded to a hung parliament, and in contrast a decisive Conservative Party victory would be likely to be slightly stronger for the British pound. The result in June 2017, with Theresa May’s Conservative government losing the majority in the House of Commons after a net loss of 13 seats, was accompanied by a sudden fall in GBPUSD from levels around 1.29 to a levels around 1.275, very much in line with our expectations based on implied distributions.

Table 2. Calibrated mixture model parameters for GBPUSD from 27 April to 22 June 2016 (Source: [1]).

Date	S_0	P_E	S_E	$S_E/S_0 - 1$	95% CI for $S_{T^*,E}$		σ_{NE}	σ_E
27 Apr 2016	1.4543	23.2%	1.3549	-6.8%	1.1727	1.5371	9.2%	16.0%
28 Apr 2016	1.4609	23.3%	1.3620	-6.8%	1.1818	1.5423	9.2%	15.9%
29 Apr 2016	1.4612	23.7%	1.3684	-6.3%	1.1856	1.5512	9.2%	16.2%
02 May 2016	1.4673	23.2%	1.3737	-6.4%	1.2001	1.5472	9.4%	15.8%
03 May 2016	1.4535	23.7%	1.3639	-6.2%	1.1845	1.5432	9.6%	16.6%
04 May 2016	1.4496	25.0%	1.3650	-5.8%	1.1768	1.5533	9.8%	17.6%
05 May 2016	1.4485	26.9%	1.3732	-5.2%	1.1839	1.5625	9.5%	17.9%
06 May 2016	1.4427	23.1%	1.3495	-6.5%	1.1766	1.5223	9.5%	16.6%
09 May 2016	1.4407	25.0%	1.3604	-5.6%	1.1875	1.5332	9.5%	17.2%
10 May 2016	1.4442	23.7%	1.3580	-6.0%	1.1915	1.5245	9.7%	16.7%
11 May 2016	1.4448	26.0%	1.3682	-5.3%	1.2027	1.5337	9.4%	16.7%
12 May 2016	1.4451	25.0%	1.3677	-5.4%	1.2038	1.5316	9.5%	16.8%
13 May 2016	1.4365	22.8%	1.3439	-6.4%	1.1860	1.5018	10.0%	16.4%
16 May 2016	1.4402	24.9%	1.3649	-5.2%	1.2061	1.5236	9.8%	17.1%
17 May 2016	1.4463	24.7%	1.3737	-5.0%	1.2286	1.5188	9.2%	15.8%
18 May 2016	1.4599	31.8%	1.4141	-3.1%	1.2637	1.5645	8.3%	16.4%
19 May 2016	1.4611	33.2%	1.4203	-2.8%	1.2744	1.5662	8.3%	16.1%
20 May 2016	1.4502	32.0%	1.4089	-2.8%	1.2700	1.5479	8.3%	15.7%
23 May 2016	1.4484	41.5%	1.4266	-1.5%	1.2974	1.5557	8.3%	15.2%
24 May 2016	1.4636	42.7%	1.4464	-1.2%	1.3241	1.5686	8.2%	14.5%
25 May 2016	1.4697	43.0%	1.4536	-1.1%	1.3325	1.5747	8.2%	14.5%
26 May 2016	1.4670	26.2%	1.3841	-5.6%	1.2358	1.5324	9.2%	18.1%
27 May 2016	1.4623	22.6%	1.3784	-5.7%	1.2207	1.5362	10.0%	19.7%
30 May 2016	1.4640	26.7%	1.4060	-4.0%	1.2592	1.5528	9.8%	19.4%
31 May 2016	1.4483	32.3%	1.4006	-3.3%	1.2511	1.5500	10.8%	20.3%
01 Jun 2016	1.4416	39.2%	1.4067	-2.4%	1.2538	1.5596	11.3%	21.3%
02 Jun 2016	1.4423	39.7%	1.4130	-2.0%	1.2740	1.5520	10.6%	19.8%
03 Jun 2016	1.4518	31.9%	1.3676	-5.8%	1.2025	1.5328	13.4%	23.9%
06 Jun 2016	1.4442	25.8%	1.3600	-5.8%	1.2081	1.5118	14.4%	23.8%
07 Jun 2016	1.4545	28.1%	1.3825	-4.9%	1.2359	1.5292	13.3%	23.5%
08 Jun 2016	1.4504	27.5%	1.3865	-4.4%	1.2511	1.5218	13.2%	22.4%
09 Jun 2016	1.4458	32.1%	1.4002	-3.2%	1.2742	1.5263	12.7%	21.6%
10 Jun 2016	1.4257	29.2%	1.3461	-5.6%	1.1033	1.5889	18.8%	43.6%
13 Jun 2016	1.4270	31.2%	1.3497	-5.4%	1.1287	1.5708	22.4%	44.5%
14 Jun 2016	1.4114	29.9%	1.3369	-5.3%	1.1417	1.5321	22.4%	41.6%
15 Jun 2016	1.4204	35.7%	1.3769	-3.1%	1.2023	1.5515	18.8%	38.9%
16 Jun 2016	1.4203	39.1%	1.3914	-2.0%	1.2319	1.5510	18.3%	37.5%
17 Jun 2016	1.4358	15.3%	1.2900	-10.2%	1.0893	1.4906	35.3%	49.7%
20 Jun 2016	1.4698	18.0%	1.3779	-6.3%	1.2308	1.5249	26.1%	46.0%
21 Jun 2016	1.4652	26.1%	1.4198	-3.1%	1.2588	1.5809	22.9%	57.3%
22 Jun 2016	1.4707	45.3%	1.4378	-2.2%	1.3323	1.5434	26.7%	44.2%

5. Conclusions

In this contribution we have surveyed the literature employing option pricing theory to analyse information embedded in the volatility surfaces

Fig. 6. USD/MXN implied densities for the day after the 2016 US election date (11 October to 3 November 2016).

pertaining to political event risk over the decade so far (2010–2017). We have cited several works that model the Swiss National Bank’s defense level for the Swiss franc and the floor on EURCHF thereby imposed. We mention our own analysis of Brexit, with reference to GBPUSD and EURGBP, and we obtain implied distributions for USD/MXN at the date of the US election, thereby describing the potential collapse in the Mexican peso to levels of 20 or more to the US dollar (a scenario which came to pass). Finally, we construct implied distributions for the 2017 French presidential and UK general elections, finding currency rate distributions which we attempt to ascribe to potential outcomes in the election. In the case of the French elections, no particular event risk analogous to Brexit came to pass, whereas the surprise factor of the Conservative Party’s poor result in the June 2017 UK general election is consistent with our expectations based on implied distributions.

It would be of interest to extend and strengthen this analysis by utilizing more quantitative methods such as the mixture model approach [1] and including additional predictive information such as betting market odds and polls data [10], which would allow us to strengthen the analysis, both in terms of describing market regimes and apportioning them to potential

Table 3. Calibrated mixture model parameters for USDMXN from 3 October to 3 November 2016.

Date	S_0	P_E	S_E	$S_E/S_0 - 1$	95% CI for $S_{T^*,E}$		σ_{NE}	σ_E
03 Oct 2016	19.3007	52.0%	19.9551	2.7%	17.2743	22.6360	12.2%	19.9%
04 Oct 2016	19.3255	46.9%	19.8175	2.7%	17.4099	22.2251	12.8%	19.6%
05 Oct 2016	19.2087	53.6%	19.8480	2.2%	17.5032	22.1928	11.4%	18.1%
06 Oct 2016	19.2361	41.9%	19.6346	4.8%	17.5119	21.7574	13.2%	20.5%
07 Oct 2016	19.2980	41.6%	20.1660	5.0%	17.7925	22.5396	13.5%	21.0%
10 Oct 2016	18.9274	49.4%	20.2575	4.3%	17.8513	22.6637	12.5%	20.9%
11 Oct 2016	18.9143	45.7%	19.7422	4.4%	17.5051	21.9792	14.4%	21.7%
12 Oct 2016	18.9151	35.4%	19.7560	5.4%	17.4737	22.0382	14.3%	19.5%
13 Oct 2016	18.9267	39.6%	19.9271	4.5%	17.9097	21.9445	12.9%	18.7%
14 Oct 2016	18.9914	40.0%	19.7775	4.0%	17.8697	21.6853	11.6%	17.4%
17 Oct 2016	18.8745	41.4%	19.7597	3.2%	18.0105	21.5090	10.8%	15.4%
18 Oct 2016	18.6130	31.0%	19.4787	3.9%	18.0344	20.9230	11.0%	13.3%
19 Oct 2016	18.5225	42.6%	19.3428	2.6%	18.1400	20.5457	10.2%	13.3%
20 Oct 2016	18.6182	55.0%	19.0058	1.3%	17.8360	20.1756	9.9%	14.1%
21 Oct 2016	18.6182	55.0%	18.8651	1.3%	17.6488	20.0814	9.8%	13.9%
24 Oct 2016	18.5507	25.3%	18.8645	3.7%	17.6939	20.0350	10.0%	14.4%
25 Oct 2016	18.5507	23.7%	19.2417	3.6%	18.1321	20.3512	9.7%	13.1%
26 Oct 2016	18.6858	26.1%	19.2106	5.4%	18.2321	20.1892	13.7%	25.8%
27 Oct 2016	18.8390	26.1%	19.7031	5.4%	17.8192	21.5870	14.5%	26.2%
28 Oct 2016	18.9923	28.1%	19.8471	5.5%	17.9833	21.7110	14.6%	30.5%
31 Oct 2016	18.8611	26.8%	20.0413	4.5%	17.9416	22.1410	13.8%	27.2%
01 Nov 2016	19.1948	25.7%	19.7114	4.3%	18.0891	21.3336	14.8%	26.1%
02 Nov 2016	19.3732	38.1%	20.0187	6.0%	18.5177	21.5198	29.2%	52.5%
03 Nov 2016	19.1728	36.2%	20.5365	5.5%	17.6777	23.3953	27.8%	48.1%

political outcomes; for now, we present this empirical study as a topical and timely contribution to the conference “Innovations in Insurance, Risk- and Asset Management”.

Fig. 7. EURUSD implied densities from 13 March to 21 April 2017 for the day (Monday 24 April 2017) after the first round French presidential election.

Fig. 8. EURUSD implied densities from 24 April to 5 May 2017 for the day (Monday 8 May 2017) after the second round French presidential election.

Fig. 9. GBPUSD implied densities from 28 April to 8 June 2017 for the day (Friday 9 June 2017) after the 2017 UK general election.

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