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Accepted Manuscript

The miracle of the markets: Identifying key campaign events in the Scottish independence referendum using betting odds.

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Abstract

This paper analyses campaign dynamics in the 2014 Scottish independence referendum by integrating time-stamped polling releases with highly granular evolving price data created by online political gambling markets. Our analysis models the relationship between poll releases and prices available on a Yes result, allowing us to measure the extent to which the release of each new poll represented an informational 'shock'. We then seek to control for polling shocks in order to isolate and analyse the effects of key campaign events; combining a multivariate time series analysis with confirmatory testing based on a micro-analysis of the movement in gambling prices in the minutes and hours following these events. We conclude that the second leaders' debate between Alex Salmond and Alistair Darling was the most influential event of the campaign, initiating a surge in the Yes side's estimated probability of victory.

Keywords: Campaign dynamics; Scottish independence referendum; Political Gambling.

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political betting in the UK (Bienkov, 2014). Prices on the outcome were available from at least 17 gambling websites and just one of these, www.betfair.com, reported over £8.6 million in matched bets on the referendum (Thomas, 2014). This extensive betting activity generated information about the likelihood of referendum's outcome as estimated by gamblers while the campaign unfolded. Our aim in this paper is to leverage the dynamic nature and high level of temporal granularity provided by political gambling market data in order to identify the effects of both emerging polling information and key events on outcome likelihoods during the Scottish independence referendum campaign.

Even a cursory review of the Scottish independence referendum indicates that there was considerable in-campaign volatility. While the No camp had a strong initial lead and, ultimately, won by a margin of over 10% (Electoral Commission, 2014); in the weeks running up to the vote the polls narrowed and there was genuine uncertainty about which side would prevail. A shock YouGov poll, released on the evening of September 6 and published in 7 September's *Sunday Times*, put the Yes option in the lead. The 'Better Together' anti-independence coalition responded to this development with a hyper-active flurry of campaigning. The apogee of their rear-guard action was a written commitment to (among other things) extensive new powers for the Scottish Parliament signed by David Cameron, Ed Miliband and Nick Clegg. 'The Vow', as it became known, appeared late in the campaign; it was published in the *Daily Record* on 16 September, 2014.

As such, it does not seem inappropriate to suggest that the volatility of the Scottish independence referendum campaign generated political commitments that will affect the

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Westminster, it is also difficult to avoid the conclusion that the campaign altered the face of UK electoral politics. Finally, the campaign has relevance to contemporary and potential future developments in UK and Scottish politics. Although Alex Salmond famously described the 2014 vote as a 'once in a generation opportunity', Nicola Sturgeon was quick to assert that a second Scottish independence referendum is 'very much on the table' following the UK's EU membership referendum on 23 June, 2016.

All of these considerations point to the substantive importance of understanding how the Scottish independence referendum campaign unfolded. More generally, the Scottish independence referendum is part of an international trend of increased use of direct democracy as a means of resolving constitutional questions in consolidated democracies (International IDEA, 2008; Peters, 2016; Scarrow, 2001; 2003). There is growing evidence supporting the idea that campaigns exert greater influence over the result of referendums than other types of elections (Hobolt, 2009; Laycock, 2013; LeDuc, 2002; de Vreese, 2007; de Vreese and Semetko, 2004; Schuk and de Vreese, 2008). This is because role of the 'fundamentals' of partisanship and economic performance can be occluded in referendum campaigns by a combination of the complexity of the issues at stake and cue uncertainty. It follows that referendums are electoral events characterised by a relative paucity of information accounting for the evolution of public preferences. As such, the data and techniques developed in this article are particularly apposite for scholars interested in better understanding referendum campaigns.

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presidential elections. Indeed, a range of papers have already used political gambling markets to trace campaign dynamics in presidential and parliamentary elections (Arnesen, 2011; Forsythe et al., 1998; Shaw and Roberts, 2000; Wolfers and Leigh, 2002). Furthermore, there is broad consensus in the contemporary literature around the assertion that campaigns can affect the outcomes of parliamentary and presidential elections (see, for instance: Arceneaux, 2005; Box-Steffensmeier et al., 2009; Campbell, 2000; Holbrook, 1994; 1996; Johnston et al., 1992; Shaw, 1999; Stevenson and Vavreck, 2000; Vavreck, 2009).

A growing array of innovations in data collection and analysis has been directed at the problem of understanding campaign dynamics in all types of election. For instance, panel studies or 'rolling cross section' survey designs can provide insights into the movement of public opinion during a campaign (Brady et al., 2006). Unfortunately, for most elections, including the Scottish independence referendum, publicly available dynamic public opinion data is limited to 'trial heat' opinion polling conducted at irregular time intervals by a variety of polling companies each with their own 'house' methodologies. In such cases, Wlezien and Erikson (2002: 423) conclude that a definitive analysis of campaign effects 'seems well-nigh impossible'. We wish to explore whether political gambling market data can help to bridge this methodological impasse.

2. Political gambling markets and campaign dynamics

Political gambling markets are frequently used to forecast election outcomes. The Iowa Electronic Markets (IEMs) are the leading source of electoral betting market predictions (Tziralis and Tatsiopoulos, 2007). Analysis of the performance of the IEMs and other political

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more than 100 days in advance of the election (Berg et al., 2008). While there are disputes as to whether the advantage of markets over polls recedes when polling data is adjusted for known biases (see: Erikson and Wlezien, 2008 and Rothschild, 2009 for opposing sides of this debate), it is commonly recognised that forecasts arising from political gambling markets produce relatively accurate predictions; and this is true even for their historical antecedents (Rhode and Strumpf, 2004).

We contend that political gambling market data can tell us about the shifts in outcome likelihoods that take place during a campaign. The simple logic underlying this proposition is that if betting markets can provide reasonable forecasts of campaign outcomes at a single time point, then their evolution over multiple time points can shed light on campaign dynamics. Because of their continuous availability, gambling market prices, if collected regularly enough, can be analysed at a very high level of temporal granularity – potentially providing greater casual insight into campaign dynamics than polls. Although authors such as Berg et al. (2001) acknowledge the dynamic nature of electoral gambling markets, campaign dynamic analyses based on price data from such markets have been relatively rare. Nonetheless, several authors (Arnesen, 2011; Forsythe et al., 1998; Shaw and Roberts, 2000; Wolfers and Leigh, 2002) have used data from electoral gambling markets to analyse the effects of campaign events.

The theoretical rationale for analysing shifts in betting prices as an indicator of changes in outcome likelihoods is that these shifts reflect the integration into betting markets of new information. Shaw and Roberts (ibid.) note that IEM prices co-vary during US presidential

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mechanism that we rely on to ensure that prices aren't distorted by the ideological leanings of the bettors is the financial incentive that is attached to making sure that one's bet reflects the likelihood of an outcome. Forsythe et al.'s (1998) analysis is particularly encouraging in this regard – they note that, while there are indeed indications that many traders in political gambling markets are influenced by their partisan ideology, a smaller group of 'marginal' traders operate largely absent of such influences and quickly capitalise on any temporary market distortions caused by ideologically-inflated or deflated prices. Provided there is a cohort of dispassionate bettors seeking to make money by gambling on the referendum, we have reason to believe that price shifts reflect the integration of new information that influences the markets' perception of underlying outcome probabilities, rather than shifts in the ideological make-up of the betting population.

If we are to argue that gambling market price shifts reflect the absorption of fresh political information, then we cannot ignore the fact that the most concrete and consistent form of new information about outcome likelihoods during election campaigns comes in the form of polling data. Our analysis develops a nuanced model of the relationship between gambling market and polling data; capturing the variable effects of new polling information on political gambling markets. It is logical that such effects are likely to be more or less pronounced depending on the extent to which a poll creates an informational 'shock' – that is the extent to which a new poll release represents a deviation from the markets' anticipated polling value. This modelling approach accords with the theoretical contention that poll information should only influence perceived outcome likelihoods to the extent that

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We seek to analyse event effects by controlling for the variability in our betting market data that can be attributed to the release of new polling information. Because polls provide direct (if imprecise) information about voting intentions, we anticipate that poll releases will account for the lion's share of variability in betting market prices throughout the course of the campaign. What remains in terms of variation, however, is most likely to be attributable to the effects of political events.

3. Identifying key events in the Scottish independence referendum campaign – Deductive versus inductive approaches

In order to conduct our analysis, we have identified several key events that took place during the referendum campaign. We used a mixed-methods approach in order to arrive at this list. We assumed *apriori* that the two televised debates between the leaders of the Yes and No campaigns (Alex Salmond and Alistair Darling, respectively) could be politically influential. In doing so, we follow a long line of researchers who have focused on televised leaders' debates as key campaign moments, particularly in American presidential campaigns (Cho and Ha, 2012; Erikson and Wlezien, 2012; Fridkin et al., 2007; Schroeder, 2008). We also created a list of events that took place during the campaign on the basis of closely following *reportage* in the British media, on the *What Scotland Thinks* blog and using Carrell et al.'s (2014) review of the campaign. This allowed us to identify a series of potentially important events that took place during the statutory referendum period which began on 30 May, 2014 (Electoral Commission, 2014). These events, and the expected direction of their effects, are summarised in Table 1.

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05 June, 2014	Barack Obama 'strong and united' UK remarks	Anti-Yes
11 June, 2014	JK Rowling pro-Union donation and statement	Anti-Yes
03 August, 2014	Closing ceremony Glasgow games	Pro-Yes
05 August, 2014	Debate 1 : Salmond Darling	Anti-Yes
13 August, 2014	Salmond announces NHS free as a constitutional right in an independent Scotland	Pro-Yes
25 August, 2014	Debate 2 : Salmond Darling	Pro-Yes
08 September, 2014	Gordon Brown 'time table' speech	Anti - Yes
16 September, 2014	The Vow published in Daily Record	Anti-Yes
17 September, 2014	Gordon Brown 'barnstormer' speech	Anti-Yes
18 September, 2014	Polls Open	

In addition to this deductive approach, we also allow for the possibility of inductively identifying influential events through our gambling market data. In order to do so we produced a ranking of the days on which the most variability in the gambling market data was observed when the effects of poll shocks and the events listed above are controlled for. We used the distribution of variability across our time series to identify days that fell into the top and bottom 5^{th} percentile of unexplained variability. The results of this examination are reported in section 5.4.

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websites and online gambling exchanges. Traditional bookmakers offer prices on outcomes at which customers are invited to place their bets. Prices are initially set on the basis of the expert opinion of specialist price-setters, and then adjusted in response to patterns of gambling activity. Gambling exchanges act as an intermediary, creating a market where bettors can offer prices at which outcomes can be 'backed' (bet on) or 'laid' (bet against) – matching prices where one customer wishes to back and another to lay. Gambling market sites display the 'best' price at which an outcome can be backed or laid – that is, the price where one gambler can immediately be matched to another.

For each time-point in our series, the prices derived from traditional bookmaking websites are the price available for backing the Yes outcome,[1] while the prices derived from betting exchanges represent the 'best' price at which a backing bet on Yes can be matched. Each observation is time-stamped. These data were gathered by collecting publicly available prices from the betting market comparison website www.oddschecker.com. To achieve this, we developed an automated page scraping program that periodically visited the website, collected and archived the HTML page source, extracted the relevant market prices and stored them in a database. Prices were collected in this way every 15 minutes. We dispose of prices (and their first differences) from 17 online gambling markets where betting on the

[1] In the analysis that follows, we use the Yes prices for simplicity of presentation, noting that our findings are replicable using the No prices.

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We use the mean price available across all 17 markets as the collective market estimate of the underlying probability of each outcome. In order to translate market prices into estimates of probabilities, we employ a procedure outlined in Wall et al. (2012) to estimate the market-adjusted implied probability. The percentage implied probability for a given set of odds can be calculated by firstly representing the odds in the 'decimal' format,[3] then dividing this number into 1 and multiplying by 100. Having calculated the implied probability for both Yes and No outcomes, we then calculate the 'market over round' which is the extent to which the sum of implied probabilities exceeds 100%. We then use the following formula to generate the 'market adjusted implied probability' for the average price on Yes at each time point for which the odds were recorded.

$$\text{Market adjusted implied probability} = [\text{Implied probability}/(100 + \text{Market over round})] * 100 \quad (1)$$

One of the unique attributes of our data is the large number of time-points for which we have observations, with between 85 and 96 observations for each day included in the analysis. This permits an extremely fine-grained analysis of how the market responds to campaign events. We employ the full range of observations when we turn to the analysis of specific events. However, when studying the entire period, we simplify the analysis by

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[2] This excludes an 11-day period from 26 June to 6 July during which time, due to a problem with our page-scraping algorithm, data on betting odds were not collected.

[3] Odds represented in the 'decimal' format represent the total amount of pay-out (including stake) that a winning bet will pay out, per unit bet. So, for example, odds of 3/1 are represented in decimal format as 4.0 – meaning that a £1 bet will return £4 (£3 profit plus £1 stake).

probabilities of a Yes outcome (hereafter referred to as *Yes Probability*), along with the daily changes in *Yes Probability*. There is considerable variation in *Yes Probability* during this period. The lowest score is 16.06%, recorded on 15 August, 2014; the highest is 33.41%, recorded on 7 September, 2014. The lion's share of the variability in the data occurred late in the campaign; with both the biggest increase and decrease occurring during September.

Table 2: Descriptive statistics of variable *Yes Probability*

	Yes Probability	Daily change in Yes Probability
N	100	100
Mean	20.57	-0.02
Std. Deviation	4.17	1.19
Min	16.06	-5.85
Max	33.41	7.39

We also avail of public opinion polling data from a range of companies which ran surveys at multiple time points during the campaign. We use a dataset of poll releases downloaded from the public opinion analysis site www.whatscotlandthinks.org which contains the poll figures, size of sample, company conducting the poll, site and date where the poll was published, and dates during which fieldwork took place. We supplement this with information on the precise release times of each opinion poll, based on the first published online news article that we could find referencing the poll in question.

[4] We note here that the analyses reported below were repeated using half-daily aggregations, and this did not affect the findings.

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ran surveys throughout the campaign. This analysis clearly shows that a significant shift towards the Yes side took place towards the end of the campaign. However, we note that the irregularity of these polls makes it impossible to link this shift to a particular campaign event with any degree of certainty. In the second step, we compare opinion polls with market prices. This comparison shows that the market prices evolved in a similar way to the polls, and that the significant shift toward the Yes camp recorded by the polls at the end of August was anticipated by the betting markets. It also shows that the betting markets were responsive to polling data. In the third stage of the analysis, we employ a multivariate time-series model to estimate the effect of campaign events on changes in market prices, while controlling for poll shocks. In the final stage, the findings of the multivariate analysis are supplemented with a micro-level examination of market movement around specific events and remaining unexplained betting market price volatility is examined.

5.1 Examination of polls

We begin by examining changes in public opinion as measured by opinion polls. We employ data provided by the six companies that ran surveys throughout the campaign.[5] Figure 1 graphs poll estimates of support for the Yes and No sides during the official campaign period for these 6 companies, with figures for 'Don't Knows' excluded. There is no clear pattern in public opinion for much of the period, with the No side maintaining a strong lead across all polling companies. However, there is a clear shift in public opinion towards the Yes side

[5] There were also two polls produced by a seventh company (Opinium). We do not report these polls in Figure 1, as they both took place in the same week and showed the same result. We do, however, include these polls below in Figure 2 when we analyse the effect of opinion polls on market prices.

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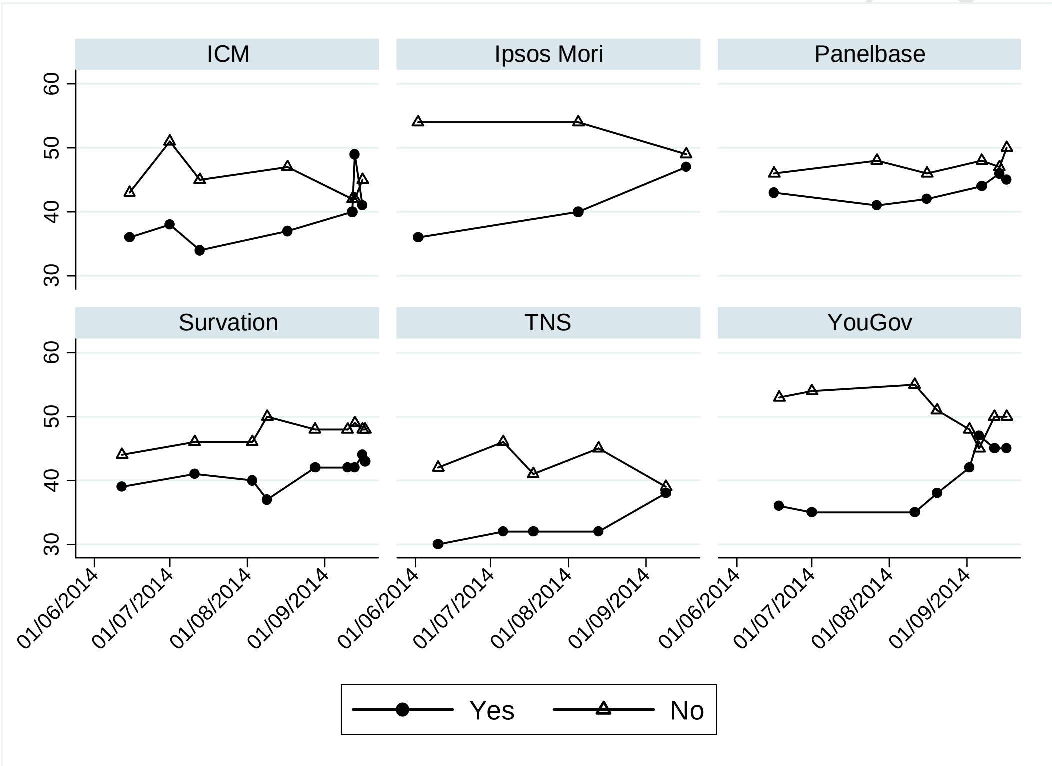
ICM and Ipsos Mori recorded a significant (>4%) increase in support for a Yes vote compared to the previous poll by that company. Both YouGov and ICM released polls that put the Yes side ahead for the first time during this period.

Figure 1: Support for Yes and No votes reported in polls



In light of the campaign events identified in Table 1, the most likely political event connected to this change appears to be the second leaders' debate, held on 25 August, 2014. However, this conclusion is highly speculative. Modest increases were already being recorded by some polling companies on 15 August, soon after the Salmond announcement regarding the NHS. Furthermore, there is a period of eleven days during this crucial period in

September actually took place in mid-August.

5.2 Comparison of polling and gambling market data

We now turn to a comparison of betting market odds and polling figures. Figure 2 graphs the evolution of the *Yes Probability* variable alongside poll releases showing the percentage support for a Yes vote (excluding undecided voters) recorded for each poll released during this period. Where more than one poll was released on the same day, we take the average score. There are a total of 31 days in which new polls were released.

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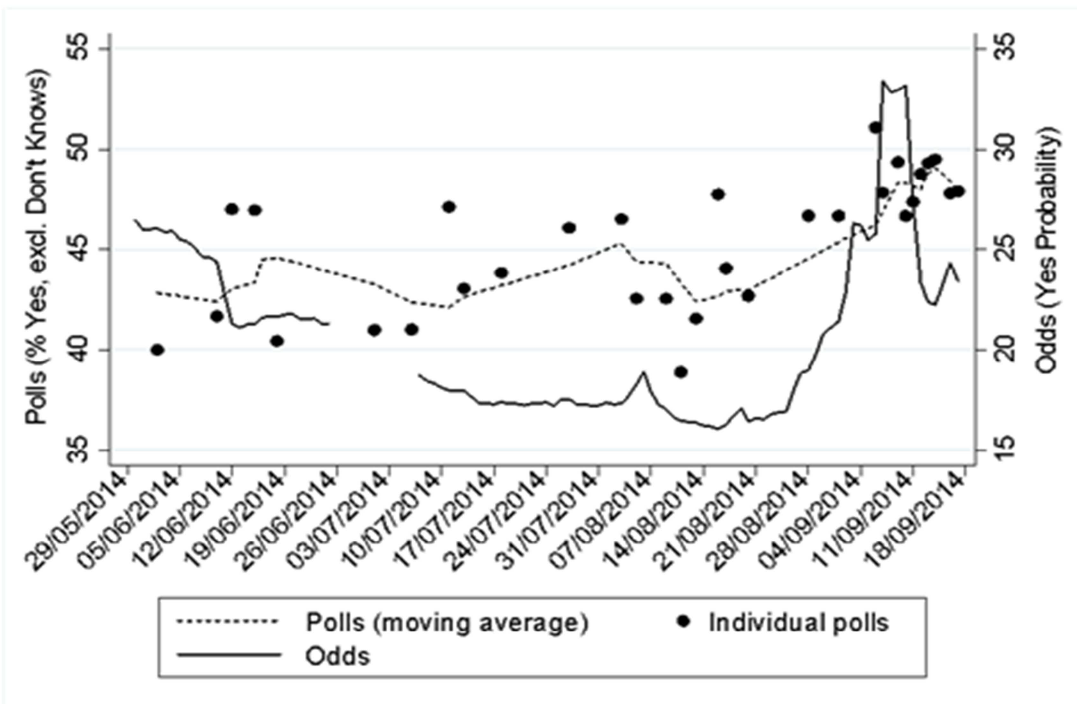
Figure 2: Support for Yes vote in polls and market prediction of a Yes vote



[6] A poll was released by YouGov on 20 August, but the interviews for this poll were conducted between the 12 and 15 August.

Bearing in mind the eventual result, one might say that the markets thus contained a more accurate assessment of the outcome likelihood than a naïve reading of the polls would have suggested.

We can examine the trend in the market prices in order to identify the main turning points (see: Bry and Boschan, 1971 for a discussion on identifying turning points in a time series). There is a pattern of gradual decline in the value of *Yes Probability* during the early part of the campaign, dropping below 17% for the first time on 10 August and staying there until 24 August. The first turning point occurred on 25 August, when the market assessment of a Yes vote began to improve sharply, with nine consecutive days of growth (by far the longest period of uninterrupted growth in the series). It is important to note that this happened before any noticeable shift is recorded in opinion polls (the first poll showing a notable increase in support for a Yes vote during this period is the Survation poll released on 28 August, 2014). Many of the subsequent sharp increases and decreases in the market prices coincided with the release of new opinion polls. Most notably, there was a dramatic increase in *Yes Probability* on 6 September, coinciding with the release of the first poll (by YouGov) to place the Yes side ahead; and there is an equally sharp decline in *Yes Probability* four days later, coinciding with the release of a poll by Survation giving the No side a substantial lead. This represents a second turning point in the series, with six of the eight days between 10 and 17 September recording a decline in the *Yes Probability* scores.

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Following Shaw and Roberts (2000), the dependent variable in this analysis is the daily change in market prices rather than the market prices themselves. We adopt this approach because the market price series is non-stationary. The non-stationarity of the series is evident in Figure 3, and is also confirmed by a unit-root test which shows that the series follows a random walk. This finding is intuitively plausible for our data: when market prices change in response to new information (such as a campaign event or opinion poll), there is no reason to expect to the market to then discard this information and revert back to the mean price. In contrast, the daily changes in *Yes Probability* have a constant mean of approximately zero over time.[7]

The most challenging aspect of this analysis is to model the effect of opinion poll releases on market prices. We seek to estimate the market's expectation of each poll result immediately before it is released, so that we can then calculate the extent to which the poll result represents a shock to the market. To do this, it is first necessary to measure the relationship between opinion polls and market odds over the course of the campaign. The relationship is measured using the market odds on the day after each opinion poll, as these odds have had time to adjust to the opinion poll results. We also allow for the possibility that the market takes the source of the opinion poll into account. The relationship between polls and odds is estimated as follows:

[7] Daily changes in Yes Probability exhibit increasing variance over time, due to the late volatility that characterised the campaign. We capture this increasing variance via a series of independent variables relating to the opinion poll shocks, as described below. The Durbin test reported in Table 4 confirms that the models we estimate using the changes in Yes Probability do not suffer from significant serial autocorrelation.

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released at time *t*; *Odds*$_{t+1}$ is the value of *Yes Probability* at midday on the day after the release of the poll; and *Company 1-Company 6* are dummy variables for each of the six polling companies. The results of this analysis are reported in Table 3. According to the coefficients reported in Table 3, we can say that (for example) the average value of YouGov polls when *Yes Probability* is at 20% is 43.82% (i.e. (20x0.38) + 35.02 + 1.2).

Table 3: Relationship between market Yes Probability and opinion polls

	b	s.e.	p
Yes Probability$_{t+1}$	0.38	0.09	0.00
ICM	2.32	1.76	0.20
IPSOS	-1.33	1.62	0.42
Panelbase	4.17	1.39	0.01
Survation	3.73	1.80	0.05
TNS	0.36	1.83	0.85
Yougov	1.20	1.55	0.45
Opinium	-0.78	2.64	0.77
Constant	35.02	2.57	0.00
Adjusted R^2		0.49	
N		30	

Note: Dependent variable is opinion poll result at time t, expressed as % support for Yes (excluding 'Don't Knows').

We use these results to make point estimations of the market's expectation for each poll, using the *Yes Probability* value available immediately prior to the poll release. Returning to the example in the previous paragraph, if we observe a *Yes Probability* of 20% immediately prior to the release of a YouGov poll, the expected poll value is 43.82%. The variable *Poll*

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This variable is used as a predictor to explain daily changes in market odds in Table 4. Not all poll shocks will have the same effect on the market odds, however. The variable *Lead Change* indicates whether or not the outcome of the poll differed from what was expected by the market in terms of which side was ahead.[9] This is interacted with the variable *Poll Shock*, as we expect the effect of a poll shock to be greater if it is associated with a lead change.[10] The model assumes that effect of a poll shock is absorbed by the market in one day. We also ran a version that included a one day lag of the poll shock, but this variable was not significant. Clearly, the market reacts very quickly to new information from opinion polls.

Model 1 in Table 4 shows the effect of poll shocks on daily changes in market prices. The adjusted R-squared for the model is 0.73, which demonstrates that opinion poll shocks, interacted with the *Lead Change* variable, explain the majority of variation in betting market prices. The coefficients for the variables *Poll Shock* and *Poll Shock*Lead Change* tell us that a poll result that puts the Yes side 1 point higher than expected by the market leads to an increase in the market *Yes Probability* of 0.19% when the poll result does not represent a lead change and 1.25% when the poll result does represent a lead change.

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[8] While most polls are released by newspapers in the morning, in a number of cases we found evidence of a preview appearing online on the evening prior to the official poll release. In these cases, we assume that the poll shock has an effect both on the day it was previewed and the day of the official release, and the variable Poll Shock takes on the value of the shock for both days.

[9] There are four observations where this variable takes on a positive value.

[10] We also ran a model that included an additional interaction for the proximity of the polls release to polling day, under the assumption that the market would react more strongly to polls closer to the end of the campaign. However, the interaction effect was not significant and we exclude it here.

	b	s.e.	p	b	s.e.	P
Poll shock	0.19	0.05	0.00	0.16	0.05	0.00
Lead change	-0.21	0.32	0.51	-0.24	0.30	0.43
Poll shock*Lead Change	1.06	0.09	0.00	1.09	0.09	0.00
Events:						
Obama				-0.26	0.42	0.54
Rowling				-0.69	0.42	0.11
Games				0.40	0.42	0.34
Debate 1				-0.44	0.43	0.31
NHS				-0.12	0.42	0.78
Debate 2				**0.93**	**0.42**	**0.03**
Brown 1				0.01	0.42	0.97
Vow				-0.60	0.59	0.31
Brown 2				-1.31	0.81	0.11
Constant	0.00	0.06	0.98	0.03	0.06	0.63
Adjusted R^2		0.73				0.76
N		100				100
Durbin's alternative test for autocorrelation		2.51 (p=0.11)				0.57 (p=0.45)

In Model 2, we also include a dummy variable for each event listed in Table 1. Each event is coded as 1 on the day it occurs and on the following day, and zero otherwise. This two-day window is appropriate to capture the effect of campaign events, which depend not only on the event itself but also on how the event is interpreted by the media in the immediate aftermath. While the coefficients of the effects for most of the events, with the exception of the announcement regarding the NHS and Gordon Brown's first intervention, are in the expected direction (see Table 1 for expectations), only the second debate between Salmond and Darling has a statistically significant effect on the market prices.

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by the researcher are *likely* causes of shifts in market sentiment. It is always possible that an event appears to have a significant effect when in fact the shift was caused by something else not included in the model. Similarly, it is possible that some of the unexplained variation in the market odds were in fact due to events that we have overlooked.

To address these concerns, we conduct two additional analyses. First, we make use of the fine-grained nature of the market data at our disposal to examine the timing of the shifts in market odds around particular events. If there was an immediate market response to the event, this greatly strengthens our confidence that the event itself was in fact a significant factor, and is not merely appearing to be so because we have omitted another important event that took place at around the same stage of the campaign. Second, we conduct an inductive analysis of the changes in the value of *Yes Probability* that are not accounted for by poll shocks. The purpose of this analysis is to highlight the days with the greatest changes in market prices not explained by our model, so that we can then search these dates to identify any events we may have overlooked.

Turning first to the micro-analysis of market prices, Figure 3 maps the evolution of *Yes Probability* over 15-minute intervals over the two periods previously identified as turning points in the series. Panel A in Figure 3 shows the period around the second debate, from 25 August to 27 August. *Yes Probability* hovered around the 17% mark for most of 25 August. During the live televised debate, which took place between 8.30pm and 10pm, a small shift in the odds is perceptible; and immediately following the end of the debate the odds jump sharply, and reach 18% by the end of the day (the highest point since 6 August). The

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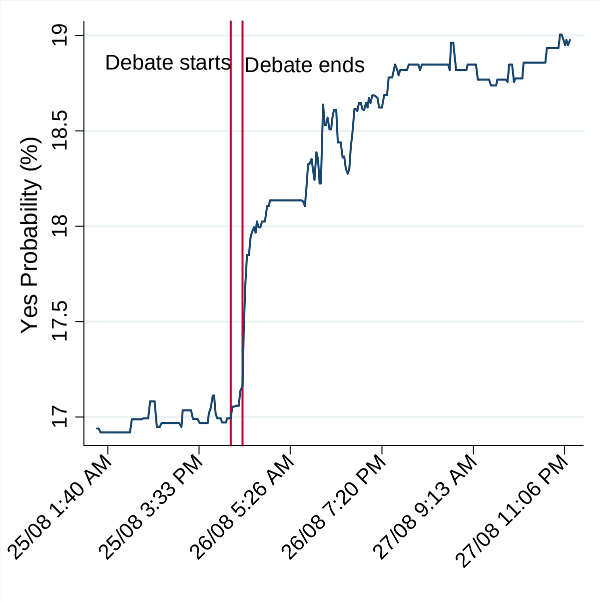
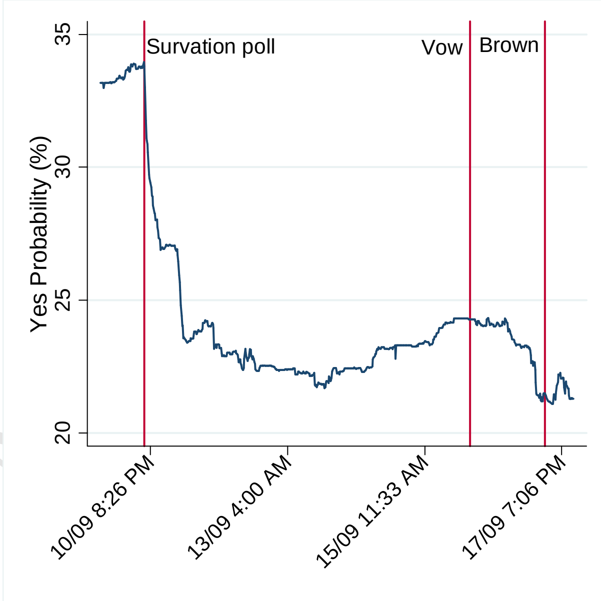
2 variable in Table 4 is not spurious.

Figure 3: Micro-analysis of significant events

A. 2nd Debate



B. Final week of campaign



Panel B in Figure 3 plots the final week of the campaign, from 10 September to 17 September, when there was a sharp decline in the value of *Yes Probability*. While none of the events during this period appeared as significant in Table 4, both the Vow and Gordon Brown's second speech occurred within the same two-day period, so it is possible that one of them did have an impact that was not picked up in our model. However, it can be seen from Figure 3 that neither event had an obvious impact on market sentiment. There was a decline in *Yes Probability* on 17 September (the day of Brown's speech), but this change took place early on the morning, while the speech was delivered at noon. By far the largest change in *Yes Probability* during this period occurred following the publication of the particular campaign event, but rather represents a market correction in response to new opinion polls.

In addition to validating the event effects that were highlighted in Table 4, we also want to be sure that we have not overlooked any significant campaign events. Panel A in Figure 4 plots the daily changes in *Yes Probability* over time, showing the previously noted increase in variation towards the end of the campaign. Panel B plots the residuals, following the regression reported in Table 4 (Model 2). This confirms that the vast majority of the variation in the daily odds changes, including the increase in variation over time, is accounted for by our model. To discover if we overlooked any significant events, we identified the tails of the distribution of the residuals – i.e. the top 5% of price increases and the top 5% of price decreases. We conducted further research on the events taking place on these 10 days, but failed to find any potentially significant campaign events. The major outlier, 2 September, occurred on the day of a YouGov poll that showed an increase for the Yes side; we conclude that the jump in the *Yes Probability* on this day was due to the greater-than-expected effect of this poll.

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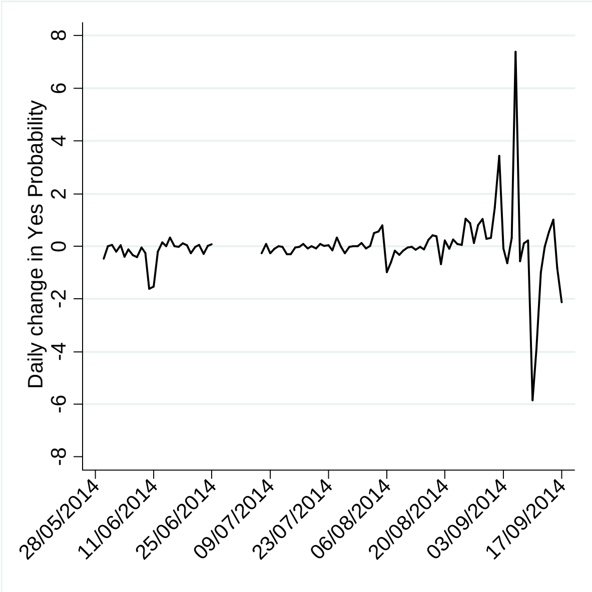
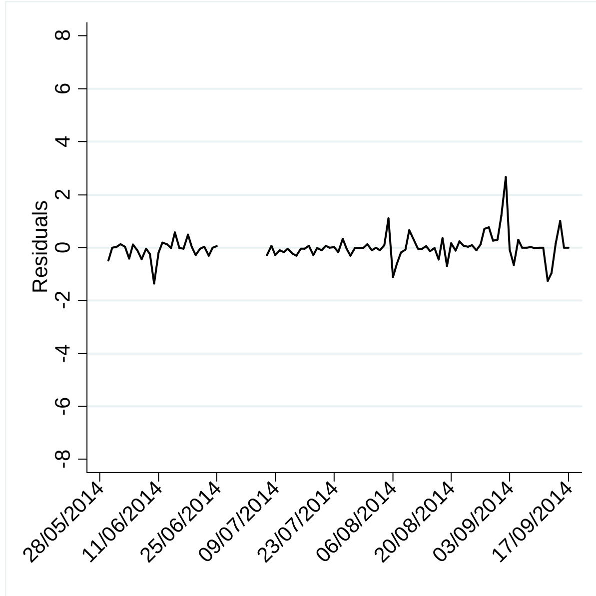
Probability (raw values) (residuals)





6. Conclusion

This paper has investigated the dynamics of the Scottish independence referendum campaign using a relatively novel source of data: the odds on offer from an array of online bookmakers and betting exchanges. Our analysis suggested that the most substantively important source of new information that drives market prices comes in the form of poll shocks, which are exacerbated when a poll defies market sentiment as to which side is in the lead.

We were able to identify only one influential political event – the second leaders' debate. This finding is supported by a multivariate time-series analysis, controlling for poll shocks, and micro-analysis of market movement in the minutes and hours following this debate. It also concurs with Curtice's (2014) analysis which reports a headline figure from the post-debate ICM poll of 71% giving Mr Salmond the victory compared to just 29% for Mr Darling

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campaign – this appears to have been a moment when the No campaign's arguments lost some of their rhetorical power (perhaps due to the fact that they had been so relentlessly repeated during the campaign) and where the Yes campaign gained traction.

Methodologically, the approach developed here offers considerable advantages to the study of campaign event effects, particularly in instances when panel data or rolling cross-section surveys are not available. We argue that online gambling markets, when properly combined with polling data, offer a fine-grained analytical tool for campaign dynamic analysis. The most appealing characteristic of gambling market data is their continual availability; gambling market prices can be captured from websites where they are freely available on a highly granular timescale. This technological affordance should come as a boon to scholars who are interested in understanding the unfolding of electoral campaigns.

Finally, a question that is of importance for the extension of the research presented here to other elections is whether the Scottish independence referendum campaign is qualitatively different from other electoral campaigns. Given the above-discussed volatility and high levels of political gambling that characterised the Scottish independence referendum campaign, it is a case where there is *apriori* a particularly high likelihood of observing campaign dynamics using price data from political gambling markets. As such, our case selection follows what Levy (2008: 12) describes as 'the inverse Sinatra inference—if I cannot make it there, I cannot make it anywhere.' If we had failed to observe polling and event-driven dynamics in the case of the Scottish independence referendum, then we would have arguably been justified in rejecting the usefulness of the data and analytic techniques

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- Combines data generated by online gambling markets with poll releases.
- Models the relationship between polling and market time series data.
- Isolates and analyses the effects of campaign events.
- Second leaders' debate was the most influential campaign event.

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