Designing Prediction Markets to Forecast Multi-Stage Elections: The 2022 French Presidential Election

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The Iowa Electronic Market (IEM) has been successful in forecasting elections around the world (Berg et al. 2008). Figure 1 is a history of election-eve accuracy, comparing forecasts to actual vote shares.[1] The absolute prediction errors for non-US elections average 2.12%.[2] Almost all of these forecasts involved single-stage elections and had a local trader base.

Many jurisdictions hold two-stage elections in which candidates (typically, many) run in the first round. In majority-runoff elections, any candidate who receives an outright majority in the first round wins. If no candidate receives a majority, the two candidates with the most votes participate in a second-stage (i.e., runoff) election. Multi-stage elections create special challenges for designing and running election-prediction markets.

The 2022 French presidential election was an important and highly contested majority-runoff election. This article describes how to design two-stage election prediction markets in general and implements a prediction market specifically for the 2022 French presidential election. By discussing our design and what we learned from the unsuccessful market launch, we make two contributions to the literature. First, we developed a market design with a reasonable number of contracts that forecasts probabilities of greatest interest in two-stage elections. This design also created interesting inter-contract pricing relationships that can be used to test market efficiency. Second, we provide more evidence on the importance of an informed trader base for successful markets.

OUTCOMES IN TWO-STAGE ELECTIONS

A two-stage election has a complex outcome space. It depends on how many candidates run, which combination qualifies for the runoff (if any), and who wins given the specific runoff-candidate combination. The number of possible outcomes increases rapidly with the number of first-round candidates: candidates can win outright, any two can qualify for a runoff, and each runoff candidate could win.

Typically, several serious candidates contend against many hopefuls. For example, in the October 28–30, 2021, polling for the 2022 French presidential election, Harris Interactive asked about voting intentions for 18 potential candidates (Lévy, Bartoli, and Gautier 2021), with five candidates receiving 10% or more of poll responses for the first-round election. Suppose 18 candidates ran in the first round. Although unlikely, each candidate *could* win in the first round. In addition, each combination of two candidates *might* appear in a runoff. For every runoff combination, there are two possible outcomes. This leads to the following:

$$\underbrace{18}_{\substack{\textit{Possible}\\ \textit{Outright}\\ \textit{Winners}}} + \underbrace{\frac{18!}{2! \times 16!}}_{\substack{\textit{Possible}\\ \textit{Runoff}\\ \textit{Combinations}}} \times \underbrace{2}_{\substack{\textit{Outcomes}\\ \textit{for each}\\ \textit{Runoff}}} = 306 \qquad (1)$$

with 306 possible outcomes, most of which have near-zero probability.

IOWA ELECTRONIC MARKET AND CONTRACT DESIGN

Open to traders worldwide, IEMs are real-money, Internet-based futures markets in which self-selected traders determine prices that forecast election outcomes.[3] The IEM is a purely order-driven market: traders place bids and asks for contracts, and prices are set when other traders accept outstanding bids or asks. There is no scoring system, no market maker, and no clearing mechanism beyond these mutually agreed-on trades. Prices change when the beliefs of price-determining traders change. Thus, the IEM aggregates information in a manner significantly different from polls, poll averages, and statistical models. Here, we used "winner-takes-all" (WTA) contracts to forecast probabilities of outcomes.

Typically, IEM WTA election markets include (1) contracts for major candidates (e.g., Macron and Le Pen) that each pay $1 if the associated candidate wins and $0 otherwise; and (2) a "rest-of-field" contract that pays $1 if any other candidate wins. Traders can trade "bundles" consisting of one of each contract for $1 directly with the exchange. Using all relevant available information, traders form beliefs about outcome

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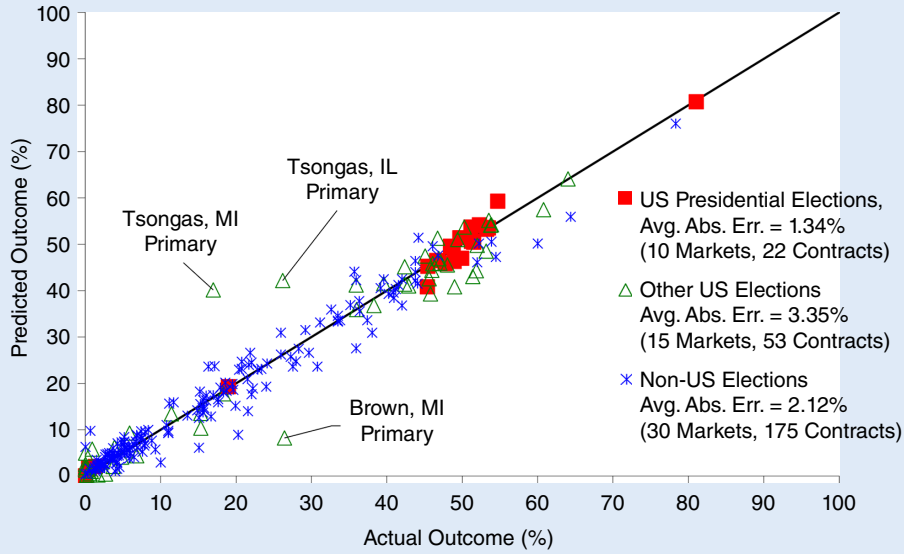
Figure 1

Accuracy of IEMs for US Presidential Elections, Other US Elections, and Non-US Elections



probabilities.[4] Then they can trade with one another, buying contracts when prices are lower than their estimated probabilities and selling contracts when prices are higher. Thus, shifting expectations change supply, demand, and contract prices.

run for the 1996 US presidential election (Berg and Rietz 2003).

A "Round 1" (R1) market forecasts first-round outcomes by listing one contract per major candidate. We define the contract *R1A* to pay $1 if candidate A wins outright in the first round and $0 otherwise. Its price should be as follows:

$$P_{R1A} = p_{A\ wins\ outright} \cdot \$1 + \left(1 - p_{A\ wins\ outright}\right) \cdot \$0 = p_{A\ wins\ outright} \quad (2)$$

where P_{R1A} is the contract's price, $p_{A wins outright}$ is the (risk-neutral) probability of the outcome,[5] and "*wins outright*" means that candidate A receives more than 50% of the vote in round 1. To minimize the number of contracts, we list (1) one contract for each major candidate; (2) an *R1Unnamed* contract to cover minor candidates that pays $1 if an unnamed candidate wins outright; and (3) an *R1Runoff* contract that pays $1 if no candidate wins outright, thereby necessitating a runoff. To add a new named candidate, C, we split the *R1Unnamed* contract into a new *R1C* contract and

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We could offer two-stage election WTA contracts to simply forecast the overall winner. However, this would not allow us to answer many interesting questions: Will anyone win outright in round 1? If no one does, who will make the runoff? How might different combinations of candidates fare in a runoff?

To run a manageable market, the contract set must span the interesting parts of the outcome space. Three markets effectively do so: a market focused on outright winners, a market focused on possible runoff combinations, and a market focused on runoff winners. We show how to (1) construct each market so that contracts span the outcome space of interest; (2) minimize the number of contracts; and (3) add new contracts as new candidates emerge. Although these markets are more complex than typical IEMs, they are only slightly more complex than combined nomination and conditional vote-share markets that were successfully

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a new *R1Unnamed* contract consisting of the remaining unnamed candidates. R1 market prices forecast the probabilities of a runoff ($P_{R1Runoff}$); each named candidate winning outright (P_{R1A}, etc.); and an unnamed candidate winning outright ($P_{R1Unnamed}$).

A "Runoff" (R) market forecasts which (if any) candidates qualify for a runoff. We define the contract *R_AxB* to pay $1 if candidates A and B qualify for the runoff and $0 otherwise. Its price should equal the probability that candidates A and B are in a runoff. To minimize the number of contracts and remain consistent with the R1 market, we list (1) one contract for each major candidate combination in which order does not matter ($p_{A\ and\ B\ in\ Runoff} = p_{B\ and\ A\ in\ Runoff}$); (2) one contract for each major candidate combined with Unnamed (*R_AxU, etc.*); (3) an Unnamed versus Unnamed contract (*R_UxU*); and (4) an *R_None* contract that pays $1 if any candidate wins outright in round 1.[6] In theory, $P_{R1Runoff} = 1\text{-}P_{R\_None}$, a testable relationship for intermarket efficiency. To add a new candidate, C, we split (1) *R_AxU* into *R_AxC* and a new *R_AxU* that represents candidate A with the remaining unnamed candidates; (2) similarly, all remaining named candidates with unnamed-candidate combinations; and (3) *R_UxU* into *R_CxU* and a new *R_UxU* reflecting remaining unnamed candidates. Again, listing only major candidates minimizes the number of contracts.

A "Round 2" (R2) market forecasts which candidate wins the runoff for any possible combination. We define the contract *R2_ADB* to pay $1 if candidate A defeats candidate B in the runoff and $0 otherwise. Its price should equal the probability that candidates A and B are in the runoff times the probability that candidate A defeats candidate B. In theory, $P_{R2\_ADB} < P_{R\_AxB}$, which becomes another testable relationship for intermarket efficiency. To minimize the number of contracts and remain consistent with the R market, we list (1) one contract for each major candidate combination with one candidate winning (the probability that the other candidate wins can be inferred); (2) one contract for each major candidate winning against an unnamed candidate in the runoff (the probability that the unnamed candidate wins can be inferred); and (3) one contract (*R2_Else*) for any other outcome (i.e., no runoff, runoffs between unnamed candidates, or first-named candidates lose to second-named candidates). This creates another testable intermarket efficiency relationship, as follows:

$$P_{R2\_Else} < P_{R\_UnnxUnn} + P_{R\_None}.$$

To add a new candidate, C, we split (1) *R2_ADU* into *R2_ADC* and a new *R2_ADU* that represents candidate A defeating remaining unnamed candidates; (2) similarly, all remaining named candidates with unnamed-candidate combinations; and (3) *R2_Else* into *R2_CDU* and a new *R2_Else* reflecting remaining other possibilities.

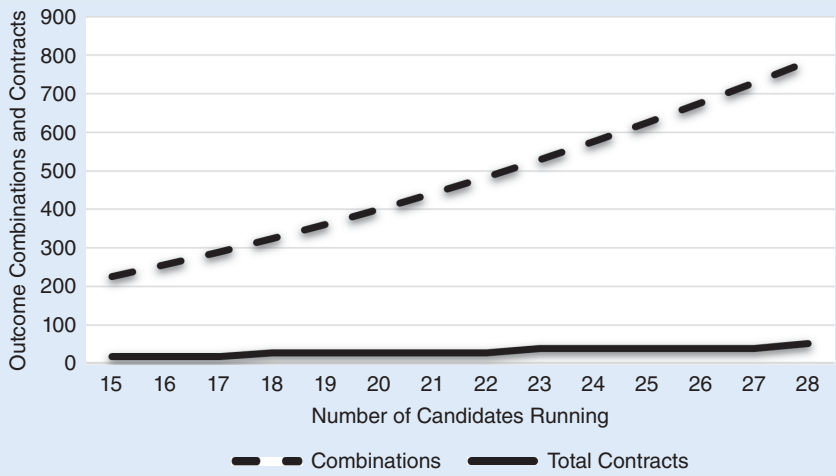
NUMBERS OF CANDIDATES, OUTCOMES, AND CONTRACTS

The R1 market requires $N+2$ contracts for N major candidates. Each additional named candidate requires one additional contract. The R market requires $\frac{(N+1)!}{2\times(N-1)!} + 2 = \frac{4+(N+1)\times N}{2}$ contracts for N major candidates. Each additional major candidate requires $N+1$ additional contracts. The R2 market requires $\frac{(N+1)!}{2\times(N-1)!} + 1 = \frac{2+(N+1)\times N}{2}$ contracts for N major candidates. Each additional major candidate requires $N+1$ additional contracts.

Figure 2 shows the relationship among the number of candidates running, the number of possible outcomes, and

Figure 2

The Number of Possible Outright Winners, Runoff Combinations, and Runoff Winners



Note: The number of possible outright winners, runoff combinations, and runoff winners for different numbers of candidates running with the total contracts needed in R1, R, and R2 prediction markets, assuming that 20% of the candidates running are major candidates with associated contracts.

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the number of contracts needed, assuming that 20% of the total candidates are major candidates with associated contracts. By focusing only on major candidates and using some contract prices to infer other probabilities, we significantly reduce the number of contracts needed to forecast two-stage elections.

Consider the IEMs with Emmanuel Macron and Marine Le Pen as the two major candidates in the 2022 French presidential election (see the prospectuses in the online appendix). These markets required 13 contracts. Table 1 shows the markets and contracts required with *hypothetical* prices that might exist (1) before round 1, and (2) after round 1 if Macron and Le Pen made it to the runoff. (Hypothetical prices allow us to discuss how to interpret prices later.)

HOW CONTRACT PRICES PREDICT MULTI-STAGE ELECTION OUTCOMES

Figure 3 shows how market prices forecast probabilities for each pathway for candidate A to win or lose the election. R1 market prices forecast probabilities of candidate A (or any other candidate) winning outright or whether there is a runoff. R market prices forecast whether a runoff will occur and, if so, who is in it. R2 market prices forecast who will win the runoff for each combination when combined with R market prices (with losing probabilities inferred from winning probabilities).

By focusing only on major candidates and using some contract prices to infer other probabilities, we significantly reduce the number of contracts needed to forecast two-stage elections.

Consider the hypothetical "before round 1" prices from table 1. Some of the forecasts are obvious. The probabilities of outright wins are in panel A, column 3. The probabilities of runoff combinations are in panel B, column 3. Dividing each

Table 1

Contracts and Hypothetical Prices for the 2022 French Presidential Election Markets

Panel A: R1 Market

		Hypothetical Prices	
Contracts	**Pays $1 If:**	**Before Round 1**	**After Round 1**
R1Macron	Macron Wins Outright	$0.050	$0.000
R1LePen	Le Pen Wins Outright	$0.040	$0.000
R1Unnamed	An Unnamed Candidate Wins Outright	$0.010	$0.000
R1Runoff	No One Wins Outright	$0.900	$1.000

Panel B: R Market

		Hypothetical Prices	
Contracts	**Pays $1 If Runoff Candidates Are:**	**Before Round 1**	**After Round 1**
R_MacxLeP	Macron and Le Pen	$0.600	$1.000
R_MacxUnn	Macron and an Unnamed Candidate	$0.150	$0.000
R_LePxUnn	Le Pen and an Unnamed Candidate	$0.090	$0.000
R_UnnxUnn	Two Unnamed Candidates	$0.060	$0.000
R_None	No Runoff	$0.100	$0.000

Panel C: R2 Market

		Hypothetical Prices	
Contracts	**Pays $1 If, in Runoff:**	**Before Round 1**	**After Round 1**
R2_MacDLeP	Macron Defeats Le Pen	$0.400	$0.667
R2_MacDUnn	Macron Defeats an Unnamed Candidate	$0.125	$0.333
R2_LePDUnn	Le Pen Defeats an Unnamed Candidate	$0.075	$0.000
R2_Else	All Other Outcomes	$0.400	$0.000

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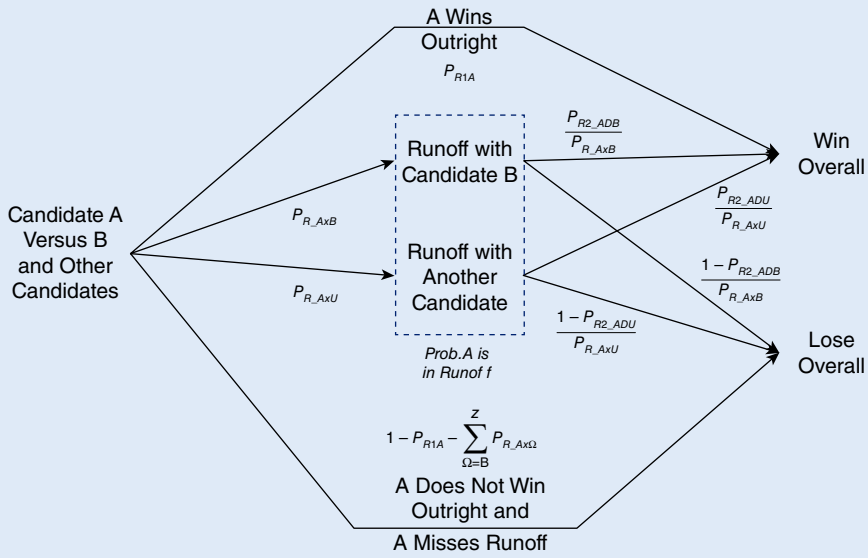
Figure 3

Pathways for Candidate A to Win or Lose a Two-Stage Election Showing How Prediction Market Prices Forecast Pathway Probabilities



panel B runoff combination by $P_{R1Runoff}$ results in the combination probabilities conditional on a runoff. Prices here are consistent with inter-contract market efficiency, as follows:

$$P_{R1Runoff} = 1 - P_{R\_None}, P_{R2\_MacDLeP} < P_{R\_MacxLeP}, P_{R2\_MacDUnn} < P_{R\_MacxUnn}, P_{R2\_LePDUnn} < P_{R\_LePxUnn}, \text{ and } P_{R2\_Else} > P_{R\_UnnxUnn} + P_{R\_None}.$$

Inconsistencies would create arbitrage opportunities.

To find the overall winning probability, sum the outcomes in which a candidate wins outright with those in which a candidate defeats another in a runoff. This results in the following:

$$p_{Macron} = \overbrace{P_{R1Macron}}^{\substack{Macron\ wins\\ outright}} + \overbrace{P_{R2\_MacDLep}}^{\substack{Macron\ defeats\\ LePen\ in\ runoff}} + \overbrace{P_{R2\_MacDUnn}}^{\substack{Macron\ defeats\ an\\ Unnamed\ Candidate\ in\ runoff}} = 0.050 + 0.400 + 0.125 = 0.575, \quad (3)$$

$$p_{LePen} = \overbrace{P_{R1Lepen}}^{\substack{LePen\ wins\\ outright}} + \overbrace{(P_{R\_MacxLep} - P_{R2\_MacDLep}) +}^{\substack{LePen\ defeats\\ Macron\ in\ runoff}} + \overbrace{P_{R2\_LePDUnn}}^{\substack{LePen\ defeats\ an\\ Unnamed\ Candidate\ in\ runoff}} = 0.040 + (0.600 - 0.400) + 0.075 = 0.315, \quad (4)$$

and

$$p_{Unnamed} = \overbrace{P_{R1Unnamed}}^{\substack{An\ Unnamed\\ Candidate\ wins\\ outright}} + \overbrace{P_{R_{UnnxUnn}}}^{\substack{Two\ Unnamed\\ Candidates\\ in\ Runoff}} + \overbrace{(P_{R_{MacxUnn}} - P_{R2_{MacDunn}})}^{\substack{An\ Unnamed\ Candidate\ defeats\\ Macron\ in\ runoff}} + \overbrace{(P_{R2\_LePDUnn} - P_{R2\_LePDUnn})}^{\substack{An\ Unnamed\ Candidate\ defeats\\ LePen\ in\ runoff}} = 0.010 + 0.060 + [0.150 - 0.125] + [0.090 - 0.075] = 0.110. \quad (5)$$

Find conditional runoff winning probabilities by dividing R2 prices by R prices, as follows:

$$p_{Macron|Macron\&LePen} = \frac{P_{R2\_MacDLeP}}{P_{R\_MacxLeP}} = \frac{0.400}{0.600} = 0.6667, \text{ and} \quad (6)$$

$$p_{LePen|Macron\&LePen} = 1 - \frac{P_{R2_{MacDLeP}}}{P_{R_{MacxLeP}}} = 1 - \frac{0.400}{0.600} = 0.3333 \quad (7)$$

Similar calculations give both Macron and Le Pen a 0.8333 probability of defeating an unnamed candidate in a runoff.

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Hypothetical prices "after round 1" show how prices collapse for most contracts after round 1. This example assumes that Macron and Le Pen were in the runoff. R1 and R markets can liquidate paying R1Runoff and R_MacxLeP $1 each. R2_MacDUnn and R2_LePxUnn can be delisted. R2_Else now pays $1 if Le Pen were to defeat Macron.

2022 FRENCH PRESIDENTIAL ELECTION MARKETS

In August 2021, the IEM opened the markets shown in table 1 without an established French trader base to determine if the election could be forecast without it. As of January 25, 2022 (i.e., 153 days since opening), only seven of the 13 contracts had *ever* traded, so there were insufficient prices to form forecasts. In the R1 market, 155 total contracts had traded on six separate days. In the R market, eight contracts traded on one day. In the R2 market, 105 contracts traded on three separate days. In comparison, volume averaged 262 contracts traded *per day* before Robert Dole became the de facto nominee in the similarly complex combined nomination and conditional vote-share markets run for the 1996 US presidential election.[7] Therefore, we speculate that having no French (informed) trader base resulted in low trading volume rather than market complexity. However, we cannot know for certain; although trading might increase closer to the election, we could not make forecasts at that time.

DISCUSSION

Using a prediction market to successfully forecast an election requires two conditions. First, the event being predicted must be clearly and unambiguously defined. In two-stage elections, this means accounting for all outcomes in a complex outcome space—even those unlikely to occur, such as an outright first-round win. Yet, the markets must be manageable and understandable for both traders and the exchange; therefore, it is important to minimize the number of contracts.

Second, to reveal information, markets must attract a sufficient number of informed traders because accurate market prices depend on "the wisdom of crowds" (Surowiecki 2005). As of this writing (January 25, 2022), there had been little trading in the IEM 2022 French presidential election markets. We appeared not to have a core group of traders interested in and informed about the election outcome. A local sponsoring organization that recruits interested traders substantially increases market activity. For example, in 2000, the IEM ran two WTA markets associated with presidential elections in Mexico and Taiwan, each with four contracts. The Mexican market did not have a sponsoring organization. During its 61 trading days, daily volume averaged 48 contracts. The Taiwan market did have a sponsoring organization: the Duke University Center for Chinese Electoral Studies. During its 38 trading days, daily volume averaged 155 contracts.

The 2022 French presidential-election markets opened more than seven months before the first ballots were cast. Traders purchased 382 contract bundles, but few individual contracts were traded. Two possible explanations for the low volume are market complexity and no local trader base. The combined nomination and conditional vote-share market for the 1996 US presidential election were similarly complex. High volumes in that market do not support the first explanation. Consistent with the second explanation, average daily market volume in the 2000 Taiwan presidential market (with a trader base) more than tripled the volume in the 2000 Mexican presidential market (without a trader base). In the future, we believe our market design can lead to viable forecasts for two-stage elections—but only with a sponsoring organization that recruits a local trader base.

DATA AVAILABILITY STATEMENT

Research documentation and data that support the findings of this study are openly available at the *PS: Political Science & Politics* Harvard Dataverse at https://doi.org/10.7910/DVN/CT7LVB.

SUPPLEMENTARY MATERIALS

To view supplementary material for this article, please visit http://doi.org/10.1017/S104909652200052X.

CONFLICTS OF INTEREST

The authors declare that there are no ethical issues or conflicts of interest in this research. ■

NOTES

1. Replication data for this article are in Berg, Gruca, and Rietz (2022).
2. The relative price accuracy of the IEM is debated elsewhere. Berg, Nelson, and Rietz (2008) found that IEM forecasts are closer to eventual election outcomes than unadjusted polls 74% of the time and that the relative accuracy improves at longer forecasting horizons. Erikson and Wlezien (2008) argued that adjusted polls fare better. Their poll-adjustment method resulted in them being closer than the IEM 55% of the time.
3. See http://tippie.uiowa.edu/iem (accessed January 7, 2022) and numerous publications (e.g., Berg, Nelson, and Rietz 2008) for additional information.
4. Because traders should account for all relevant information, doing so should mitigate issues such as pre-electoral alliances and other unknown (to the researcher) impact factors.
5. Technically, the IEM forecasts risk-neutral probabilities. Absent significant asymmetric hedging demand, these should approximate true probabilities. Berg and Rietz (2019) studied WTA market accuracy. For price ranges and probabilities typical in elections, they found that WTA markets accurately forecast probabilities.
6. If we had not been interested in which candidate might win outright, we could have dispensed with the R1 market entirely because the *R_None* contract captures the probability of an outright win without distinguishing who will win.
7. Volume averaged 71 contracts per day during an equivalent period after Dole became the de facto nominee and, presumably, the market became simpler.

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