Using Options to Measure the Full Value-Effect of an Event:

Application to Obamacare

Abstract

Many event studies only measure a fraction of an event's full value effect because they do not adjust for market anticipation of the event. We present a method based on stock and options prices to measure the full effect that accounts for market anticipation. We apply the method to passage of Obamacare. Our method estimates the full value effect of Obamacare on the healthcare sector as $55 billion, compared to $16 billion when market anticipation is ignored. The method is applicable to most major events because it only requires that some affected firms have traded stock options.

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1. Introduction

The seminal work of Fama, Fisher, Jensen, and Roll (1969) established the event study method to measure whether the announcement of new information has a statistically significant effect on a firm's stock market value. Thousands of subsequent event studies use this basic approach with various statistical tools and expected return models. But many of these studies only measure a fraction of an event's value effect because the events are partly anticipated by investors. As an extreme example, Bhattacharya, Doauk, Jorgenson, and Kehr (2000) show that unrestricted pre-event insider trading on the Mexican Stock Exchange virtually eliminates any measurable value effect on corporate news announcement dates. Although full investor anticipation is uncommon, so are complete surprises. We propose a method that

uses stock and option prices to account for the degree of investor anticipation and, better estimate the full value effect of an event.

Our method generalizes earlier efforts by Subramanian (2004), Barraclough, Robinson, Smith, and Whaley (2013), and Borochin (2014) to disentangle two value effects caused by a merger announcement: the synergy value and the signal about the standalone values of the bidder and target. Their key insight is to exploit unique information from options prices to identify the synergy and standalone values, along with the ex ante probability that the merger will be completed. In our application, the most important estimate is the ex ante probability that our event will occur. We compute the change in event probability close to the event, and use that change to determine the full value effect of the event.

The purpose of our study is to introduce a more general method to address all significant events that affect firms with traded options. We apply this more general method to estimate probabilities to a complex event: U.S. House of Representatives passage of the healthcare reform law, the Patient Protection and Affordable Care Act of 2010 (PPACA). Hereafter, we refer to the PPACA by its popularized name: "Obamacare" . We also examine a related event with different potential for investor anticipation: the subsequent 2012 Supreme Court ruling on Obamacare's constitutionality, which was potentially a greater surprise due to the Court's higher opacity.

The notion that good estimates of event probabilities could be useful is not new. Brennan (1990) explains that stock price changes due to partly anticipated events must be adjusted to properly measure the full value effect of an event. Malatesta and Thompson (1985), Acharya (1993), Chaplinsky and Hansen (1993), Prabhala (1997), and Bhagat, Dong, Hirshleifer, and Noah (2005) suggest that firm-specific attributes can be used to estimate the event probability.

The potential problem with this approach is that data on relevant firm-specific attributes may be scarce. Even if available, these data may not provide reliable probability estimates for events that are exogenous to the firm. Furthermore, when private information makes up the bulk of the explanatory power of the event probability, using public information to predict the event probability will be of little

value. Our method produces a market-based event probability that likely captures at least some of the effects of private information.

More recently, Wolfers and Zitzewitz (2009) and Snowberg, Wolfers and Zitzewitz (2007, 2008) use the traded event securities from prediction markets to estimate event probabilities and compute the full value effect. The primary limitation to this approach is that prediction markets cover few events because only certain ones attract sufficient numbers of betting participants. Indeed, one reason that we select Obamacare passage to illustrate our method is that it also had event securities traded on Intrade, the leading prediction market at the time. We compare the Intrade-generated probabilities for the 2010 and 2012 events to those we generate from options and stock prices as a robustness check.

Our financial market-generated probabilities have two advantages over prediction market-generated probabilities: (1) they are derived from assets with much larger dollar volumes of trades, [1] and (2), they can be estimated for any event that impacts companies with traded stock options. Intrade shut down on March 11, 2013, making a financial market-based alternative to predictive markets all the more appealing.

Interestingly, Intrade's Obamacare passage probability matches our model probability quite closely, but Intrade's Supreme Court decision probability differs considerably from ours. We estimate the Obamacare passage probability at 70 percent two days before Congressional passage, compared to 76 percent for the Intrade probability. For the Supreme Court constitutionality ruling, however, our probability was 68 percent, while the Intrade probability was just 30 percent.[2] Various investment analysts at the time suggested a 50 percent probability was appropriate. Intrade traders were much more

[1] The daily value of Obamacare contracts on Intrade averaged about $90,000 around the 2010 House vote event, while the average daily dollar value of stock ($277 million) and notional value of options ($397 million) traded for each company in our model totaled $674 million. The daily Intrade value was $35,000 during the 2012 Supreme Court event, while the average dollar stock and notional options trade value was $640 million.

[2] These are the probabilities on June 26, 2012, two days before the ruling was announced. Before oral arguments were held March 26-28, 2012, there was little difference between the two but that changed after oral arguments. The Intrade probability was 66 percent on March 25, 2012, but fell to 35 percent on March 29, 2012. Analysts' reports set the probability at 65 percent before oral arguments and 50 percent afterward.

pessimistic about the Supreme Court vote, perhaps reflecting greater opacity of the Supreme Court to outsiders.

The greater opacity of Supreme Court events compared to Congressional events is likely due to more public news about the votes of Congressmen compared to those of Supreme Court justices, who do not make public statements about their votes. Experts sell their private insights on Congress and the Supreme Court to stock investors (see Jerke, 2010), and those insights could be relatively more important for gauging the likelihood of Supreme Court events. Therefore, the beliefs of stock investors and Intrade investors could diverge more for Supreme Court events. Indeed, our model-generated probability for the Supreme Court ruling was more prescient given that Obamacare was ruled constitutional.

We do not expect the stocks of all healthcare firms to be significantly impacted by Obamacare. Some healthcare sectors were required to pay fees designed to offset profit "windfalls" caused by wider insurance coverage under Obamacare.[3] For example, Obamacare imposes a fee (tax) on brand name pharmaceutical sales to offset the additional profit pharmaceutical firms should earn from sales to people newly insured under Obamacare. In turn, the fee is used to help pay the premiums of those required to buy health insurance who cannot fully afford it. We find that pharmaceutical stock showed little reaction to Obamacare passage, and little unusual trading around the event. Conversely, hospital firms were not required to pay fees, and we find significant positive abnormal returns and trading for them around Obamacare passage.

Before adjusting for the probability of the event happening, we estimate that hospital firms gained $1.18 billion, but the gain is $3.95 billion after adjustment. However, for-profit hospitals account for only one ninth of all patient days and hospital surgical operations. Assuming similar valuation for non-profit hospitals, the gain is $35.5 billion. To put this in perspective, the fees and discounts imposed by Obamacare on pharmaceutical firms was estimated at $84.8 billion over ten years (Johnson, 2010).

[3] The fees were negotiated between the Obama administration and industry representatives. The pharmaceutical industry praised by President Obama for accepting substantial fees, whereas the insurance industry was criticized for its aggressive lobbying and refusals to negotiate. Kirkpatrick (2009) quotes President Obama as follows: "To their credit, the pharmaceutical companies have already agreed to put up $80 billion" but that the health insurance companies "need to be held accountable."

We estimate that the insurance industry gained $2.92 billion unadjusted, $9.75 billion after probability adjustment, and $19.5 billion to account for the fact that half of those insured use non-profit insurers. The total effect of Obamacare comes to about $55 billion.[4] Of course, this is a ballpark estimate given that firms in other industries could be indirectly affected. Nevertheless, we can say that the effect was substantial for some sectors of the healthcare industry and minimal for others.

The next section develops a simple model that illustrates how we measure the full effect of an event, along with how we identify the parameters of the model. Section 3 describes the healthcare reform event in more detail, along with analysts' perceptions of the probabilities of House passage and the Supreme Court ruling. Section 4 describes the data and the sample, and reports the model results. Section 5 uses results from Section 4 to estimate the net effect of Obamacare on the healthcare industry. Section 6 is a conclusion.

2. A simple framework for measuring the full stock value effect of an event

In this section, we set up the problem using a simple model of a stock whose current price reflects the expected value of a future event. We show that one cannot typically use the observed price change on the event announcement date to measure the full effect of an event on a company's per share value. Next, we present a model that uses a firm's stock and options prices to identify the unknown parameters that can be used to determine the full effect. We also discuss some potential complications that could impact our identification strategy. Finally, we discuss the empirical method that we apply to option and stock price data to estimate the model parameters.

2.1 Measuring the full stock value effect of an event

[4] We find that Obamacare had no significant effect on the value of medical device firms. Similar to pharmaceutical firms, they also have to pay fees under Obamacare. We do not report results for medical device firms because they are essentially repeats of the pharmaceutical firm results. That is, there is no net effect of Obamacare on their market values, there is no evidence of abnormal trading in their shares around the PPACA, and they provide no reliable estimate of the Obamacare probability.

Consider a stock whose current price is S_t, and whose future value will be either S_n if there is no event at time T, or $(S_n + V_e)$, where V_e is the full value effect of the event, if the event occurs at time T. Assume that the stock's expected return is small enough, or that T is short enough, that the effects of discounting can be ignored. If the probability of the event is *p*, then the stock price at time t is:

$$S_t = p\,(S_n + V_e) + (1 - p)\,S_n = S_n + p\,V_e. \qquad (1)$$

We also suppress the subscript T from the right-hand-side variables. At the end of each day t, investors reassess the event probability as well as the values of V_e and S_n. Therefore, the change in the stock price on day t is:

$$\Delta S_t = \Delta S_{n,t} + \Delta p_t\,V_e + p\,\Delta V_{e,t} + \Delta p_t\,\Delta V_{e,t}\,. \qquad (2)$$

Event studies often implicitly assume that there are no changes in the values of V_e and S_n, and that the event is a complete surprise (Δp_t =1). Therefore, the full value effect is equivalent to the stock price change on event day t :

$$\Delta S_t = V_e\,. \qquad (3)$$

One contribution of our paper is that we relax the assumption that the event is a complete surprise and allow Δp_t to differ from one, to reflect partial investor anticipation of the event. If we also assume no changes in the values of V_e and S_n , then the full value effect is:

$$V_e = \Delta S_t\,/\Delta p_t\,. \qquad (4)$$

Our joint estimation of probability and state prices allows us to relax the assumptions of no changes in the values of V_e and S_n, producing a more general form of the value effect using equation (2):

$$V_e = \frac{\Delta S_t - \Delta S_{n,t} - p\,\Delta V_{e,t} - \Delta p_t\,\Delta V_{e,t}}{\Delta p_t}, \quad (5)$$

or

$$V_{e,t} = V_e + \Delta V_{e,t} = \frac{\Delta S_t - \Delta S_{n,t} - p\,\Delta V_{e,t}}{\Delta p_t}. \quad (6)$$

Equation 6 can be used to compute $V_{e,t}$ at the end of each period t if one knows the changes in the variables during period t, plus the event probability at the start of period t. Our estimation method below can be used to compute the inputs to equation (6) on a daily basis, except for the event day when p jumps to 1, or drops to 0. Once the event uncertainty is resolved during the event day, the end-of-day stock and option prices fully incorporate or exclude the particular event value. They reflect either ($S_n + V_e$) or S_n but not a probability weighted average of both.

For days preceding the event, our method provides a much more direct and simple way to compute the value of the event because it provides estimates of the event state price ($S_n + V_e$), and the no-event state price (S_n). Therefore, we can easily compute the full value effect as the difference between these two values, i.e.,

$$V_e = (S_n + V_e) - (S_n). \quad (7)$$

Because we wish to use the most updated information about the event, which includes the event day, we use equation 4. This should work well for our events because we use a very short event period during which we observe no other significant events that would change S_n and V_e, Nevertheless, we also assess the reasonability of those results using equation (7) and the state prices derived from the model for the days preceding the event.

2.2 The model and identification strategy

For most events, the event probability and its change are unknown, although investors spend time and resources forming estimates of them. In some limited cases, investor estimates are available in prediction markets. Wolfers and Zitzewitz (2009) and Snowberg, Wolfers and Zitzewitz (2007,2008) show how the prices of traded contracts on the outcomes of political events can be used as estimates of the event probabilities. They promote the combination of prediction market probability estimates and event studies as a way to more precisely measure the value effects of political events. This clever use of prediction markets provides the probability change required to measure the value effect with equation 4.

Their approach is limited, however, by the menu of events that prediction market owners are willing to securitize and offer for trade. Often the most widely traded event securities, and therefore, most profitable for prediction markets to offer, are events featured prominently in the popular press, such as presidential elections. Congressional passage of a new piece of technical legislation, or adoption of an arcane regulatory rule by a government agency, could generate large value effects for certain firms, yet never draw enough interest from prediction markets traders to warrant an event security.

Asset prices from stock and options markets offer the opportunity to estimate a wider variety of event probabilities. They have greater trading volume than prediction markets, and each nonredundant security adds independent information to help identify event probabilities and other unknowns.

The identification strategy of our paper, and the closely related papers of Barraclough, Robinson, Smith, and Whaley (2013) and Borochin (2014), follow from the mergers literature that tries to identify at least four merger-related unknowns. The crux of the problem is that the two stock prices of the acquirer and target are not enough to identify the probability that the merger will be completed, the synergies created, and the stand alone values of the firms conditioned on the merger announcement.

Several clever ways of identifying the unknowns have been proposed. For example, Bhagat, Dong, Hirschleifer, and Noah (2005) use the characteristics of an offer to estimate the probability that it will be completed. They also use information generated from intervening announcements, such as a

second offer, to infer synergies. A second offer reduces the probability of the first offer's acceptance, impacting the first bidder's stock price. It also increases the overall probability that the target will be acquired and impacts the target's stock price, but does not impact the first bidder's stand alone value. Similarly, Baker, Pan, and Wurgler (2012) show that the merger probability jumps for offers priced around the target's 52 week high, and they use the jump as an instrumental variable to identify overpayments made by acquirers.

Hietala, Kaplan, and Robinson (2003) model the current stock prices of the bidder and target as a probability weighted averages of two future state prices; a merged state price and an unmerged state price. They show that under certain conditions, including two bidders, one can identify the unknowns such as acquirer overpayments. Subramanian (2004) and Bester, Martinez, and Rosu (2013) use this setup of probability weighting firm values in merged and unmerged states to derive merging firms' options prices. For example, they set the current price of a call option on the target equal to the probability weighted average of two hypothetical call options, one with its underlying asset price equal to the target's merged state price, and the other with its underlying asset price equal to the target's unmerged state price. This setup is crucial to our model.

Our model identifies the event unknowns in equation 2 using a firm's stock price and several of its call options. Consider N traded call options on our event-affected stock, each with the expiration date of $T_c > T$, and differentiated only by their exercise prices X_i, i = 1, 2, 3,…, N. Then the stock price equation 1 can be augmented with option pricing equations to form our model. :

$$S_t = p\,(S_n + V_e) + (1 - p)\,S_n$$

$$C_{1t}[S_t, X_1] = pc_{1t}[(S_n + V_e), \sigma_e, X_1] + (1 - p)c_{1t}[S_n, \sigma_n, X_1]$$

$$C_{2t}[S_t, X_2] = pc_{2t}[(S_n + V_e), \sigma_e, X_2] + (1 - p)c_{2t}[S_n, \sigma_n, X_2]$$

...

$$C_{Nt}[S_t, X_N] = pc_{Nt}[(S_n + V_e), \sigma_e, X_N] + (1 - p)c_{Nt}[S_n, \sigma_n, X_N]. \quad (8)$$

This system of N+1equations can be used to identify up to N+1 parameters, assuming that a firm has traded stock and N traded option contracts. Much like the stock price is defined by two state-contingent payoffs, each option price is expressed as a claim on two options whose values are state-contingent. We suppress the risk free rate, r, and expiration date T_c, from the options equations because they are the same for each equation. $C_{it}[S_t, X_i]$ is the observed price of call option i, with exercise price X_i, $c_{it}[(S_n + V_e), \sigma_e, X_i]$ is the theoretical (Black-Scholes or binomial) price of the option contingent on the event occurring, σ_e, is its associated return volatility, $c_{it}[S_n, \sigma_n, X_i]$ is the theoretical price of the option contingent on no event occurring, and σ_n, is its associated return volatility.

System (5) contains five unknown parameters, *p*, S_n, V_e, σ_e, and σ_n, therefore, we need prices on four traded options, along with the stock price, to just identify the system. We will use eight options in our model estimation so that the system will be overidentified. Barraclough, Robinson, Smith and Whaley (2013) and Borochin (2014) show that these unknowns can be identified regardless of whether they are independently or jointly distributed, with the latter being more likely.

We have chosen to only use call options in our estimations, but put options could also be used to increase the number of identifying restrictions. Including a put with exercise price X_i is particularly useful if a call option with exercise price X_i is either not offered or seldom traded. Of course, if put-call parity holds closely, then one should not use both a put and call with the same exercise price and expiration date in system (5) because their prices are interdependent. One can also use options with expiration dates different from T_c if additional restrictions are required, but then additional unknown volatility parameters must be estimated, adding to the number of options required to identify all of the unknown parameters.

Add stuff about vol smile and linearity of exercise-option price function above.

2.2 Potential complications for parameter identification

Our simple model assumes that the firm's value depends on a single event, however, at any point in time, a firm's stock and options prices could be affected by more than one event. This could obscure some of the parameter estimates, making them noisy or difficult to identify. Consider a hypothetical example using the passage by the U.S. House of Representatives of Obamacare on March 21, 2010. The event occurred at the end of the first quarter, and the sample firms issued their first quarter financial reports in the following months. Hence, the next major event for our sample of firms was their quarterly earnings reports, which could have common industry effects.

Figure 1 illustrates the possible interplay between the events. For simplicity, we assume that the Obamacare event occurs one period in the future, and the earnings event occurs two periods in the future. Our model estimates are grounded in the market prices of a firm's stock and options prices on each day t. The most important model estimate is the Obamacare event probability p. When we estimate the model, we ignore the earnings event and its probability q, and attribute the daily changes in estimates of p to new political information that changes the probability that Obamacare will pass the House.

[Figure 1 here]

A potential estimation problem arises if the two events are related. Suppose that at time t, the earnings event probability q increases, and this somehow increases the Obamacare probability p. Then our model could attribute an increase in the stock price at time t to new information about an increase in p, but the increase is due to an increase in q. Another possibility is if Obamacare contains an immediate tax on high-earning companies, then the two events would be linked because an increase in earnings combined with Obamacare passage implies greater tax expense for a high earning firm. Furthermore, the effect is asymmetric, affecting only our estimate of the passage state price.

We believe that this identification problem is not an issue in our case because the two events are unrelated. Furthermore, changes in the stock price due to changes in expectations about the firm's future earnings affects the two Obamacare state prices at time t+1 by the same amount. Hence, there is a parallel shift in both state prices (passage and rejection), but no change in the implied Obamacare state-specific drifts in price over time, or the probability of passage.

Our model identifies parameter changes related to new information about Obamacare. New information about Obamacare could affect the passage state price or the passage probability, but not the rejection state price. Obamacare information has no effect on the rejection state price because that is the price investor expect under the condition of no Obamacare.

Figure 2 shows a stylized stock price pattern for a firm experiencing a hypothetical event. We assume that the event has a positive effect on the firm's market value. The state price conditioned on the event exceeds the state price conditioned on no event. We also assume that the Event state price drifts at a two percent rate per period, and the NoEvent state price drifts at a one percent rate (they could drift at the same rates if systematic risk is the same for both states).

[Figure 2 here]

The figure shows how the actual stock price drifts somewhere in between the two state-specific prices, closer to the Event (NoEvent) price if the event probability is above (below) 50 percent. The drift rate of the actual stock price is also a weighted average of the state-specific drift rates. New information about the event is introduced periodically as an increase in the event probability, where the event uncertainty is fully resolved in the last period. We could have decreased the probability periodically and had the stock price end up at the NoEvent price. Many other stock price patterns are possible by moving the probability up and down during the event period.

We are unlikely to find an ideal pattern such as the one in Figure 2 for our event because there could be unspecified future events that impact identification of the current one. We minimize the effects of unknown events in the following ways. First, we focus on what we believe is the major event common to a group of firms over the same calendar period. If information about smaller common events is released during our event period, the effects should be small. Second, if some firms in the group experience major firm-specific events, we minimize their effects by estimating the model parameters for each firm, and then using group averages as our final parameter estimates. Third, our estimates of the full value effects of the event will rely on model estimates obtained over only a few days at most. A short event period

should minimize the chance that information about another significant event is released during our event period.

2.3 Parameter estimation method

Our method estimates the market's expectations about firm values in the two possible states; the event state and the no-event state. In our first empirical application, the event state is "the U.S. House of Representatives passes Obamacare," and the no-event state is "the House does not pass Obamacare." Of course, we will only observe the firm's stock price in one of the two states. Nevertheless, we can still identify the market's latent beliefs about a firm's value in both states.

Under no-arbitrage conditions, the two state values for our event must be reflected in the values of the securities of the affected firms. For common stock, the relation between the state values and stock price is linear, but for options, the relation is nonlinear. Each option provides unique information to the system because each has a different exercise price (or expiration if one chooses to include options with different expiration dates). With different exercise prices, each observed option price changes at a different rate in response to observed stock price changes. Similarly, the theoretical options values respond differently to changes in the latent state-contingent firm values because their exercise prices differ.

We select short-maturity, near-the-money, highly-traded options for our system because these options are highly concave in stock price changes (high gamma), hence, they provide non-redundant information to our system, and more reliable identification of the unknown parameters. Additionally, a high trade volume could make the contract price less noisy and more informative.

We treat the state-specific equity values that determine option payoffs as latent variables to be estimated. Those values can change each day, along with the probability that the event will occur. Daily stock price changes capture useful information about changes in market expectations about the two future state payoffs and the event probability. Therefore, we produce separate estimates of the variables of

interest for each day of our event period, representing market expectations for each day. This allows us to track the evolution of beliefs as the event day approaches.

The theoretical values of the options in (5) can be computed accurately using the binomial or Black-Scholes model and by selecting at-the-money and near-the-money options from the menu of traded options for the firms affected by the event. Note also that we will focus most of our analysis on the event day or a short event window around the event day. This allows us to present the equations in (5) using the physical or true probabilities, when in fact, those equations hold precisely only for the risk neutral probabilities. The difference between the risk neutral and true probabilities depends on the size of the stock risk premium. The premium should be small because the event has little systematic risk associated with it and because our event window is very short.[5]

State-contingent pricing models similar to the framework in (5) have been solved in Subramanian (2004), Barraclough, Robinson, Smith and Whaley (2013) and Borochin (2014) using a variety of methods. For ease of use and replication, we describe the results obtained using the Global Optimization toolbox in MATLAB. This package was developed to optimize multivariate objective functions in the presence of local minima, which fits the highly nonlinear framework in (5) well.

Our problem is to find the vector of unknown parameters $\theta = \{ p, S_n, V_e, \sigma_e, \text{and } \sigma_n \}$ that solves (5). We use an overidentified system based on (5) to construct an objective vector. This objective is the cumulative absolute difference (CAD) criterion between a given day's observed stock and option closing prices and the theoretical prices implied by model parameters θ. Define P_t as the vector of market prices, i.e., the left hand side of the price equations in (5), and $\hat{P}_t(\theta)$ as the vector of theoretical values, i.e., the right hand side in (5). Our objective function $M(\theta)$, where e is a vector of ones, is the CAD criterion:[6]

[5] If one uses our method to estimate the current probability of an event expected to occur far in the future, then one should take care to interpret the estimated probability as a risk neutral probability, which underestimates the true event probability if the event under consideration is a priced risk.

[6] The use of the CAD objective follows Jackwerth and Rubinstein (1996) and Subramanian (2004). It may be substituted for a sum of square difference objective (Barraclough et al, 2013; Borochin, 2014) without affecting the results.

$$M(\theta) = \text{abs}[P_t - \hat{P}_t(\theta)]'e \quad (8)$$

We compute Fama and MacBeth (1973) standard errors from the time series of estimates. Statistics based on these standard errors should be conservative because they combine variation due to belief revisions with estimation noise.

We use the Cox and Rubinstein (1979) binomial pricing model to estimate the call option value as a function $\hat{C}_t(\theta)$. This model accounts for the early exercise premium from dividend payouts and is therefore a less noisy estimator of the unknowns than an analogous estimation using the Black-Scholes formula. We address the term structure of volatility issues first raised by Barone-Adesi, Brown and Harlow (1994) in their study of options in merger events by including two separate parameters for state-contingent volatility.

We specify the range of θ from which the estimation will draw proposals for each of the five unknowns as follows. The range of the risk-neutral probability is the open interval (.01,.99), and the state-contingent payoffs and volatilities are constrained to be within 15% of the current price and option-implied volatility levels, respectively. This constraint on the parameter space rules out implausibly high and low state-contingent values and volatility levels. To avoid ruling out valid solutions, we specify a support region that is greater than the realized changes in stock values on the event day. To avoid the issue of label switching between the event and no-event states, we employ a standard identifiability constraint (Stephens, 2000; Jasra, Holmes and Stephens, 2005) of $V_e > 0$.[7]

We then use the multi-start global optimization solver in Matlab to estimate a θ_t for each firm-day's prices. The optimization is run with 3000 different starting points[8] to minimize the chance of finding a local, rather than the global, minimum. Putting the time series of firm-specific estimates

[7] A constraint of $V_e < 0$ would serve the same purpose of differentiating the two state-contingent payoffs. We choose the former since we observe positive market reaction to the passage of Obamacare for the relevant firms. This choice does not affect the generality of the estimation, only the relative labeling of the two event states.

[8] The larger the sets of starting points, the higher the likelihood of finding the global maximum. Values above 3000 do not seem to change the estimation results, suggesting it is sufficient.

together allows us to track the evolution of the fundamental market expectations about the likelihood and impact of the event on a single firm.

Many firms are exposed to the healthcare legislation, and therefore, each can provide useful information about its expected effect. Each firm's estimate of θ_t is also subject to firm-specific noise in its stock and options prices. To maximize usable information and reduce noise, we average the firm-specific estimates of θ_t across groups of firms to produce an overall estimate of θ_t.[9] We group firms whose stock prices show clear evidence that they are affected by the Obamacare event.

3. The Obamacare passage event

In this section we describe the Obamacare event, and discuss how it was expected to affect the profitability of different industries in the healthcare sector of the economy. We treat the U.S. House of Representatives passage of Obamacare as our focus event because it has more news associated with it compared to the U.S. Supreme Court ruling on the constitutionality of Obamacare.[10] We characterize the Court ruling as a possible reversal of Obamacare passage, hence, it was expected to have similar but opposite effects when compared with House passage.

The House passage of Obamacare was a major but relatively uncertain event. Many on both sides of the healthcare reform debate believed that it would have large impacts on the healthcare sector. Liberto (2011) reports that $1.06 billion was spent on Obamacare -related lobbying by various interests during 2009 and 2010. A single company (Amgen) hired 33 lobbyists and spent $10.2 million. Many lobbied to include (exclude) provisions favorable (unfavorable) to them.

[9] Another option is to jointly estimate unknowns using data from several firms at once. In the merger literature, this approach is taken by Subramanian (2004), Bester Martinez and Rosu (2011), Barraclough Robinson Smith and Whaley (2013) and Borochin (2014) who use both target and acquirer data simultaneously. Since the number of firms significantly affected by a large event is much greater than those affected by a merger, the number of parameters to be estimated is substantially higher. For our event, we find that trying to estimate the parameters for many firms simultaneously results in poorer quality estimation.

[10] The Supreme Court's decision involved several issues but the crucial issue was Obamacare's mandate that all individuals purchase health insurance or pay a penalty (tax). Without this mandate, the insurance pool would not be sufficient to support Obamacare.

The importance of Obamacare was also reflected in substantial political maneuvering. In section 3.1, we describe the political environment leading up to the House passage, and then briefly describe the legal challenges that led to the Supreme Court ruling. In section 3.2, we use analyst reports from investment banks to gauge how investment analysts perceived the effects of Obamacare, and how they handicapped the probability that it would pass the House. Similarly, we discuss how analysts judged the probability that the Supreme Court would rule Obamacare unconstitutional.

3.1 The political steps leading to Obamacare passage by the U.S. House of Representatives

President Obama and Congressional Democrats invested considerable political capital to pass Obamacare. Obamacare was composed and passed by the Senate on December 24, 2009 following intricate political gyrations. Table 1 lists the major political steps taken to pass Obamacare.

[Table 1 here]

Passage of Obamacare in the House remained highly uncertain until March 9, 2010, when a speech by Speaker Pelosi made it clear that she would push Obamacare through the House, and implied that it would pass the Senate using "reconciliation".[11] Reconciliation circumvents filibusters and only a simple majority of Senators is required to pass a reconciliation bill. The House narrowly passed Obamacare on March 21, 2010 by a vote of 219-212, with 34 Democrats and all Republican representatives voting "no". It was no surprise that President Obama signed the bill on March 23, 2010.

In an attempt to stop Obamacare in the courts, 28 states filed lawsuits against it, most notably Florida. After a few unfavorable rulings by state and U.S. circuit courts, the Obama administration appealed to the Supreme Court to resolve the constitutionality of Obamacare, and the Court agreed on November 14, 2011 to hear the case.

[11] See Pelosi Remarks at the 2010 Legislative Conference for National Association of Counties, March 9, 2010, http://pelosi.house.gov/news/press-releases/2010/03/releases-March10-conf.shtml, last accessed December 29, 2010.

The Supreme Court held oral arguments for three days starting on March 26, 2012.[12] During oral arguments, the usual swing voter Justice Kennedy appeared skeptical that Obamacare was constitutional. Except indirectly during oral arguments, the justices do not make their opinions public before a final ruling is announced, therefore, there is little relevant news about the outcome compared to the House vote, where representatives often publicly state or change their views. The ruling was announced three months later on June 28, 2012, with Chief Justice Roberts as the swing voter, forming the 5-4 majority that upheld Obamacare.

3.2 Investor perception of Obamacare passage

The investment community had a wide range of beliefs about the likelihood that healthcare reform would pass. We searched the analysts' reports of major investment firms on the Thomson One Banker database for those that mentioned "healthcare reform" and the "probability", "likelihood", or "chance" of Obamacare passage.

Table 2 illustrates how uncertain analysts were about the probability of Obamacare passage. This uncertainty was partly due to previous efforts at comprehensive healthcare reform that failed (e.g. the Clinton Administration in the 1990's). Senator Kennedy's death and the election of Republican Scott Brown on January 19, 2010 to replace him created additional uncertainty among analysts. But in the days just before passage, most analysts moved their estimates of the chance of Obamacare passage to somewhere around 50 percent. This implies that passage was still uncertain but was not a complete surprise.

[Table 2 here]

In the next section, we show that our model estimate of the probability of Obamacare passage started rising around March 17, 2010, although it was already at around 60 percent when it jumped just before Obamacare passage on March 21, 2010.

[12] See http://en.wikipedia.org/wiki/Constitutional_challenges_to_the_Patient_Protection_and_Affordable_Care_Act, last accessed August 12, 2013.

Regardless of their probability assessments, most investment analysts judged the effects on healthcare firms similarly. They weighed increased sales volume from more Obamacare -insured patients, against lower reimbursement rates per patient from the government. Obamacare also levied fees on healthcare firms to claw back some of the additional profit that firms would earn from higher patient volumes.

Hospitals in particular were expected to do well on net because they would see fewer uninsured patients in their emergency rooms where they were required to give uncompensated care. Another positive for hospitals was that the final bill included fees only for pharmaceutical and insurance firms.

There was much less news and analyst reporting surrounding the Supreme Court ruling on Obamacare. We again searched Thomson One Banker for analyst estimates of the "probability", "likelihood", or "chance" that the "Supreme Court" would rule Obamacare constitutional. On March 23, 2012, Deutsche Bank reported results from an investor survey that showed 83% believed that there was at least a 50% chance that Obamacare would be held constitutional. On June 4, 2012, Cowen and Company reported that their expert consultants estimated that the probability fell from 65% before oral arguments on March 26, 2012, to 50% afterward. The change was due to Justice Kennedy's skeptical questions about requiring everyone to buy health insurance. On June 21, 2012, Deutsche Bank also estimated a 50% chance that Obamacare would be held constitutional.

4. The data and the sample

4.1 Data sources

Stock returns, volumes, and shares outstanding are taken from the Center for Research in Securities Prices (CRSP) daily master file. Daily option-related data are taken from OptionMetrics, including expiration dates, exercise prices, closing best bid and ask price quotes across all exchanges, trading volume, implied volatilities, and open interest. OptionMetrics also provides stock closing prices,

with the option and stock closing prices captured within one minute of each other.[13] We also obtain cash dividend records on underlying stocks from OptionMetrics. Option prices used in our model are the midpoint of the closing bid and asked prices. We use annualized 1-month LIBOR as the proxy for the risk free rate.

One reason for selecting Obamacare passage is that Intrade offered an event security on Obamacare passage, with trading starting in January 2010. It also offered an event security on the Supreme Court's constitutionality decision, with trading starting in January 2011. Intrade was an online prediction market offering event securities whose prices can be interpreted as the probabilities of particular events. We compare the Intrade probabilities with our model-generated probabilities as a robustness check.

Intrade's House passage security offered holders a one dollar payout if Obamacare passed the House of Representatives by June of 2010, and zero otherwise. The Supreme Court security offered holders a one dollar payout if the Supreme Court ruled Obamacare unconstitutional by December 31, 2012. Hereafter, we adjust the data for the Supreme Court security so it can be interpreted as the probability that the Supreme Court would rule that Obamacare was constitutional. Intrade provided trade by trade data, so we select the trades closest to the close of trading in the U.S. securities markets (4 PM Eastern Time) and averaged their prices to get daily closing prices that time-match the closing stock and options prices.[14]

4.2 The sample of firms in the healthcare industry

The Obamacare event is expected to have significant effects on firms in the healthcare industry. We select the major sectors of the healthcare industry from the North American Industrial Classification System (NAICS) codes as follows: Hospitals (622110, 622210, 622310), Direct Health and Medical

[13] This helps minimize noise introduced by asynchronicity in reported closing prices between the option and stock markets.

[14] Intrade was a 24 hour predictive market, although it marks its own daily close of trading at 7 PM Greenwich Mean Time. Intrade closed down on March 11, 2013, making a financial market-based alternative even more attractive.

Insurance Carriers (524114), Pharmaceutical/Biological Products (325411, 325412, 325413, 325414), and Medical Equipment and Supplies (339112, 339113). Because Obamacare treats the Pharmaceutical/Biological Products industry and the Medical Equipment and Supplies industry similarly, and we find a similar negligible effect of Obamacare events on both industries, we present results for the Pharmaceutical/Biological Products industry but not the Medical Equipment and Supplies industry.

Table 3 lists our sample of companies for three industries: hospital, health insurance, and pharmaceutical/biotech. We use six firms from each industry. We found that using at least eight traded options to estimate the model parameters for each firm on each day produced stable model estimates. There are only six firms with at least eight daily-traded options in each of the hospital and health insurance industries. The pharmaceutical industry offered more firms with the required data, however, we selected the six top firms to be consistent. Including more than six firms in the pharmaceutical group has no effect on the results. This results in a sample of eight option prices and one stock price per firm per day with a sample of 18 firms. Therefore, our sample consists of 162 closing price observations per day, or 2430 observations for the 15-day pre-event period for each event.

[Table 3 here]

As deduced from the analyst reports, the investment community did not consider the event (House passage of Obamacare) to be relatively likely until early- to mid-March, therefore, we start our event period on March 1, 2010. Our more important results are focused on only a few days around the day of passage. We use the same length event period (15 trading days prior to the event date) for the Supreme Court event, starting with June 7, 2012.

Our method requires that a company's stock and options prices be sensitive to the event, in order to reliably identify and estimate the model parameters. That is, investors must consider the event to be important enough to have an impact on their trading and pricing. Furthermore, this must hold on average because our final parameter estimates are averages of the firm-specific parameters for the firms in industries that exhibit significant event impacts (to reduce firm-specific parameter noise).

To decide if an industry group is affected by the event, we examine the cumulative average abnormal returns (CAARs) and cumulative average abnormal volume (CAAV) for the groups during the event period. [15] We apply standard event study methods and use Eventus software for the computations. We use the market model with the equal-weighted CRSP index as the market index.

Table 4 presents the CAARs and CAAVs covering various overlapping event windows. Each window ends with day 0, which is the "event day." Because the House event occurs on a Sunday, the event day is the next trading day, March 22, 2010. The shortest event window [-1; 0] includes the event day plus the first trading day before the event, March 19, 2010. The other windows cover the event day plus one week of pre-event trading [-5; 0], or two weeks of pre-event trading [-10; 0], or three weeks of pre-event trading [-15; 0]. The Supreme Court event day is June 28, 2012, and we use similar event windows relative to that date.

[Table 4 here]

Table 4 provides support for the notion that Obamacare passage and the Supreme Court ruling had significant net effects on the hospital and health insurance industries, but not the pharmaceutical industry, at least from an investor's perspective. The CAARs and CAAVs for the pharmaceutical group are all relatively small and statistically insignificant, except for ten days before the Supreme Court event which show marginally significant CAARs.

The hospital firms were most highly affected, consistent with investment analyst expectations. Most of the CAARs and CAAVs for the hospital group are relatively large and statistically significant. The large positive CAAVs imply that investors were trading well above normal amounts of the firms' shares in the days leading up to Obamacare passage.

The insurance group has smaller CAARs than the hospital group, but they are still substantial enough to expect that our model could pick up pricing effects from the Obamacare event. The significant CAAVs for the group also support the notion that investors were trading insurance firms' stocks in

[15] See Campbell and Wasley (1996) for details on volume event studies, where log-transformed relative trading volume replaces returns in the traditional return event study

anticipation of the House passage and the Supreme Court decision. The negative CAARs in reaction to the Supreme Court decision can be explained as follow. The court ruled that the individual mandate was constitutional (the crucial issue), but also ruled that Obamacare could not be used to force states to expand Medicaid. Insurance companies manage the care of Medicaid patients, and Cowen and Company (June 4, 2012) projected that Medicaid expansion would increase Medicaid coverage by sixteen million people. Therefore, no Medicaid expansion would mean fewer Medicaid patients managed by insurance companies.

Although pharmaceutical firms experienced positive CAARs, none are statistically significant within five trading days of the event, and all are relatively small. Furthermore, there is very little evidence of above normal trade volume during the event period. Based upon this evidence, most of the model parameters estimates that we present below are averages for a sample of twelve firms; the six hospital firms plus the six insurance firms.

We also examined options trading around the two events for the twelve firms. Trading volume was very similar for both events. Trading increased on average by 167% during the [-2; 0] event period, and fell by 121% on the day following the event. Because daily options volume is highly volatile, neither of these results is statistically significant. Open interest increased during the [-15; -1] event period by about 21% for the House event, and then fell by 26% on the event day. The decline on the event day is statistically significant at the one percent level. Open interest rose only 7% for the Supreme Court decision during the [-15; -1] event period, with no significant decline on the event day.

4.3 Model estimates of Obamacare passage probability and Supreme Court constitutionality probability

For each trading day from March 1, 2010 to March 23, 2010, and from June 7, 2012 to June, 29, 2012, we estimate our model parameters using the set of equations in (5) for each firm, and then average across firms. Figures 3 and 5 illustrate the probability estimates for the House passage event and the Supreme Court ruling event, respectively. The probability of the event implied by stock and option prices

is the most important parameter for our purposes. We report the associated series of daily Intrade-generated probabilities for comparison.[16]

[Figure 3 here]

Figure 3 shows that our daily model probabilities and Intrade probabilities move along together throughout the event period (correlation of 0.59), but deviate from one another in several ways. We do not expect the two series to track each other exactly because stock and option investors and Intrade traders do not necessarily have the same information and expectations about Obamacare.

The two series diverge substantially at the end of the period because there should be little Intrade security price change after the event day. But stock prices reflect the passing of one event and the emergence of the next event. For our sample of firms, the emerging event is likely to be their coming earnings reports, which could have some common industry influences. At the close of trading on the event date, uncertainty about Obamacare has been resolved, hence the Intrade probability goes to 99 percent. But because stock and option prices reflect forward-looking events, the model probability based on the close of trading reflects the next event, perhaps the forthcoming first-quarter earnings.

If Obamacare was the only event, we expect that the model also would have generated a probability close to 100 percent. Therefore, because the true Obamacare passage probability is 100 percent at the end of trading on March 22, 2010, and the model probability at the end of trading on March 18, 2010 is 70 percent, we compute the change in event probability during the two day event window [-1; 0] to be 30 percent.

Note that the model probability and the Intrade probability are quite close on March 19th, 18th, and 17th, although the model probability is somewhat lower. The lower model probability is consistent with lower estimates we found in analyst reports (see above). Even when analysts started raising their probability estimates starting around March 16, 2010, none of them set their probabilities as high as the

[16] Note that we plot parameter estimates for an extra day beyond the event in order to illustrate some differences between the Intrade-generated and asset-price generated series. Also note that the two-day periods with no observation markers are weekends during which there are no model-generated estimates because there are no stock and option price changes.

Intrade probabilities. The rising probabilities could have reflected the fact that on March 15, 2010, President Obama announced that he would delay a visit to Thailand in order to help push Obamacare through the House (see Cowen and Company, March 16, 2010).

Before March 16, 2010, the model and the Intrade probabilities appear to be somewhat noisy. Nevertheless, some of that volatility could reflect news about the prospects of Obamacare passage. For example, the large (small) jump in the model (Intrade) probability on March 9, 2010 coincides with Speaker Pelosi's speech about pushing Obamacare through the House. The standard deviations of the probability series are 0.14 for the Intrade series and 0.09 for the model-generated series. Of course, these standard deviations overestimate the uncertainty associated with the probabilities because they include variation from both noise and changes in information.

We have more confidence in the estimates over the last several days of the event period because the CAARs and CAAVs showed significant investor activity close to the event day. The model should fit better when investors make greater stock prices adjustments or more trades that incorporate important Obamacare news, such as Obama delaying his Thailand trip from March 19, 2010 to March 21, 2010. This could imply that he expected it to pass by March 21, 2010.

The importance of investor activity for our model to generate reliable parameters is considered in Figure 4. We replace the model probabilities generated from the twelve hospital and insurance firms, with model probabilities generated from the six pharmaceutical firms. The pharmaceutical group exhibited insignificant abnormal returns (CAARs) and trading volumes (CAAVs). The pharmaceutical group probability shows little trend upward over time and is far from the Intrade probability on March 19, 2010. Its correlation with the Intrade probability series is actually negative (-0.24). We place little confidence in the pharmaceutical group probability estimates.

[Figure 4 here]

Figure 5 illustrates the time series of model-based and Intrade-based probabilities associated with the Supreme Court event. Unlike for the House event, there is little variation in the probabilities until the last few days before the event. The standard deviation of each series is only 0.04. There is some common

movement between the two probability series over time, and some convergence between them on the day before the event (June 27, 2012), but otherwise, there is a large gap between the probabilities derived from stock and options prices compared to those obtained from Intrade.

[Figure 5 here]

What could explain such a large difference between the two series of probability estimates? Our model estimates reflect much larger trades than the Intrade estimates. The daily trade value for the Intrade Obamacare securities during the week leading up to the Supreme Court event averaged only about $35,000. One might expect stock and options investors to be better informed, and in fact the model-based probabilities were closer to predicting the eventual outcome. The larger model-based probability is also consistent with the probability estimates sent by stock analysts to their investors during the period (see above). Analysts often hired legal experts to provide insight for their private reports (Cowen and Company, June 4, 2012). The model-based and Intrade probabilities were much closer for the House passage event, perhaps because that event involved more publicly disclosed information.

4.4 Model estimates of the two state prices

A. Passage or rejection of Obamacare by the House of Representatives

For each of the twelve sample firms, we obtain an Obamacare passage state price and an Obamacare rejection state price for each trading day between March 1, 2010 and March 23, 2010, using the set of equations in (5). We also collect the actual stock price each day. All of these prices are scaled by the passage state price estimated on March 1, 2010. Therefore, each state price series can be viewed as a cumulative return, with a starting price measured relative to the Obamacare passage price. Finally, we average the state prices and the actual prices each day across the twelve firms.

We plot the three price series in Figure 6. The passage price starts at 1, and the rejection price starts at about 0.95. As in the stylized example in Figure 2, the actual price is simply the weighted average of the two state prices, with the weight being the model-generated probability shown in Figure 3. That

probability starts at about 0.50, hence, the actual market price starts at about 0.975, squarely in between the two state prices.

[Figure 6 here]

Note that there is very little appreciation in the actual price until March 15th or 16th. The slight appreciation up to that point is almost entirely due to the appreciation in the passage price. Indeed, the rejection state price is essentially flat until the event date, when it jumps from 0.95 to 1. Then it jumps again on the day after the event by another five percent. In contrast, the passage state price appreciates at a constant rate during the last eight days of the period.

What accounts for the sharp difference in behavior between the two state prices? Actually, the two prices move together until March 9, 2010 (House Speaker Pelosi speech date) and then start to diverge. We believe that after March 9, stock and option investors start to focus more on Obamacare news, and our model picks this up. The potential positive or negative effects of the House vote becomes more evident in the state prices as we approach the event day.

The unusual behavior of the rejection state price on the event day and the following day likely reflects the transition from one event to the next. Had there been only the Obamacare event to consider, then on the event day, the rejection price would be irrelevant, the Obamacare probability would be 1, and the actual and passage prices would be the same. The actual price on March 22, 2010 is 1.088 and the model-generated passage state price is shown as 1.108. But we know that the passage probability is 100 percent, so the actual price and the passage price should be the same, i.e., 1.088. Therefore, the 1.108 is the up-state price for the next event, for example, if the sample firms end up reporting unexpectedly high first quarter earnings. The new event (e.g. earnings reports) has up- and down-state prices that incorporate the positive Obamacare event value. The new spread between those prices reflects the value difference between the new up and down states.

Another way to understand the unusual behavior of the rejection state price is to consider what it would have looked like if Obamacare had been rejected. In that case, the rejection price path would have

been smoother and the passage state price would have fall sharply, ending up close to the rejection state price, although not equal to it because of the effect of the next event.

B. Constitutional or unconstitutional ruling by the Supreme Court

We repeat the same analysis for the Supreme Court event. For each trading day between June 7, 2012 and June 29, 2012, and for each of the twelve sample firms, we estimate a constitutional state price and an unconstitutional state price and collect the actual stock price for each day. All of these prices are scaled by the constitutional state price estimated for June 7, 2012.

Figure 7 plots the three series of prices during the event period. The prices move together but exhibit little appreciation until the end of the period, starting June 26 and ending June 28. The smaller appreciation for the Supreme Court event can be explained by the negative CAARs for the insurance firms, which brings down the average when combined with the positive hospital CAARs. For the House event, both the hospital and insurance firms had positive CAARs.

[Figure 7 here]

The large rise in the unconstitutional state price on the day before the event and the event day again likely reflects the transition from one event to the next. The new event could be the common effects expected for the firms' second quarter earnings reports, because the Supreme Court event comes at the end of June 2012.

4.5 Model estimates of the two state price volatilities for the House passage-rejection event and the Supreme Court constitutional-unconstitutional event

In addition to the two state prices, our model provides estimates of the volatilities of the two state prices implied by the options pricing model. For each of the twelve sample firms, we obtain an Obamacare passage state price volatility and an Obamacare rejection state price volatility for each trading day between March 1, 2010 and March 23, 2010. We average the state price volatilities each day across

the twelve firms. We do the same to obtain the Supreme Court constitutional state price volatility and the Supreme Court unconstitutional state price volatility for each trading day between June 7, 2012 and June 29, 2012.

We plot the volatility series for each event in Figure 8, Panels A and B. The standard deviation of each series is about 0.01. The important feature of both panels is that the volatilities are lower when the state includes Obamacare. Investors expected that the average volatility of the twelve firms with Obamacare in force would be lower than if it was rejected. This expectation could reflect the fact that with Obamacare in force, the government could more closely regulate the healthcare industry. Typically, regulated industries have less volatile cash flows. Consistent with this interpretation, Epstein (2009) suggests that Obamacare more or less turns the healthcare industry into a regulated public utility.

5. Assessing the full value effect of Obamacare

We can now compute the full effect of Obamacare passage on the market value of the equity of the firms in the hospital and health insurance industries. Because Table 4 shows no significant CAARs for the pharmaceutical industry, we do not compute an effect for that industry. The full value effect is estimated by the value of the equity for an industry, times the CAAR for the industry, divided by the change in our model-based estimate of the event probability over the [-1; 0] window.

At the close of trading March 18, 2010, the hospital firms covered in CRSP had an equity market value of $15.3 billion. The CAAR for the hospital industry over the [-1; 0] event window is 7.74%. If one assumed that the House passage was a complete surprise, the value effect of passage on the hospital industry amounts to $1.18 billion. But based on our model estimate that the probability of the event changed during the [-1; 0] event window by 30% (100% - 70%), the full value effect is $3.95 billion.

According to the American Hospital Association (2011), in 2010, for-profit hospitals accounted for only about one ninth of all patient days and hospital surgical operations. Assuming similar valuation for non-profit hospitals, the industry's net worth is $138 billion. Therefore, the net effect of Obamacare on

the hospital industry was about $35.5 billion. To put this in perspective, the fees and discounts imposed by Obamacare on pharmaceutical firms was estimated by Johnson (2010) at $84.8 billion over ten years.

The value effect on the insurance industry is estimated as follows. At the close of trading on March 18, 2010, the health insurance firms covered in CRSP had an equity market value of $137.8 billion. The CAAR for the health insurance industry over the [-1; 0] event window is 2.12%. Assuming a complete surprise, the value effect of passage on the insurance industry amounts to $2.92 billion. Using the change in event probability during the [-1; 0] event window of 30%, the full value effect is $9.75 billion. But again, this estimate ignores the fact that about half of those covered by health insurance are covered by non-profit health insurers.[17] Assuming similar valuation for non-profit insurers, the net effect of Obamacare on the health insurance industry was about $19.5 billion.

The total effect of Obamacare comes to $55 billion. This is a ballpark figure based on assumptions about the value of the nonprofit portions of the hospital and health insurance industries. The effect on the equity market value of the for-profit portion of these industries is more precise, about $13.7 billion. This assumes that CRSP includes most of the for-profit hospital and health insurance companies. It also excludes any effects on firms' bond values, and we do not consider the effects on firms that supply the hospital and health insurance industries or the effects on firms that might be required to offer better insurance to their workers because of Obamacare.[18]

The value effect for the Supreme Court constitutionality decision is not exactly comparable to the House passage because it was not a pure acceptance of Obamacare. It affected the insurance industry differently than the House passage event. The Supreme Court decision has no statistically significant effect on the insurance industry. The effect on the hospital industry, however, was quite similar to the House passage effect (CAAR of 6.85% compared to 7.74%).

[17] See "Basic Facts & Figures: Nonprofit Health Plans," Alliance for Advancing Nonprofit Healthcare, http://www.nonprofithealthcare.org/resources/BasicFacts-NonprofitHealthPlans.pdf, last accessed on 8/15/2013.

[18] We considered some firms that supply the hospital industry but found little or no reliable effects.

The full value effect on the hospital industry is computed as follows. At the close of trading June 26, 2012, the hospital firms covered in CRSP had an equity market value of $25.5 billion. The CAAR for the hospital industry over the [-1; 0] event window is 6.85%. Based on our model estimate that the probability of the event changed during the [-1; 0] event window by 32% (100% - 68%), the full value effect is about $5.46 billion. Again adjusting for the fact that for-profit hospitals account for only one ninth of all hospital patient days, the effect was about $50 billion. The difference in value effect compared to the House event is mostly because the value of firms in the hospital industry rose considerably between March 2010 and June 2012.

If one uses the Intrade probabilities to measure the value effects, the House event effects would have been boosted somewhat because one would use 26% as the change in event probability during the [-1;0] event period compared to the 30% from our model. But for the Supreme Court event, the difference is substantial. The change in the Intrade probability is 75% compared to just 32% from our model. We have argued that Intrade traders were much too pessimistic about the chances that the Supreme Court would rule Obamacare constitutional. Had stock and options investors had similar beliefs, one would have expected much larger CAARs for hospital firms than those we observed.

One could also measure the changes in probabilities and the value effects over different event windows. We selected a short window because we believe that investors could be more focused on the event closer to when it occurs, hence, stock and options prices could better reflect the event probability during that period. Had we selected the [-5;0] event window, for example, the estimated value effect would have been larger. Although the probability change over that window is larger (40% instead or 30%) so that the adjustment for market anticipation is smaller, the abnormal returns for both the hospital and insurance companies are larger. Hence, our estimate using the short window could be conservative.

6. Conclusion

This paper introduces a method similar to those developed in the mergers literature that uses stock and options prices to estimate ex ante event probabilities. We use the probabilities to compute the full value effects of an event; the U.S. House of Representatives passage of the healthcare reform law (Obamacare). Many event studies do not adjust for the fact that their events are partly anticipated, and in many cases, the degree of anticipation is difficult to measure. In our case, the adjustment triples the measured effect of the event on the market value of the affected firms.

Our method can generate ex ante probabilities for events that affect firms with liquid options. We believe that it is likely to be more precise than alternative methods such as using public data on firm-specific attributes to estimate event probabilities, or using event securities from relatively small prediction markets, because our method employs high-volume assets whose prices may partly reflect nonpublic information. For an event with substantial public information available (House passage), we find our probability estimate and that of a prediction market are quite close. But for an event with little public information (Supreme Court constitutionality), the estimates differ considerably.

We believe that our method could be useful for ex ante and ex post public policy analysis. For example, when legislation has offsetting provisions, the method could be used to measure the net dollar effect of those provisions on the affected company or industry. For Obamacare, we find that the positive and negative provisions affecting the pharmaceutical industry just about offset one another. But the hospital industry benefited considerably from Obamacare passage; by about $35.5 billion.

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Table 1

Chronological political steps to passage of Obamacare

Date	Political Events
January 2008-November 2008	Presidential candidate Obama pledges to pass comprehensive healthcare reform in an effort to distinguish himself from Democratic candidates and Republican John McCain.
February 24, 2009	President Obama describes his healthcare vision to a joint session of Congress.
March 2009	President Obama holds meetings with industry leaders about healthcare reform.
April 2009-August 2009	House and Senate craft bills - many Congressmen return home to hold contentious town hall meetings after which more security was assigned to some Congressmen.
November 7, 2009	House passes a healthcare reform bill which was ignored by the Senate.
December 24, 2009	Senate passes Obamacare after attaching it to another House-passed revenue bill to maneuver around the requirement that all revenue-related bills must start in the House. Special provisions were added to create a filibuster-proof majority.
January 2010-February 2010	House Speaker Pelosi adds several amendments to satisfy colleagues but the bill would then require re-passage by the Senate. But re-passage was uncertain because Senator Kennedy had died, and replacement Republican Scott Brown pledged to filibuster in the Senate.
February 25, 2010	President Obama holds healthcare summit with Democrats and Republicans.
March 9, 2010	House Speaker Pelosi implies that unusual "reconciliation" could be used to pass the amended Obamacare bill in the House and then the Senate vote would require a simple majority.
March 21, 2010	The House narrowly passes Obamacare.
March 23, 2010	Obama signs Obamacare into law.

Table 2

Investment analysts perceptions of the probability of Obamacare passage

This table lists analysts' estimates of the probability that Obamacare would pass during the months leading to its eventual passage in the U.S. House of Representatives on March 21, 2010. The dates listed are the dates of the analysts' reports. Analyst reports to their clients are compiled in the Thomson One Banker database, which we searched for the terms "healthcare reform" and "probability", "likelihood", or "chance" of Obamacare passage.

Date of Analyst Report	Analyst Estimate of the Probability that Obamacare would Pass
January 7, 2010	Wells Fargo puts the chance of Obamacare passage by the House at 10%, and the chance for passage of any comprehensive healthcare law at 20-30 %.
January 20, 2010	Morgan Stanley reduces the chance of Obamacare passage to 40% citing Republican Scott Brown's election to the Senate replacing Democrat Senator Kennedy on January 19, 2010.
January 20, 2010	Deutsche Bank changes its opinion of Obamacare from "imminently passable" to "unlikely to pass" citing Republican Scott Brown's election.
January 20, 2010	Jeffries International and Wells Fargo downgraded the chance for Obamacare passage because they viewed using reconciliation to be too politically risky for Democrats.
January 21, 2010	Credit Suisse described Obamacare as no longer viable.
February 23, 2010	Sanford C. Bernstein & Co. judged Obamacare passage to be 20% because mid-term 2010 elections would divide Democrats and make using reconciliation unlikely.
February 23, 2010	Raymond James & Associates estimated Obamacare passage at 20-30%.
March 3, 2010	Well Fargo estimated Obamacare passage at 30% if it came up for vote before March 26, 2010, when Congress was due for its spring break.
March 4, 2010	Avondale Partners estimated passage at 51% after President Obama, Speaker Pelosi, and Senator Majority Leader Reid started to meet frequently.
March 5, 2010	Cowen and Company upgraded its estimate of Obamacare passage from 30% to 50%.
March 16, 2010	Madison Williams and Company expected Obamacare passage soon because Speaker Pelosi and President Obama made personal calls to wavering Democrats, and President Obama had delayed a scheduled trip to Thailand until March 21, 2010.
March 17, 2010	Sanford C. Bernstein & Co. reported that the House Budget Committee had passed a reconciliation bill and upgraded their estimate of Obamacare passage from 20% to above 50%.

Table 3

Sample of firms in three healthcare-related industries

The stock and options prices of these firms are used to estimate the probability that Obamacare would pass, and that probability is later used to measure the full value effect of Obamacare passage.

Industry	Company
Hospital	Tenet Healthcare Corp.
	Community Health Systems
	Universal Health Services Inc.
	Lifepoint Hospitals Inc.
	Healthsouth Corp.
	Health Management Associates Inc.
Health Insurance	Aetna Inc.
	Cigna Corporation
	Wellpoint Inc.
	Health Net Inc.
	United Health Group Inc.
	Wellcare Health Plans Inc.
Pharmaceuticals/Biotech	Bristol Myers Squibb Co.
	Merck & Cc. Inc.
	Pfizer Inc.
	Amgen Inc.
	Johnson & Johnson
	Abbott Labs

Table 4

Cumulative Average Abnormal Returns and Cumulative Average Abnormal Volume for Firms Grouped By Industry around Two Events: Passage of Obamacare and the Supreme Court Ruling on the Constitutionality of Obamacare

This table reports Cumulative Average Abnormal Returns (CAARs) and Cumulative Average Abnormal Volume (CAAV) around the passage by the U.S. House of Representatives of Obamacare on March 21, 2010, and the Supreme Court ruling on Obamacare constitutionality on June 28, 2012. Because March 21, 2010 is a Sunday, the next trading day, March 22, 2010 is our "event date," for the House passage. Because healthcare reform was expected to affect different industries differently, we group firms into three industries defined by their North American Industrial Classification System (NAICS) codes: Hospitals (622110, 622210, 622310), Direct Health and Medical Insurance Carriers (524114), and Pharmaceutical/Biological Products (325411, 325412, 325413, 325414). Each daily abnormal return or abnormal volume is the average for the six firms in the particular industry group, and these are compounded over various event windows, i.e., several trading days preceding the event plus the event day. Abnormal returns and volume are estimated using standard event-study methods and the CRSP Equal-Weighted Index as the market index. *t*-statistics (cross-section adjusted) are reported in parentheses.

Panel A. House Passage of Obamacare - Cumulative Average Abnormal Returns (CAARs)

[Event Windows; Event Day = 0]	Hospital Group	Insurance Group	Pharmaceutical Group
[-1; 0]	7.74% (2.66)***	2.12% (0.63)	0.80% (0.50)
[-2; 0]	8.04% (2.25)**	5.42% (2.31)**	1.32% (0.67)
[-5; 0]	11.36% (2.24)**	4.76% (0.81)	1.77% (0.63)
[-10; 0]	7.87% (1.13)	2.86% (0.36)	1.41% (0.37)
[-15; 0]	8.61% (1.02)	1.83% (0.19)	0.88% (0.19)

Panel B: House Passage of Obamacare - Cumulative Average Abnormal Volume (CAAV)

[-1; 0]	93.89% (1.93)**	83.86% (3.58)***	23.38% (1.19)
[-2; 0]	136.10% (2.35)***	139.33% (4.30)***	25.72% (0.96)
[-5; 0]	204.15% (2.06)**	96.95% (1.64)*	-20.38% (-0.09)
[-10; 0]	233.59% (2.17)**	2.05% (0.14)	-90.83% (-0.56)
[-15; 0]	204.52% (1.47)*	-44.25% (-0.14)	-213.02% (-1.09)

Panel C: Supreme Court Ruling Obamacare Constitutional - Cumulative Average Abnormal Returns (CAARs)			
[-1; 0]	6.85% (6.62)***	-1.30% (-1.19)	0.28% (1.31)
[-2; 0]	8.79% (8.35)***	-0.79% (-0.81)	0.39% (1.01)
[-5; 0]	7.81% (10.81)***	-0.70% (-0.79)	0.68% (1.00)
[-10; 0]	10.49% (7.34)***	-3.20% (-2.46)**	1.37% (2.09)*
[-15; 0]	12.65% (7.94)***	-5.02% (-3.00)**	2.56% (2.19)*
Panel D: Supreme Court Ruling Obamacare Constitutional - Cumulative Average Abnormal Volume (CAAV)			
[-1; 0]	306.40% (8.23)***	307.02% (10.74)***	-23.66% (-1.00)
[-2; 0]	389.83% (8.54)***	385.29% (11.00)***	-43.28% (-1.49)
[-5; 0]	602.02% (9.33)***	570.09% (11.51)***	-33.33% (-0.80)
[-10; 0]	999.00% (11.60)***	962.47% (14.35)***	-44.70% (-0.81)
[-15; 0]	999.00% (11.97)***	999.00% (17.06)***	-8.52% (-0.12)

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% (one-tail) test levels, respectively.

Figure 1

Complications in model parameter estimation arising from more than one major event impacting the event period.

This figure is used to illustrate how a succession of events could impact the estimate that we obtain from our model of the probability of the first event happening. In our case, our focus is on the event probability that the U.S. House of Representatives will pass Obamacare. A potentially confounding event for our sample is the common industry-wide effect of firms' subsequent quarterly earnings announcements.

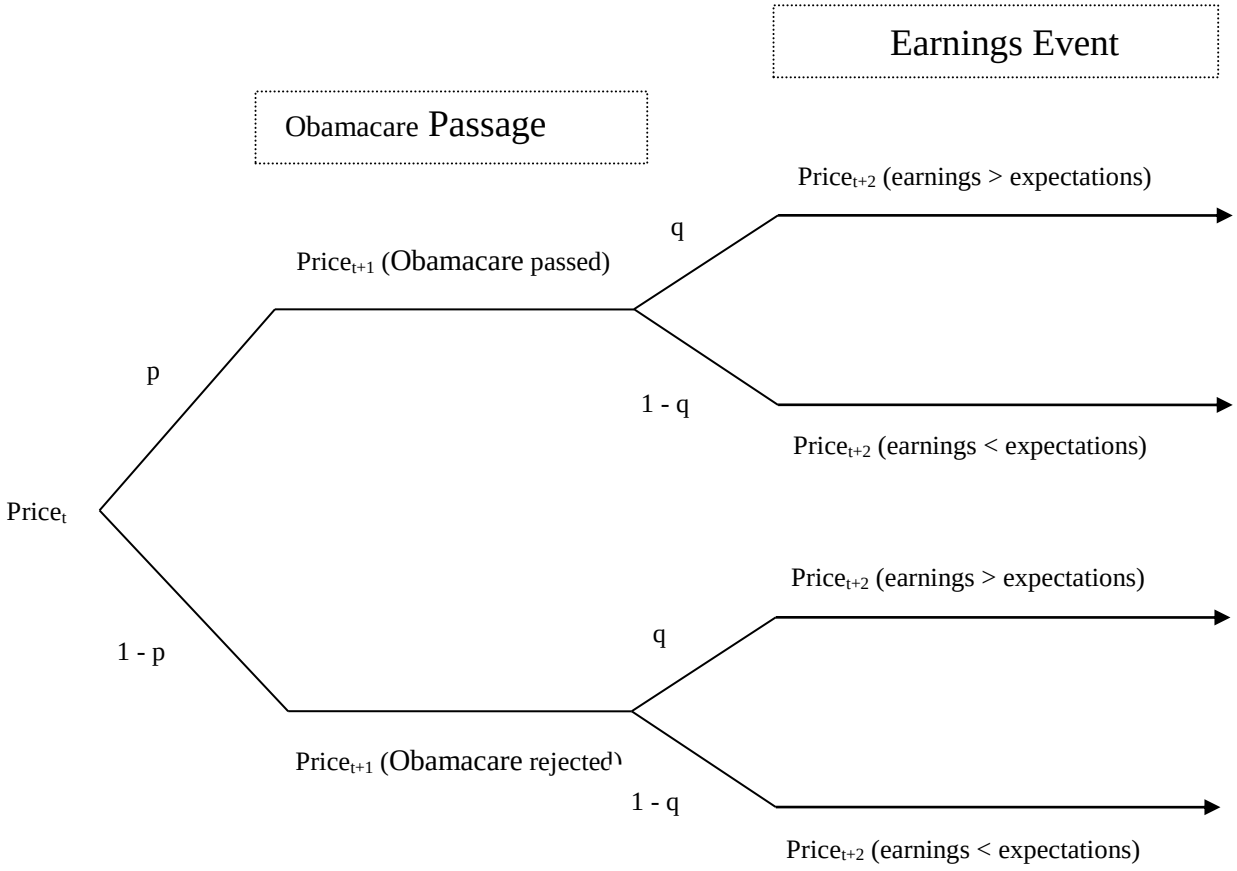


Figure 2

Stylized stock price pattern for a firm experiencing an event

This figure portrays an idealized stock price path ("Actual") for a firm whose value will be impacted by whether or not an event occurs. The "Event" ("NoEvent") stock price is the price that the stock would take if uncertainty had been resolved and it was known for sure that the event would (would not) occur. The Actual stock price is a weighted average of the Event and NoEvent prices, where the weight is the probability that the event will occur. In this case, the probability of the event occurring increases consistently in steps over time until the event occurs, and the Actual stock price equals the Event stock price. Many other Actual price paths are possible depending upon the change in the probability at each point in time.

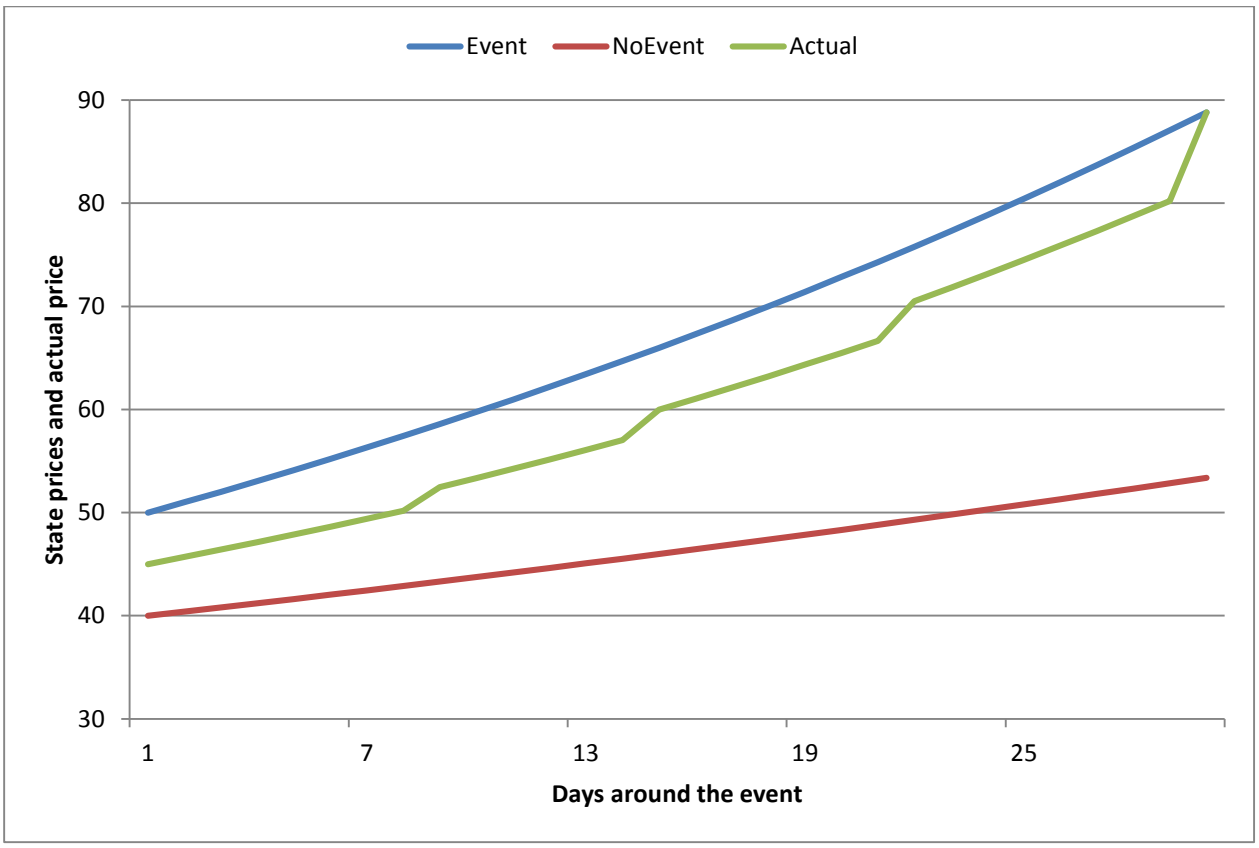


Figure 3

The model-generated probability of Obamacare passage compared to the Intrade-generated probability

This figure plots the model-generated probability of Obamacare passage by the U.S. House of Representatives, which is the probability implied by the stock and options prices of six hospital firms and six insurance firms. The Intrade-generated probability of Obamacare passage is the price of an event security traded on the Intrade prediction market. Probabilities are shown for three weeks of trading before the event, the event day (March 22, 2010), and the day following the event.

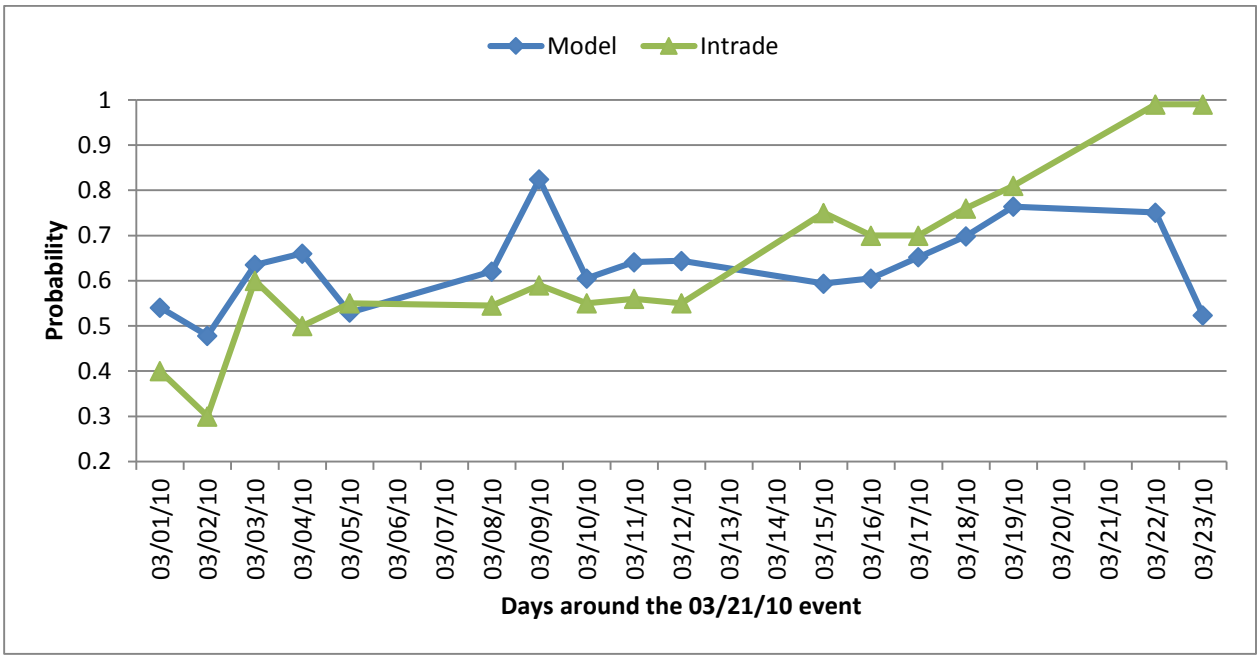


Figure 4

The model-generated probability of Obamacare passage estimated from the pharmaceutical group of firms compared to the Intrade-generated probability

This figure plots the probability of Obamacare passage by the U.S. House of Representatives that is implied by the stock and options prices of six pharmaceutical firms. Because Obamacare has no significant net effect on pharmaceutical firms, the probabilities implied by their stock and options prices are relatively uninformative. Hence, they differ substantially from the Intrade-generated probabilities, which are the prices of an event security traded on the Intrade prediction market. Probabilities are shown for three weeks of trading before the event, the event day (March 22, 2010), and the day following the event.

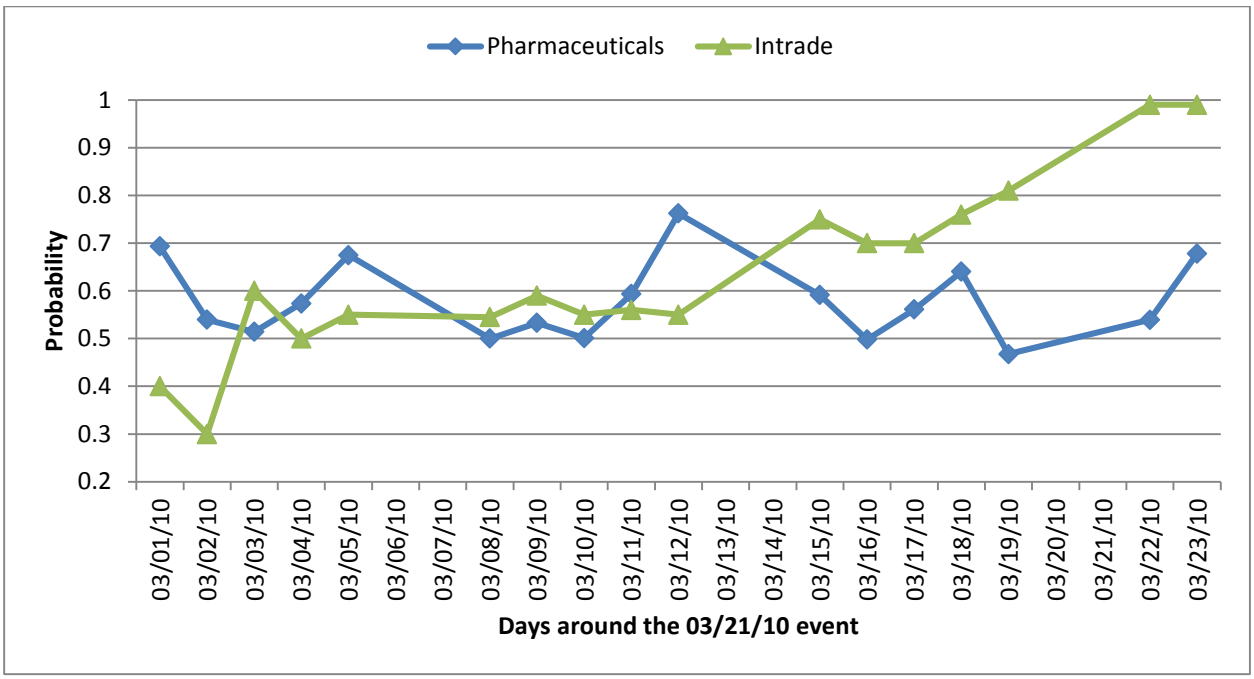


Figure 5

The model-generated probability that the Supreme Court rules that Obamacare is constitutional compared to the Intrade-generated probability

This figure plots the model-generated probability that the Supreme Court rules that Obamacare is constitutional, which is the probability implied by the stock and options prices of six hospital firms and six insurance firms. The Intrade-generated probability of the Supreme Court's constitutionality ruling is the price of an event security traded on the Intrade prediction market. Probabilities are shown for three weeks of trading before the event, the event day (June 28, 2012), and the day following the event.

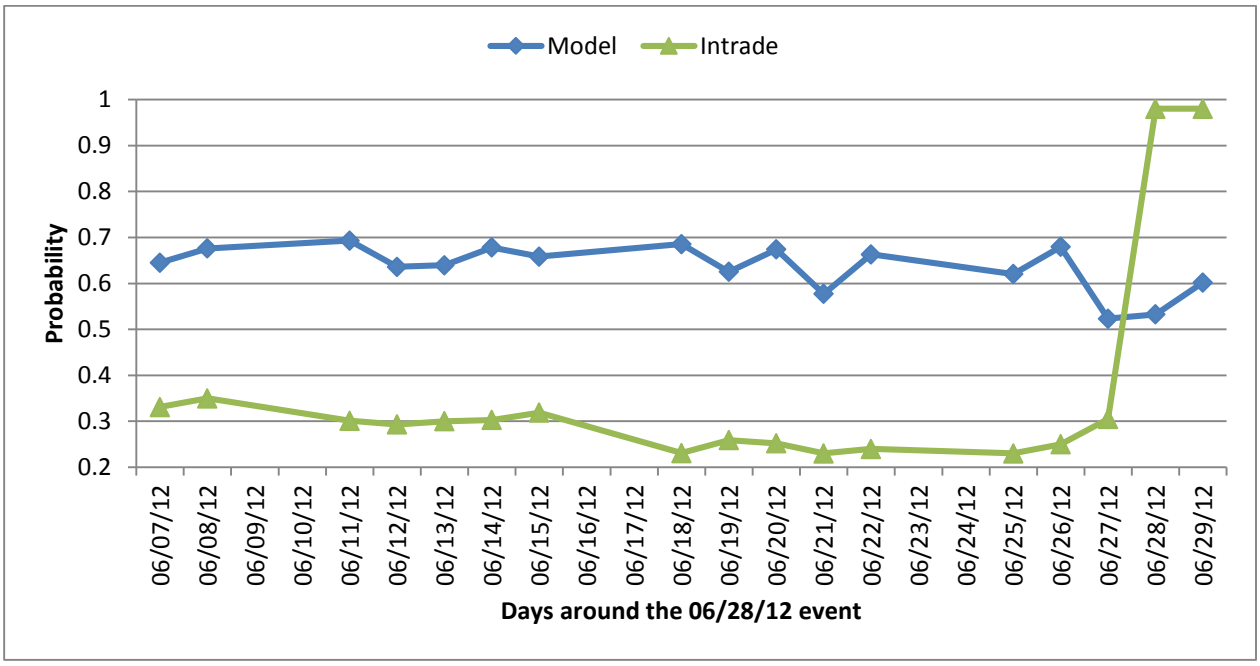


Figure 6

The model-generated state prices for Obamacare passage and rejection states and the actual average stock prices

The model generates an Obamacare passage state price and a Obamacare rejection state price for the stocks of each of the six hospital firms and six insurance firms, for each trading day during the event period. The state prices, and the actual stock prices, are scaled by the passage state price at the start of the event period (March 1, 2010), so that the scaled prices can be viewed as cumulative returns over the U.S. House of Representatives Obamacare passage event period. The average of the prices for the six hospital firms and six insurance firms is plotted for three weeks of trading before the event, the event day (March 22, 2010), and the day following the event.

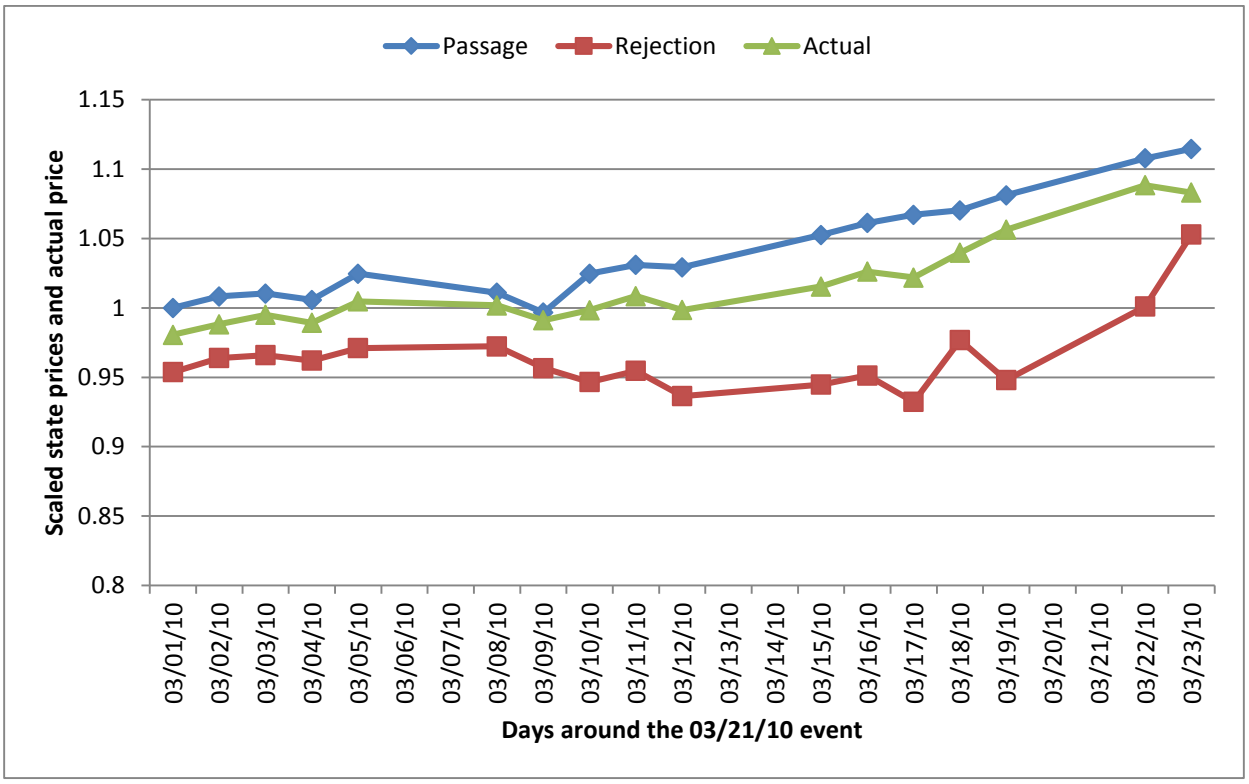


Figure 7

The model-generated state prices for the Supreme Court ruling that Obamacare is constitutional or unconstitutional and the actual average stock prices

The model generates an Obamacare constitutional state price and an Obamacare unconstitutional state price for the stocks of each of the six hospital firms and six insurance firms, for each trading day during the event period. The state prices, and the actual stock prices, are scaled by the constitutional state price at the start of the event period (June 7, 2012), so that the scaled prices can be viewed as cumulative returns over the Supreme Court Obamacare constitutionality event period. The average of the prices for the six hospital firms and six insurance firms is plotted for three weeks of trading before the event, the event day (June 28, 2012), and the day following the event.

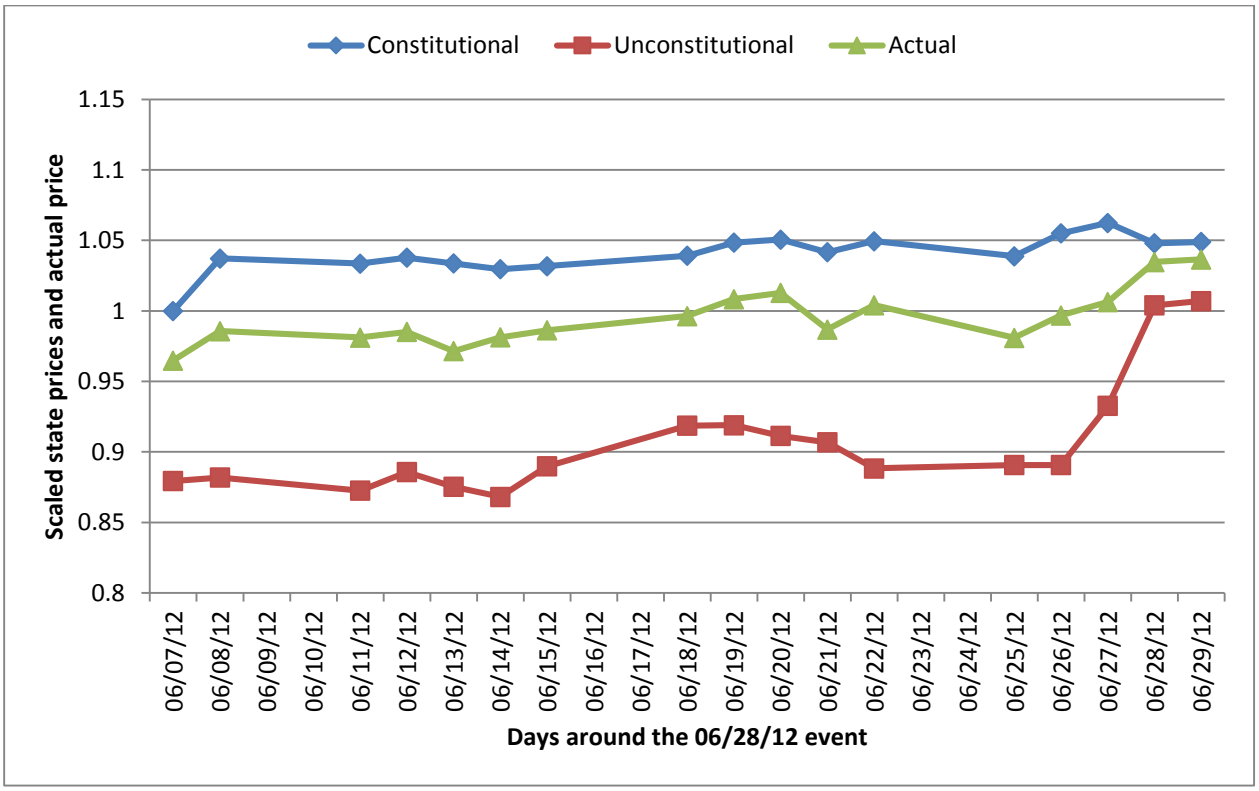
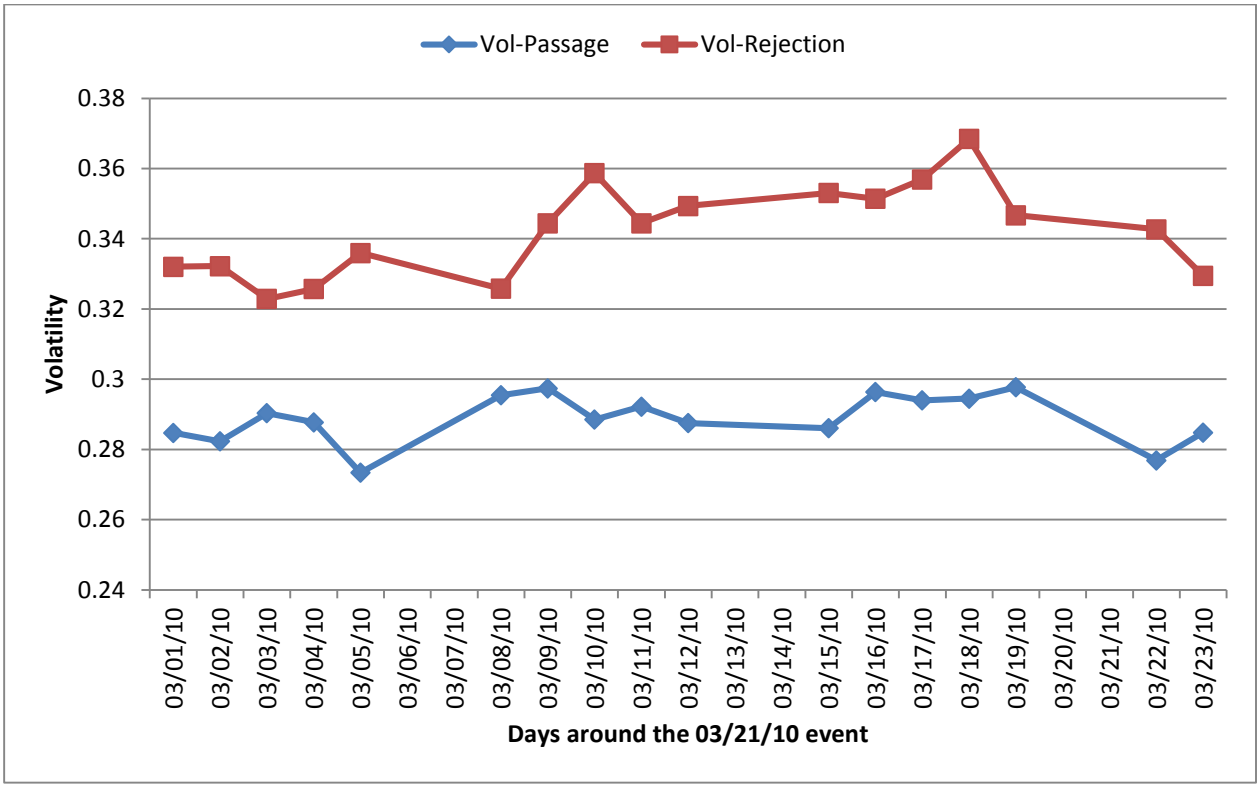


Figure 8

Average model-generated state price volatilities

The model generates volatilities for the two state prices for the Obamacare -related events, for each of the six hospital firms and six insurance firms, for each trading day during the respective event periods. The average volatilities for the twelve firms are plotted for the U.S. House of Representatives Obamacare passage event in Panel A and for the Supreme Court Obamacare constitutionality event in Pane B, for three weeks of trading before the event, the event day, and the day following the event.

Panel A. U.S. House of Representatives Obamacare passage event



Panel B. Supreme Court Obamacare constitutionality ruling event