Identifying the Heterogeneous Impact of Highly Anticipated Events: Evidence from the Tax Cuts and Jobs Act

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Overview

Motivation/Background

- The market's reaction to events can be misleading, especially with high anticipation
  - Huberman and Schwert (1985), Bhattacharya et al. (2000)
- We use simulation to quantify anticipation bias
- We propose a new method to pool data across firms to capture the counterfactual outcome
- The difference is the true event impact

Motivation/Background

Three main approaches to dealing with anticipation

- Firm characteristics (Malatesta and Thompson, 1985; Brennan, 1990)
- Firm-level counterfactual estimation models using stock and options data
  - Subramanian (2004)
  - Barraclough, Robinson, Smith, Whaley (2013)
  - Borochin (2014)
  - Borochin, Golec (2016)

Motivation/Background

- Predictive markets
  - Snowberg et al. (2007)
  - Wolfers and Zitzewitz (2009)
  - Snowberg et al. (2011)
- Characteristics need customization, firm-level estimations require identifying assumptions, betting markets are illiquid
- We can recover *heterogeneous* impacts of market-wide events
  - No need to specify an ex-ante ordering of event payoffs
- Eg, TCJA effect on a particular firm depends on its R&D, overseas operations, deferred tax assets

Main Findings

- Anticipation of an event can break traditional econometric inference in simulations
  - at 80% anticipation, correlation between firm price reaction and true event impact is only 0.44
  - for 96% anticipation (eg. Tax Cuts and Jobs Act) the correlation drops to 0.20
  - the estimated aggregate impact across all firms is near zero at 96% anticipation, despite a meaningful true effect
- We derive a new method to let the data tell us which firm has positive/negative impact from a heterogeneous event, robust to high anticipation
- Applying this method to the TCJA yields an impact estimate of 12.36%, strongest for growth firms with high patent counts

Contribution

- No satisfactory way to address highly-anticipated economy-wide effects with both winners and losers
- These are usually very important events, and simulation shows that naive analyses are very misleading
- We provide a way to address these events

Traditional Econometric Setup

The share price of a firm i exposed to an event is

$$P_{i,T+1} = \begin{cases} s_i x_i \epsilon_i & \text{if } \mathbb{I} = 1 \\ x_i \epsilon_i, & \text{if } \mathbb{I} = 0 \end{cases}$$

Therefore, the stock price of firm i at time T is calculated as:

$$\begin{aligned} P_{i,T} &= \mathbb{E}_T[\mathbb{I}(s_i x_i \epsilon_i) + (1 - \mathbb{I})(x_i \epsilon_i) | s_i, x_i] \\ &= q s_i x_i \mathbb{E}[\epsilon_i] + (1 - q) x_i \mathbb{E}[\epsilon_i] \\ &= (q s_i + (1 - q)) x_i \end{aligned}$$

How do we estimate the impact of the event s_i?

Traditional Econometric Setup

Given $\mathbb{I} = 1$, this is calculated as:

$$\frac{P_{i,T+1} - P_{i,T}}{P_{i,T}} = \frac{s_i x_i \epsilon_i - (q s_i + (1-q)) x_i}{(q s_i + (1-q)) x_i} = \frac{s_i \epsilon_i - (q s_i + (1-q))}{(q s_i + (1-q))}$$

If the event was completely unanticipated, plugging in $q = 0$ yields:

$$\frac{P_{i,T+1} - P_{i,T}}{P_{i,T}} = s_i \epsilon_i - 1$$

However, the traditional approach falters whenn $q > 0$, capturing only the unanticipated impact. But is it at least positively correlated?

Traditional Econometric Setup

To estimate the net aggregate impact of the event $\mu_s - 1$, the traditional event study methodology would suggest taking the average of the individual estimates:

$$\frac{1}{N}\sum_{i=1}^{N}\frac{P_{i,T+1}-P_{i,T}}{P_{i,T}} \quad = \quad \frac{1}{N}\sum_{i=1}^{N}\frac{s_i\epsilon_i-(qs_i+(1-q))}{(qs_i+(1-q))}$$

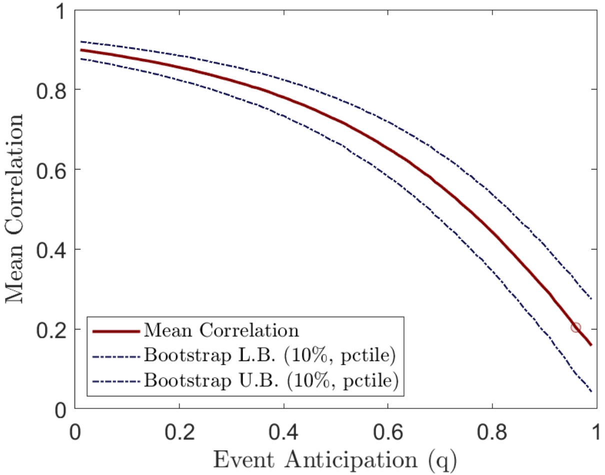
If $q=0$, this would be a reasonable estimator:

$$\mathbb{E}\left[\frac{1}{N}\sum_{i=1}^{N}\frac{P_{i,T+1}-P_{i,T}}{P_{i,T}}\right] \quad = \quad \frac{1}{N}\sum_{i=1}^{N}(\mathbb{E}[s_i]-1)=\mu_s-1$$

However, for positive values of q, this estimator would only capture the unanticipated fraction of the aggregate impact of the event. Given that q is not clear, a low estimate may be due to a low true impact (low μ_s) or high anticipation (high q).

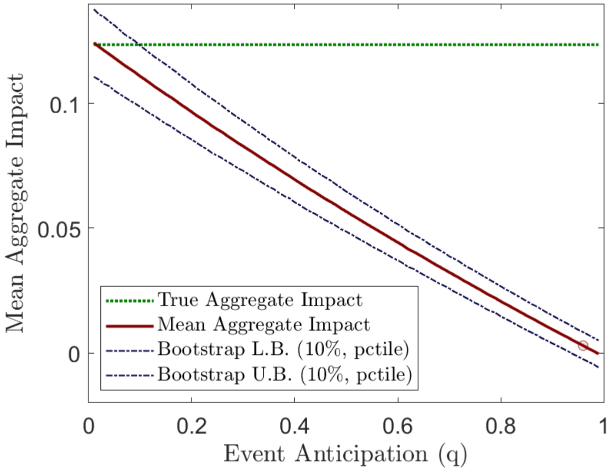
Simulation of Performance of Estimator of Firm Impact

The Correlation Between $(P_{i,T+1} - P_{i,T})/P_{i,T}$ and $s_i - 1$



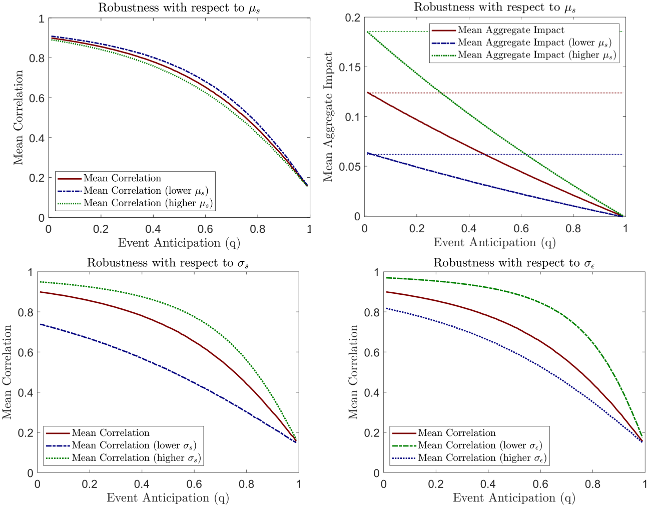
Simulation of Performance of Estimator of Aggregate Impact

The True and Estimated Net Aggregate Impact $\mu_s - 1$



Robustness of Simulation

Do magnitudes of true impact and noise matter?



Application to TCJA

- The 2017 Tax Cuts and Jobs Act (TCJA) was a highly anticipated event
- Moreover, the TCJA had winners and losers
- Our simulation results show that the traditional approach can fail to properly estimate firm impacts of such an event, even after it occurs
- Empirical analysis presents a roadmap for other applications of our general methodology

Estimating the Counterfactual

For a firm i given the stock price $S_{i,t}$ and N call options with unique strikes K_j and a common τ that ends after the event, the prices of the $N+1$ assets are:

$$
\begin{aligned}
S_{i,t} =& E_t(q) \cdot E_t(S_{i,u}) + (1 - E_t(q)) \cdot E_t(S_{i,d}) \\
c_{i,1,t} =& E_t(q) \cdot C(E_t(S_{i,u}), E_t(\sigma_{i,u}), K_1, \tau) + (1 - E_t(q)) \cdot C(E_t(S_{i,d}), E_t(\sigma_{i,d}), K_1, \tau) \\
& \dots \\
c_{i,N,t} =& E_t(q) \cdot C(E_t(S_{i,u}), E_t(\sigma_{i,u}), K_N, \tau) + (1 - E_t(q)) \cdot C(E_t(S_{i,d}), E_t(\sigma_{i,d}), K_N, \tau)
\end{aligned}
$$

Why not puts?

Identification

- Five parameters: q_i the probability of TCJA passage, $S_{i,u}$ and $\sigma_{i,u}$ the value and volatility of firm i if TCJA passes, $S_{i,d}$ and $\sigma_{i,d}$ if not
- Label switching is a problem, prior settings (eg M&A, Obamacare) allow for identifying assumption such as $S_{i,u} > S_{i,d}$ that does not apply here
- Our innovation is to consider both possibilities simultaneously, and pick the more applicable one

$$V_{i,t,winner}(q,\theta) = \min_{\theta} |P_{i,t} - \hat{P}_{i,t}(q,\theta)| \;\; s.t.\; S_{i,u} \geq S_{i,d}$$

$$V_{i,t,loser}(q,\theta) = \min_{\theta} |P_{i,t} - \hat{P}_{i,t}(q,\theta)| \;\; s.t.\; S_{i,u} < S_{i,d}$$

Identification

- We classify the firm as a "winner" if the $S_{i,u} \geq S_{i,d}$ restriction results in a better fit more than half of the time over the 30-day period from November 10 to December 2, 2017
- It is a "loser" otherwise. In other words, we let the data tell us which identifying restriction is more appropriate for each firm.
- Once this has been established, we repeat the optimization with the appropriate restriction in place:

$$V_{i,t}(q,\theta) = \begin{cases} \min_\theta |P_{i,t} - \hat{P}_{i,t}(q,\theta)| \;\; s.t.\; S_{i,u} \geq S_{i,d} & \text{if firm } i \text{ is a ``winner''} \\ \min_\theta |P_{i,t} - \hat{P}_{i,t}(q,\theta)| \;\; s.t.\; S_{i,u} < S_{i,d} & \text{otherwise} \end{cases}$$

Identification

- Getting q right is key, so we develop a specialized version of the estimator for a common q across all M firms

$$W_{i,t}(q,\theta_i) = \begin{cases} |1 - \hat{P}_{i,t}(q,\theta_i)/P_{i,t}| \;\; s.t.\; S_{i,u} \geq S_{i,d} & \text{if firm } i \text{ is a ``winner''} \\ |1 - \hat{P}_{i,t}(q,\theta_i)/P_{i,t}| \;\; s.t.\; S_{i,u} < S_{i,d} & \text{otherwise} \end{cases}$$

$$\left(q_t, \{\theta_{i,t}\}_{i=1}^{M}\right) = \underset{q,\{\theta_i\}_{i=1}^{M}}{\arg\min} \left\{ \sum_{i=1}^{M} W_{i,t}(q,\theta_i) \right\}$$

- Benefit is clear, we get $M \times N$ call option restrictions (600 in our application) on q_t
- Cost is daunting, $4M + 1$ parameters must be jointly estimated

Identification

- However, note that the firm-specific parameters $\{\theta_{i,t}\}_{i=1}^{M}$ depends on the results from other firms only through the common event probability q
- Thus, we first divide the range $q \in [0, 1]$ into a discrete grid Q
- Then, for each firm i, on each date t, and for every $q \in Q$, we estimate $\theta_{q,i,t}$ which minimizes $W_{i,t}(q, \theta_i)$ given q
- The common probability on day t can be calculated as:

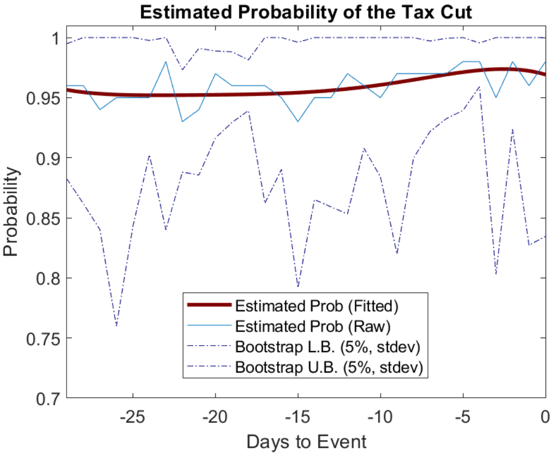
$$q_t = \arg\min_{q} \left\{ \sum_{i=1}^{M} W_{i,t}(q, \theta_{q,i,t}) \right\}$$

Data

- OptionMetrics and Compustat data over debate window, November 10 to December 2, 2017
- Top 100 firms by option volume, cumulatively between 29% and 50% of daily call volume in 2017Q4, 22% of Compustat market cap
- Adding more firms increases reliance on zero-volume contracts, ie uninformative and stale prices
- We also add innovation measures and tax assets and liabilities

Probability of TCJA Passage

Confidence interval from bootstrap standard deviation, 1000 simulations each day of 100 firms drawn with replacement



Comparison of Estimates

$S_u/S_d - 1$	RET	CAR[-3,0]	CAR[-5,0]	CAR[-7,0]	CAR[-10,0]
12.36%	0.68%	0.96%	0.89%	1.09%	2.29%

$S_u/S_d - 1$	RET	CAR[-3,0]	CAR[-5,0]	CAR[-7,0]	CAR[-10,0]
1.000	0.135	0.183	0.133	0.197	0.233

What Makes Winners and Losers?

We split the sample using the S_u/S_d ratio, and check whether characteristics are significantly different across the two groups

Firm Attributes	Differences	t-statistics
R&D Intensity	0.021***	(4.05)
Patent Count	0.498***	(5.37)
Total Citations	0.489***	(4.86)
Total Originality	0.345***	(4.53)
Total Generality	0.201***	(4.09)
Average Citations	-0.014	(-0.86)
Average Originality	-0.018***	(-3.41)
Average Generality	-0.009**	(-2.16)
Tangibility	-0.029***	(-2.98)
Sales Growth	0.040***	(6.44)
Asset Growth	0.022***	(3.39)
Employment Growth	0.011**	(2.51)
Cash Effective Tax Rate	-1.616***	(-3.59)
Indefinitely Reinvested Foreign Earnings/Assets	-0.048***	(-5.14)
Net Tax Assets/Assets	-0.023***	(-4.50)
Cash/Asset	-0.006*	(-1.76)
Market to Book Ratio	-0.088	(-1.64)
Size (log(assets))	0.232***	(3.56)
Leverage	-0.012*	(-1.95)
Asset Maturity	-0.727***	(-4.13)
Property Plant and Equipment/Assets	-0.029***	(-2.98)
Profitability	-0.014***	(-3.95)
Return on Assets (ROA)	-0.015***	(-4.97)
Return on Equity (ROE)	-0.057***	(-3.48)
Whited-Wu Index	-0.011***	(-3.01)
Advertising Expenses	-0.007***	(-5.54)

Economic Significance

We split the sample into two using the median of firm characteristics, and test the S_u/S_d ratio difference

S_u/S_d ratio	Differences	t-statistics
R&D Intensity	0.026***	(3.74)
Patent Count	0.036***	(6.52)
Total Citations	0.036***	(6.52)
Total Originality	0.027***	(4.83)
Total Generality	0.020***	(3.55)
Average Citations	0.005	(0.86)
Average Originality	-0.034***	(-6.09)
Average Generality	-0.017***	(-3.00)
Tangibility	-0.006	(-1.07)
Sales Growth	0.020***	(3.67)
Asset Growth	0.012**	(2.19)
Employment Growth	0.002	(0.37)
Cash Effective Tax Rate	-0.021***	(-3.71)
Indefinitely Reinvested Foreign Earnings/Assets	-0.021***	(-3.42)
Net Tax Assets/Assets	-0.006	(-1.11)
Cash/Asset	-0.022***	(-4.03)
Market to Book Ratio	-0.011*	(-1.94)
Size (log(assets))	0.019***	(3.46)
Leverage	-0.004	(-0.79)
Asset Maturity	-0.004	(-0.66)
Property Plant and Equipment/Assets	-0.006	(-1.07)
Profitability	-0.008	(-1.37)
Return on Assets (ROA)	-0.031***	(-5.58)
Return on Equity (ROE)	-0.017***	(-3.10)
Whited-Wu Index	-0.017***	(-3.10)
Advertising Expenses	-0.015**	(-2.24)

Conclusion

- We develop a method to estimate ex-ante event probabilities for highly anticipated events, which is also robust to firm-level heterogeneity in the impact of the event
  - TCJA passage more than 90% likely
  - Impact is estimated at 12.36% across a sample of the 100 large firms, compared to an average of 0.68% when ignoring anticipation
- We demonstrate the existence of a downward bias for the aggregate impact of an event across multiple firms from anticipation

Conclusion

- TCJA application shows that large firms with high patent counts and growth prospects are the greatest relative winners
- Two innovation strategies: the production of a few high-quality patents versus a large number of mediocre patents
- TCJA appears to encourage the latter

Thank You!