City Hall Has Been Hacked!
The Financial Costs of Lax Cybersecurity

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*The views stated herein are those of the authors and are not necessarily the views of the Chicago Fed, the Richmond Fed, or the Federal Reserve System.
Motivation

- State and local governments are attractive targets for cyber attacks:
  - Store and manage substantial amounts of personal identifiable information (PII)
  - Inadequate cybersecurity

- States and localities operate the nation’s infrastructure
  - Cyberattacks such as data breaches more disruptive than attacks on corporates

- Data breaches have the potential to impose large welfare losses:
  - Remediation and litigation costs absorb public resources/taxpayer money
  - Negative externalities—leaked PII facilitates fraudulent activity
Cybersecurity at State and Local Governments

- Effect of data breaches on governments:
  - Negative abnormal bond returns in the secondary market
  - Increase in financing costs in the primary market

- The implementation of data breach notification laws at the state level:
  - Staggered implementation between 2002 and 2021 (penalties in some cases)
  - No effect on the incidence of future data breaches (despite higher spending)
  - Incentives to bolster cybersecurity may still be insufficient
Data

- Data on operational risk incidents (external and internal) from Advisen:
  - Over 1,000 attacked public entities, over 2,200 external data breaches since 2004
  - Bridge to other data via the Census of Governments

- Primary market issuance from Mergent:
  - Detailed information on bond characteristics, yields, and amounts.

- Secondary market data on municipal bond trading from the MSRB:
  - All transactions since 2010.

- Hand-collected data on state breach notification laws:
  - National conference of state legislatures (NCSL), LexisNexis
  - Enactment and effective dates, covered entities, penalties for violations (if any)
Data

- Risk of external data breaches across government size and type.

A. Government Size

B. Government Type
Data Breaches and Abnormal Bond Returns

- Examine the bond response to data breaches using an event study approach:

\[
rb,s,k = (Db,s \cdot yb,s - Db,k \cdot yb,k)
\]

\[
arb,s,k = rb,s,k - \sum_{t=k+1}^{s} R_t^l
\]

- \(y_{b,t} (D_{b,t})\) yield to maturity (duration) of bond \(b\) at time \(t\)

- \(rb,s,k\) duration-adjusted return on bond \(b\) btw two adjacent trades, \(s\) and \(k\)

- Index return, \(R_t^l\), \(l\) denotes remaining maturity–credit rating buckets
Data Breaches and Abnormal Bond Returns

- Negative abnormal returns around external data breaches of about 16-17 bps.

<table>
<thead>
<tr>
<th>Abnormal Bond Returns</th>
<th>Duration Adjustment</th>
<th>Risk/Maturity Adjustment</th>
<th>10-day Return</th>
<th>Bond Return</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>-16.112***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No</td>
<td>No</td>
<td>-17.744***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5.301***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2.433)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.295)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.516)</td>
</tr>
<tr>
<td>Observations</td>
<td>36,179</td>
<td>35,679</td>
<td>35,677</td>
<td></td>
</tr>
<tr>
<td>Number of Events</td>
<td>2,582</td>
<td>2,573</td>
<td>2,573</td>
<td></td>
</tr>
</tbody>
</table>
Data Breaches and Abnormal Bond Returns

- Returns similar across different types of bonds.

<table>
<thead>
<tr>
<th>Bond Return</th>
<th>Collateral</th>
<th>Double</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rev</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GO</td>
<td>-17.808***</td>
<td>-17.518***</td>
<td>-15.154***</td>
</tr>
<tr>
<td>Double</td>
<td>-18.233***</td>
<td>-15.154***</td>
<td>-18.891***</td>
</tr>
<tr>
<td>Senior</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subordinated</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Observations | 14,844 | 18,960 | 522 | 10,947 | 24,732 |
| Number of Events | 1,674 | 810 | 117 | 1,533 | 2,221 |
Data Breaches and Issuance Costs

- Primary markets provide unique insights into consequences for taxpayers.

- Use yields of muni bond offerings as a measure of issuance costs

\[ Y_{i,t} = \sum_{j=-2}^{j \geq +3} \beta_j Breach_{i,t+j} + \delta X + \mu + \epsilon_{i,t} \]

- \( Y_{i,t} = \{ \text{bond issuance, yields, offering type} \} \)

- \( Breach_{i,t+j} = 1 \) if government \( i \) suffers an external data breach in year \( t + j \)

- government type-year, state-year, entity FEs & size controls
## External Data Breaches and Primary Bond Markets

<table>
<thead>
<tr>
<th>Breach Year</th>
<th>Outcome variable:</th>
<th>(1) Log(Issuance)</th>
<th>(2) Offering Yield</th>
<th>(3) Negotiated</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td></td>
<td>0.010 (0.038)</td>
<td>-0.005 (0.036)</td>
<td>0.057 (0.041)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.064 (0.043)</td>
<td></td>
<td>0.010 (0.017)</td>
</tr>
<tr>
<td>-1</td>
<td></td>
<td>0.019 (0.032)</td>
<td>0.000 (0.034)</td>
<td>0.034 (0.036)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.029 (0.039)</td>
<td></td>
<td>0.006 (0.025)</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>-0.030 (0.044)</td>
<td>-0.043 (0.045)</td>
<td>0.107** (0.040)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.113*** (0.039)</td>
<td></td>
<td>0.039* (0.023)</td>
</tr>
<tr>
<td>+1</td>
<td></td>
<td>0.027 (0.028)</td>
<td>0.047* (0.026)</td>
<td>0.102** (0.045)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.116** (0.044)</td>
<td></td>
<td>0.034 (0.027)</td>
</tr>
<tr>
<td>+2</td>
<td></td>
<td>-0.019 (0.034)</td>
<td>-0.028 (0.037)</td>
<td>0.056 (0.047)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.046 (0.051)</td>
<td></td>
<td>0.056** (0.026)</td>
</tr>
<tr>
<td>≥ +3</td>
<td></td>
<td>0.000 (0.028)</td>
<td>0.010 (0.027)</td>
<td>0.129*** (0.046)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.104** (0.047)</td>
<td></td>
<td>0.048 (0.035)</td>
</tr>
</tbody>
</table>

| R²         | 0.721             | 0.719             |
| N          | 48,206            | 42,777            |

| Government FE  | Yes  | Yes  | Yes  | Yes  | Yes  | Yes  |
| MatMonths×Year FE | Yes  | Yes  | Yes  | Yes  | Yes  | Yes  |
| Type×Year FE   | No    | Yes  | No    | Yes  | No    | Yes  |
| Type×Size      | No    | Yes  | No    | Yes  | No    | Yes  |

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Data Breach Notification Laws

- Most states now have data breach notification laws
- Public entities required to notify residents of data breaches
Data Breach Notification Laws

- Role for regulation?
  - Higher financing costs detract resources from the community
  - Loss of personal data increases chance of fraud
  - Regulation may incentivize investment in cybersecurity by penalizing breaches

\[
Y_{i,s,t} = \sum_{j=-2}^{4+} \beta_j \text{Law}_{s,t+j} + \mu + \epsilon_{i,s,t}
\]

- \( \text{Law}_{s,t+j} \) equals one if entity \( i \) in state \( s \) is covered by law is enacted \( j \) years ago
- treatment whenever law allows for monetary penalties and apply to local govt
Effect of Data Breach Notification Laws

A. Total Expenditures (Local)

B. Total Expenditures (Any)

- Temporary increase in expenditures in the enactment year
Effect of Data Breach Notification Laws

C. Prob. of Cyberattack (Local)

D. Prob. of Cyberattack (Any)

- No improvement in cybersecurity
- No significant reduction in the likelihood of future data breaches
Effectiveness of Breach Notification

- Data breach notification laws not associated with better cybersecurity

- Tradeoff between ex-ante cost to improve cybersecurity + ex-post remediation costs

- Alternative incentive schemes:
  - Safe harbor against data breach lawsuits if comply with industry-recognized cybersecurity programs
  - Possibly providing incentives to invest ex-ante
Conclusion

- Significant costs of neglecting cybersecurity
  - Data breaches expose municipalities to additional financing costs and expenditures
  - This is in addition to the loss of privacy and fraud

- Data breach laws appear ineffective at reducing cyber risk:
  - They do not reduce the likelihood of future external data breaches