

# Do Banks Price Firms' Data Breaches?

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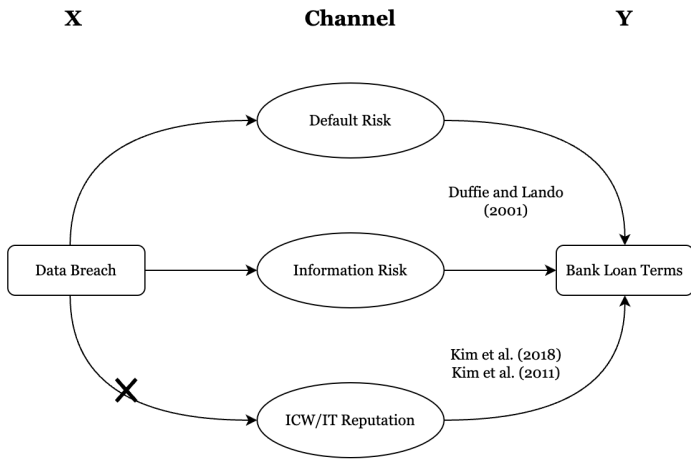
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# The story



# Sample development

Step	Authors'	Mine
# data breaches from 2005 (2010) to 2014 (2020)	551	587
Less:		
# firms with a prior breach event	(16)	(9)
# events that are not the most significant	(70)	(195)
# event firms lacking the data for (PSM)	(252)	(155)
# event firms after PSM	213	228
event firms + control firms	426	456
Bank loan observations from 2003 (2008) to 2016 (2022)	1,428	2,165
Less:		
financial services industries	(254)	(166)
bridge loans and non-fund-based facilities	(55)	(NA)
insufficient to calculate control variables	(37)	(26)
Final sample involving 139 (149) data breach event firms	1,081	1,973

# Probit Regression

$$\begin{aligned}\Phi^{-1}(\text{Data Breach Event}_t) = & \alpha_0 + \alpha_1 \text{Firm Size}_{t-1} + \alpha_2 \text{Leverage}_{t-1} + \alpha_3 \text{ROA}_{t-1} \\ & + \alpha_4 \text{Operational Risk}_{t-1} + \alpha_5 \text{Tangibility}_{t-1} \\ & + \alpha_6 \text{Z-score}_{t-1} + \alpha_7 \text{MB}_{t-1} + \alpha_8 \text{IT Expertise}_{t-1} \\ & + \alpha_9 \text{IT Reputation}_{t-1} + \alpha_{10} \text{Number of Segments}_{t-1} \\ & + \alpha_{11} \text{ICW}_{t-1} + \alpha \text{Industry} + \alpha \text{Year} + \varepsilon\end{aligned}$$

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```
reg_formula <- breach ~ firm_size + leverage + roa +
  operational_risk + tangibility + z_score + mb +
  it_expertise + fyear + industry
```

```
ps_model <- glm(reg_formula, data = psm_panel,
  family = binomial(link = "probit"))
```

# Probit Regression (Cont.)

	Authors'	Mine
Firm Size <sub>t-1</sub>	0.154***	0.182***
Leverage <sub>t-1</sub>	-0.016	0.199*
ROA <sub>t-1</sub>	0.089***	-0.164
Operational Risk <sub>t-1</sub>	0.358*	0.761
Tangibility <sub>t-1</sub>	-0.005	-0.331*
Z-score <sub>t-1</sub>	-0.086	0.002
MB <sub>t-1</sub>	-0.000**	0.010
IT Expertise <sub>t-1</sub>	0.233***	-0.024
IT Reputation <sub>t-1</sub>	0.222**	NA
Number of Segments <sub>t-1</sub>	-0.009	NA
ICW <sub>t-1</sub>	-0.134	NA
Intercept	-7.881***	-11.895
Industry/Year	Included	Included
Number of Observations	57,462	33,157
Pseudo R <sup>2</sup>	0.166	0.243

# Difference in Variables for firms Matched by PSM

Variable	Treated	Control	Diff.	p
Firm Size	8.308 (8.846)	8.190 (8.752)	0.118 (0.094)	0.591 (0.545)
Leverage	0.459 (0.653)	0.485 (0.679)	-0.026 (-0.026)	0.768 (0.397)
ROA	0.122 (0.134)	0.124 (0.130)	-0.002 (0.003)	0.859 (0.693)
Operational Risk	0.059 (0.039)	0.077 (0.036)	-0.018 (0.002)	0.137 (0.472)
Tangibility	0.431 (0.237)	0.449 (0.241)	-0.018 (-0.003)	0.643 (0.881)
Z-score	3.245 (4.965)	2.129 (4.770)	1.116 (0.196)	0.408 (0.809)
MB	2.330 (1.619)	2.455 (1.552)	-0.125 (0.067)	0.859 (0.683)
IT Expertise	0.364 (0.123)	0.341 (0.105)	0.023 (0.018)	0.616 (0.567)
IT Reputation	0.092	0.083	0.009	0.735
Number of Segments	2.055	1.853	0.203	0.252
ICW	0.028	0.009	0.018	0.154

# Descriptive statistics

Variable	Authors' Mean	My Mean
<i>Bank Loan Characteristics</i>		
Loan Spread	210.500	173.673
Loan Amount	0.954	1.781
Maturity	55.310	47.196
Performance Pricing	0.423	0.298
Secured	0.485	0.276
Total Covenants	3.096	5.104
<i>Data Breach Variables</i>		
Breach	0.543	0.568
Post	0.475	0.375
<i>Firm-Level Variables</i>		
Firm Size	8.779	9.422
Leverage	0.503	0.650
ROA	0.144	0.136
Operational Risk	0.043	0.032
Tangibility	0.568	0.285
Z-Score	2.883	3.966
MB	2.372	1.329
IT Expertise	0.391	0.114

## DiD

$$\begin{aligned} \text{Loan Contract Terms} = & \beta_0 + \beta_1 \text{Data Breach} \times \text{Year}_{-1} + \beta_1 \text{Data Breach} \times \text{Year}_0 \\ & + \beta_1 \text{Data Breach} \times \text{Year}_1 + \beta_1 \text{Data Breach} \times \text{Year}_2 \\ & + \beta \text{Controls} + \varepsilon \end{aligned}$$

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```
rhs_formula <- ~ breach:year_pre_1 + breach:year_0 +
  breach:year_post_1 + breach:year_post_2 + log(
    loan_amount + 1) + log(loan_maturity + 1) +
    performance_pricing + firm_size + leverage + roa
    + operational_risk + tangibility + z_score + mb +
    it_expertise

model_loan_spread <- plm(update.formula(rhs_formula,
  log(loan_spread) ~ .), data = did_panel, index =
  c("Ticker", "loan_year"), model = "within",
  effect = "twoways")
```



# Authors' DiD Result

<b>Dependent Variable</b>	<b>(1)</b> <i>Ln(Loan Spread)</i>	<b>(2)</b> <i>Secured</i>	<b>(3)</b> <i>Number of Total Covenants</i>
<i>Data Breach * Year -1</i>	-0.014 (-0.17)	-0.008 (-0.18)	-0.332 (-0.96)
<i>Data Breach * Year 0</i>	0.052 (0.66)	0.067 (1.41)	-0.074 (-0.21)
<i>Data Breach * Year 1</i>	0.221** (2.41)	0.114** (2.26)	0.783* (1.84)
<i>Data Breach * Year 2+</i>	0.037 (0.49)	0.097** (2.14)	0.830** (2.13)
<i>Ln(Loan Size)</i>	-0.369*** (-6.82)	-0.129*** (-3.95)	0.196 (0.82)
<i>Ln(Loan Maturity)</i>	0.197*** (4.56)	0.114*** (4.79)	-0.145 (-0.91)
<i>Performance Pricing</i>	-0.193*** (-5.25)	-0.029 (-1.19)	2.135*** (9.44)
<i>Firm Size</i>	-0.089 (-0.82)	-0.024 (-0.43)	-1.096* (-1.94)
<i>Leverage</i>	0.360* (1.93)	-0.237* (-1.85)	-2.853** (-2.46)
<i>ROA</i>	-3.625*** (-3.93)	-0.848 (-1.57)	-10.396** (-2.51)
<i>Operational Risk</i>	0.593	-0.070	6.207

# Authors' DiD Result (Cont.)

	(0.56)	(-0.12)	(1.53)
<i>Tangibility</i>	-0.322*	0.089	-1.232
	(-1.66)	(0.69)	(-1.13)
<i>Z-score</i>	0.064	-0.038	-0.186
	(1.00)	(-1.30)	(-0.71)
<i>MB</i>	0.002	0.008	-0.029
	(0.20)	(1.51)	(-0.44)
<i>IT Expertise</i>	-0.044	-0.078*	0.065
	(-0.70)	(-1.85)	(0.20)
<i>IT Reputation</i>	0.089	-0.060	0.309
	(1.00)	(-1.10)	(0.86)
<i>Number of Segments</i>	-0.064***	-0.005	0.185*
	(-2.84)	(-0.33)	(1.68)
<i>ICW</i>	-0.162	0.045	0.608
	(-0.92)	(0.49)	(0.72)
<i>Credit Spread</i>	0.375***	0.130*	1.774***
	(3.49)	(1.87)	(3.60)
<i>Term Spread</i>	0.119**	0.092**	0.950***
	(2.08)	(2.51)	(3.33)
<i>Intercept</i>	5.339***	0.812	10.657*
	(5.12)	(1.32)	(1.80)
<i>Firm/Year</i>	Included	Included	Included
<i>Number of Observations</i>	1,081	1,081	1,081
<i>R<sup>2</sup></i>	0.756	0.672	0.609

# Replication DiD Result

	Loan Spread	Total Covenants	Secured
Breach:Year -1	0.009 (0.063)	-0.163 (0.330)	-0.033 (0.041)
Breach:Year 0	-0.010 (0.064)	0.022 (0.318)	-0.028 (0.041)
Breach:Year 1	-0.031 (0.066)	-0.202 (0.415)	-0.025 (0.045)
Breach:Year 2+	-0.033 (0.045)	-0.177 (0.251)	0.008 (0.030)
Log(Loan Amount)	-0.018 (0.016)	-0.090 (0.103)	-0.018* (0.010)
Log(Loan Maturity)	-0.010 (0.022)	-0.031 (0.124)	0.066*** (0.014)
Performance Pricing	0.082*** (0.027)	0.172 (0.136)	0.043** (0.018)

## Replication DiD Result (Cont.)

	Loan Spread	Total Covenants	Secured
Firm Size	-0.200*** (0.037)	-0.365* (0.211)	-0.037 (0.024)
Leverage	0.844*** (0.128)	1.012 (0.922)	0.203** (0.085)
ROA	-1.075*** (0.248)	-1.156 (2.257)	0.021 (0.168)
Operational Risk	0.309 (0.638)	-3.580 (3.449)	0.170 (0.418)
Tangibility	0.309 (0.237)	2.320 (1.417)	-0.398*** (0.154)
Z-Score	0.029* (0.016)	-0.103 (0.102)	-0.012 (0.011)
MB	-0.079** (0.031)	0.094 (0.232)	-0.039* (0.021)
IT Expertise	-0.161*** (0.054)	0.120 (0.288)	0.009 (0.034)
Observations	1,608	850	1,889

# Possible reasons for no results

- Data breach sample
- Loan data
- Control variable
- Coding error
- Pattern not generalisable