Collateral versus Bank Lending Channel: Evidence from a massive earthquake

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INTRODUCTION

Credit constraint and distribution of wealth

- Under the asymmetric information between lenders and borrowers, lending capacity is constrained
- Holmström and Tirole (1997): the extent of these constraints are influenced by the financial status of intermediaries as well as of firms
- **Collateral channel**: changes in firms' collateral value affect their credit availability
- **Bank lending channel**: changes in banks' capital affect their capacity to extend loans

- A large number of studies that respectively examine the existence of these two channels

A number of important questions

- Comparison of the size of impact through these two channels
  - Which channel causes larger/longer impact?
- Identification of one channel after controlling for the other
  - Most of previous studies rely on the real estate value information at the regional level
  - Thus, not able to distinguish changes in the value of real estate held by firms from changes in the value of capital held by banks
- Examination of the impact on firm activities among firms with tighter credit constraint
- Evaluation of measures that possibly alleviate the negative impact

What we do

- Focus on the occurrence of a massive earthquake as a source of exogenous shocks to asset values owned by borrowers and lenders
  - Damage to firm assets → impact through collateral channel
  - Damage to bank assets → impact through bank lending channel
- Examine and compare the impact of the damage on credit availability through the two channels
- Examine the impact of more severe credit constraints on firm activities
  - Loan amount outstanding; activity level; capital investment
- Find ways that possibly alleviate such negative impact
  - Capital injection; insurance against earthquakes; subsidies for recovery investment; firm-bank relationships

Preview of results

- Both collateral and bank lending channel exist after the Tohoku Earthquake occurred in 2011
- The economic impact is comparable in size between these two channels, while the impact through the lending channel is more persistent than the collateral channel
  - 1 std. shock to a firm's tangible assets →6.5 percentage-point increase in probability of firms not raising sufficient amount funds
  - 1 std. shock to a bank's special losses →4.4 percentage-point increase
- More severe credit constraints for firms result in their lower activity levels
- Subsidies to firms for recovery investment alleviate the negative impact through the collateral channel

BACKGROUND

Previous literature on the collateral channel

- Gan (2007a)
  - Burst of the asset price bubble in Japan in the early 1990s that caused adverse shocks to the value of real estate held by firms
  - Firms that had larger amount of real estate in the bubble period reduced their loans and investment more substantially
- Chaney, Sraer, and Thesmar (2012)
  - Real estate booms before the financial crisis in the US
  - Firms that had larger amount of real estate issued larger amount of debt and implemented more sizable capital investment
- Cvijanović (2014), Lin (2014)
  - Focus on the same period of real estate booms as in CST
  - An increase in collateral values → larger leverage and bond issues, smaller funding cost, and simpler debt contract terms
- Adelino, Schoar, and Severino (2015)
  - Small businesses in areas with greater increases in house prices experienced stronger growth in employment
- Schmalz, Sraer, and Thesmar (2017)
  - Compare homeowners and renters in France and implement difference-in-differences
  - An increase in collateral values leads to a higher probability for homeowners to become entrepreneurs
- Wu, Gyourko, and Deng (2015)
  - Panel dataset on land prices and investment in 35 Chinese cities
  - No evidence for the collateral channel

Previous literature on the bank lending channel

Papers that focus on the real estate-related shocks to banks

- Gan (2007b)
  - Burst of the asset price bubble in Japan in the early 1990s that caused adverse shocks to the value of real estate
  - Banks that had larger exposure to real estate reduced lending
- Chakraborty, Goldstein, and MacKinlay (2017)
  - Focus on the period between 1988 and 2006 in the US
  - Banks that are active in strong housing markets increase mortgage lending and decrease commercial lending
- Cuñat, Cvijanović, and Yuan (2017)
  - Focus on the period of real estate price decline in the US
  - In response to real estate price declines, banks not only reduced real estate-related lending, but reduced other types of loans

Note that there are many papers that focus on other types of shocks to banks (e.g. monetary policies, liquidity shocks): Khwaja and Mian (2008), Schnabl (2012), and Hosono et al. (2016)

The Great East Japan (Tohoku) Earthquake

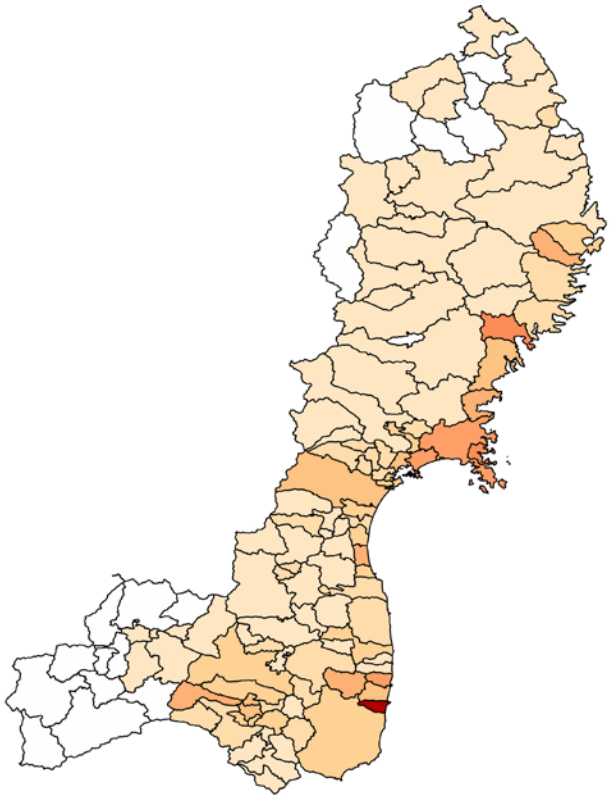
- Occurred in March 11, 2011 with the Magnitude 9.0, the fourth largest earthquake in the world since 1900
- Casualties and damage caused by the earthquake

Numbers of	
deaths	19575
people missing	2577
injured	6230
houses totally destroyed	121776
houses half destroyed	280326
houses partially destroyed	744269
damaged non-residential buildings	106587

Report on the Great East Japan Earthquake issued by the Fire Department on September 8, 2017.

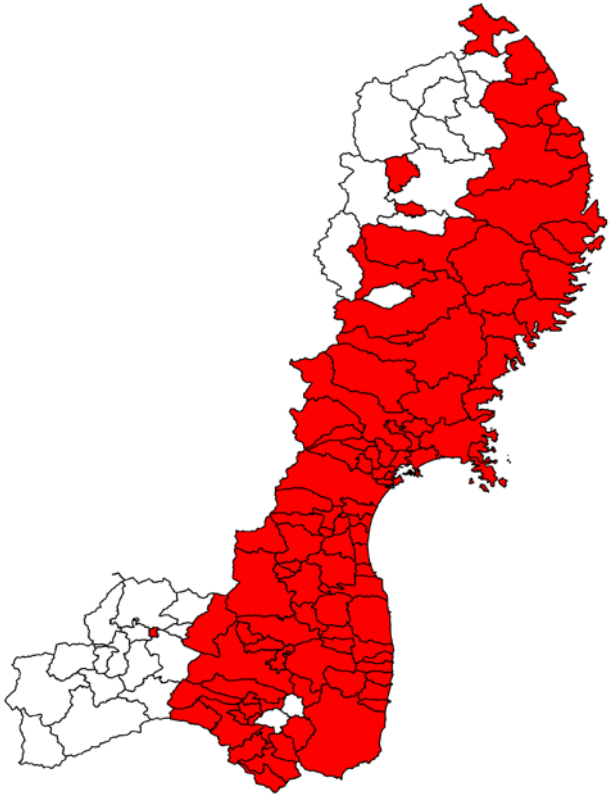
- Enormous amount of damage to real estate (land, houses, and buildings) held by firms and banks, which was caused by tremor (both inland and along the coast) and tsunami (along the coast)
- Other types of damage by the earthquake: nuclear power plant disaster and indirect damage through supply chains

The Great East Japan (Tohoku) Earthquake



Areas with severe damage to houses and buildings

Tsunami-affected areas



Disaster-affected areas designated by the government

Empirical challenge and our contribution

- To the authors' knowledge, no previous studies have simultaneously identified the collateral and bank lending channels using the micro-level data

- We do this for the first time by
  - Focusing on the Tohoku earthquake that incurred massive losses to assets held by borrower firms and lender banks
  - Using the data that identify the amount of asset damage for individual firms, banks, and bank branches
  - Limiting the sample to firms that had demand for new loans

- Further, we do the following two things
  - Examine how the damage affects firm activities: damage → credit constraints → firm activities
  - Find ways that possibly alleviate the negative impact

EMPIRICAL APPROACH

Data

We construct a panel dataset from the following three sources

- ***Surveys on firms after the Tohoku earthquake*** (by the Center for Recovery from the Earthquake at the Graduate School of Economics of Tohoku University)
- Implemented four times (July 2012, August-September 2013, August-September 2014, and October-November 2015)
- The first wave survey sent out questionnaires to 30000 firms out of 56101 firms headquartered in the three prefectures (Iwate, Miyagi and Fukushima) and Hachinohe-city of Aomori prefecture and recorded in the Tokyo Shoko Research (TSR) Database. 7021 firms responded.
- In later survey waves, 7481, 5713, and 4116 firms responded
- Questionnaires include: damage by the earthquake, demand for new loans, financial support, investment, relocation, transaction relationships, and employment

Data

- ***Firm characteristics information from the TSR Database***
  - Address, number of employees, the primary bank and branch a firm transacts with, and the industry that a firm belongs to

- ***Bank information from disclosure documents***
  - Bank-level balance sheet information on total assets, loans, deposits, capital, special losses, and capital injection by the government
  - Branch-level information on its operation after the earthquake: whether it has been closed at all, the number of closed days, whether it relocated in different places when resumed operations

Variables

In below are the major variables used for the analysis

- ***Credit constraint variables***

  Constrained1:

  1: a firm does not raise either sufficient or necessary amount of funds

  0: a firm raises sufficient amount of funds

  Constrained2:

  3: a firm neither obtains new loans nor raises necessary amount of funds,

  2: it obtains new loans but does not raise sufficient amount of funds,

  1: it obtains new loans and raises sufficient amount of funds

- ***Firm activity variables***

  Activity_Level: Level of a firm's activities in a year relative to the level in the year before the Tohoku Earthquake

  Investment: Amount of tangible investment in a year/amount of tangible assets outstanding at the end of the previous year

  Loan_Ratio: Amount of loans outstanding / amount of total assets outstanding at the end of year

Variables

- ***Firm damage variables***

  F_Damage_Tangibles: Amount of damage on a firm's non-land tangible assets / total amount of the firm's assets before the earthquake

  F_Damage_Land: Amount of damage on a firm's land assets / total amount of the firm's assets before the earthquake

- ***Bank damage variables***

  B_Special_Loss: Special loss for a firm's primary bank in the FY2010/ total asset amount of the bank at the end of the fiscal year. Primary bank for a firm is the one that extends the largest amount of loans to the firm.

  dB_CapRatio_Basel: Change in the risk-weighted asset capital ratio of a firm's primary bank from fiscal year 2009 to 2010

  dB_CapRatio: Change in the capital ratio of a firm's primary bank

  B_Branch_Reloc[_sum]: 1 if the bank branch that a firm used to transact with operated at different locations after the earthquake, and 0 otherwise. We also aggregate this information to construct a variable at the bank-level

  B_Branch_Closed[_sum]: 1 if the bank branch closed at least one day after the earthquake, and 0 otherwise. We also aggregate this information to construct a variable at the bank-level

Variables

- ***Variables on financial support and etc.***

  To banks

  Injection: 1 if the primary bank for a firm receives capital injection by the government after the earthquake, and 0 otherwise

  To firms

  Insurance: 1 if a firm had purchased insurance policies against earthquakes, and 0 otherwise

  Subsidy: 1 if a firm receives subsidies for recovery investment from the government, and 0 otherwise

  Variables on firm-bank relationships

  Num_bank: Number of banks a firm used to transact with

  Duration_bank: Number of transaction years with the primary bank

Empirical strategy

Determinants of firms' credit constraints

- Probit or ordered probit model using financial difficulty status as dependent variables
- In the probit model a latent variable Z^* is

$$Z_{it}^* = \varphi_1 F\_Damage_i + \varphi_2 B\_Damage_i + X_{it}'\delta + \epsilon_{it} \quad (1)$$

$Z_{it} = 1$ if $Z_{it}^* > 0$

- In the ordered probit model, a latent variable Z^* is

$$Z_{it}^* = \beta_1 F\_Damage_i + \beta_2 B\_Damage_i + X_{it}'\gamma + \varepsilon_{it} \quad (2)$$

$Z_{it} = j$ if $\alpha_{j-1} < Z_{it}^* \leq \alpha_j$,

where *j=1, 2, 3*.

- The cdf that gives the probability for the observation *it* choosing alternative *j* is the standard normal
- $\varphi_1$and β_1 represent the impact transmitted through the collateral channel, while $\varphi_2$and β_2 represent the impact through the bank lending channel
- The sample is limited to those that had demand for new loans

Empirical strategy

Determinants of firms' activities

- Treatment regression model using firm activities as dependent variables in the second stage

- The first stage is the same as (1) in the previous slide

- In the second stage, we have

$$Y_{it} = \mu_1 \hat{Z}_i + \mu_2 F\_Damage_i + X'_{it}\theta + \omega_{it} \quad (3)$$

- μ_1 represents impact of the predicted status of a firm's credit constraints. These predicted status is driven by damage to firms' collateral values as well as by damage to banks' capital

Some notes on the empirical strategy

- We limit the sample to firms that demand new loans in a year These firms include
  - Firms that obtained new loans
  - Firms that applied for new loans but rejected
  - Firms that had demand for new loans but did not apply since they expected rejection
- In addition to the damage we mainly focus on, we control for a variety of damage using the variables from the firm surveys
  - Indirect damage through supply chain networks
  - Damage caused by the nuclear power plant disaster
- We repeat cross-sectional estimations for each year (years 2012, 2013, 2014, and 2015) in order to examine the persistence of the impact caused by the damage
- In the second stage of the activity estimation, we include F_Damage_i, while excluding B_Damage_i from the explanatory variables. Damage to firms' tangible assets may affect their activities in multiple ways:
  - Tighter credit constraints due to collateral damage
  - Smaller capacity for production
  - Demand for recovery investment

SUMMARY STATISTICS

Variables on damage

	N	mean	sd	min	p25	p50	p75	max
F_Damage_Tangibles	1190	0.1541	0.3932	0	0	0.0188	0.1133	3.2787
F_Damage_Land	1190	0.0198	0.0841	0	0	0	0	0.6093
B_Special_Loss	1190	0.0037	0.0033	0.0000	0.0008	0.0027	0.0083	0.0090
dB_CapRatio_Basel	1176	-0.0054	0.0102	-0.0291	-0.0160	-0.0040	-0.0002	0.0671
B_Branch_Reloc	1190	0.1420	0.3492	0	0	0	0	1
B_Branch_Reloc_sum	1190	0.1021	0.1248	0	0.0690	0.0789	0.1197	0.6667
Cus_Damage	1190	0.4782	0.4997	0	0	0	1	1
Sup_Damage	1190	0.3782	0.4851	0	0	0	1	1
Damaged_Area	1190	0.8319	0.3741	0	1	1	1	1
Tsunami_Area	1190	0.2059	0.4045	0	0	0	0	1
Evacuation_Area	1190	0.0118	0.1079	0	0	0	0	1

- A majority of firms in the sample report damage to their non-land tangible assets, while only a limited number of them report damage to their land
- Banks report non-negligible amount of special losses, which reduced their capital ratios. These losses seem to be caused by the Tohoku earthquake (see the next slide)
- A substantial number of firms experienced relocation of bank branches that they used to transact with
- A number of firms were indirectly affected by the damage on their suppliers and customers
- About 20% of them were located in the tsunami-affected area, while only one percent of them were located near from the nuclear power plant

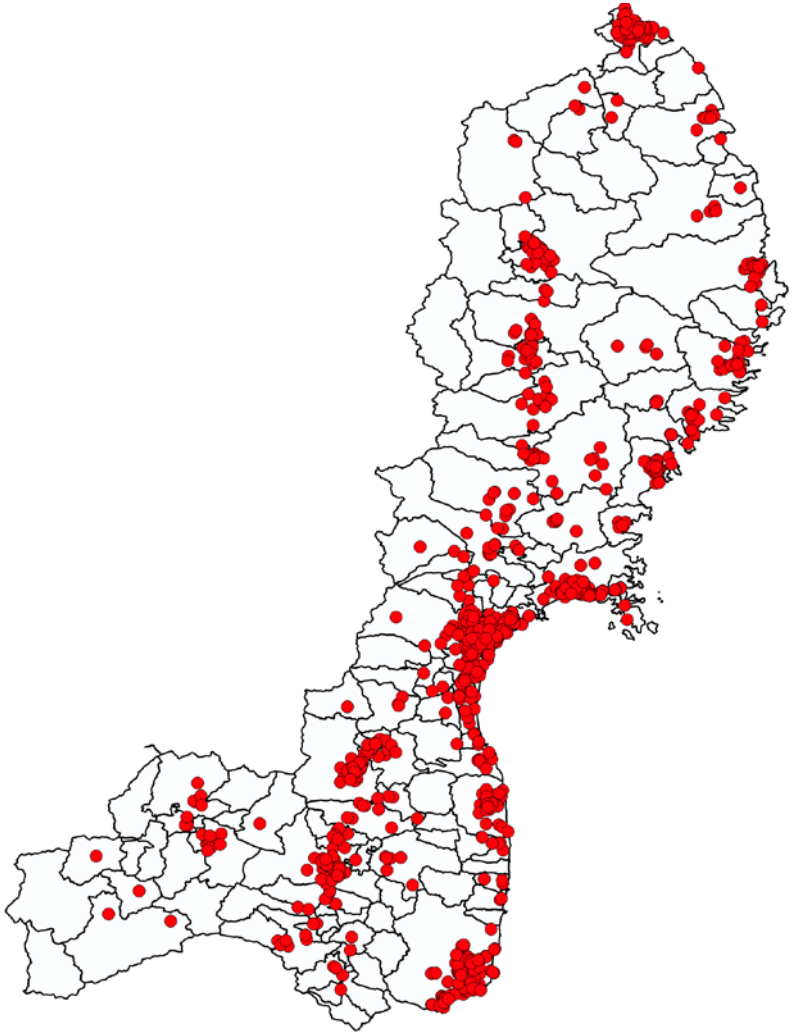
Damage to banks

Top 30 banks in terms of special losses in FY2010 (in our sample dataset)

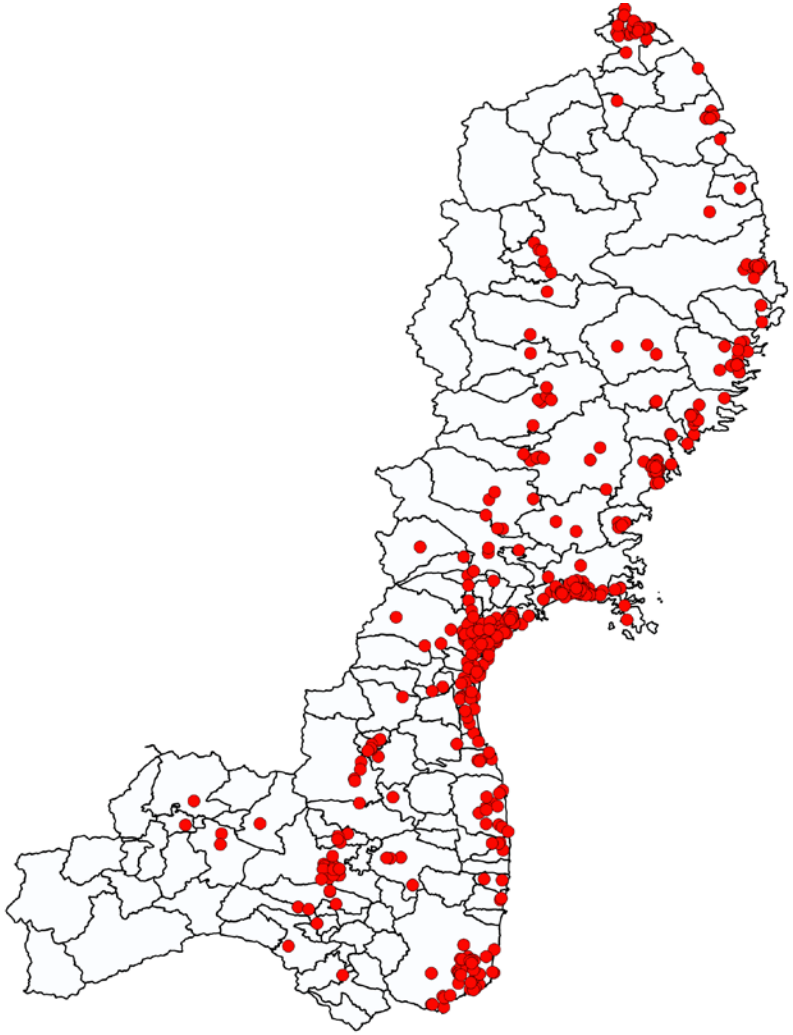
Bank name	B_Special_Loss	dB_CapRatio_Basel	B_Branch_Closed_sum	B_Branch_Reloc_sum	Injection
Fukushima	0.00900	-0.014	0.2364	0.0727	0
77	0.00825	-0.016	0.3451	0.1197	1
Tohoku	0.00695	-0.0106	0.1379	0.0690	1
Kitanihon	0.00538	-0.006	0.1235	0.0864	0
Ishinomaki	0.00412	-0.0077	1	0.6667	1
Sendai	0.00411	-0.0185	0.1690	0.1268	1
Iwate	0.00273	-0.0002	0.0734	0.0734	0
Daito	0.00264	0.0031	0.1111	0.0794	0
Iwaki	0.00199	-0.002	0.6842	0.2632	1
Sen-nan	0.00168	0.0005	0.0625	0.0625	0
Kesennuma	0.00167	-0.0291	0.9167	0.6667	1
Morinomiyako	0.00163	0.0025	0.2667	0.2667	0
Soso	0.00150	-0.0065	0.8750	0.5000	1
Ishinomaki shoko	0.00147	0.0134	0.2500	0.1667	0
Miyako	0.00144	-0.004	0.7778	0.6667	1
Aizu shoko	0.00109	0.0016	0	0	0
Sukagawa	0.00108	-0.0008	0.0769	0.0769	0
Kirayaka	0.00098	-0.0104	0.0339	0.0254	1
Himawari	0.00096	-0.0001	1	0.0625	0
Asuka	0.00096	0.0009			0
Toho	0.00075	-0.0004	0.3070	0.0789	0
Aoimori	0.00072	0.0113	0.0137	0	0
Ichinoseki	0.00067	0.0076	0	0	0
Development bank of	0.00063	0.0142	0	0	0
Miyagi Dai-ichi	0.00055	0.0024	0.0769	0	0
Aomori	0.00040	-0.0097	0	0	0
Nihonmatsu	0.00037	0.0014	0	0	0
Japan Finance Corpor	0.00037				0
Fukushimaken Shoko	0.00028		0.0625	0	0
Fukushima	0.00025	0.0028	0.0385	0	0

- Banks with large special losses tend to reduce their capital ratios
- Many of their branches were either closed or relocated
- Some of the banks with large special losses are injected with capital by the government after the earthquake

Geographical distribution of damage to firms' tangible assets

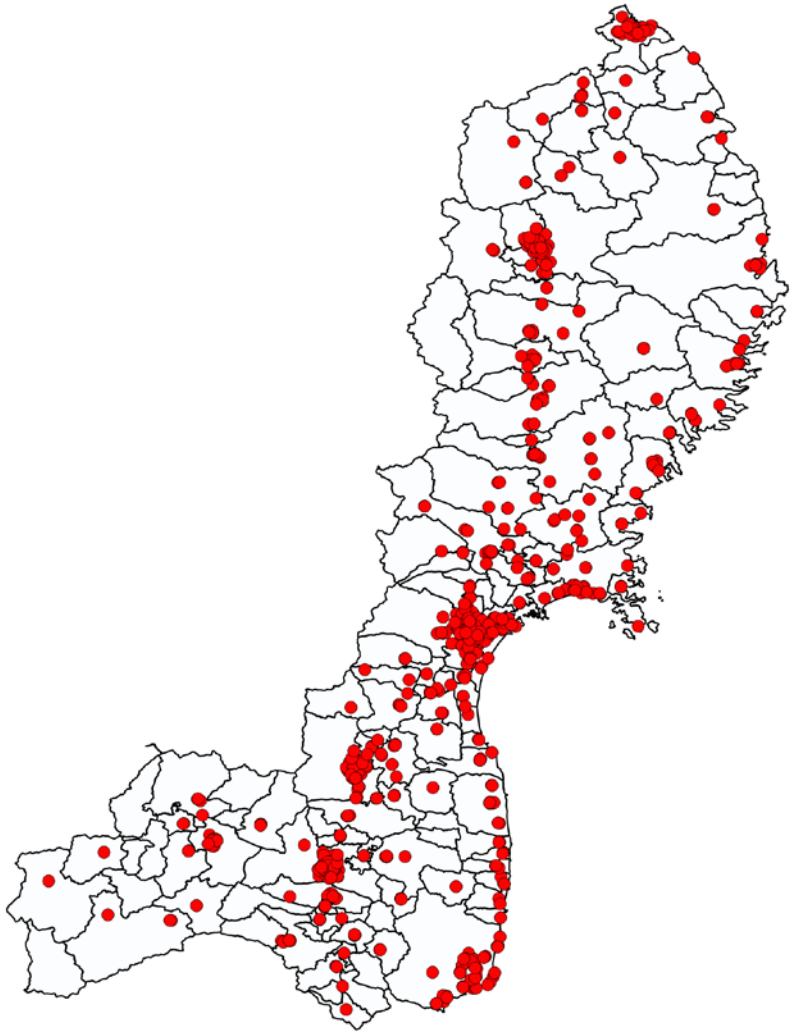


Location of firms in the sample

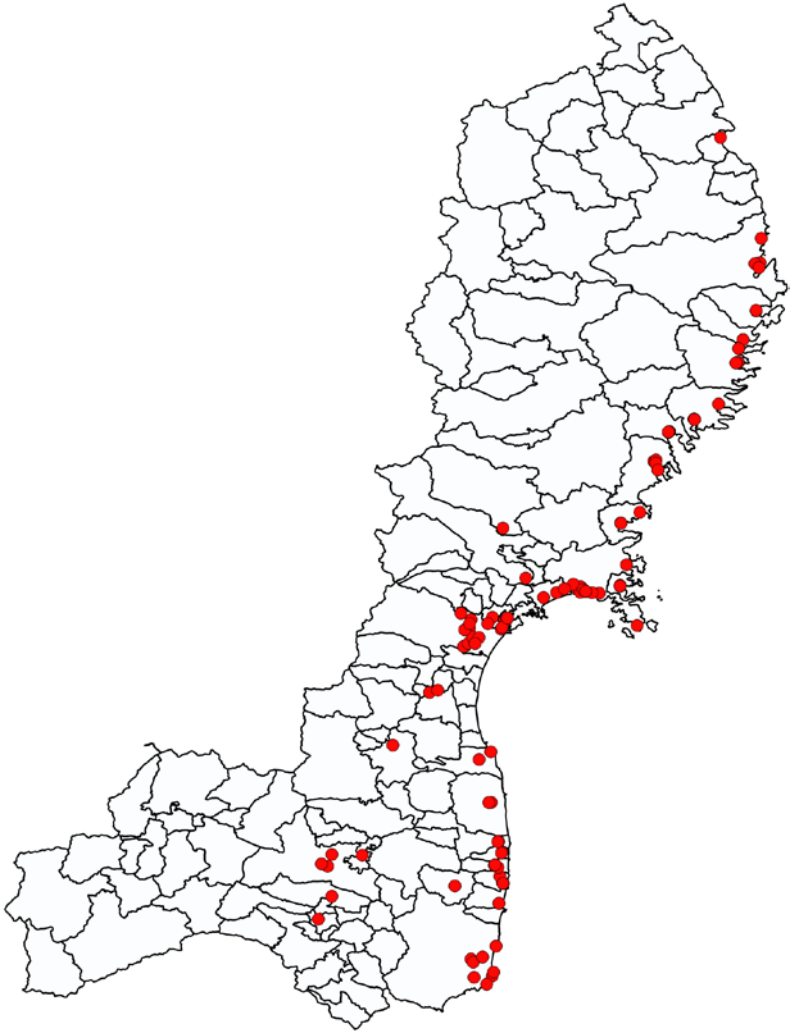


Location of firms that were rather severely damaged in their non-land tangible asset

Geographical distribution of bank damage



Location of bank branches and headquarters



Location of bank branches and headquarters that were relocated

Variables on credit constraint, activity, support, and others

	N	mean	sd	min	p25	p50	p75	max
Credit constraint variables								
Constrained1	1190	0.4933	0.5002	0	0	0	1	1
Constrained2	1122	1.5036	0.5749	1	1	1	2	3
Firm activity variables								
Activity_Level	958	93.4438	30.1284	0	80	96	100	300
Investment	504	0.2509	0.4807	0	0.0179	0.0686	0.2719	4.5320
Loan_Ratio	995	0.5978	0.7004	0	0.2336	0.4603	0.7018	5
Financial support variables								
Injection	1190	0.3924	0.4885	0	0	0	1	1
Insurance	1190	0.2815	0.4499	0	0	0	1	1
Subsidy	1190	0.2370	0.4254	0	0	0	0	1
Num_bank	1088	2.5983	1.8493	0	1	2	3	19
Duration_bank	1067	30.9428	15.9727	0	20	30	40	100
Control variables								
Employment	1190	33.6370	71.8974	1	8	18	35	1637
Business_Condition	1190	3.2101	1.0709	1	2	3	4	5
Leverage	1190	0.8647	0.6623	0.0002	0.5749	0.7979	0.9657	6.5
Construction	1190	0.3025	0.4593	0	0	0	1	1
Manufacturing	1190	0.1714	0.3769	0	0	0	0	1
Utilities, IT, and Transportation	1190	0.0840	0.2774	0	0	0	0	1
Wholesale	1190	0.1437	0.3508	0	0	0	0	1
Retail	1190	0.1294	0.3357	0	0	0	0	1
Services	1190	0.1689	0.3747	0	0	0	0	1

- Among firms that demand new loans, about half of them do not raise sufficient amount of funds and 5% of them do not obtain new loans

RESULTS OF CREDIT CONSTRAINT ESTIMATION

Credit constraint estimation (baseline)

	(1)	(2)	(3)	(5)	(7)	(8)	(9)	(11)
	Dependent variable=Constrained1				Dependent variable = Constrained2			
VARIABLES	Probit model estimation				Ordered probit model estimation			
F_Damage_Tangibles	0.467***		0.450***	0.479***	0.390***		0.379***	0.394***
	(0.128)		(0.127)	(0.126)	(0.0986)		(0.0985)	(0.0977)
F_Damage_Land		0.992*				0.675		
		(0.509)				(0.477)		
B_Special_Loss	37.91***	38.47***		40.18***	40.65***	41.87***		43.40***
	(12.04)	(11.99)		(12.22)	(11.53)	(11.51)		(11.77)
dB_CapRatio_Basel			-12.35***				-13.70***	
			(4.077)				(4.022)	
B_Branch_Reloc	-0.0883	-0.0361	-0.0710		-0.132	-0.0801	-0.117	
	(0.123)	(0.121)	(0.123)		(0.117)	(0.116)	(0.116)	
B_Branch_Reloc_sum	0.211	0.318	0.102		0.284	0.347	0.148	
	(0.336)	(0.332)	(0.344)		(0.318)	(0.317)	(0.324)	
B_Branch_Closed				-0.0554				-0.0629
				(0.0943)				(0.0904)
B_Branch_Closed_sum				-0.0917				-0.122
				(0.193)				(0.187)
Number of observations	1,190	1,190	1,176	1,190	1,122	1,122	1,110	1,122

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Credit constraint estimation (baseline)

Existence of collateral and bank lending channels

- Firms with larger damage to non-land tangible assets face difficulties for raising funds

  → **Consistent with the collateral channel story**

- Firms that transact with the bank with larger special losses face difficulties for raising funds

  → **Consistent with the bank lending channel story**

- No significant adverse impact among firms transacted with damaged branches

  → **Damage to the capital held by an entire bank rather than damage to individual bank branches may matter for the bank lending channel**

Economic significance of the impact through these two channels:

	Marginal effect	One standard deviation	Change in the probability caused by a one sd shock
F_Damage_Tangibles	0.1662	0.3932	0.0654
B_Special_Loss	13.4988	0.0033	0.0442

- Impact through these two channels are comparable in size and both economically significant

Credit constraint estimation (different periods)

	(13)	(14)	(15)	(16)
	Dependent variable = Constrained1			
	Probit model estimation			
Period=	**2**	**3**	**4**	**5**
	~July 2012	**~Aug/Sep 2013**	**~Aug/Sep 2014**	**~Oct/Nov 2015**
VARIABLES				
F_Damage_Tangibles	0.467***	0.0877	-0.0613	0.0928
	(0.128)	(0.109)	(0.131)	(0.177)
B_Special_Loss	37.91***	30.75**	7.373	-21.64
	(12.04)	(13.29)	(19.36)	(21.77)
B_Branch_Reloc	-0.0883	-0.0892	-0.260	-0.146
	(0.123)	(0.159)	(0.213)	(0.250)
B_Branch_Reloc_sum	0.211	0.103	-0.0792	0.619
	(0.336)	(0.473)	(0.612)	(0.934)
Number of observations	1,190	953	506	427
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1			

Persistence of the impact through these two channels

- Firms with larger damage to collateral values face difficulties in raising funds in period 2, but this negative effect disappears in period 3 and later
- Firms that transact with the bank with larger special losses face difficulties in raising funds both in periods 2 and 3, but this negative effect disappears in periods 4 and 5
- No significant adverse impact for firms that transacted with closed/relocated branches in any period

Credit constraint estimation (effect of financial support)

	(17)	(18)	(19)	(20)	(21)
	Dependent variable = Constrained1				
VARIABLES	Probit model estimation				
F_Damage_Tangibles	0.470***	0.401***	0.883***	0.952***	0.240
	(0.128)	(0.141)	(0.277)	(0.290)	(0.294)
B_Special_Loss	50.63**	39.88***	38.00***	42.97***	43.92***
	(23.81)	(12.11)	(12.07)	(12.56)	(12.65)
Injection	0.224				
	(0.240)				
B_Special_Loss*Injection	-38.02				
	(38.84)				
Insurance		-0.215**			
		(0.0958)			
F_Damage_Tangibles*Insurance		0.283			
		(0.304)			
Subsidy			-0.0470		
			(0.111)		
F_Damage_Tangibles*Subsidy			-0.520*		
			(0.310)		
Num_Bank				0.0266	
				(0.0238)	
F_Damage_Tangibles*Num_Bank				-0.216*	
				(0.112)	
Duration_Bank					-0.00426
					(0.00284)
F_Damage_Tangibles*Duration_Bank					0.00740
					(0.00899)
Number of observations	1,190	1,190	1,190	1,088	1,067

Credit constraint estimation (effect of financial support)

Earthquake insurance versus subsidy for recovery investment

- Coefficient on *Insurance* is significant, while the coefficient on *F_Damage*Subsidy* is significant
- Insurance and subsidy alleviate credit constraints in a different manner
  - Insurance money is disbursed based on the damage that already occurred but not based on the future investment demand
  - Subsidy for recovery investment is disbursed for the future investment plan
- We may say the following:
  - The subsidy for recovery investment reduces the impact of negative shocks through the collateral channel, while the insurance money eases the credit constrain in general

Number of transaction relationships

- Coefficient on *F_Damage*Num_Bank* is marginally negatively significant
- Multiple relationships with banks alleviate the negative impact caused by the damage to collateral values

Capital injection to banks

- Coefficient on *B_Special_Loss*Injection* is insignificant but negative
- Further examination is needed, but capital injection to banks may have a potential to alleviate the negative impact through the bank lending channel

RESULTS OF FIRM ACTIVITY ESTIMATION

Activity estimation

Purpose of the analysis

- Examine how the credit constraint caused by the damage to firm and/or bank assets affects firms' behavior
- Focus on three variables: activity level, capital investment, and loan amount outstanding
- Employ treatment regression method and employ *B_Special_Loss* for an instrument
- For comparison, also employ OLS
- Study the coefficients on *Constrained1* in each estimation

	(1)	(2)	(3)	(5)	(6)	(7)	(9)	(10)	(11)
Dependent variable:	Activity_Level	Constrained1	Activity_Level	Investment	Constrained1	Investment	Loan_Ratio	Constrained1	Loan_Ratio
Esimation method:	Treatment regression		OLS	Treatment regression		OLS	Treatment regression		OLS
	Second stage	First stage		Second stage	First stage		Second stage	First stage	
Constrained1	-27.74***		-3.087	0.169		0.130***	-0.808***		0.0631
	(8.464)		(1.892)	(0.129)		(0.0451)	(0.0570)		(0.0400)
F_Damage_Tangibles	-5.167**	0.383***	-7.562***	0.395***	0.151	0.403***	0.571***	0.469***	0.468***
	(2.506)	(0.114)	(2.109)	(0.0575)	(0.164)	(0.0558)	(0.0601)	(0.101)	(0.0503)
B_Special_Loss		37.28***			52.15***			25.49***	
		(12.07)			(18.12)			(9.520)	
athrho	0.540***			-0.0639			0.998***		
	(0.192)			(0.158)			(0.0592)		
Number of observatio	1,037	1,037	1,050	552	552	563	1,075	1,075	1,087
R_squared			0.146			0.147			0.310

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Activity estimation

Findings

- In columns (1) and (9), firms with more severe credit constraints decrease their activity level and loan outstanding amount, which is different from the results using OLS
- In column (5), more severe credit constraints do not have a significantly negative or positive impact on investment

- The variable *Constrained1* is contaminated by confounding factors such as demand for recovery investment. Hence, in the OLS (in columns (3)(7)(11)) all of its coefficients have substantial upward biases
- In contrast, we control for such confounding factors in the treatment estimations in columns (1)(5)(9)

- Overall, more severe credit constraints caused by the damage to assets held by firms and/or banks has a negative impact on firms' activity level

- However, no significant negative impact on their capital investment

CONCLUSION

Summary of results

- Both collateral and bank lending channel exist after the Tohoku Earthquake occurred in 2011
- On the one hand, the impacts of the shocks on credit constraints transmitted through these two channels are economically significant and comparable in magnitude
- On the other hand, the impact through the bank lending channel is more persistent than that through the collateral channel
- More severe credit constraints result in lower activity level among borrower firms, while no significant impact on capital investment
- Subsidies to firms for recovery investment alleviate the negative impact through the collateral channel, while insurance money ease the firms' overall credit constraints

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