Risk Management in Financial Institutions

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Determinants of Risk Management in Financial Institutions

- **Risk management in financial institutions**
    - Since financial crisis, much debate of risk management failures
    - Yet basic patterns and determinants are not known
    - Essential for monetary and macro-prudential policy

- **Empirical work guided by risk management theory**

- **Identification**
    - Drop in net worth due to drop in local house prices
    - Difference-in-difference and triple-differences estimation

- **Interest rate & foreign exchange risk**
    - Largest markets for derivatives
    - Banks largest users of tradable securities for hedging purposes

Theory: Risk Management Subject to Financial Constraints

- **Froot/Scharfstein/Stein (1993)**
    - Financial constraints imply effective risk aversion
    - Prediction: more constrained firms hedge more (counterfactual!)

- **Rampini/Viswanathan (2010, 2013)**
    - Risk management requires net worth
    - Financial constraints link financing and risk management
    - Basic prediction: financing and risk management trade-off
        - Constrained firms hedge less as financing dominates hedging concerns

- **Risk management in financial institutions**
    - Froot/Stein (1998), Rampini/Viswanathan (2019), Vuillemey (forthcoming)

- Evidence on risk management and risk exposures ▶ Empirical literature

Hypothesis and Preview of Results

- **Hypothesis: net worth key determinant of risk management**
  - Prediction for hedging in cross section and time series

- **Empirical evidence on relation between hedging and net worth**
  - Positive and significant relation in cross section
    - ... and within institution over time
  - Identification: **net worth drops lead to cut in risk management**
    - and **differentially so for institutions with high real estate exposure**

- **No evidence for alternative hypotheses**

Data

- **Data sources**
  - Call reports and CRSP
  - Time frame: 1995-2013; quarterly data; up to 76 quarters

- **Unit of observation: Bank holding companies (BHCs)**
  - 22,723 BHC-quarter observations
  - Evidence similar at bank level

- **Sample**
  - Exclude main dealers, results robust to their inclusion

Measurement: Interest Rate & Foreign Exchange Hedging

- **Net interest rate hedging**
  - Change in market value of interest rate derivatives

- **Gross interest rate hedging**
  - Gross notional of interest rate derivatives for hedging purposes

- **Gross foreign exchange hedging**
  - Gross notional of FX derivatives for hedging purposes

- All scaled by total assets

Hedging in Financial Institutions – Descriptive Statistics

■ Descriptive statistics for hedging, trading, and exposure

Panel A: Descriptive statistics

|	Mean	S.D.	5th	10th	25th	Median	75th	90th	95th	98th	99th	Obs.
Hedging variables												
Net IR hedg.	0.016	0.325	-0.798	-0.182	0	0	0	0.236	0.986	0.986	0.986	19,832
Gross IR hedg.	0.039	0.088	0	0	0	0.001	0.034	0.120	0.203	0.344	0.570	22,723
Gross FX hedg.	0.001	0.009	0	0	0	0	0	0	0.002	0.014	0.026	22,707
Trading variables												
Gross IR trad.	0.031	0.161	0	0	0	0	0	0.019	0.110	0.504	1.218	22,723
Gross FX trad.	0.012	0.098	0	0	0	0	0	0	0.010	0.072	0.483	22,723
Exposure variables												
Maturity gap	0.094	0.178	-0.196	-0.120	-0.011	0.091	0.205	0.317	0.384	0.468	0.538	22,697
FX exposure	0.007	0.046	0	0	0	0	0	0	0.006	0.091	0.222	19,284

Measurement: Net Worth of Financial Institutions

- **Key state variable: Net worth**
  - Net worth determines tightness of financial constraints

- Construct (new) **Net worth index** – first principal component of
  - (1) Market value of equity / Market value of assets [weight: 0.307]
  - (2) Size (log Total book assets) [weight: 0.149]
  - (3) Net income / Total assets [weight: 0.272]
  - (4) Cash dividends / Total assets [weight: 0.272]

- Construct **Net worth index (ex size)** – first principal component of
  - (1) Market value of equity / Market value of assets [weight: 0.359]
  - (3) Net income / Total assets [weight: 0.329]
  - (4) Cash dividends / Total assets [weight: 0.312]

- Evidence using individual components and ratings similar
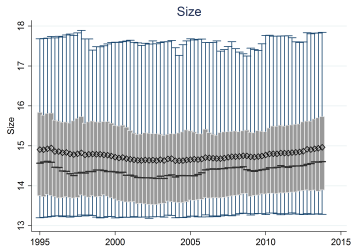
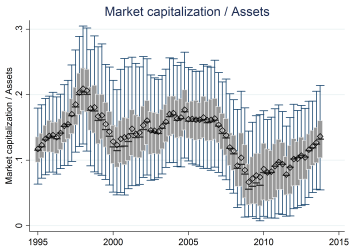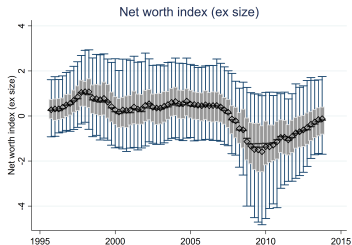# Net Worth Index for Financial Institutions

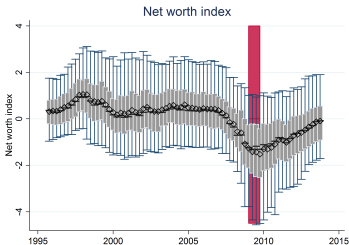- **Distribution of net worth index over time**
  - ... with median (dash), mean (diamond)
  - ... and 5th/95th (whiskers) and 25th/75th (rectangles) percentiles
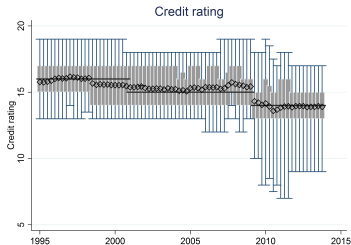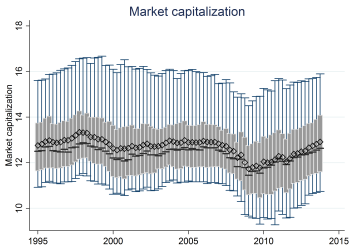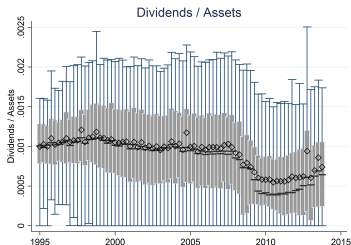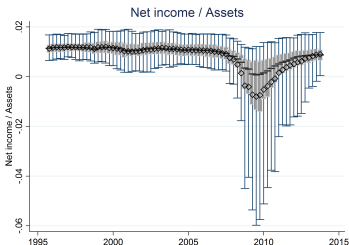

Net worth index
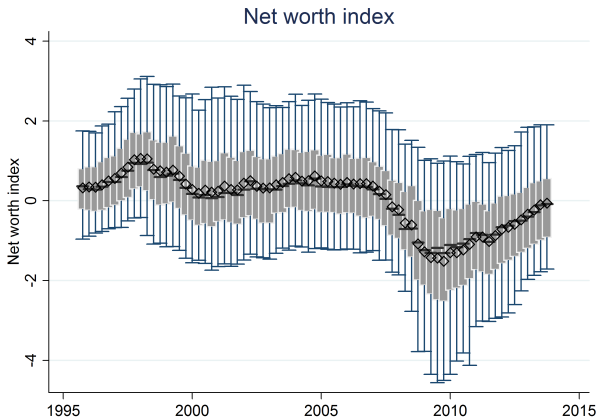
Net Worth of Financial Institutions – Main Variables

- **Distribution of main net worth measures over time**

Net Worth of Financial Institutions – Auxiliary Variables

- **Distribution of auxiliary net worth measures over time**

Stylized Facts: Cross-Section & Within Evidence

- **Strong positive relation between hedging and net worth**
  - ... for interest rate and foreign exchange hedging
  - ... in pooled, Tobit, and within regressions
  - ... controlling for exposures

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.161***	0.173***	0.054***	0.148***	0.156***	0.042***	0.137**	0.152***	0.022***
	(0.024)	(0.024)	(0.012)	(0.035)	(0.028)	(0.007)	(0.057)	(0.046)	(0.006)
Exposure	0.106**	0.085**	0.004	0.170***	0.115***	0.015***	0.321**	0.040*	0.090***
	(0.041)	(0.034)	(0.007)	(0.059)	(0.041)	(0.004)	(0.165)	(0.021)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.181	0.181	0.221	0.061	0.028	0.012	0.127	0.105	0.019
Obs.	18,396	18,396	18,396	20,562	20,652	20,652	19,270	19,270	19,270

Stylized Facts: Cross-Section & Within Evidence (Cont'd)

■ **Positive relation between hedging and net worth indices**

	Net IR hedging			Gross IR hedging			Gross FX hedging		
	Pooled	Tobit	Within	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.161***	0.173***	0.054***	0.148***	0.156***	0.042***	0.137**	0.152***	0.022***
	(0.024)	(0.024)	(0.012)	(0.035)	(0.028)	(0.007)	(0.057)	(0.046)	(0.006)
Exposure	0.106**	0.085**	0.004	0.170***	0.115***	0.015***	0.321**	0.040*	0.090***
	(0.041)	(0.034)	(0.007)	(0.059)	(0.041)	(0.004)	(0.165)	(0.021)	(0.005)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.181	0.181	0.221	0.061	0.028	0.012	0.127	0.105	0.019
Obs.	18,396	18,396	18,396	20,562	20,652	20,652	19,270	19,270	19,270
NWIndex (ex size)	0.070***	0.078***	0.049***	0.032	0.056***	0.036***	0.106*	0.085***	0.022***
	(0.023)	(0.007)	(0.011)	(0.026)	(0.006)	(0.006)	(0.062)	(0.006)	(0.006)
Exposure	0.117***	0.098***	0.004	0.182***	0.126***	0.015***	0.328**	0.049***	0.090***
	(0.043)	(0.005)	(0.007)	(0.061)	(0.005)	(0.004)	(0.167)	(0.003)	(0.006)
Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y	N	N	Y
R^2/Within-R^2	0.165	0.123	0.221	0.045	0.016	0.012	0.121	0.089	0.019
Obs.	18,396	18,396	18,396	20,562	20,652	20,652	19,270	19,270	19,270

Difference-in-Differences – Interest Rate Hedging

- **Interest rate hedging** in treatment and control group
  - Treatment – house price drop above median (2007Q1-2008Q4)
  - Mortgage-weighted avg ZIP code level house price change
  - Price change: -21.1% (median -18.2%) vs. -6.2% (median -4.2%)
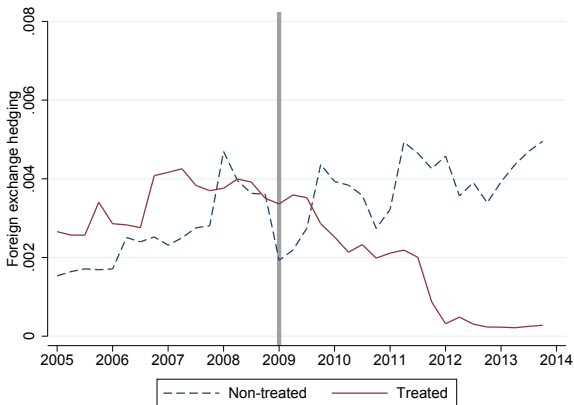
Panel A: Interest rate hedging

Difference-in-Differences – Foreign Exchange Hedging

■ **Foreign exchange hedging** in treatment and control group

■ Treatment – house price drop above median

Panel B: Foreign exchange hedging

Difference-in-Differences and Triple-Differences Estimation

- **Treatment – house price change below median**
  - **Triple-differences by tercile in real estate exposure** in 2008Q4

Panel A: Baseline estimation

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$\text{Post}_t \times \text{Treated}_i$	-0.122*	0.002	-0.309***	-0.113	-0.221***	-0.045
	(0.061)	(0.106)	(0.071)	(0.097)	(0.062)	(0.066)
$\text{Post}_t \times \text{Treated}_i \times \text{MidRE}_i$		-0.124		-0.259**		-0.185
		(0.125)		(0.115)		(0.110)
$\text{Post}_t \times \text{Treated}_i \times \text{HighRE}_i$		-0.299**		-0.325***		-0.312***
		(0.121)		(0.115)		(0.105)
$\text{Post}_t \times \text{MidRE}_i/\text{HighRE}_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.133	0.241	0.029	0.030	0.020	0.021
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Propensity Score Matched DiD and Triple-D Estimation

- **Treatment – house price change below median**
  - **Propensity score matching** by financial variables & exposures

Panel B: Estimation with propensity score matching

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$Post_t \times Treated_i$	-0.222*	0.006	-0.336***	-0.052	-0.192**	-0.091
	(0.140)	(0.108)	(0.111)	(0.114)	(0.095)	(0.090)
$Post_t \times Treated_i \times MidRE_i$		-0.131*		-0.245**		-0.235*
		(0.112)		(0.119)		(0.090)
$Post_t \times Treated_i \times HighRE_i$		-0.414***		-0.421***		-0.351***
		(0.121)		(0.142)		(0.120)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.142	0.231	0.035	0.041	0.024	0.027
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

DiD and Triple-D Estimation – Net Worth

- **Treatment affects net worth**
  - ... and differentially so for institutions with high real estate exposure

Panel A: Effect of treatment on net worth

	NWIndex		NWIndex (ex size)		MktCap/Assets		Size	
$\text{Post}_t \times \text{Treated}_i$	-0.412***	-0.295***	-0.438***	-0.257***	-0.263***	-0.209***	-0.205***	0.049
	(0.055)	(0.056)	(0.056)	(0.054)	(0.041)	(0.041)	(0.061)	(0.061)
$\text{Post}_t \times \text{Treated}_i$		-0.031		-0.049		0.023		-0.412***
$\times \text{MidRE}_i$		(0.048)		(0.051)		(0.035)		(0.052)
$\text{Post}_t \times \text{Treated}_i$		-0.517***		-0.562***		-0.239***		-0.971***
$\times \text{HighRE}_i$		(0.048)		(0.052)		(0.032)		(0.050)
$\text{Post}_t \times \text{MidRE}_i/\text{HighRE}_i$	Y	Y	Y	Y	Y	Y	Y	Y
Exposure	N	N	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y	Y	Y
Within-R^2	0.296	0.324	0.312	0.345	0.374	0.382	0.005	0.068
Obs.	4,788	4,788	4,788	4,788	4,804	4,804	4,804	4,804

DiD and Triple-D Estimation – Exposures

- **No effect of treatment on measures of exposures**
  - Interest rate exposure: maturity gap (net assets repricing in 1 year)
  - FX exposure: income from loans in foreign offices

Panel B: Effect of treatment on risk exposures

	Maturity gap			FX exposure		
	Unmatched	Unmatched	Matched	Unmatched	Unmatched	Matched
$\text{Post}_t \times \text{Treated}_i$	-0.159	-0.153	-0.101	0.091	0.111	0.091
	(0.133)	(0.186)	(0.164)	(0.081)	(0.135)	(0.112)
$\text{Post}_t \times \text{Treated}_i \times \text{MidRE}_i$		-0.004	0.002		-0.013	0.002
		(0.293)	(0.285)		(0.101)	(0.097)
$\text{Post}_t \times \text{Treated}_i \times \text{HighRE}_i$		-0.011	-0.022		-0.016	-0.018
		(0.262)	(0.241)		(0.102)	(0.098)
$\text{Post}_t \times \text{MidRE}_i / \text{HighRE}_i$	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.112	0.112	0.121	0.012	0.040	0.038
Obs.	4,804	4,804	4,804	4,511	4,804	4,804

Robustness – Placebo Tests

- **Evidence on parallel trends**
  - Include year-treatment dummies in pre-treatment period

	Net IR hedging		Gross IR hedging		Gross FX hedging	
	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
2005	-0.073	-0.003	0.049	0.043	0.066	0.035
	(0.124)	(0.123)	(0.090)	(0.092)	(0.077)	(0.068)
2006	-0.003	0.019	-0.021	0.018	0.089	0.032
	(0.134)	(0.131)	(0.090)	(0.092)	(0.077)	(0.068)
2007	0.107	0.085	-0.007	-0.002	0.121	0.060
	(0.124)	(0.123)	(0.091)	(0.092)	(0.077)	(0.068)
2008	-	-	-	-	-	-
	-	-	-	-	-	-
2009	0.072	0.020	-0.217*	-0.223*	0.051	0.045
	(0.134)	(0.128)	(0.090)	(0.092)	(0.077)	(0.068)
2010	-0.063	-0.153	-0.378***	-0.397***	-0.069	-0.141*
	(0.151)	(0.151)	(0.090)	(0.092)	(0.077)	(0.068)
2011	-0.218*	-0.270*	-0.413***	-0.418***	-0.147*	0.165**
	(0.122)	(0.125)	(0.090)	(0.092)	(0.077)	(0.068)
2012	-0.218*	-0.328**	-0.388***	-0.370***	-0.228***	-0.183***
	(0.124)	(0.124)	(0.090)	(0.092)	(0.077)	(0.068)
2013	-0.154	-0.221*	-0.327***	-0.338***	-0.269***	-0.271***
	(0.123)	(0.123)	(0.090)	(0.092)	(0.077)	(0.068)
Exposure	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.323	0.325	0.025	0.026	0.018	0.017
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

Treatment Based on Housing Supply Elasticity

- **Treatment – housing supply elasticity below median**
  - Mortgage-weighted avg MSA-level housing supply elast. (Saiz 2010)
  - Housing supply elasticity: 1.54 (median 1.56) vs. 3.18 (median 3.19)
  - House price change: -16.1% vs. -6.5%

Panel B: Estimation with propensity score matching

	Net IR hedging		Gross IR hedging		Gross FX hedging	
$Post_t \times Treated_i$	-0.157*	0.013	-0.224**	-0.041	-0.126	0.016
	(0.082)	(0.099)	(0.110)	(0.118)	(0.090)	(0.093)
$Post_t \times Treated_i \times MidRE_i$		-0.166		-0.200**		-0.0126
		(0.128)		(0.126)		(0.092)
$Post_t \times Treated_i \times HighRE_i$		-0.252**		-0.298***		-0.195**
		(0.125)		(0.126)		(0.092)
$Post_t \times MidRE_i/HighRE_i$	Y	Y	Y	Y	Y	Y
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Within-R^2	0.082	0.095	0.022	0.022	0.017	0.018
Obs.	4,268	4,268	4,804	4,804	4,804	4,804

External Validity – IV Based on House Prices

- **Instrument net worth with house price changes**
  - Mortgage-weighted avg ZIP-level house price changes

Panel A: First stage

	NWIndex		NWIndex (ex size)		MktCap/Assets		Size	
Δ House prices	0.106***	0.107***	0.115***	0.121***	0.168***	0.129***	-0.001	-0.006
	(0.034)	(0.032)	(0.034)	(0.029)	(0.030)	(0.029)	(0.031)	(0.009)
Exposure	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y	N	Y
R^2/Within-R^2	0.295	0.436	0.312	0.431	0.391	0.562	0.017	0.693
F-statistic	17.12	16.45	18.64	17.17	23.10	21.96	5.15	15.47
Obs.	12,843	12,843	12,843	12,843	13,470	13,470	13,470	13,470

Panel B: Second stage

	Net IR hedging		Gross IR hedging		Gross FX hedging	
NWIndex (instr.)	0.227***	0.178***	0.076**	0.041	0.005	0.001
	(0.062)	(0.061)	(0.039)	(0.029)	(0.017)	(0.005)
Exposure	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	Y	N	Y	N	Y
Obs.	12,843	12,843	12,843	12,843	12,843	12,843

No Evidence for Alternative Hypothesis

- **Not sophistication or fixed costs**
  - Evidence at the intensive margin and within-variation
  - Similar results excluding bottom tercile or controlling for size terciles

- **Not risk shifting**
  - Same pattern away from default (excluding bottom tercile)
  - Strong positive relation between trading and net worth

- **Not risk exposures**

- **Not regulatory capital**
 - No strong relation with regulatory capital

Trading and Net Worth

Positive and significant relation between trading and net worth

- … both in cross-section and for IR hedging within institutions

	Gross IR trading			Gross FX trading		
	Pooled	Tobit	Within	Pooled	Tobit	Within
NWIndex	0.210***	0.207***	0.021***	0.160**	0.202***	-0.013***
	(0.053)	(0.046)	(0.005)	(0.067)	(0.062)	(0.004)
Exposure	N	N	N	N	N	N
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	N	N	Y	N	N	Y
R^2/Within-R^2	0.035	0.056	0.028	0.029	0.103	0.007
Obs.	20,568	20,568	20,568	20,568	20,568	20,568

Alternative Hypothesis: Regulatory Capital

- Measurement
  - Total/Tier 1 regulatory capital / Risk-weighted assets

- **Weak relation between hedging and regulatory capital**
  - Weak relation with mixed signs (mostly negative)

- Davidson-MacKinnon (1981)'s J-test of model nestedness
  - Regulatory capital, but not net worth, typically rejected
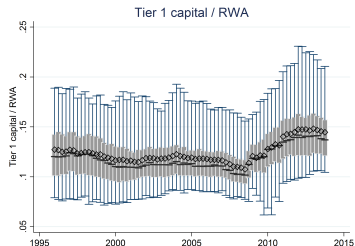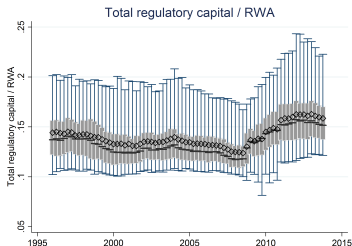
Conclusion

- **Financial institutions with higher net worth hedge more**
    - New and robust stylized fact in cross section and time series
    - Interest rate and foreign exchange hedging
    - DiD/Triple-D specification – causal effect of net worth on hedging

- **Financing needs of hedging key barrier to risk management**

- **Key for macro-finance and monetary/macro-prudential policy**

Empirical Literature

- Risk exposures and risk management by financial institutions
  - Effect on lending policies
    - Purnanadam (2007), Landier/Sraer/Thesmar (2015)
  - Begenau/Piazzesi/Schneider (2015)
    - New methodology to measure interest rate risk
    - Trading positions increase interest rate risk exposures
  - Monetary policy and risk exposures
    - Drechsler/Savov/Schnabl (2017), Di Tella/Kurlat (2018)

- Corporate hedging – mostly: single cross-section; user dummies
  - Tufano (1996)
    - Hedging by gold mining firms; focus on executives' incentives
  - **Rampini/Sufi/Viswanathan (2014)**
    - Empirical laboratory: airlines' fuel price risk management
    - Advantage: measurement – fraction expected fuel expenses hedged
    - Panel data at intensive and extensive margin
    - Financial constraints impede risk management