

# Playing the devil's advocate: The causal effect of risk management on loan quality

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Chicago, May 2014

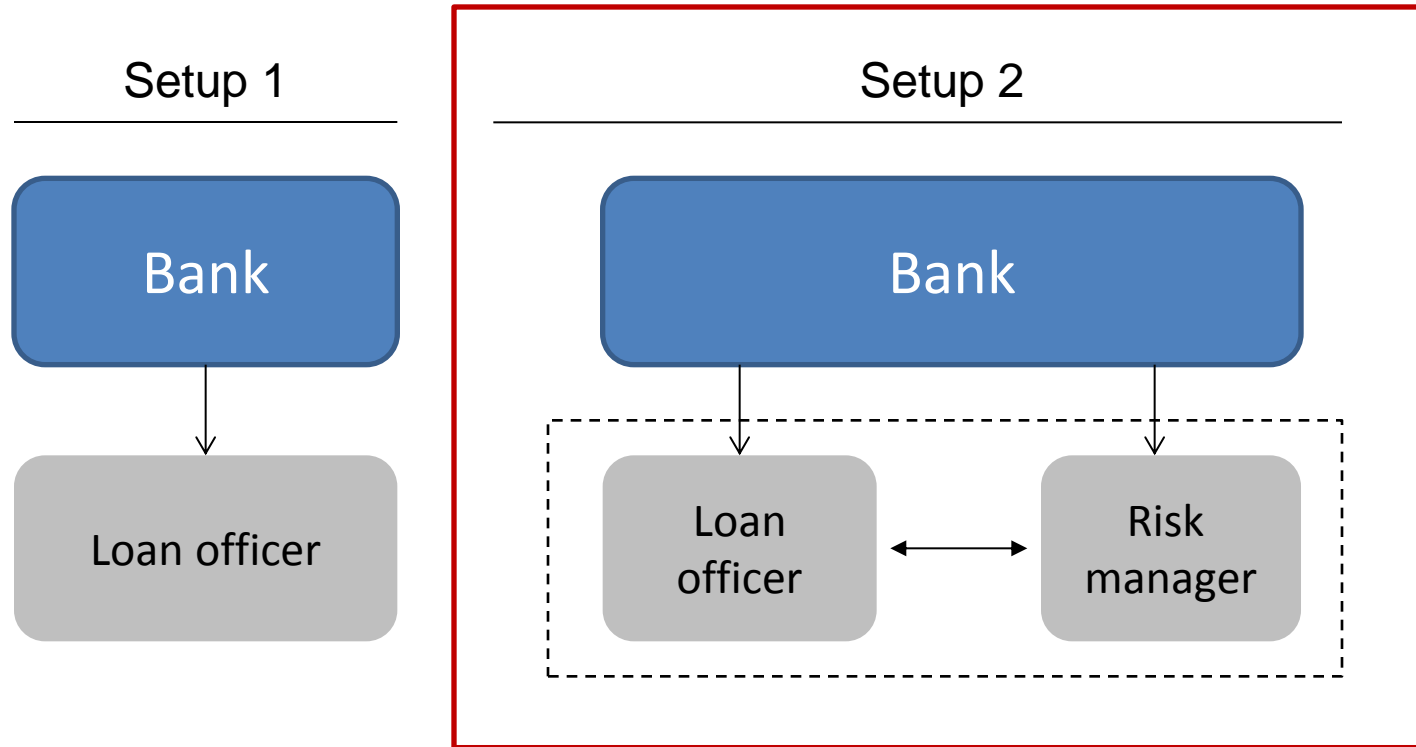
# The canonization process

- Proposal: Person X to be elevated to level of Saint
- Devil's advocate: Doesn't know more, but different incentives
- Effect: Candidates are rarely rejected, the presence of the devil's advocate is sufficient to enforce appropriate behavior
- I think risk management has a similar role

# Outline

1. Role of risk management: 4-eyes-principle
2. Causal effect of risk management on loan quality
3. Reason: Devil's advocate explanation

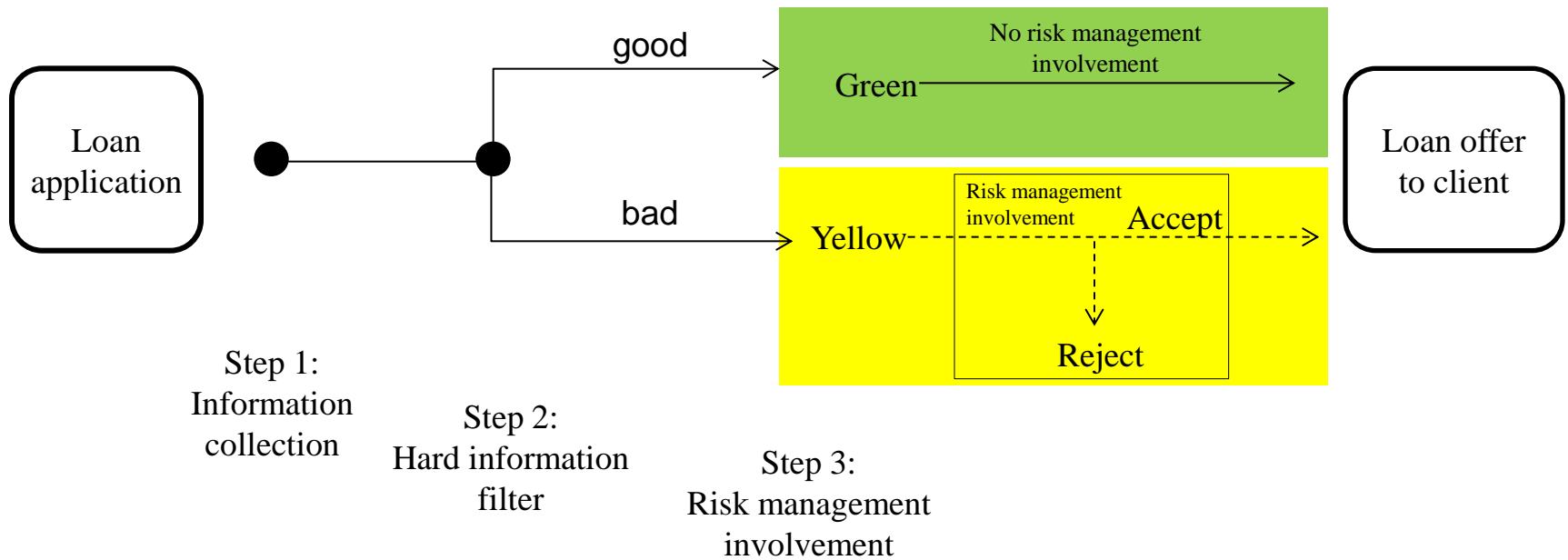
# Motivation



**Research question:**

**What is the effect of risk mgmt involvement on default rates?**

# 4-eyes principle: How does it work?



# Hypothesis

- Models are Superior to Experts Hypothesis:
  - Tversky and Kahnemann (1974)
  - Meehl (1954), Dawes, Faust and Meehl (1989): Clinical versus actuarial judgment
- Hidden Cost of Control Hypothesis:
  - Falk and Kosfeld (2006)
- Efficient Advocacy Hypothesis:
  - Dewatripont and Tirole (1999): Advocats
  - Holmstrom and Milgrom (1990, 1991): Splitting responsibility

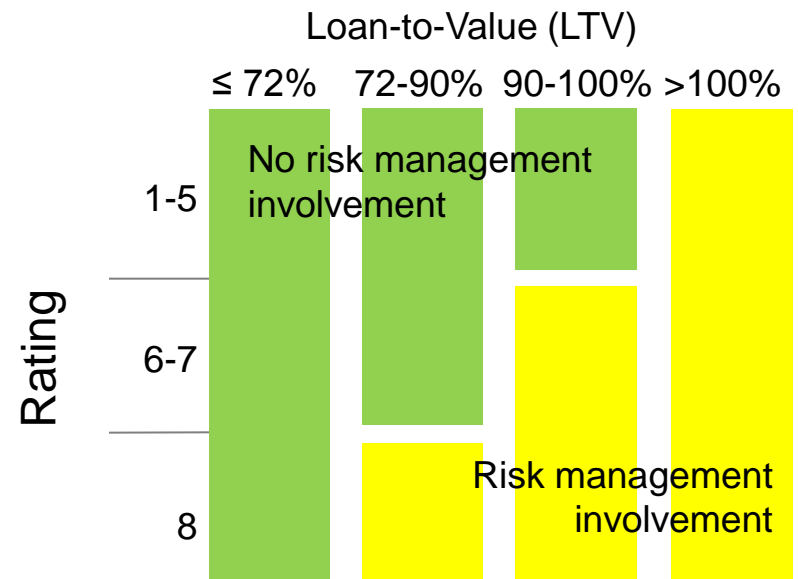
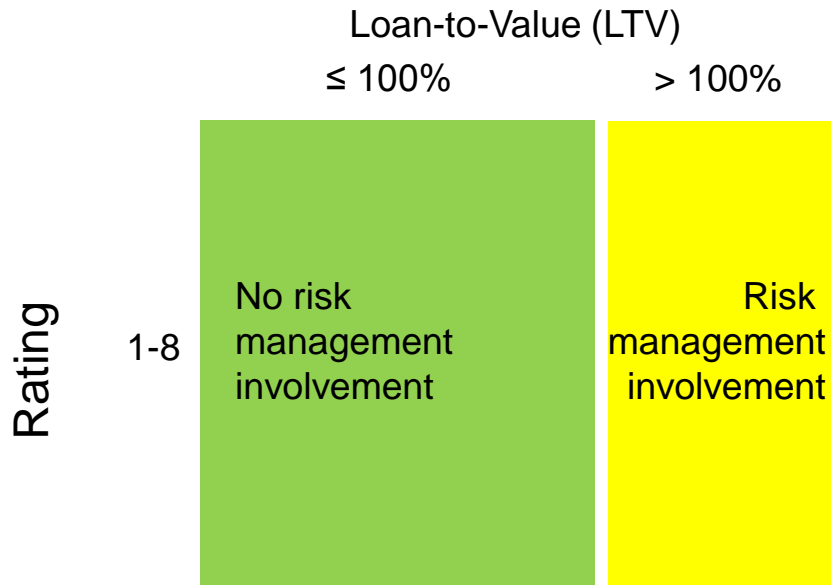
# Institutional set-up

- 75,000 retail mortgage applications from 2008-2011 at European bank
- Volume-incentivized loan officers
- Risk managers located in one single town, no client contact, pure hard information decision, responsible for several branches („repeated game“)
- Risk management involvement based on sharp rating and LTV
  - Causal identification: Regression discontinuity design
  - Thresholds changes during sample period: Diff-in-Diff

# Risk management involvement

Subperiod 1  
(Feb2008 – Apr2009)

Subperiod 2  
(May2009 – Sep2011)





# Descriptives

		(1)				(2)			
		Witout risk management involvement				With risk management involvement			
		N	Mean	Median	Std.Dev.	N	Mean	Median	Std.Dev.
<b>Key variables</b>									
Rating	Number (1=Best, 8=Worst)	67,860	3.75	4.00	1.69	8,512	5.78	6.00	1.94
LTV		67,860	70.69%	75.41%	24.24%	8,512	102.06%	100.00%	9.35%
Loan granted	Dummy (0/1)	67,860	43.01%	0.00%	49.51%	8,512	28.42%	0.00%	45.11%
Default rate		29,184	2.81%	0.00%	16.52%	2,419	3.18%	0.00%	17.56%
<b>Other loan characteristics</b>									
Loan amount	EUR	67,860	116,039	100,000	78,008	8,512	139,422	122,000	82,865
Loan maturity	Months	67,860	120.00	120.00	43.00	8,512	124.00	120.00	39.00
Bank's expected recovery rate		67,860	77.15%	77.38%	12.36%	8,512	69.32%	70.85%	8.50%
House (0/1)	Dummy (0/1)	67,860	77.13%	100.00%	42.00%	8,512	66.91%	100.00%	47.06%
<b>Other customer characteristics</b>									
Age	Years	67,860	43.50	43.00	10.40	8,512	38.44	38.00	8.95
Number of borrowers	All	67,860	1.67	2.00	0.51	8,512	1.43	1.00	0.53
Relationship customer	Dummy (0/1)	67,860	0.63	1.00	0.48	8,512	0.41	0.00	0.49
Interest coverage		67,860	31.30%	21.79%	62.81%	8,512	20.95%	17.37%	16.75%

# RDD: Descriptive evidence (I/II)

Panel B: Subperiod 2 (May 2009 – September 2011)

Rating	LTV				Total	Number of loans
	< 72%	72%-90%	90%-100%	> 100%		
1,2	0.17%	0.51%	0.38%	0.00%	0.28%	5,024
3,4	0.73%	1.40%	3.42%	0.58%	1.76%	9,588
5	0.81%	1.72%	4.36%	3.53%	2.48%	3,059
6	1.66%	2.54%	2.54%	4.04%	2.37%	1,860
7	2.17%	6.84%	3.46%	5.08%	4.59%	1,241
8	2.48%	3.77%	4.84%	4.00%	3.65%	821
Total	0.73%	1.97%	3.20%	1.79%	1.81%	21,593
Number of loans	8,919	5,681	6,212	781	21,593	

# RDD: Descriptive evidence (II/II)

## Subperiod 1 (Feb 2008 – Apr 2009)

Rating	LTV				Total	Number of loans
	< 72%	72%-90%	90%-100%	> 100%		
1,2	0.53%	1.83%	0.65%	0.00%	0.83%	1,445
3,4	1.89%	2.59%	5.26%	1.77%	3.25%	5,050
5	3.13%	4.15%	9.36%	5.26%	6.27%	1,149
6	4.67%	4.30%	14.15%	6.25%	9.39%	863
7	5.88%	7.00%	17.44%	7.14%	11.95%	862
8	4.09%	11.35%	15.97%	6.25%	11.54%	641
Total	2.22%	3.75%	8.71%	2.97%	5.05%	10,010
Number of loans	3,558	2,213	3,802	437	10,010	

## Subperiod 2 (May 2009 – Sep 2011)

Rating	LTV				Total	Number of loans
	< 72%	72%-90%	90%-100%	> 100%		
1,2	0.17%	0.51%	0.38%	0.00%	0.28%	5,024
3,4	0.73%	1.40%	3.42%	0.58%	1.76%	9,588
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# Regression discontinuity: Strategy

## 1. Identifying assumptions:

- No contaminating threshold:
  - No change in other processes, pricing, etc.
- Similarity on both sides of threshold / no manipulation assumption
  - No discontinuity in covariates
  - No discontinuity in default rates in subperiod 1
  - McCrary density test: borderline significant ( $t=1.5$ ) → IV using initial scoring trial

## 2. Implementation

- Local linear regression with optimal bandwidth selector (McCrary (2008))
- Robustness: 50% and 200% of optimal bandwidth
- Robustness: Higher order polynomial
- Robustness: IV-regression

# Discontinuity in default rate

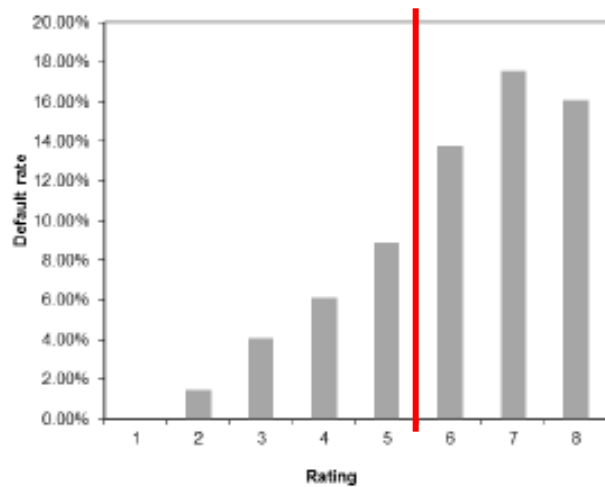
Subperiod 1  
(Feb 2008 – Apr 2009)

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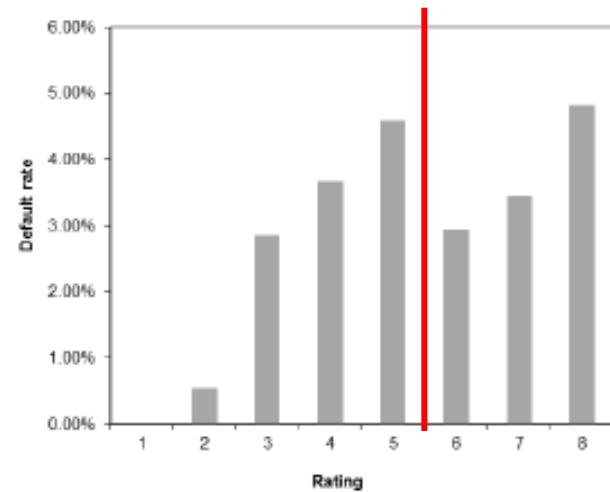
Subperiod 2  
(May 2009 – Sep 2011)

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**Panel A: Default rates**



**Panel A: Default rates**

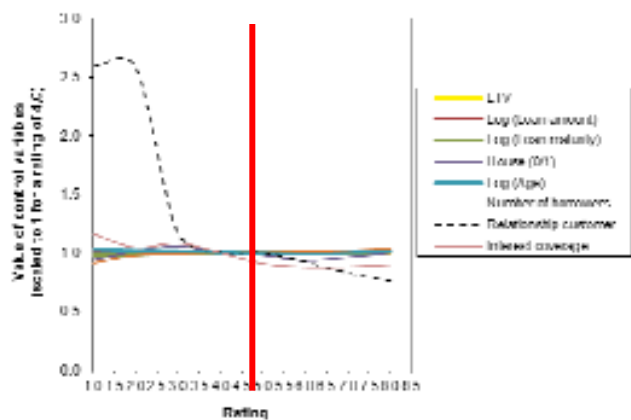


# No discontinuity in covariates

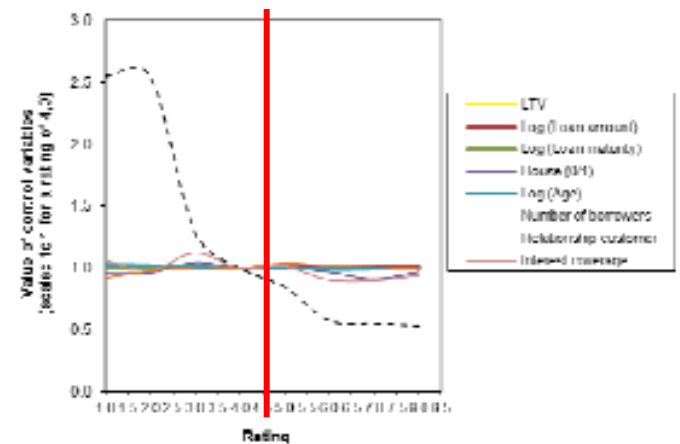
Subperiod 1  
(Feb 2008 – Apr 2009)

Subperiod 2  
(May 2009 – Sep 2011)

Panel B: Covariates



Panel B: Covariates

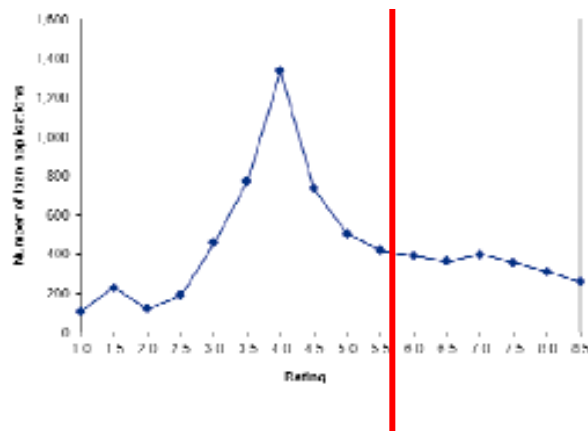


# Manipulation of running variable

Subperiod 1  
(Feb 2008 – Apr 2009)

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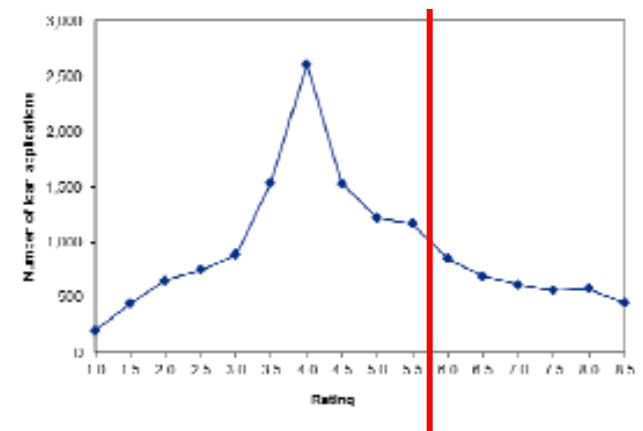
Panel C: Distribution of loan applications



Subperiod 2  
(May 2009 – Sep 2011)

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Panel C: Distribution of loan applications



# RDD: Regression results

	(1)		(2)		(3)		(4)		(5)	
<b>Dependent</b>	Default (0/1)		Default (0/1)		Default (0/1)		Default (0/1)		Default (0/1)	
<b>Model</b>	Logit		Logit		Logit		Linear		IV	
<b>Sample</b>	Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%	
<b>Methodology</b>	Local regression +/- 2 notches around RMI cutoff		Local regression +/- 2 notches around RMI cutoff		Local regression +/- 2 notches around RMI cutoff		Local regression +/- 2 notches around RMI cutoff		Local regression +/- 2 notches around RMI cutoff	
<b>Parameter</b>	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Coeff.	t-stat	Coeff.	t-stat
<b>INFERENCE</b>										
Risk mgmt involvement (0/1)	0.343**	(-2.50)	0.313***	(-2.62)	0.315***	(-2.65)	-0.033***	(-2.90)	-0.029*	(-1.73)
<b>RATING</b>										
(Rating-CutOff) x Affected	1.104	(0.58)	1.168	(0.92)	1.166	(0.94)	0.006	(0.91)	0.007	(1.48)
(Rating-CutOff) x (1-Affected)	1.893**	(2.18)	1.762*	(1.87)	1.743*	(1.83)	0.015	(1.61)	0.005	(0.55)
Other customer controls	No		Yes		Yes		Yes		Yes	
Other loan controlss	No		Yes		Yes		Yes		Yes	
Region fixed effects	No		No		Yes		Yes		Yes	
<b>Diagnostics</b>										
Pseudo. R <sup>2</sup> / Adj. R <sup>2</sup>	0.01		0.08		0.09		0.03		0.03	
N	4,013		4,013		4,013		4,013		4,013	
<b>FIRST-STAGE REGRESSION</b>										
Initial Rating > RMI cutoff									0.897***	(69.49)
Other customer controls										Yes
Other loan controls										Yes
Region fixed effects										Yes
Adj. R <sup>2</sup>										0.86
N										4,013



# RDD: Robustness

Dependent	(1)		(2)		(3)		(4)	
Model	Default (0/1)		Default (0/1)		Default (0/1)		Loss	
Sample	Logit, Odds Ratios		Logit, Marginal Effects		Linear		Linear	
Parameter	Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%		Subperiod 2, LTV 90-100%	
	Odds Ratio	z-stat	Average marginal effects	z-stat	Coeff.	t-stat	Coeff.	t-stat
<b>METHODOLOGY</b>								
<b>LOCAL REGRESSION</b>								
Optimal bandwidth (+/- 2 notches around RMI cutoff)	0.315***	(-2.65)	-0.040***	(-2.63)	-0.033***	(-2.90)	-0.010***	(-3.02)
1/2 x Optimal bandwidth (+/- 1 notch around RMI cutoff)	0.227**	(-2.49)	-0.051**	(-2.57)	-0.040***	(-2.91)	-0.015***	(-3.41)
2 x Optimal bandwidth (+/- 4 notches around RMI cutoff)	0.328***	(-3.30)	-0.035***	(-3.26)	-0.033***	(-3.43)	-0.010***	(-3.76)
<b>HIGHER-ORDER POLYNOMIAL</b>								
2 <sup>nd</sup> order	0.246**	(-2.20)	-0.042**	(-2.30)	-0.041***	(-3.19)	-0.013***	(-3.41)
3 <sup>rd</sup> order	0.230**	(-2.24)	-0.044**	(-2.35)	-0.032**	(-2.16)	-0.012***	(-2.78)
4 <sup>th</sup> order	0.218**	(-2.39)	-0.045**	(-2.50)	-0.042**	(-2.39)	-0.016***	(-3.10)

# Diff-in-Diff: Descriptive evidence

## Subperiod 1 (Feb 2008 – Apr 2009)

Rating	LTV				Total	Number of loans
	< 72%	72%-90%	90%-100%	> 100%		
1,2	0.53%	1.83%	0.65%	0.00%	0.83%	1,445
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Total	2.22%	3.75%	8.71%	2.97%	5.05%	10,010
Number of loans	3,558	2,213	3,802	437	10,010	

## Subperiod 2 (May 2009 – Sep 2011)

Rating	LTV				Total	Number of loans
	< 72%	72%-90%	90%-100%	> 100%		
1,2	0.17%	0.51%	0.38%	0.00%	0.28%	5,024
3,4	0.73%	1.40%	3.42%	0.58%	1.76%	9,588
5	0.81%	1.72%	4.36%	3.53%	2.48%	3,059
6	1.66%	2.54%	2.54%	4.04%	2.37%	1,860
7	2.17%	6.84%	3.46%	5.08%	4.59%	1,241
8	2.48%	3.77%	4.84%	4.00%	3.65%	821
Total	0.73%	1.97%	3.20%	1.79%	1.81%	21,593
Number of loans	8,919	5,681	6,212	781	21,593	

# Difference in difference: Basic strategy

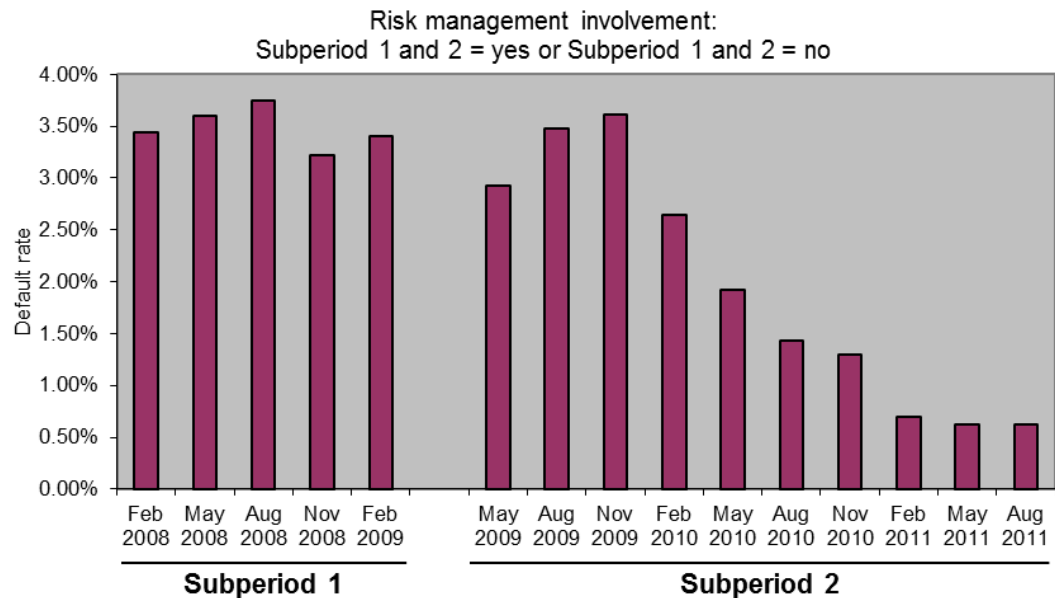
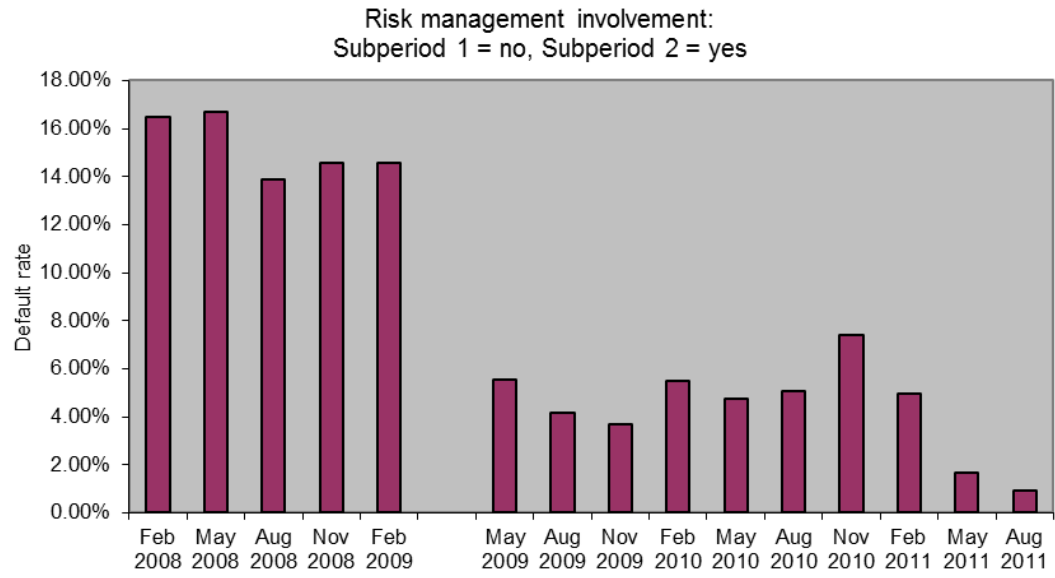
## 1. Identifying assumptions

- No contaminating event
- Similar development in absence of treatment → Parallel trend

## 2. Implementation

- Standard difference-in-difference estimator
- Narrow window around month of threshold change
- „RDD in time“

# Diff-in-Diff: Graphs



# Pre-event parallel trends

Dependent Model	(1)		(2)		(3)		(4)		(5)	
	Default (0/1) Logit		Default (0/1) Logit		Default (0/1) Logit		Default (0/1) Logit		Default (0/1) Logit	
Sample	5 quarters before May 2009		4 quarters before May 2009		3 quarters before May 2009		2 quarters before May 2009		1 quarters before May 2009	
Parameter	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat
<b>TIME TREND</b>										
Time	0.993	(-0.44)	0.988	(-0.67)	0.974	(-0.72)	0.962	(-0.63)	1.027	(0.17)
Time x Affected	0.996	(-0.16)	1.004	(0.12)	1.047	(0.70)	1.106	(1.10)	1.254	(0.61)
<b>CONSTANTS</b>										
Constant	0.035***	(-21.59)	0.034***	(-20.68)	0.032***	(-17.29)	0.031***	(-15.18)	0.036***	(-16.62)
Affected	4.864***	(10.50)	4.977***	(9.45)	5.665***	(6.78)	6.578***	(7.27)	6.358***	(4.58)
<b>Diagnostics</b>										
Adj. R <sup>2</sup>	0.06		0.06		0.05		0.06		0.05	
N	10,010		8,076		5,614		3,600		1,689	

# Diff-in-Diff: Regression results

Dependent Model Sample Parameter	(1)		(2)		(3)		(4)		(5)	
	Default (0/1)		Default (0/1)		Default (0/1)		Default (0/1)		Default (0/1)	
	Logit		Logit		Logit		Logit		Logit	
	Total		Total		Total		Total		Total	
	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat
<b>INFERENCE</b>										
Affected x After	0.414***	(-4.54)	0.400***	(-4.66)	0.409***	(-4.57)	0.392***	(-4.75)	0.407***	(-4.57)
Affected	5.010***	(13.96)	1.144	(0.83)	1.134	(0.76)	1.277	(1.46)	1.231	(1.24)
After	0.478***	(-6.91)	0.507***	(-6.16)	0.482***	(-6.32)	0.458***	(-6.65)	0.463***	(-6.69)
<b>RATING (Reference: Rating =1)</b>										
Rating = 2			3.896**	(2.32)	4.138**	(2.42)	4.369**	(2.52)	4.325**	(2.51)
Rating = 3			8.083***	(3.38)	8.884***	(3.53)	7.335***	(3.22)	7.047***	(3.15)
Rating = 4			13.768***	(4.35)	15.088***	(4.50)	12.524***	(4.23)	11.892***	(4.13)
Rating = 5			17.423***	(4.73)	18.952***	(4.86)	15.932***	(4.59)	15.293***	(4.50)
Rating = 6			24.593***	(5.23)	26.041***	(5.33)	19.490***	(4.81)	18.912***	(4.73)
Rating = 7			37.624***	(5.89)	39.388***	(5.95)	28.984***	(5.42)	28.189***	(5.35)
Rating = 8			35.800***	(5.74)	38.209***	(5.84)	28.126***	(5.28)	27.773***	(5.23)
<b>LTV (Reference: LTV&gt;100%)</b>										
LTV ≤ 72%			0.673	(-1.52)	0.902	(-0.43)	1.311	(1.10)	1.340	(1.21)
72% ≤ LTV ≤ 90%			1.191	(0.79)	1.411*	(1.68)	1.964***	(3.22)	2.078***	(3.63)
90% ≤ LTV ≤ 100%			2.362***	(3.50)	2.480***	(3.73)	3.021***	(4.68)	3.096***	(4.85)
Other customer controls	No		No		Yes		Yes		Yes	
Other loan controlss	No		No		No		Yes		Yes	
Region fixed effects	No		No		No		No		Yes	
<b>Diagnostics</b>										
Adj. R <sup>2</sup>	0.06		0.11		0.13		0.16		0.16	
N	31,603		31,603		31,603		31,603		14,748	

# Diff-in-Diff: Establishing jump in May 2009

Dependent Model	(1)		(2)		(3)		(4)	
	Default (0/1)		Default (0/1)		Default (0/1)		Default (0/1)	
Sample	Logit		Logit		Logit		Logit	
Parameter	+/- 4 quarters around event		+/- 4 quarters around event		+/- 4 quarters around event		Total	
	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat
<b>INFERENCE</b>								
Affected x After	0.371***	(-3.13)	0.361**	(-2.50)	0.203**	(-2.21)	0.299**	(-1.97)
Affected	1.292	(1.28)	1.310	(0.91)	1.265	(0.74)	1.694	(1.18)
After	0.787*	(-1.75)	1.027	(0.11)	1.018	(0.07)	0.747	(-1.24)
<b>TIME TRENDS</b>								
Time trend affected			0.981	(-0.68)				
Time trend non-affected			0.980	(-1.36)				
<b>TIME TRENDS PRE</b>								
Time trend pre affected					0.972	(-1.06)	Yes, 3 <sup>rd</sup> order polynomial	
Time trend pre non-affected					0.976	(-1.22)	Yes, 3 <sup>rd</sup> order polynomial	
<b>TIME TRENDS POST</b>								
Time trend post affected					1.077	(0.84)	Yes, 3 <sup>rd</sup> order polynomial	
Time trend post non-affected					0.984	(-0.83)	Yes, 3 <sup>rd</sup> order polynomial	
Rating controls	Yes		Yes		Yes		Yes	
LTV controls	Yes		Yes		Yes		Yes	
Other customer controls	Yes		No		Yes		Yes	
Other loan controls	Yes		No		Yes		Yes	
Region fixed effects	Yes		No		No		Yes	
<b>Diagnostics</b>								
Adj. R <sup>2</sup>	0.16		0.16		0.16		0.18	
N	14,748		14,748		14,748		31,603	

# Why does risk mgmt reduce default rates?

- Experience: No
  - Default rates independent of loan officer experience
- Entrenchment: No
  - Effect of risk management not larger for relationship customers
- Agency: Yes
  - Set-up: Same information, different incentives
  - High acceptance rates by risk management (>80%) (WIP)
  - Number of trials (WIP)



# Alternative explanations

Dependent Model	(1)		(2)		(3)		(4)	
	Default (0/1)		Default (0/1)		Default (0/1)		Default (0/1)	
Remark	Logit		Logit		Logit		Logit	
	Experience measured via number of loan applications over past 12months		Experience measured via number of <i>successful</i> loan applications over past 12months		Relationship = 1 if borrower has an account at the bank <i>or a prior loan</i>		Relationship = 1 if borrower has an account at the bank	
Parameter	Odds Ratio	z-stat	Odds Ratio	z-stat	Odds Ratio	z-stat	Coeff.	t-stat
<b>INFERENCE</b>								
Risk mgmt involvement (0/1)	0.335**	(-2.55)	0.410**	(-2.00)	0.335**	(-2.50)	0.341**	(-2.44)
Risk mgmt involvement x High Experience	1.047	(0.10)	0.700	(-0.68)				
Risk mgmt involvement x Relationship					1.624	(0.49)	1.192	(0.19)
High Experience Dummy	0.931	(-0.34)	0.897	(-0.50)				
Relationship Dummy					0.901	(-0.15)	0.543**	(-2.07)
<b>RATING</b>								
(Rating-CutOff) x Affected	1.083	(0.61)	1.081	(0.92)	1.082	(0.60)	1.084	(0.62)
(Rating-CutOff) x (1-Affected)	1.745*	(1.82)	1.774*	(1.82)	1.740*	(1.84)	1.743*	(1.84)
Other customer controls	Yes		Yes		Yes		Yes	
Other loan controls	Yes		Yes		Yes		Yes	
Region fixed effects	Yes		No		Yes		Yes	
<b>Diagnostics</b>								
Pseudo. R <sup>2</sup> / Adj. R <sup>2</sup>	0.09		0.09		0.09		0.09	
N	4,013		4,013		4,013		4,013	

# Conclusion

- Dual role of risk management and loan officers in a bank's organizational structure
  - It helps to reduce default rates by ~50%
  - Mechanism: Mitigation of agency conflicts within banks (devil's advocat)
- Discussion: Do we need to fix incentives in the one-agent model or move towards a two-agent model?
  - Observation from recent crisis: Biggest losses in areas without 4-eyes-principle (automated lending, trading)

# Appendix

# Functional form

- Functional form: Logit
  - 0/1-dependent variable (Default: yes/no)
  - Effects are likely to be multiplicative, not additive (e.g. improvement in the economy decreases default rates from 10% → 5% and 1% → 0.5% and not from 10% → 9% and 1% → 0%)
- I will show odds-ratio + z-stats
- Interpretation
  - Odds-ratio = 1: No effect on default rates
  - Odds-ratio = 0.4: 60% reduction in default rates for one unit increase in x

$$\frac{\frac{p(x+dx)}{1-p(x+dx)}}{\frac{p(x)}{1-p(x)}} \approx \frac{p(x+dx)}{p(x)} \quad \text{for small } p(x)$$