Managing Duration Gaps: The Role of Interbank Markets*

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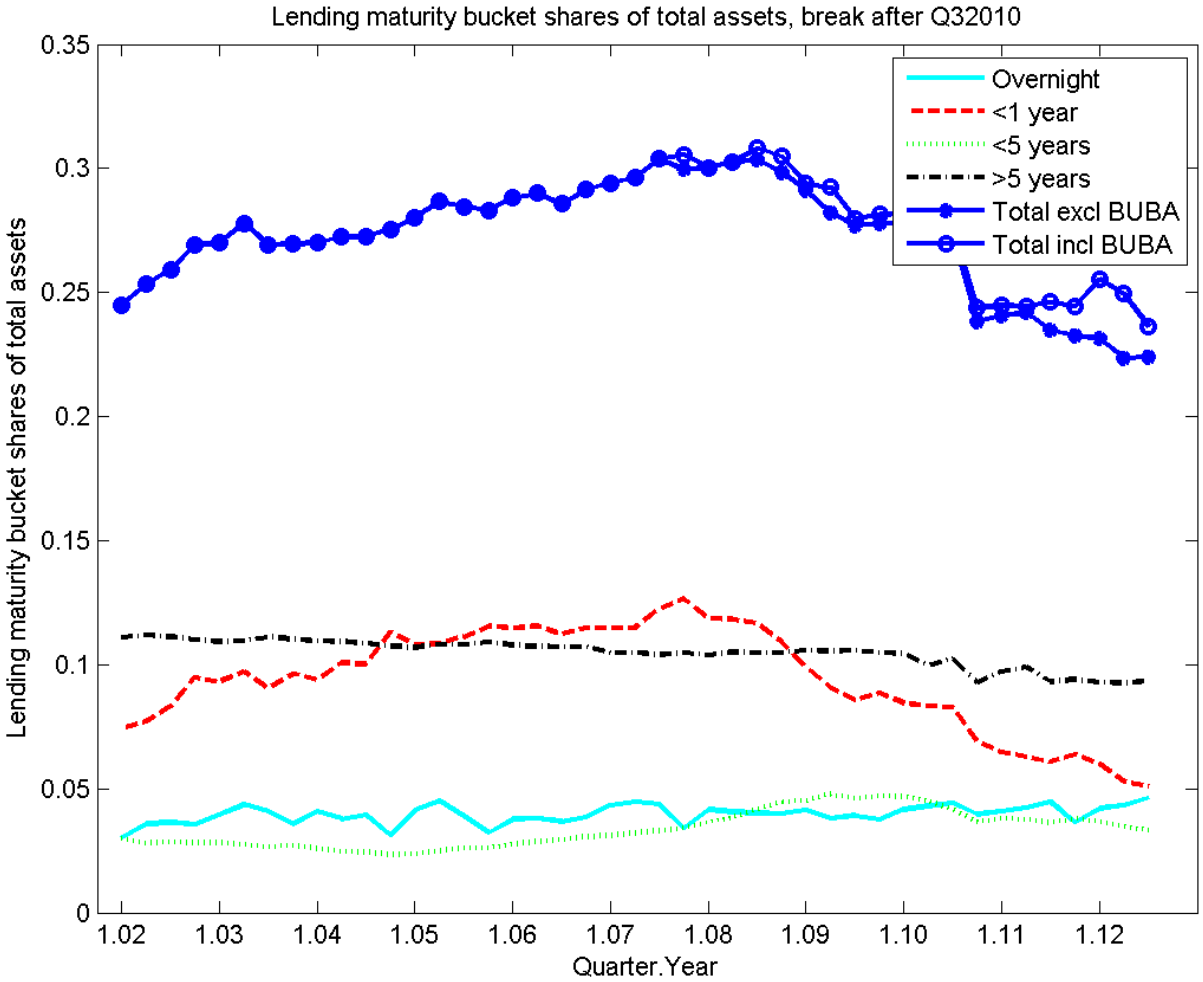
*Joint work with Co-Pierre Georg (University of Cape Town and Deutsche Bundesbank) and Jan-Pieter Krahnen (Goethe University Frankfurt, House of Finance, CFS and CEPR). The views presented are not necessarily the views of the Deutsche Bundesbank or Hong Kong Monetary Authority.

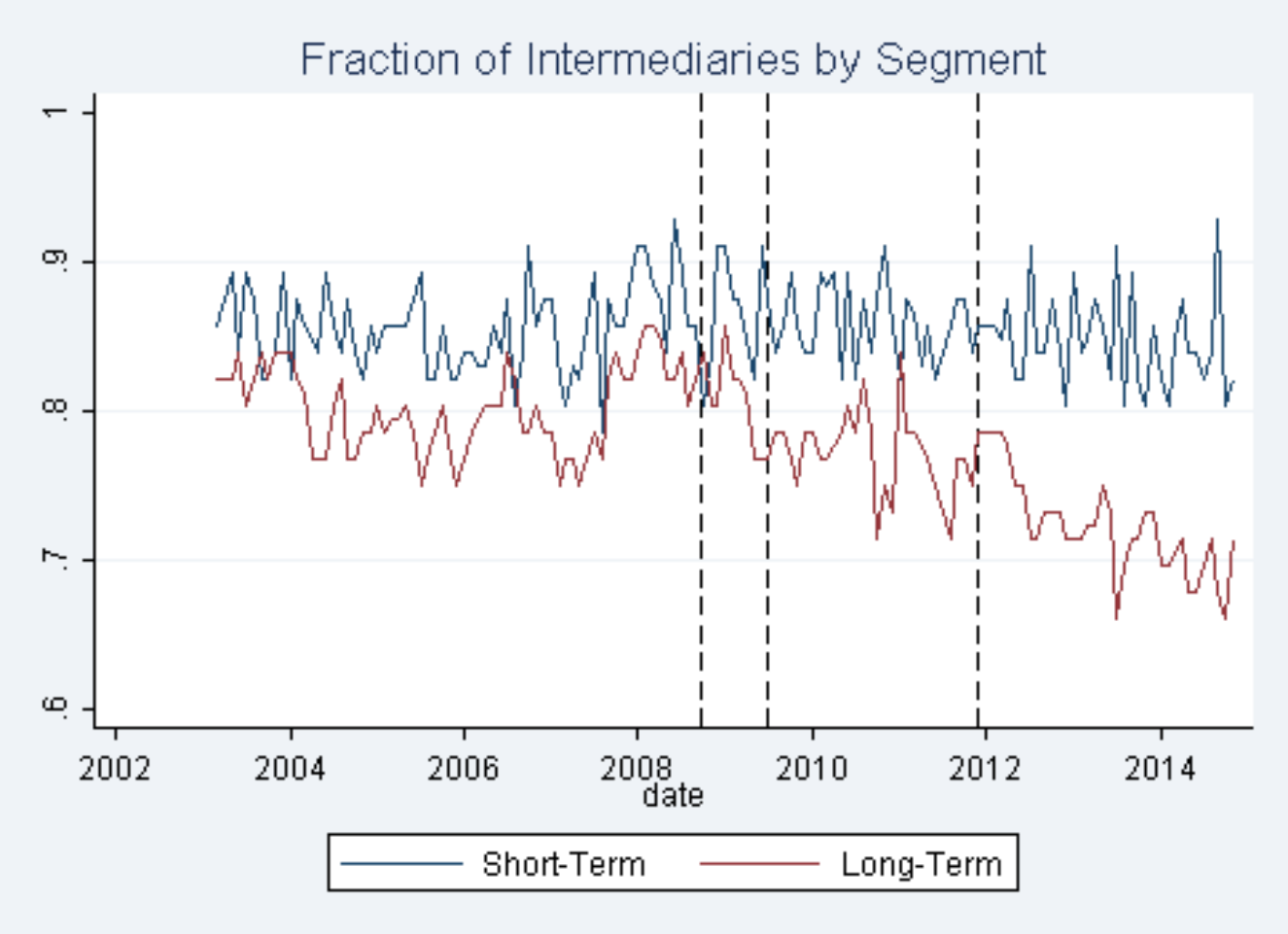
Interbank Market: Size and Maturities



→ Maturities essentially **long-term**

→ Interbank market **very large**

Fraction of Interbank Intermediaries



→Most banks lend and borrow at the same time

Overview

Why do banks fund each other long term?
Why is the interbank market so big?
Why do banks hold interbank assets and liabilities at the same time?

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Findings

- Interbank exposures are large, sparse, long-term, non-netted;
- An **intermediation layer** is "stacked" on top of the household-firm intermediation process;
- Dynamics of interbank exposures suggest a role for **duration gap management**;
- Banks 'offloaded' more **interest rate risk** at the ECB after Lehman bankruptcy.

Agenda

- Hypotheses ←
- Data Set and Analysis
- Conclusion

Embed Analysis in Existing Literature

- Role of interbank markets to insure against adverse **liquidity shocks** (Allen and Gale (2000), Allen, Carletti and Gale (2009), Freixas et al. 2000, Freixas and Jorge (2008)).
  $\rightarrow$ Extend liquidity insurance motive with **maturity dimension**

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  $\rightarrow$ Extend liquidity insurance motive with **maturity dimension**

- Management of **interest rate risk** (Abad et al. (2016), Di Tella and Kurlat (2017), Vuillemey (2016), Vuillemey (2017)) which is the current or prospective risk to the bank's **capital and earnings** arising from **adverse movements in interest rates**.
  $\rightarrow$ Investigate interest rate risk emerging from banks' client and interbank business.

Using Stylized Facts and Extant Theory we Propose Three Hypotheses

H1: Overall innovation in net interbank exposure is driven by concurrent underlying client business.

H2: Overall innovation in net interbank exposure is driven by concurrent underlying client business, primarily in the same maturity bucket.

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H1: Overall innovation in net interbank exposure is driven by concurrent underlying client business.

H2: Overall innovation in net interbank exposure is driven by concurrent underlying client business, primarily in the same maturity bucket.

H3: The interbank book, consisting of borrowing and lending positions, grows over time by accumulating gross interbank exposures towards counterparties rather than netting across existing exposures.

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Data Set

Bundesbank's '**balance sheet statistic**' based on banks' mandatory reporting.

Monthly data from February 2002 to December 2014.

Concentrate on sub-sample of about 100 **commercial banks** (excluding savings and cooperative banking sectors, all results robust if complete dataset is used).

Key variables:

- Short- (overnight) and long-term **interbank** assets and liabilities;
- Short- (overnight) and long-term **deposits**;
- Short- (up to one year) and long-term **loans**.

Empirical Strategy and Results: H2 (Long-Term)

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$$+\text{Controls} + \beta_i + \beta_t + \beta_{iT} + \epsilon_{it} \quad (1)$$

with $\text{Net Liquidity Supply}_{it} = IB^{Lending}_{it} - IB^{Borrowing}_{it}$

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Confirmed if	$\gamma_0 > 0$	$\gamma_0 > \alpha_0$	$\delta_0 < 0$	$\delta_0 < \beta_0$

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Result (normal sample):

Confirmed if	$\gamma_0 > 0$	$\gamma_0 > \alpha_0$	$\delta_0 < 0$	$\delta_0 < \beta_0$
Estimates	$\gamma_0 = 0.49^{***}$	$\alpha_0 = 0.49^{***}$	$\delta_0 = -0.84^{***}$	$\beta_0 = -0.29^{***}$
	✓		✓	✓

Results: H2

LT liquidity shocks affect banks' LT interbank exposure (Q1✓):

- Increase in LT business loans **reduces net liquidity supply** to interbank market
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Banks following strategy 1 rather than 2 can provide answers to Q2 and Q3.
$\rightarrow$ Split up regression framework into system of seemingly unrelated equations to investigate H3.

Empirical Strategy and Results: H3

Hypothesis:
The interbank book grows over time by accumulating gross interbank exposures towards counterparties rather than netting existing exposures.

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$$\frac{\Delta(\text{Gross Interbank Assets})_{it}^{LT}}{\text{Assets}_{i,t-1}} = \sum_{j=0}^{12} \alpha_j \frac{\Delta\text{Deposits}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} + \sum_{j=0}^{12} \beta_j \frac{\Delta\text{Loans}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} + \text{Controls} + \beta_i + \beta_t + \beta_{iT} + \epsilon_{it} \quad (2)$$

$$\frac{\Delta(\text{Gross Interbank Liabilities})_{it}^{LT}}{\text{Assets}_{i,t-1}} = \sum_{j=0}^{12} \gamma_j \frac{\Delta\text{Deposits}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} + \sum_{j=0}^{12} \delta_j \frac{\Delta\text{Loans}_{i,t-j}^{LT}}{\text{Assets}_{i,t-j-1}} + \text{Controls} + \beta_i + \beta_t + \beta_{iT} + \epsilon_{it} \quad (3)$$

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Estimates	$\alpha_0 = 0.33^{***}$	$\gamma_0 = -0.12^{***}$	$\delta_0 = 0.85^{***}$	$\beta_0 = 0.02$
	✓	✓	✓	✓

Findings Consistent with Banks Limiting Duration Gaps

- Results from H2 are consistent with a banking strategy aiming at limiting **maturity mismatches** across time bands;
- Banks follow this strategy in their asset liability management to control **investment risks** and to fulfill regulatory requirements:
  - "...vast majority of credit institutions use maturity mismatch approaches [for liquidity management]: i.e., models that compare cash inflows and outflows for different time horizons in order to calculate net funding requirements, which are then used to set liquidity limits." †
  - "Policies [for liquidity management] should reflect the board's tolerance for risk [...]. Typical risk guidelines include [...] targeted cash flow gaps over discrete and cumulative periods and under expected and adverse business conditions." ‡

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What was the effect of the global financial crisis (GFC) on role of interbank market to manage maturity mismatch emerging from client book?

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Impact of GFC on Interbank Market's Role to Limit Maturity Mismatch

Hypothesis	H1		H2 (ST)		H2 (LT)		H3	
Sample	N	C	N	C	N	C	N	C
α	0.91 ***	0.76 ***	0.8 ***	0.36 ***	0.49 ***	0.22 ***	0.33 ***	0.18 ***
β	-0.93 ***	-0.78 ***	- 0.71 ***	- 0.43 ***	- 0.29 ***	- 0.18 ***	0.02	0.01
γ	NA	NA	0.66 ***	0.29 ***	0.49 ***	0.20 ***	- 0.12 ***	- 0.03
δ	NA	NA	- 0.70 ***	- 0.19	- 0.84 ***	- 0.05	0.85 ***	0.04

- Effects of client book on interbank book **significantly smaller** after Lehman;
- Results indicate **reduced role of interbank market** for managing maturity mismatches after Lehman event;
- In the following, we further investigate the role of client book, interbank book, and central bank book on banks' **maturity mismatch**.

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- Basel Committee on Banking Supervision (2016) uses related concept to investigate effect of changes in interest rates on banks **economic value of equity**.
- We compute **modified duration** of assets and liabilities in **client book**, **interbank book**, and **central bank book** to investigate changes in interest rates on equity.

Duration Gap as Measure for Interest Rate Risk

Percent change in banks' equity from a percentage point increase in interest rates can be approximated by

$$\frac{\Delta Equity}{Equity} \approx \frac{(\sum Assets \cdot MD^A - \sum Liabilities \cdot MD^L)}{Equity} \Delta i$$

where

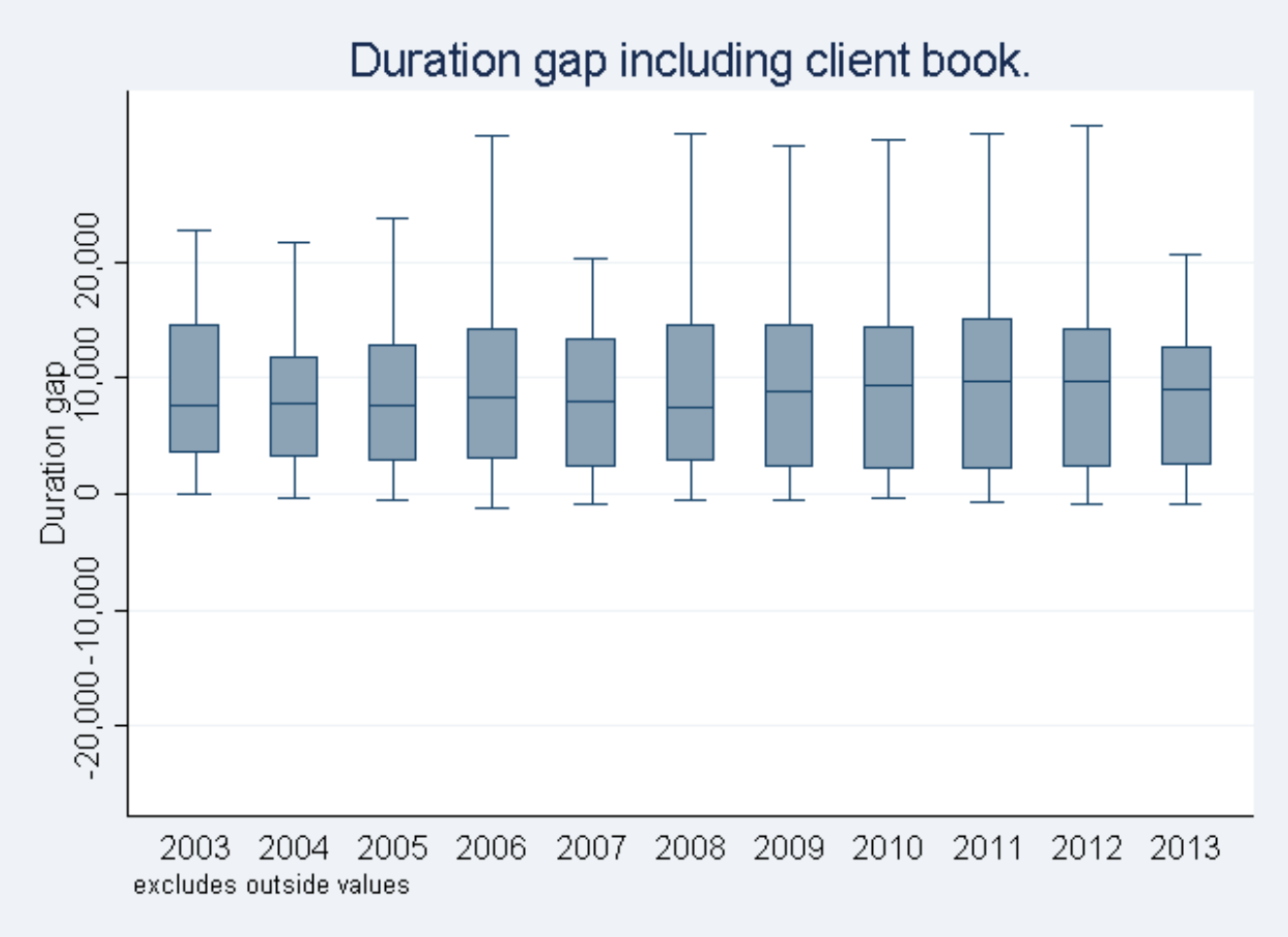
$$MD^A = \frac{\sum_j (MFIAssets_t^j \cdot \omega_1^j + NonMFIAssets_t^j \cdot \omega_2^j)}{\sum_j (MFIAssets_t^j + NonMFIAssets_t^j)}$$

and

$$MD^L = \frac{\sum_j (MFILiab_t^j \cdot \omega_3^j + NonMFILiab_t^j \cdot \omega_4^j)}{\sum_j (MFILiab_t^j + NonMFILiab_t^j)}$$

are the **modified duration** of assets and liabilities of interbank (MFI) and client (NonMFI) books, respectively, and the ω weights are maturities of the respective positions.

Banks' Duration Gap in Client Book Over Time



$\rightarrow$ On average, an increase in interest rates by one percentage point would decrease banks' equity by 27 X 0.01=27%, if client book is considered in isolation.

Management of Interest Rate Risk: Interbank, Client, and Central Bank

Time	Moment	IB Book	C Book	IB+C Books	IB+C+CB Books
2004-2006	Mean	-6.80	26.18	19.38	12.46
	Std	13.30	24.09	16.02	16.72
2007-2009	Mean	-6.95	26.74	19.78	12.57
	Std	13.49	24.87	17.18	18.09
2010-2011	Mean	-7.04	27.56	20.52	13.17
	Std	12.36	24.67	17.65	17.71
2012-2014	Mean	-6.58	26.52	19.94	12.82
	Std	11.28	24.96	17.63	15.71

where: IB = interbank; C = Client; CB = Central Bank

- Interest risk exposure is more than halved by interbank plus central bank books

Impact of Central Bank Book on Banks' Duration Gap After Lehman

- To assess impact of central bank's non-standard monetary policy we carry out two sets of regressions:
  1. $DG_{it}^{client+ib} = const + \alpha_i + Lehman + \epsilon_{it}$
  2. $DG_{it}^{client+ib+cb} = const + \alpha_i + Lehman + \epsilon_{it}$

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  2. $DG_{it}^{client+ib+cb} = const + \alpha_i + Lehman + \epsilon_{it}$
- Result: While in regression (1) the dummy is insignificant, it turns **significantly negative** in regression (2), indicating that banks 'offloaded' more interest rate risk at the central bank after the Lehman bankruptcy.

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  Why is the interbank market so big?
  $\rightarrow$Banks **buffer** sequentially opposing **LT liquidity shocks** via taking **offsetting** LT interbank positions rather than netting existing positions (H3).

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  $\rightarrow$Banks use interbank market as insurance mechanism against **LT liquidity shocks** (H2).
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  $\rightarrow$Banks **buffer** sequentially opposing **LT liquidity shocks** via taking **offsetting** LT interbank positions rather than netting existing positions (H3).
- Interbank book reflects client book, inversely.
- Interbank markets allow banks to actively manage term structure risk (inherited from client book).
- After Lehman default banks offloaded interest rate risk at the central bank.

References

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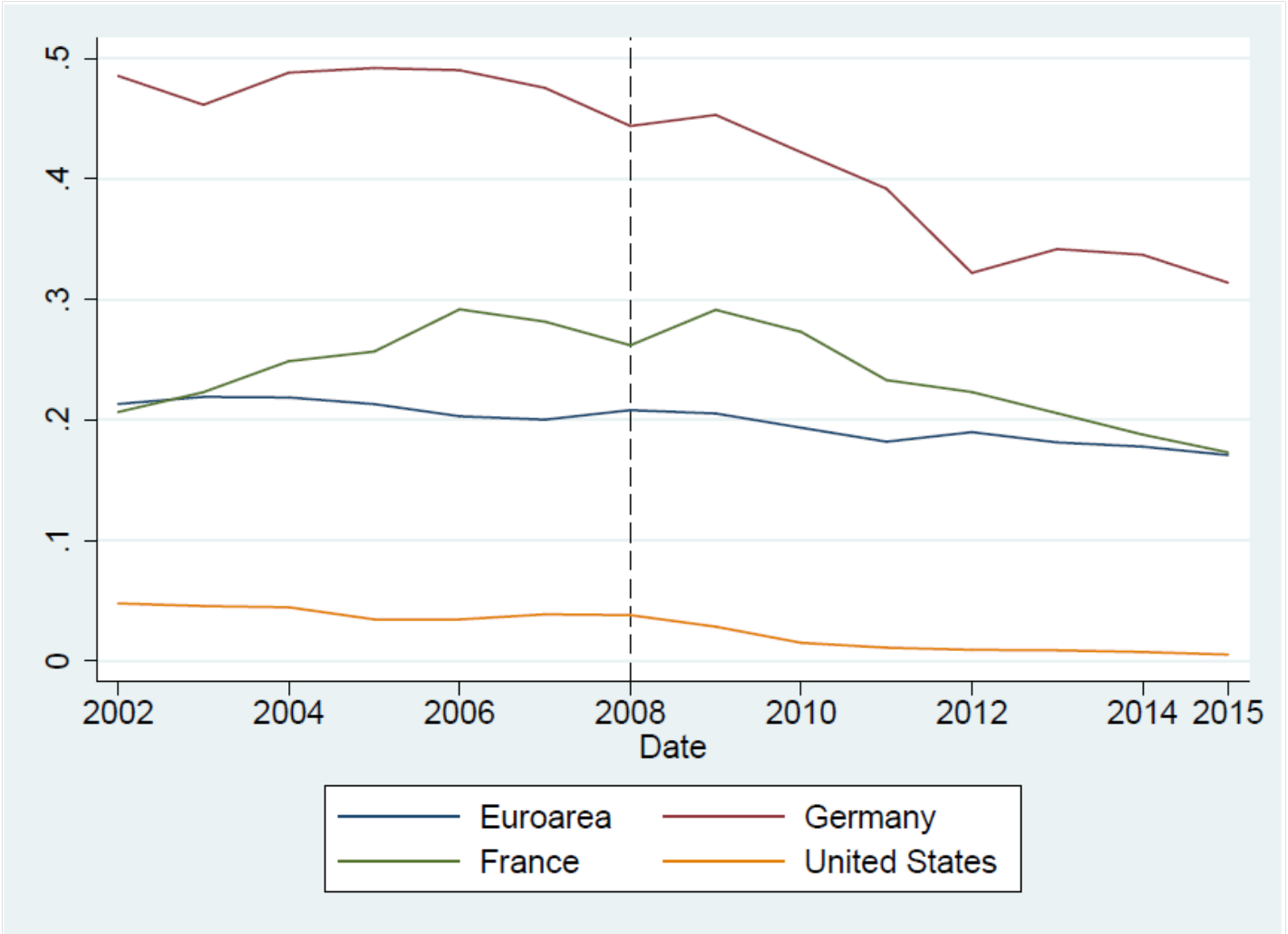
Ratio of Interbank Assets to Total Assets



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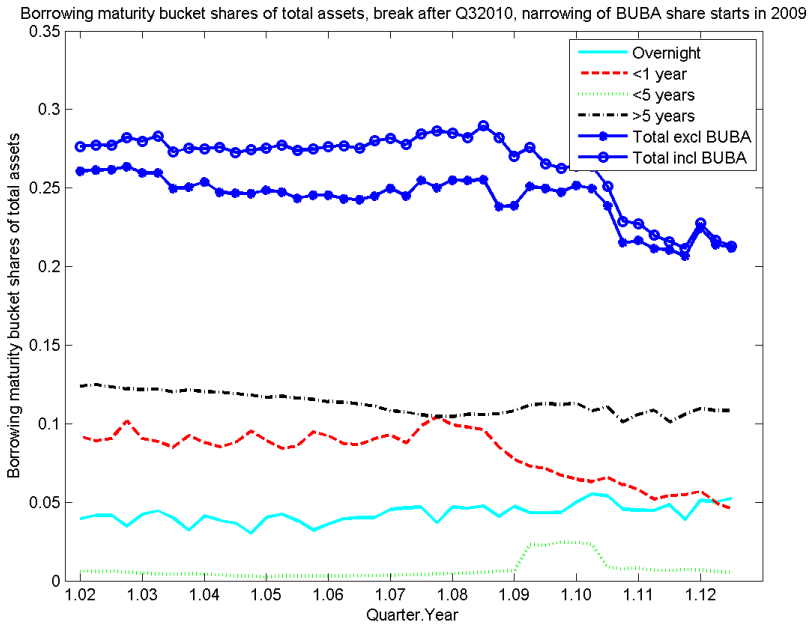
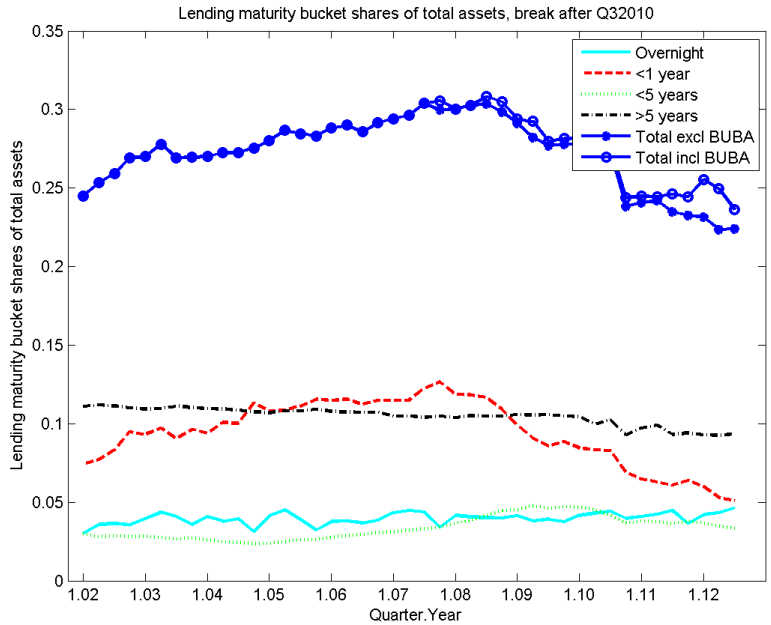
Interbank Maturities Essentially Long-Term





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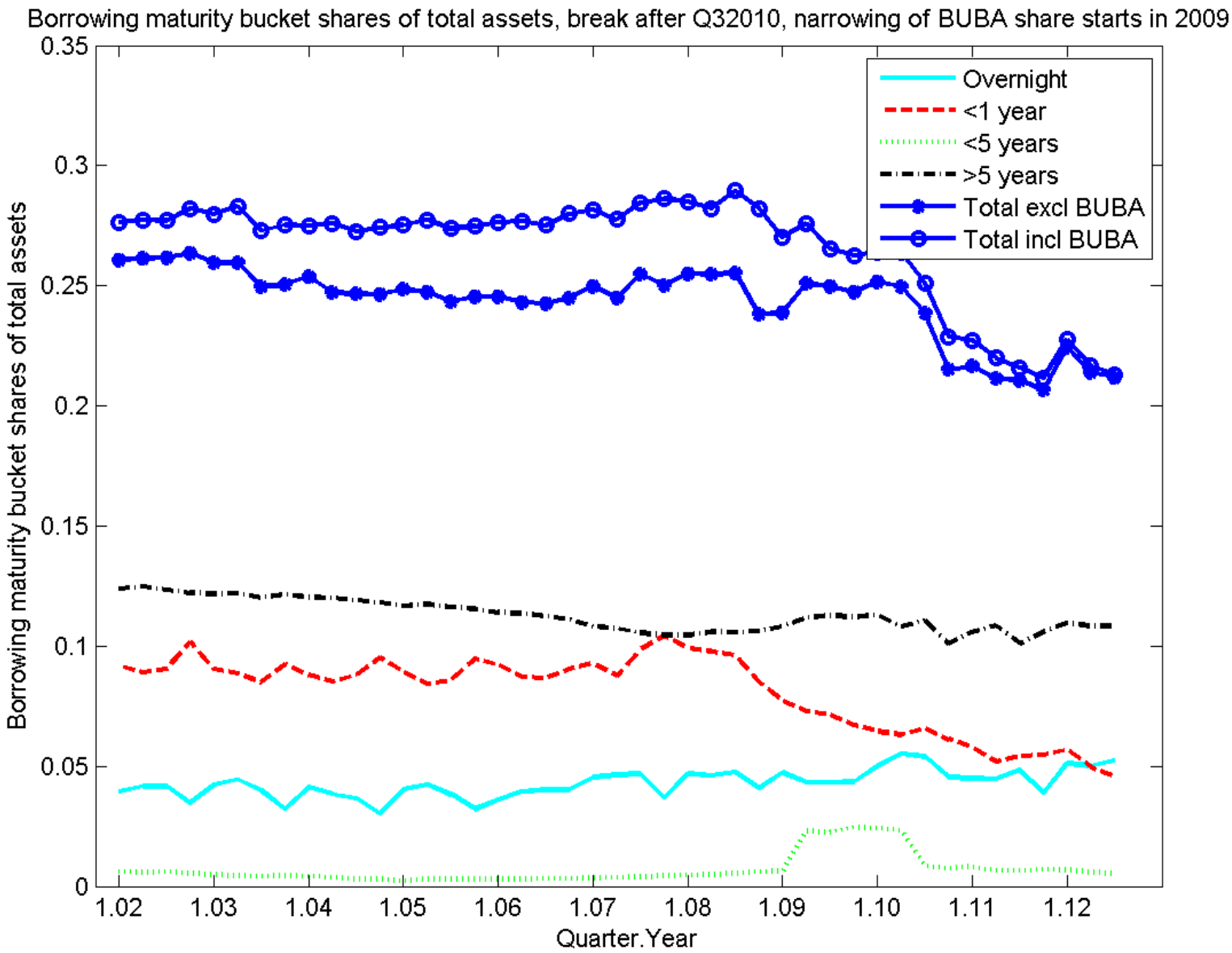

Empirical Strategy and Results: H1

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Result (normal sample):

Confirmed if	$\alpha_0 > 0$ (✓)	$\beta_0 < 0$ (✓)
Estimates	$\alpha_0 = 0.91^{***}$	$\beta_0 = -0.93^{***}$

Empirical Strategy and Results: H1

Dependent variable: $\frac{\Delta(\text{Net Liquidity Supply})_{it}}{\text{Assets}_{i,t-1}}$

	Full Sample			Normal Sample			Crisis Sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ Loans	−0.859***	−0.864***	−0.874***	−0.914***	−0.924***	−0.931***	−0.750***	−0.758***	−0.781***
	(0.0500)	(0.0500)	(0.0522)	(0.0253)	(0.0269)	(0.0310)	(0.0798)	(0.0804)	(0.0823)
Δ Deposits	0.831***	0.836***	0.847***	0.913***	0.906***	0.908***	0.724***	0.735***	0.756***
	(0.0463)	(0.0455)	(0.0460)	(0.0265)	(0.0272)	(0.0298)	(0.0732)	(0.0749)	(0.0776)
Δ Central Bank Assets	0.194***	0.187***	0.160**	0.204*	0.144	0.111	0.238**	0.225**	0.197**
	(0.0712)	(0.0712)	(0.0647)	(0.116)	(0.128)	(0.163)	(0.0958)	(0.0962)	(0.0883)
Δ Central Bank Liabilities	−0.213***	−0.199***	−0.152***	−0.167**	−0.141**	−0.115	−0.275***	−0.269***	−0.208***
	(0.0546)	(0.0520)	(0.0454)	(0.0696)	(0.0658)	(0.0701)	(0.0572)	(0.0551)	(0.0516)
Constant	0.00267	0.00284	0.00653*	0.00230	0.00248	0.00406	−0.00319	−0.00353	−0.00176
	(0.00315)	(0.00322)	(0.00352)	(0.00285)	(0.00312)	(0.00383)	(0.00240)	(0.00239)	(0.00225)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Lags Included	12	12	12	12	12	12	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month Fixed-Effects	No	Yes	No	No	Yes	No	No	Yes	No
Bank×Year Fixed-Effects	No	No	Yes	No	No	Yes	No	No	Yes
N	7810	7810	7810	3740	3740	3740	4070	4070	4070
R^2	0.761	0.753	0.766	0.837	0.829	0.835	0.683	0.673	0.696

Empirical Strategy and Results: H2 (Short-Term)

Hypothesis:
Overall innovation in net interbank exposure is driven by underlying client business, primarily in the same maturity bucket.

Empirical Strategy:

$$\frac{\Delta(\text{Net Liquidity Supply})^{ST}_{it}}{\text{Assets}_{i,t-1}} = \sum_{j=0}^{12} \alpha_j \frac{\Delta\text{Deposits}^{ST}_{i,t-j}}{\text{Assets}_{i,t-j-1}} + \sum_{j=0}^{12} \beta_j \frac{\Delta\text{Loans}^{ST}_{i,t-j}}{\text{Assets}_{i,t-j-1}} + \sum_{j=0}^{12} \gamma_j \frac{\Delta\text{Deposits}^{LT}_{i,t-j}}{\text{Assets}_{i,t-j-1}} + \sum_{j=0}^{12} \delta_j \frac{\Delta\text{Loans}^{LT}_{i,t-j}}{\text{Assets}_{i,t-j-1}} + \text{Controls} + \beta_i + \beta_t + \beta_{iT} + \epsilon_{it} \quad (4)$$

Result (normal sample):

Confirmed if	$\alpha_0 > 0$ (✓)	$\alpha_0 > \gamma_0$	$\beta_0 < 0$ (✓)	$\beta_0 < \delta_0$
Estimates	$\alpha_0 = 0.8^{***}$	$\gamma_0 = 0.66^{***}$	$\beta_0 = -0.71^{***}$	$\delta_0 = -0.7^{***}$

Empirical Strategy and Results: H2 (Short-Term)

Dependent variable: $\frac{\Delta(\text{Net Liquidity Supply})^{ST}_{it}}{\text{Assets}_{i,t-1}}$

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Long-term net Interbank Lending	−0.598***	−0.702***	−0.574***
	(0.0830)	(0.0591)	(0.104)
Δ Short-term Loans	−0.560***	−0.709***	−0.429***
	(0.111)	(0.0575)	(0.133)
Δ Long-term Loans	−0.485***	−0.696***	−0.194
	(0.149)	(0.0537)	(0.139)
Δ Short-term Deposits	0.621***	0.801***	0.364***
	(0.107)	(0.0689)	(0.117)
Δ Long-term Deposits	0.391***	0.657***	0.290***
	(0.0772)	(0.126)	(0.0753)
Δ Central Bank Assets	−0.244*	−0.703***	−0.154
	(0.128)	(0.195)	(0.100)
Δ Central Bank Liabilities	0.382***	0.497***	0.256**
	(0.0997)	(0.0899)	(0.114)
Constant	−0.00277	−0.00799	−0.000533
	(0.00405)	(0.00486)	(0.00270)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes
Month Fixed-Effects	Yes	Yes	Yes
Bank×Year Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4070
R^2 (overall)	0.651	0.757	0.602

Empirical Strategy and Results: H2 (Long-Term)

Dependent variable: $\frac{\Delta(\text{Net Liquidity Supply})^{LT}_{it}}{\text{Assets}_{i,t-1}}$

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Short-term net Interbank Lending	−0.253***	−0.225***	−0.318***
	(0.0411)	(0.0552)	(0.0471)
Δ Short-term Loans	−0.222***	−0.288***	−0.181***
	(0.0585)	(0.0685)	(0.0563)
Δ Long-term Loans	−0.536**	−0.840***	−0.0484
	(0.233)	(0.0725)	(0.0363)
Δ Short-term Deposits	0.416***	0.493***	0.224***
	(0.110)	(0.153)	(0.0372)
Δ Long-term Deposits	0.304***	0.485***	0.202***
	(0.0788)	(0.122)	(0.0612)
Δ Central Bank Assets	−0.102*	−0.470***	−0.0798
	(0.0569)	(0.137)	(0.0553)
Δ Central Bank Liabilities	0.280**	0.428***	0.170**
	(0.123)	(0.146)	(0.0765)
Constant	−0.00268	−0.00809	−0.00423
	(0.00367)	(0.00573)	(0.00264)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes
Month Fixed-Effects	Yes	Yes	Yes
Bank×Year Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4070
R^2 (overall)	0.439	0.583	0.382

Empirical Strategy and Results: H3 (Lending)

Dependent variable: $\frac{\Delta(\text{Gross Interbank Assets})^{LT}_{it}}{\text{Assets}_{i,t-1}}$

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Short-term Interbank Assets	−0.220***	−0.186***	−0.287***
	(0.0441)	(0.0506)	(0.0528)
Δ Short-term Loans	−0.197***	−0.232***	−0.161***
	(0.0538)	(0.0631)	(0.0565)
Δ Long-term Loans	−0.00592	0.0153	0.00949
	(0.0211)	(0.0340)	(0.0262)
Δ Short-term Deposits	0.371***	0.462***	0.214***
	(0.117)	(0.155)	(0.0378)
Δ Long-term Deposits	0.236***	0.334***	0.176***
	(0.0618)	(0.117)	(0.0537)
Δ Central Bank Assets	−0.0989**	−0.402**	−0.0785
	(0.0491)	(0.158)	(0.0488)
Δ Central Bank Liabilities	0.239**	0.385**	0.111**
	(0.121)	(0.161)	(0.0545)
Constant	−0.000925	−0.00105	−0.00675**
	(0.00331)	(0.00483)	(0.00278)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes
Month Fixed-Effects	Yes	Yes	Yes
Bank×Year Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4070
R^2 (overall)	0.388	0.475	0.371

Empirical Strategy and Results: H3 (Borrowing)

Dependent variable: $\frac{\Delta(\text{Gross Interbank Liabilities})_{it}^{LT}}{\text{Assets}_{i,t-1}}$

	Full Sample	Normal Sample	Crisis Sample
	(1)	(2)	(3)
Δ Short-term Interbank Liabilities	−0.0302	−0.0832	−0.00978
	(0.0385)	(0.0518)	(0.0207)
Δ Short-term Loans	0.0151	0.0445**	0.00845
	(0.0162)	(0.0207)	(0.00640)
Δ Long-term Loans	0.517**	0.845***	0.0428
	(0.248)	(0.101)	(0.0275)
Δ Short-term Deposits	−0.0353*	−0.0125	−0.0189
	(0.0205)	(0.00828)	(0.0158)
Δ Long-term Deposits	−0.0640*	−0.119***	−0.0253
	(0.0365)	(0.0370)	(0.0245)
Δ Central Bank Assets	0.00132	0.0496	−0.00106
	(0.00749)	(0.0612)	(0.00567)
Δ Central Bank Liabilities	−0.0313	−0.0349	−0.0458
	(0.0344)	(0.0233)	(0.0431)
Constant	0.00186	0.00659**	−0.00247*
	(0.00232)	(0.00264)	(0.00127)
Controls	Yes	Yes	Yes
Number of Lags Included	12	12	12
Bank Fixed-Effects	Yes	Yes	Yes
Month Fixed-Effects	Yes	Yes	Yes
Bank×Year Fixed-Effects	Yes	Yes	Yes
N	7810	3740	4070
R^2 (observed)	0.523	0.783	0.264

Impact of Central Bank on Banks' Duration Gap After Lehman

Dependent Variables:	$DG^{Client+Interbank}$	$DG^{Client+Interbank+CentralBank}$
Constant	6.313^{***}	6.817^{***}
Lehman Dummy	-0.247	-1.076^{***}
N	1950	1950
R^2	0.912	0.901

Macaulay Duration and Modified Duration

- **Macaulay duration** of an asset which consists of fixed cash flows is the weighted average maturity of cash flows:

  $MacD = \frac{\sum_{i=1}^{n} t_i PV_i}{\sum_{i=1}^{n} PV_i}$

  with
  - PV_i the present value of the ith cash payment from an asset;
  - t_i time in years until the ith payment is received.
- **Modified duration** is the percentage derivative of price with respect to yield.
- If an asset's yield is continuously compounded, modified duration is equal to the Macaulay duration.