EUROPEAN CENTRAL BANK
EUROSYSTEM

Work in progress

In search of macroprudential policy effectiveness

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Session 2: Macroprudential regulation

Sixth Brunel Banking Conference

BANK REGULATION, PERFORMANCE AND STABILITY - FACING GLOBAL CHALLENGES PERFORMANCE
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Outline

Introduction and motivation

Systematic searching of literature

Treatment of interaction variables

How does macroprudential policy effect bank resilience?

Conclusions

What do we know about the effectiveness of macroprudential policy?

- Araujo et al. (2020):
  - Significant effects on credit: Larger effects found in studies using micro-level data compared to those using macro-level data.
  - Heterogeneity across countries: effects tend to be stronger in emerging markets, although these come with larger confidence intervals.
  - Impact on economic activity: Tightening of macroprudential policy has a negative impact on economic activity in the near term.
  - Effects of Different Tools: Different macroprudential tools have varying impacts, e.g. tightening loan-to-value (LTV) or debt-service-to-income (DSTI) ratios has significant effects on reducing household credit, but effects on house prices are weaker and more imprecise.

What do we know about the effectiveness of macroprudential policy?

- Malovaná et al. (2022):
  - **Borrower-based measures have significant impact on credit:** loan-to-value (LTV), debt-to-income (DTI), and debt service-to-income (DSTI) limits, can lower credit growth, with stronger effects when multiple measures are applied simultaneously.
  - **Strong evidence of publication bias found:** researchers show a preference for reporting negative and significant estimates while under-reporting positive or non-significant results. This bias inflates the perceived effectiveness of borrower-based measures in reducing credit growth.
  - **Heterogeneity in Estimates:** differences in estimated effects are primarily explained by model specification, estimation method, and underlying data characteristics.

What do we know about the effectiveness of macroprudential policy?

- Malovaná et al. (2023):
  - **Variable Impact of bank capital on lending:** Increasing the simple capital-to-asset ratio positively influences annual credit growth, while raising capital requirements negatively impacts lending, with a significant publication bias found in the latter.
  - **Heterogeneity and influencing factors:** substantial variability in estimates found, explained by differences in data, model specifications, and macroeconomic conditions, with more positive effects on corporate credit compared to household or total credit.
  - **Policy and low Interest Rates:** The relationship between bank capital and lending weakens during periods of low interest rates, underscoring the need for carefully crafted capital regulations to ensure a balance between financial stability and credit availability.

And, what don't we know about the effectiveness of macroprudential policy?

- It is unclear whether commonly-accepted literature searching practices could be a source of bias in meta-regression analysis
- Meta-regression analysts often discard estimates of effects conditioned on interaction variables
- All three of these meta-regression studies collected data on the effectiveness of macroprudential policy through 2020, and the literature has exploded since then (more on this later)
- More is known about the financial-cycle moderating impacts of macroprudential policy than the resilience-enhancing aspects

Typical search syntax used for meta-studies

Araujo et al. (2020):
"Effectiveness of macroprudential policies" [also replacing "effectiveness" with "effect" and "impact"

Malovaná et al. (2022):
"LTV" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "loan-to-value" OR "loan-to-income" OR "debt-service-to-income" OR "debt-to-income" AND "lending" OR "credit" "loans"

Malovaná et al. (2023):
"bank capital regulation" OR "capital requirements" OR "bank capital" OR "capitalsurplus" OR "capital ratio" OR "macroprudential regulation" OR "macroprudential policy" AND "lending" OR "credit" OR "loans"

Subsequent screening considered 300-500 studies, but how many hits did Google Scholar produce?

Systematic searching of literature

Google Scholar search syntax used in previous metaregression studies and their equivalents in Web of Science and SCOPUS

	Google Scholar	Web of Science	SCOPUS
APPVY1	"Effectiveness of macroprudential policies" (4, 41)	TS=("Effectiveness of macroprudential policies")	TITLE-ABS-KEY("Effectiveness of macroprudential policies")
APPVY1B	"Effectiveness" AND "macroprudential policies" (4, 46)	TS=("Effectiveness" AND "macroprudential policies")	TITLE-ABS-KEY("Effectiveness" AND "macroprudential policies")
APPVY2	"Effect of macroprudential policies" (4, 35)	"Effect of macroprudential policies"	TITLE-ABS-KEY("Effect of macroprudential policies")
APPVY2B	"Effect" AND "macroprudential policies" (4, 39)	TS=("Effect" AND "macroprudential policies")	TITLE-ABS-KEY("Effect" AND "macroprudential policies")
APPVY3	"Impact of macroprudential policies" (4, 35)	TS=("Impact of macroprudential policies")	TITLE-ABS-KEY("Impact of macroprudential policies")
APPVY3B	"Impact" AND macroprudential policies" (4, 39)	TS=("Impact" AND macroprudential policies")	TITLE-ABS-KEY("Impact" AND "macroprudential policies")
APPVY4B	"Macroprudential policies" AND ("Effectiveness" OR "Effect" OR "Impact") (8,71)	TS=("Macroprudential policies") AND TS=("Effectiveness" OR "Effect" OR "Impact")	TITLE-ABS-KEY("Macroprudential policies") AND (TITLE-ABS-KEY("Effectiveness") OR TITLE-ABS-KEY("Effect") OR TITLE-ABS-KEY("Impact"))
MHBG21	"bank capital regulation" OR "capital requirements" OR "bank capital" OR "capital surplus" OR "capital ratio" OR "macroprudential regulation" OR "macroprudential policy" AND "lending" OR "credit" OR "loans"	TS=("bank capital regulation" OR "capital requirements" OR "bank capital" OR "capital surplus" OR "capital ratio" OR "macroprudential regulation" OR "macroprudential policy") AND TS=("lending" OR "credit" OR "loans")	TITLE-ABS-KEY("bank capital regulation" OR "capital requirements" OR "bank capital" OR "capital surplus" OR "capital ratio" OR "macroprudential regulation" OR "macroprudential policy") AND (TITLE-ABS-KEY("lending" OR "credit" OR "loans"))
MHGB22	"LTV" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "loan-to-value" OR "loan-to-income" OR "debt-service-to-income" OR "debt-to-income" AND "lending" OR "credit" "loans"	TS=("LTV" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "loan-to-value" OR "loan-to-income" OR "debt-service-to-income" OR "debt-to-income") AND TS=("lending" OR "credit" OR "loans")	TITLE-ABS-KEY("LTV" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "loan-to-value" OR "loan-to-income" OR "debt-service-to-income" OR "debt-to-income") AND (TITLE-ABS-KEY("lending" OR "credit" OR "loans"))
MHBG21 + MHGB22	("macroprudential policy" OR "loan-to-value" OR "LTV" OR "capital requirements" OR "bank capital" OR "macroprudential regulation" OR "debt-to-income" OR "debt-service-to-income" OR "bank capital regulation" OR "capital ratio" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "capital surplus" OR "loan-to-income") AND ("credit" OR "lending" OR "loans")	TS=("macroprudential policy" OR "loan-to-value" OR "LTV" OR "capital requirements" OR "bank capital" OR "macroprudential regulation" OR "debt-to-income" OR "debt-service-to-income" OR "bank capital regulation" OR "capital ratio" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "capital surplus" OR "loan-to-income") AND TS=("credit" OR "lending" OR "loans")	TITLE-ABS-KEY("macroprudential policy" OR "loan-to-value" OR "LTV" OR "capital requirements" OR "bank capital" OR "macroprudential regulation" OR "debt-to-income" OR "debt-service-to-income" OR "bank capital regulation" OR "capital ratio" OR "LTI" OR "DSTI" OR "DTI" OR "borrower-based" OR "capital surplus" OR "loan-to-income") AND (TITLE-ABS-KEY("credit" OR "lending" OR "loans"))

Number of studies identified by earlier meta-researchers with search syntax used in previous meta-regression studies: 65 studies in total

	# of 65 studies	(words, characters)	Google Scholar		Web of Science		SCOPUS	
			to 2020*	All	to 2020*	All	to 2020*	All
APPVY1	-	(4, 41)	964	1780	11	23	23	45
APPVY1B	10	(4, 46)	4370	7440	44	86	93	170
APPVY2	-	(4, 35)	132	312	82	8	22	57
APPVY2B	19	(4, 39)	6380	11000	35	86	195	416
APPVY3	-	(4, 35)	311	674	8	21	15	45
APPVY3B	11	(4, 39)	6800	11700	59	123	146	308
APPVY4B	21	(8, 71)	7510	12800	102	221	313	633
MHBG21	46	(27, 210)	18200	19000	1074	1836	1328	2399
MHGB22	33	(23, 281)	18000	128000	292	490	436	813
MHBG21 + MHGB22	55	(45, 353)	775000	2070000	1824	2194	1655	3033

*The time search window for MHBG21 and MHGB22 is 2010 to 2020, inclusive.

Analysis of language used in studies of macroprudential policy effectiveness: Titles

	Key parameters		Double-check						
	# of unique words/terr	230	230						
	Total # of words/terms	509	509	Rank		Total-to-	% of words		
				Average	Weighted	unique ratio	Total	Unique	Ratio
	New categories								
1	Macroprudential policy						**15.72%**	**19.13%**	0.82
1.A	General			94	37	3.55	7.66%	4.78%	1.60
1.B	Specific			119	102	1.24	8.06%	14.35%	0.56
2	Policy objective						**7.86%**	**13.91%**	0.56
2.A	General			175	175	1.00	1.96%	4.35%	0.45
2.B	Specific			123	98	1.36	5.89%	9.57%	0.62
3	Effectiveness						**9.04%**	**9.57%**	0.94
3.A	General			134	134	1.00	0.98%	2.17%	0.45
3.B	Specific			99	53	2.41	8.06%	7.39%	1.09
4	Empirical study						**14.73%**	**21.74%**	0.68
4.A	General			111	53	2.46	6.29%	5.65%	1.11
4.B	Unit of analysis			94	79	1.27	2.75%	4.78%	0.58
4.C	Data type			102	102	1.00	0.59%	1.30%	0.45
4.D	Specific methodology			152	152	1.00	0.59%	1.30%	0.45
4.E	Region/Country			127	118	1.15	4.52%	8.70%	0.52
5	Other relevant			163	152	1.10	**2.16%**	**4.35%**	0.50
6	Monetary policy			42	39	2.50	**0.98%**	**0.87%**	1.13
7	Stopwords			74	16	7.07	**40.28%**	**12.61%**	3.19
8	Dates, numbers, etc.			61	56	1.17	**1.38%**	**2.61%**	0.53
9	Words having low discriminatory power			138	125	1.14	**7.86%**	**15.22%**	0.52
Memo	Useful words/terms						50.49%	69.57%	
	Number of words/terms						509	230	
	Category where words are used frequently								
							100.00%	100.00%	
	Titles reveal information on		Macroprudential policy	Keywords reveal information on			Macroprudential policy		
			Effectivenesss				Policy objective		
			Empirical study				Monetary policy		
			Monetary policy						
	Value-added								

Analysis of language used in studies of macroprudential policy effectiveness: Key words

	Key parameters		Double-check						
	# of unique words	146	146						
	Total # of words	274	274						
				Rank		Total-to-	% of words		
				Average	Weighted	unique ratio	Total	Unique	Ratio
	New categories								
1	Macroprudential policy						**37.23%**	**29.45%**	1.26
1.A	General			75	17	5.10	18.61%	6.85%	2.72
1.B	Specific			69	50	1.55	18.61%	22.60%	0.82
2	Policy objective						**32.12%**	**30.14%**	1.07
2.A	General			50	30	2.18	8.76%	7.53%	1.16
2.B	Specific			69	42	1.94	23.36%	22.60%	1.03
3	Effectiveness						**3.65%**	**4.11%**	0.89
3.A	General			67	67	1.00	0.36%	0.68%	0.53
3.B	Specific			84	56	1.80	3.28%	3.42%	0.96
4	Empirical study						**15.33%**	**22.60%**	0.68
4.A	General			118	118	1.00	1.09%	2.05%	0.53
4.B	Unit of analysis			71	61	1.25	1.82%	2.74%	0.67
4.C	Data type			46	39	1.50	2.19%	2.74%	0.80
4.D	Specific methodology			86	74	1.33	7.30%	10.27%	0.71
4.E	Region/Country			84	77	1.14	2.92%	4.79%	0.61
5	Other relevant			83	67	1.33	**4.38%**	**6.16%**	0.71
6	Monetary policy			94	32	3.33	**3.65%**	**2.05%**	1.78
7	Stopwords			N/A	N/A	N/A	**0.00%**	**0.00%**	N/A
8	Dates, numbers, etc.			N/A	N/A	N/A	**0.00%**	**0.00%**	N/A
9	Words having low discriminatory power			82	71	1.25	**3.65%**	**5.48%**	0.67
Memo	Useful words						96.35%	94.52%	
	Number of words/terms						274	146	
	Category where words are used frequently								
					Adding-up check		100.00%	100.00%	
	Titles reveal information on		Macroprudential policy	Keywords reveal information on			Macroprudential policy		
			Effectivenesss				Policy objective		
			Empirical study				Monetary policy		
			Monetary policy						
	Value-added								

A complement minimizing search algorithm: Results for Macroprudential policy terms

SUMMARY OUTPUT TABLE	Algorithm + plurals + missing top-10					
		Source	# Hits		selection	
Term #		of term	Total	Incrementa	criteria	
1	macroprudential policy	T, K	36	36	A, TT	
2	macroprudential policies	T, K	21	8	A, TT	
3	capital requirement	K	14	7	A, TT	
4	loan-to-value ratio	T, K	16	5	A, TT	
5	changing regulation	O	2	2	A	
6	liquidity regulation	T	2	2	A	
7	bank capital	K	12	1	A, TT	
8	ltv ratios	K	5	1	A	
9	macroprudential instruments	T, K	6	1	A, TT	
10	macroprudential measures	T	10	1	A, TT	
11	macro-prudential tool	T	3	1	A	
12	bank capital requirement	K	7	0	TT	
13	capital buffer	T, K	6	0	TT	
14	capital requirements	T, K	12	0	TT, P	
15	loan-to-value ratios	T, K	9	0	TT, P	
16	macroprudential regulation	K	8	0	TT	
17	macroprudential tool	T	8	0	TT	
18	macroprudential tools	T	6	0	TT, P	
						Count
	# of studies identified			65		
	Correlation - Algorithm selection-Total Hits (only for terms selected by algorithm					0.78
	R-squared					0.61

Notes: In the column entitled source of term, T,K, and O denote title, key words, and other respectively. In the column entitled “selection criteria”, A, TT, and P denote algorithm, top ten, and plural respectively.

A complement minimizing search algorithm: Results for policy

SUMMARY OUTPUT TABLE	Algorithm + plurals + missing top-10					
		Source	# Hits		selection	
Term #		of term	Total	Incrementa	criteria	
1	credit growth	O	23	23	A	
2	housing market	K	11	8	A, TT	
3	financial stability	K	13	4	A, TT	
4	systemic risk	K	8	4	A, TT	
5	financial cycle	K	5	4	A	
6	credit supply	T, K	7	4	A, TT	
7	loan growth	K	3	3	A	
8	house prices	T, K	13	2	A, TT, P	
9	financial intermediation	K	2	2	A	
10	auto loans	T, K	2	2	A	
11	mortgage risk	T	2	2	A	
12	household credit	T, K	4	1	A	
13	housing finance	T	4	1	A	
14	capital ratios	T	2	1	A	
15	residential investment	K	2	1	A	
16	bank risk	T, K	1	1	A	
17	mortgage pricing	T, K	1	1	A	
18	probability of crisis	O	1	1	A	
19	bank credit	K	8	0	TT	
20	bank lending	T, K	8	0	TT	
21	house price growth	K	6	0	TT	
22	housing credit	K	6	0	TT	
						Count
	# of studies identified			65		
	Marginal correlation - Algorithm selection-Total Hits (only for terms selected by					0.66
	R-squared					0.43

Notes: In the column entitled source of term, T,K, and O denote title, key words, and other respectively. In the column entitled “selection criteria”, A, TT, and P denote algorithm, top ten, and plural respectively.

A complement minimizing search algorithm: Results for policy effectiveness terms

SUMMARY OUTPUT TABLE	Algorithm + plurals + missing top-10					
		Source	# Hits		selection	
Term #		of term	Total	Incrementa	criteria	
1	effect	T	53	53	A, TT	
2	impact	T	26	6	A, TT	
3	affect	T	16	2	A, TT	
4	consequences	O	3	2	A	
5	influence	T	4	1	A, TT	
6	amplify	O	2	1	A	
7	effective	T	30	0	TT	
8	effects	T	28	0	TT, P	
9	effectiveness	T, K	24	0	TT	
10	work	T	8	0	TT	
11	transmission	T	5	0	TT	
12	respond	T	4	0	TT	
13	leak	T	3	0	TT	
						Count
	# of studies identified			65		
	Marginal correlation - Algorithm selection-Total Hits (only for terms selected by					0.22
	R-squared					0.05

Notes: In the column entitled source of term, T,K, and O denote title, key words, and other respectively. In the column entitled “selection criteria”, A, TT, and P denote algorithm, top ten, and plural respectively.

A complement minimizing search algorithm: Results for empirical study terms

SUMMARY OUTPUT TABLE		Algorithm + plurals + missing top-10				
		Source	# Hits		selection	
Term #		of term	Total	Incrementa	criteria	
1	data	T, K	39	39	A, TT	
2	find	O	31	12	A, TT	
3	evidence	T	33	6	A, TT	
4	banks	T, K	27	2	A, TT, P	
5	countries	T	22	1	A, TT	
6	empirical	T	14	1	A, TT	
7	estimated	O	33	1	A	
8	vector autoregression	O	31	1	A	
9	estimating	T	22	1	A	
10	co-integration	K	15	1	A	
11	panel	T, K	14	0	TT	
12	economies	T, K	8	0	TT	
13	country	T	6	0	TT	
14	regressions	K	4	0	TT	
						Count
	# of studies identified			65		
	Marginal correlation - Algorithm selection-Total Hits (only for terms selected by					0.55
	R-squared					0.30

Notes: In the column entitled source of term, T,K, and O denote title, key words, and other respectively. In the column entitled “selection criteria”, A, TT, and P denote algorithm, top ten, and plural respectively.

Number of studies identified by complement minimizing search algorithm

	# of 65 studies	(words, characters)	Google Scholar		Web of Science		SCOPUS	
			2010 - 2020	2010 -	2010 - 2020	2010 -	2010 – 2020	2010 -
Policy (A)	65	(32, 279)	17300	16600	1814	2781	3541	3645
Policy (A,TT,P)	65	(54, 466)	19500	19200	3068	4490	3810	5650
Objective (A)	65	(54, 374)	17700	17900	15475	23604	10569	16405
Objective (A,TT,P)	65	(67, 453)	17700	17900	17118	26124	12005	18642
Effectiveness (A)	65	(11, 78)	755000	788000	6501049	9530243	240801	384860
Effectiveness (A,TT,P)	65	(25, 176)	738000	791000	11533081	16759794	299975	472820
Empirical (A)	65	(20, 149)	761000	786000	7425642	10739386	313839	485500
Empirical (A,TT,P)	65	(28, 205)	741000	797000	7668181	11082036	349878	537775
Policy + Effectiveness (A)	65	(44, 366)	17300	17100	825	1360	1297	2092
Policy + Effectiveness (A,TT,P)	65	(80, 651)	19500	19800	1868	2860	1578	2523
Policy + Effectiveness + Objective (A)	65	(99,747)	17700	17400	357	622	572	936
Policy + Effectiveness + Objective (A,TT,P)	65	(148,1111)	19200	19500	842	1357	780	1266
Policy + Effectiveness + Objective + Empirical (A)	65	(120,903)	17700	17400	315	566	529	873
Policy + Effectiveness + Objective + Empirical (A,TT,P)	65	(177,1323)	18900	19900	679	1123	661	1092

Treatment of interaction variables

Consider the simple interaction model:

$$Y = b_0 + b_1\, X + b_2\ \ (X \cdot I) + \epsilon$$

The effect of X on Y is then $b_1 + b_2 \cdot I$

If we allow dependence, then:

$$Var(b_1 + b_2 \cdot I) = Var(\, b_1\,) + 2 \cdot I \cdot Cov(b_1, b_2\,) + I^2 \cdot Var(\, b_2\,) + b_2^2 \cdot Var(I) + 2\big(Cov(\, b_1\,, I) + \ I \cdot Cov(b_2\,, I)\big)b_2$$

Under independence, the expression is:

$$Var(b_1 + b_2 \cdot I) = Var(\, b_1) + I \cdot 2\ \cdot Var(\, b_2) + b_2^2\ \cdot Var(I) + Var(\, b_2\,) \cdot Var(I)$$

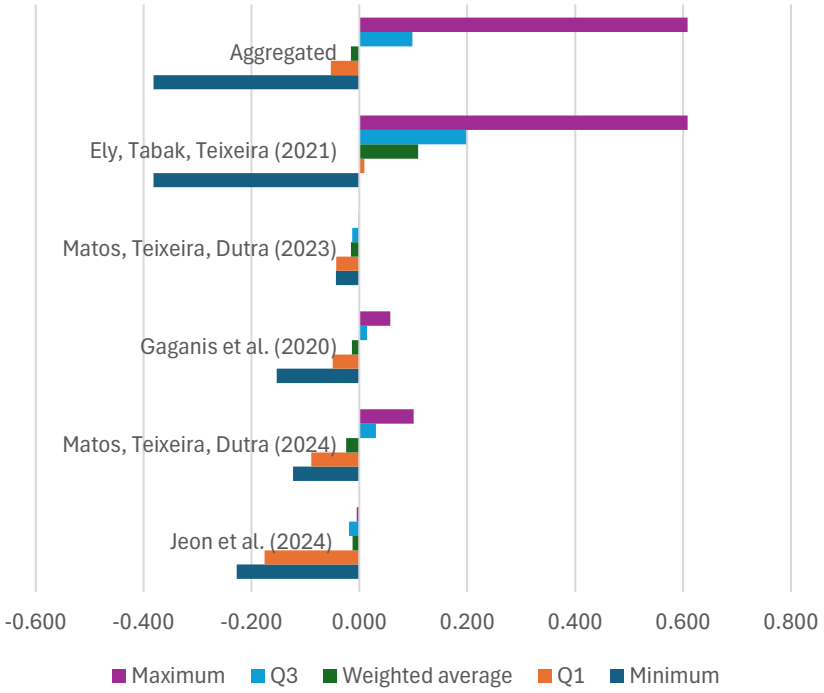
Meta-regression analysis of the effect of macroprudential policy on bank resilience

- Five studies with a homogenous measure of bank risk: Z-score measured annually
- All of them include interaction terms

Macroprudential policies raise bank risk

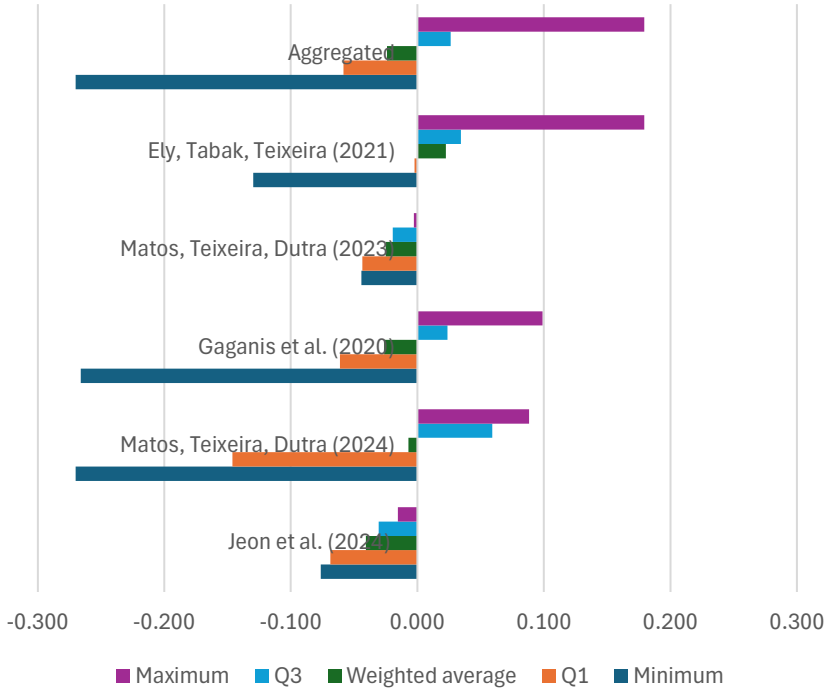
$$\beta = \frac{b}{\sigma_y} \cdot$$

Partially standardised coefficients



$$\beta = \frac{\sigma_x}{\sigma_y} \cdot b$$

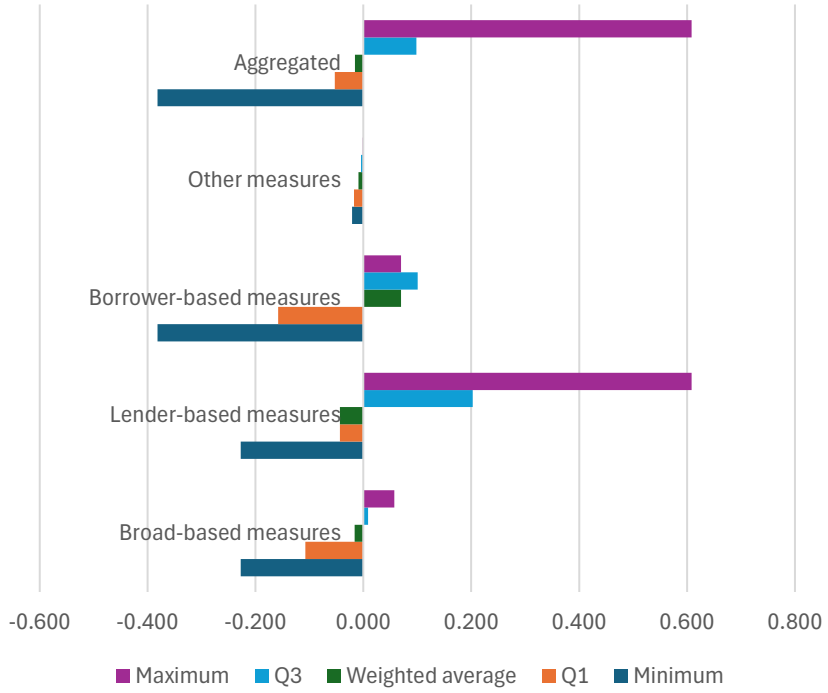
Fully standardised coefficients



Borrower-based measures lower bank risk, while lender-based and other measures raise it

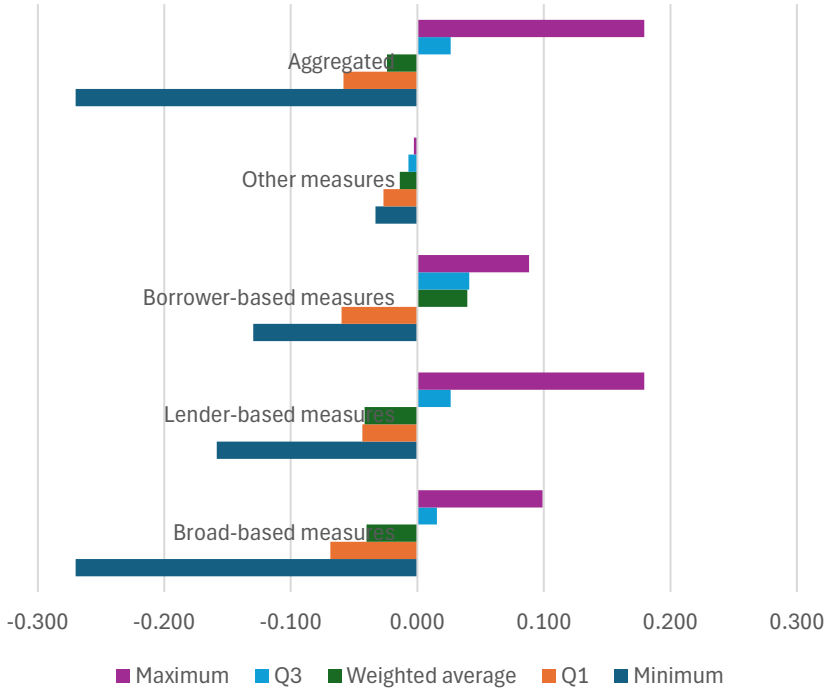
$$\beta = \frac{b}{\sigma_y} \cdot$$

Partially standardised coefficients



$$\beta = \frac{\sigma_x}{\sigma_y} \cdot b$$

Fully standardised coefficients

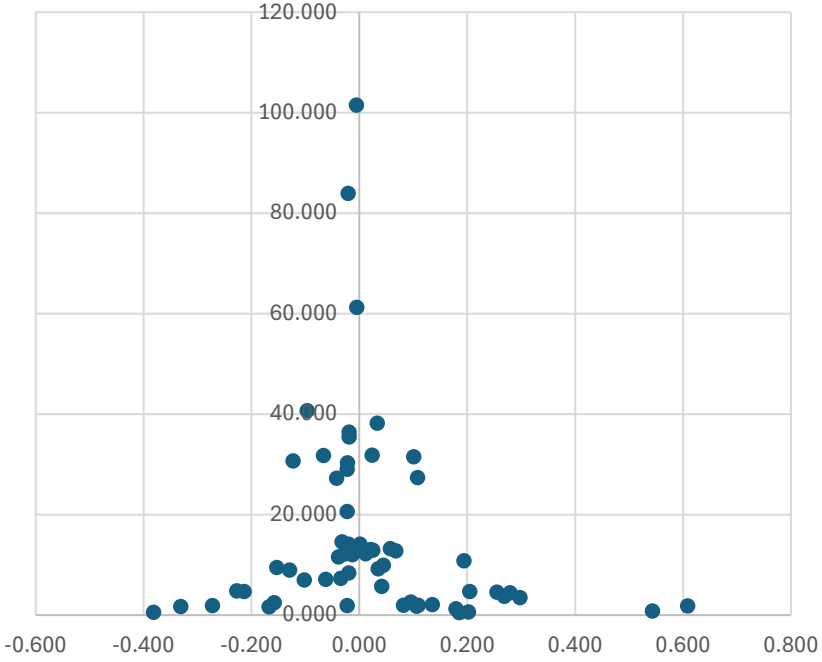


Macroprudential policies raise bank risk

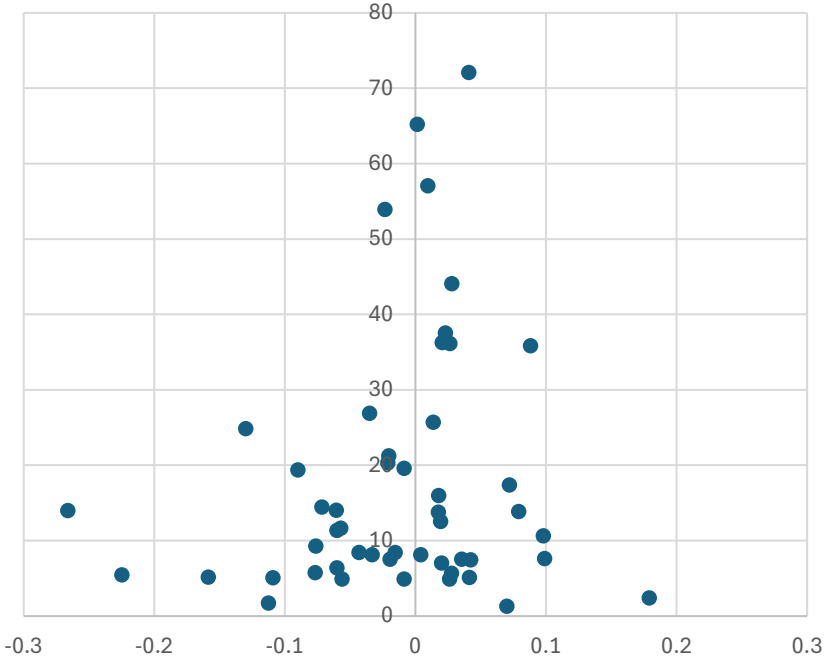
$$\beta = \frac{b}{\sigma_y} \cdot$$

$$\beta = \frac{\sigma_x}{\sigma_y} \cdot b$$

Funnel plot of partially standardized coefficients



Funnel plot of fully standardised coefficients



How does macroprudential policy effect bank resilience?

Funnel Asymmetry test: $t_i = \beta_1 + \beta_0 \cdot (1/SE) + v_i$

Negative effects of macroprudential policy on bank risk are genuine

Partial Standardisation

Regression Statistics	
Multiple R	0.666
R Square	0.443
Adjusted R Square	0.434
Standard Error	3.072
Observations	67

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	487.969	487.969	51.696	0.000
Residual	65	613.546	9.439		
Total	66	1101.515			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.135	0.394	-0.343	0.733	-0.923	0.653
Bias adjusted effect	-0.015	0.002	-7.190	0.000	-0.020	-0.011

Full standardisation

Regression Statistics	
Multiple R	0.614393
R Square	0.377479
Adjusted R Square	0.366161
Standard Error	4.567177
Observations	57

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	695.661	695.661	33.350	0.000
Residual	55	1147.251	20.859		
Total	56	1842.912			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-0.235	0.654	-0.359	0.721	-1.545
Bias adjusted effect	-0.026	0.005	-5.775	0.000	-0.035

Conclusions

"A critical feature of this search is that it should be as comprehensive as possible", Stanley and Doucouliagos (2012)

- The search step in meta-regression analysis could be prone to bias if it relies on Google Scholar
- Many meta-regression practitioners add a further step of so-called "snowballing" but there is a more efficient way to be as comprehensive as possible
- A complement-minimizing algorithm also ensures that meta-regression analyses are replicable