Predicting Episodes Of Financial Distress in Peru's Banking Sector

Aggregated Index CAMELS Approach

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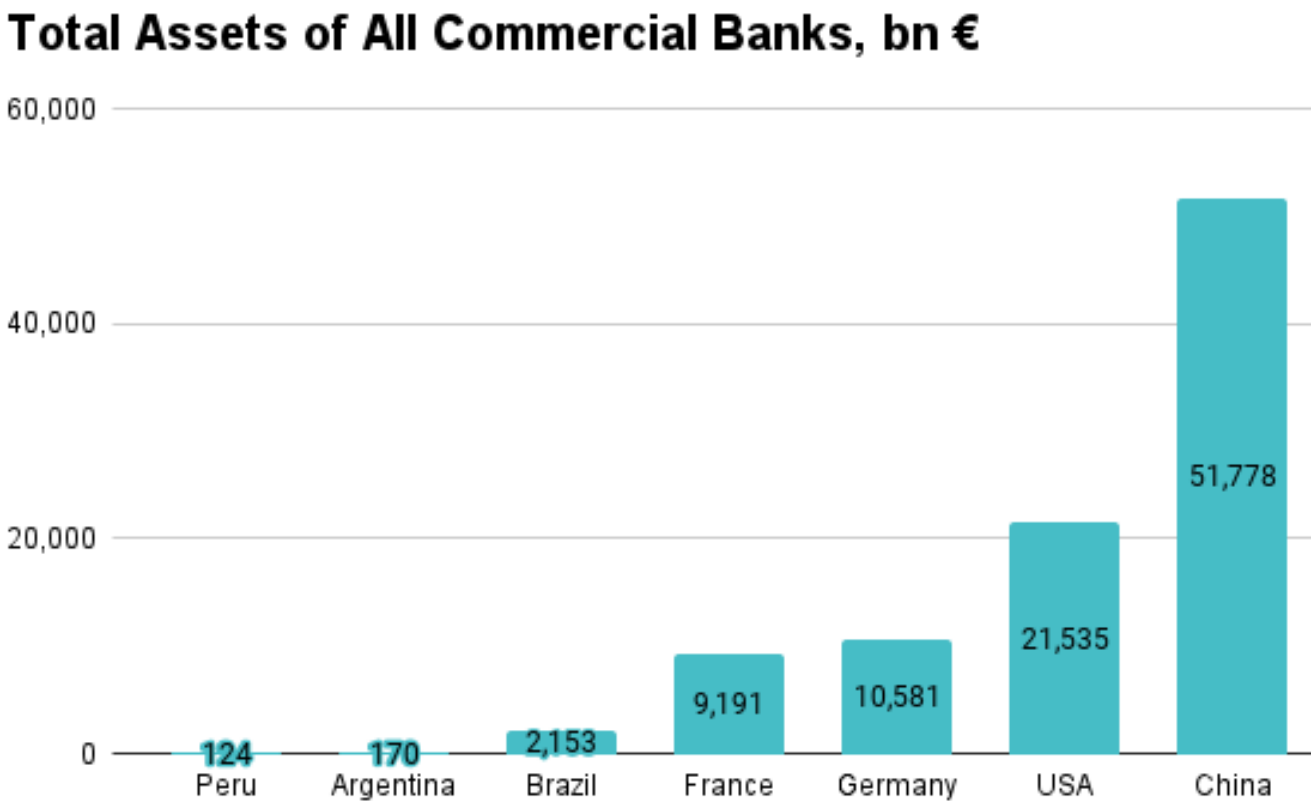
Section

Motivación

- Necesidad de nuevas herramientas para monitoriar la estabilidad financiera.
- Explorer canales alternativos que puedan ocasionar episodios de stress financiero
- Transmitir de manera clara la salud del sistema financiero y cuan factible es que se registren episodios de stress financiero.
-

Sector Bancario Peruano- Comparación



Episodios de Stress Financiero en el Perú

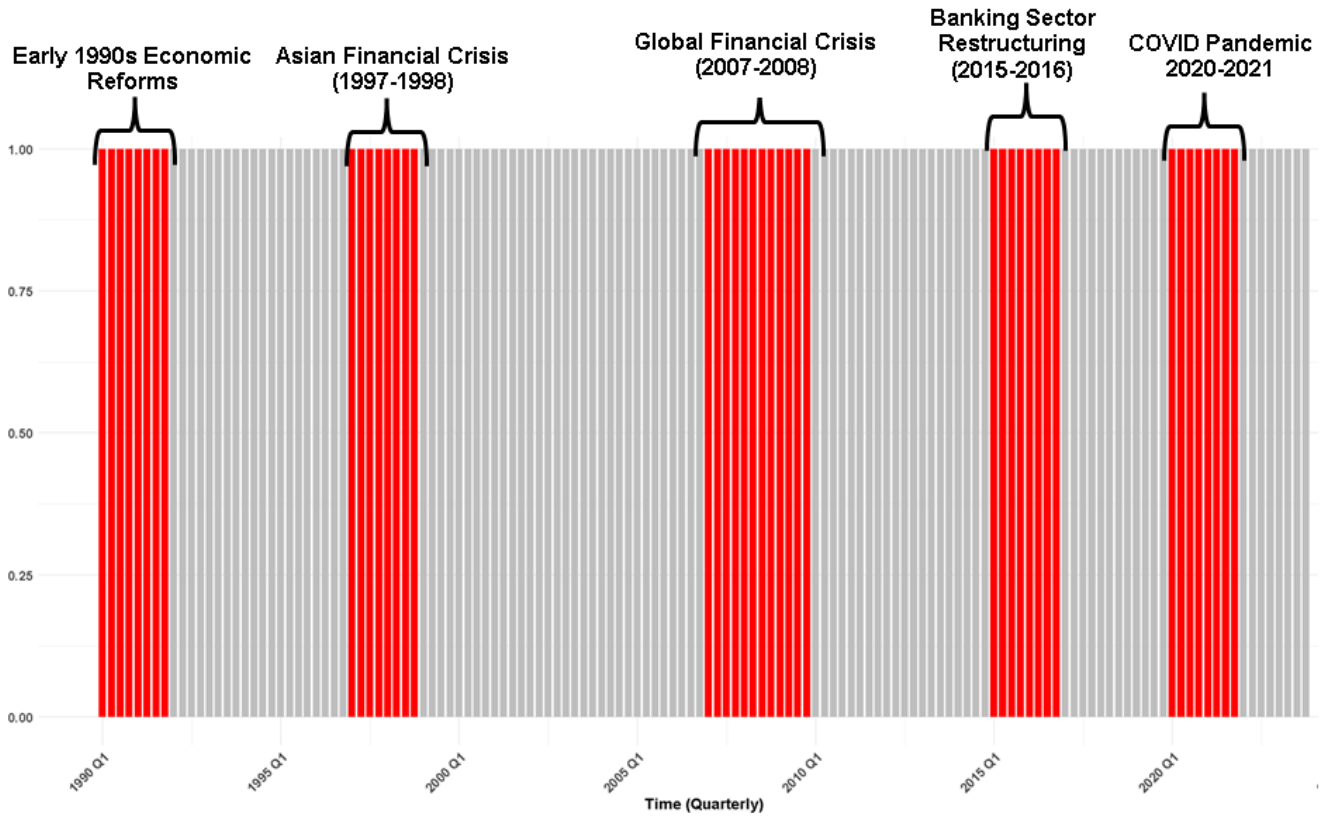


Figure: Periods of financial distress

Canal de transmisión de episodios de stress financiero

- La inestabilidad del sistema financiero surge de dos fuentes principales: la primera es la tendencia colectiva de los agentes a sobreexponerse al riesgo durante los periodos de auge crediticio y a volverse aversos al riesgo durante las recesiones del ciclo crediticio.
- La segunda fuente, que es el enfoque de este estudio, es que los bancos, de manera individual, típicamente no consideran los efectos de sus acciones en el sector bancario en general. Banco de Inglaterra (2009)

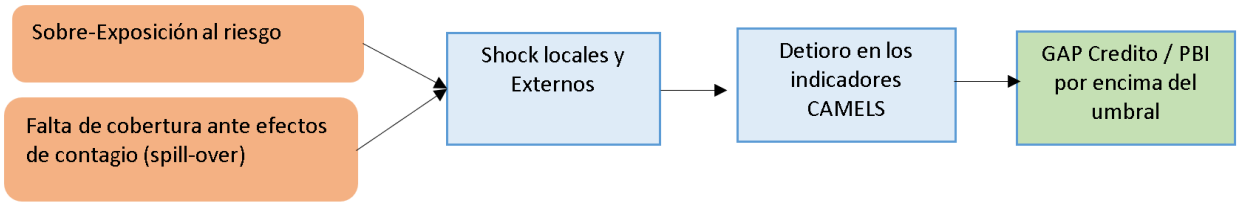


Figure: Transmisión de episodios de stress

Preguntas claves abordadas por este documento

- **¿Cuáles son las herramientas e instrumentos existentes y cómo pueden mejorarse para predecir de manera más efectiva episodios de estrés financiero en el sector bancario de Perú?**
- **¿Cuáles son los indicadores clave que señalan de manera más efectiva la proximidad de un episodio de stress financiero?**
- **¿Qué técnicas de agregación ofrecen el mejor resultadoo en cuanto pronóstico de episodios de stress?**

Section

Definición de stress financiero y episodios de stress financiero

- Borio, Lowe, and others (2002) : Usando una combinación de multiples indicadores (Brecha del precio de los activos, brecha de Inversión y Brecha del ratio Credito-PBI) determina que un umbral óptimo es de 4%.
- **Basilea: Cuando la brecha del ratio Crédito-PBI es mayor a 2%. Esta definición esta asociada a las recomendaciones de buffer de capitales -BIS Working Papers No 317 -2010**

Brecha Crédito/PBI - Credit-GDP gap

- **Assessing the Risk of Banking Crises**
  - *Claudio Borio and Philip Lowe, 2002*
- **Characterizing the Financial Cycle: Don't Lose Sight of the Medium Term!**
  - *Mathias Drehmann, Claudio Borio, and Kostas Tsatsaronis, 2012*
- **"Mapping Heat in the U.S. Financial System," Aikman et al. (2015)**
- **A Heatmap for Monitoring Systemic Risk in Norway**
  - *Øyvind A. Lind, Kristian Lindquist, Martin D. Riiser, Henrik Solheim, Bjørn H. Vatne,2017*

La metodologia CAMEL

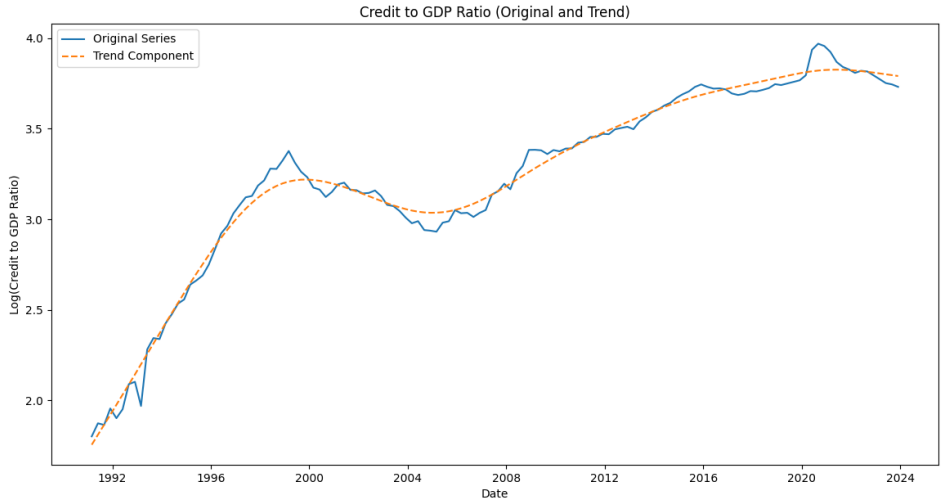
- *Capital Adequacy* - Arbatli and Johansen (2017) and Galán (2021)
- *Asset Quality* - Ghosh (2015)
- *Management* - Ellul and Yerramilli (2013)
- *Earnings* - Distinguin et al. (2006), Arena (2008), Berger et al. (2016)
- *Liquidity* - Accornero et al. (2018),
- *Sensitivity to Market Risk* - Berger and Bouwman (2013)

Section

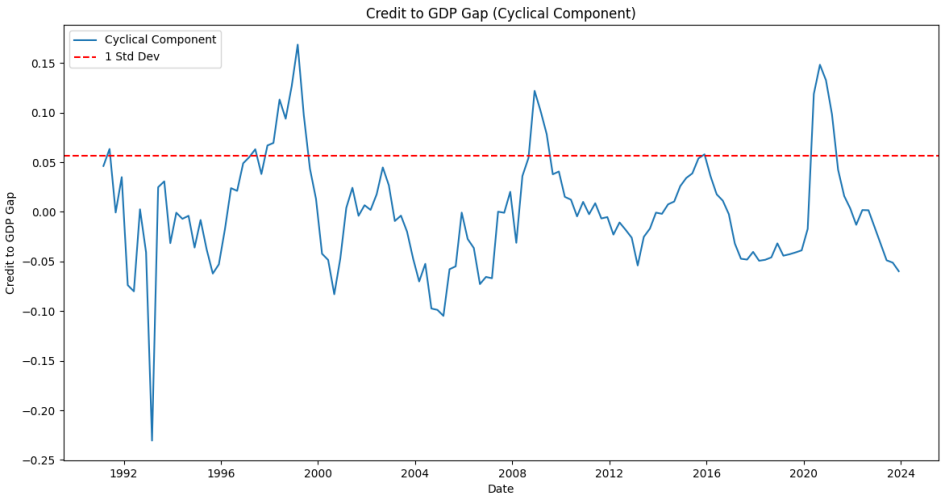
Data

- Superintendencia de Banca y Seguros del Peru (SBS) & Banco Central de Reserva del Perú
- 1994Q4 to 2023Q4
- Información agregada de todo el sistema bancario
- Información de los 4 principales bancos (Por total de Activos)
- PBI

Brecha Crédito-PBI / Credit to GDP Gap



$\lambda = 1600$ for quarterly (Aikamn, 2015)



Ratios Financieros 1/2

Ratio	**Formula**	**Category**
Capital Ratio	$\frac{\text{Total Equity}}{\text{Total Assets}}$	Capital Adequacy
Core Funding to Loan Ratio	$\frac{\text{Total Deposits+Debt}}{\text{Total Loans}}$	Capital Adequacy
NPL Ratio	$\frac{\text{Non-Performing Loan}}{\text{Total Loans}}$	Asset Quality
Cost to Risk	$\frac{\text{Annualized Loan Loss Provision Expenses}}{\text{1-year Total Loans Average}}$	Asset Quality
NPL Ratio Net Provision	$\frac{\text{(Non-Performing Loan}-\text{Provisions)}}{\text{Total Loans}}$	Asset Quality
NPL Ratio	$\frac{\text{Non-Performing Loan}}{\text{Total Loans}}$	Asset Quality
Operative Assets	$\frac{\text{Annualized Operative Expenses}}{\text{1-year Average Total Assets}}$	Management Capability
Cost to Income Ratio	$\frac{\text{Annualized Operative Expenses}}{\text{Annualized Operative Margin}}$	Management Capability
Loan Operative Ratio	$\frac{\text{Annualized Operative Expenses}}{\text{1-year Average Total Loans}}$	Management Capability

Table: Financial Ratios and Formulas

Financial Ratios 2/2

Ratio	**Formula**	**Category**
Net Interest Margin	$\frac{\text{Annualized Gross Financial Margin}}{\text{Annualized Financial Income}}$	Earnings
ROA	$\frac{\text{Annualized Net Profit}}{\text{1-year Total Assets Average}}$	Earnings
ROE	$\frac{\text{Annualized Net Profit}}{\text{1-year Total Equity Average}}$	Earnings
Credit to Deposit Ratio	$\frac{\text{Total Deposits}}{\text{Total Loans}}$	Liquidity
Liquidity Ratio	$\frac{\text{Short Term Assets}}{\text{Short Term Liabilities}}$	Liquidity
Total Assets	ln(Total Assets)	Sensitivity
Total Loans	ln(Total Loans)	Sensitivity

- Adjust the direction of the ratios

Estandarización de Indicadores

$$z_{it} = \frac{X_{it} - \mu_{it}}{\sigma_{it}}$$

- Rolling window, 20 quarters (5 years)
- X_{it} , indicator value
- μ_{it}, mean
- σ_{it}, standard diviation
- i financial ratio and t is time

Normalization

$$x_t = F_N(y_t) = \begin{cases} \frac{r}{N} & \text{for } y_r \leq y_t < y_{r+1},\ r = 1, 2, \ldots, N-1 \\ 1 & \text{for } y_t \geq y_{max} \end{cases}$$

- Sorting
- Calculating

Normalized Dataset

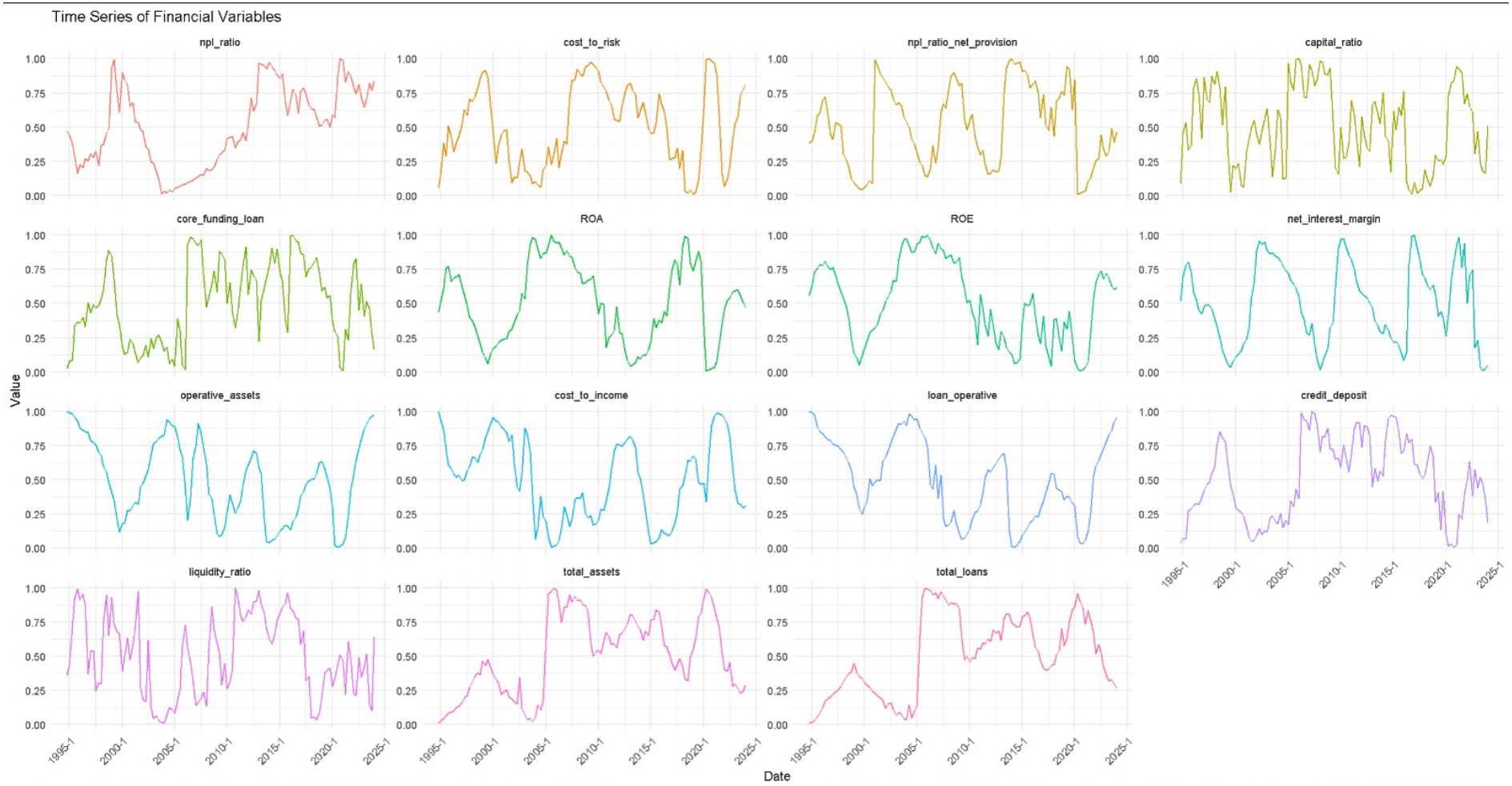


Figure: Normalized Financial Ratios

Técnicas de Agregación

- **Arithmetic Average**:

$$\text{Index Arym}(ct) = \frac{1}{p}\sum_{i=1}^{p} X_{cit} \tag{1}$$

- **Geometric Average**:

$$\text{Index Geom}(ct) = \left(\prod_{i=1}^{p} X_{cit}\right)^{\frac{1}{p}} \tag{2}$$

- **Root Mean Square**:

$$\text{Index RMS}(ct) = \sqrt{\frac{1}{p}\sum_{i=1}^{p} X_{cit}^2} \tag{3}$$

- **Principal Components**:

$$\text{Index PCA}(ct) = \alpha_{11}X_{c1t} + \alpha_{12}X_{c2t} + \cdots + \alpha_{1p}X_{cpt} \tag{4}$$

Información Agregada

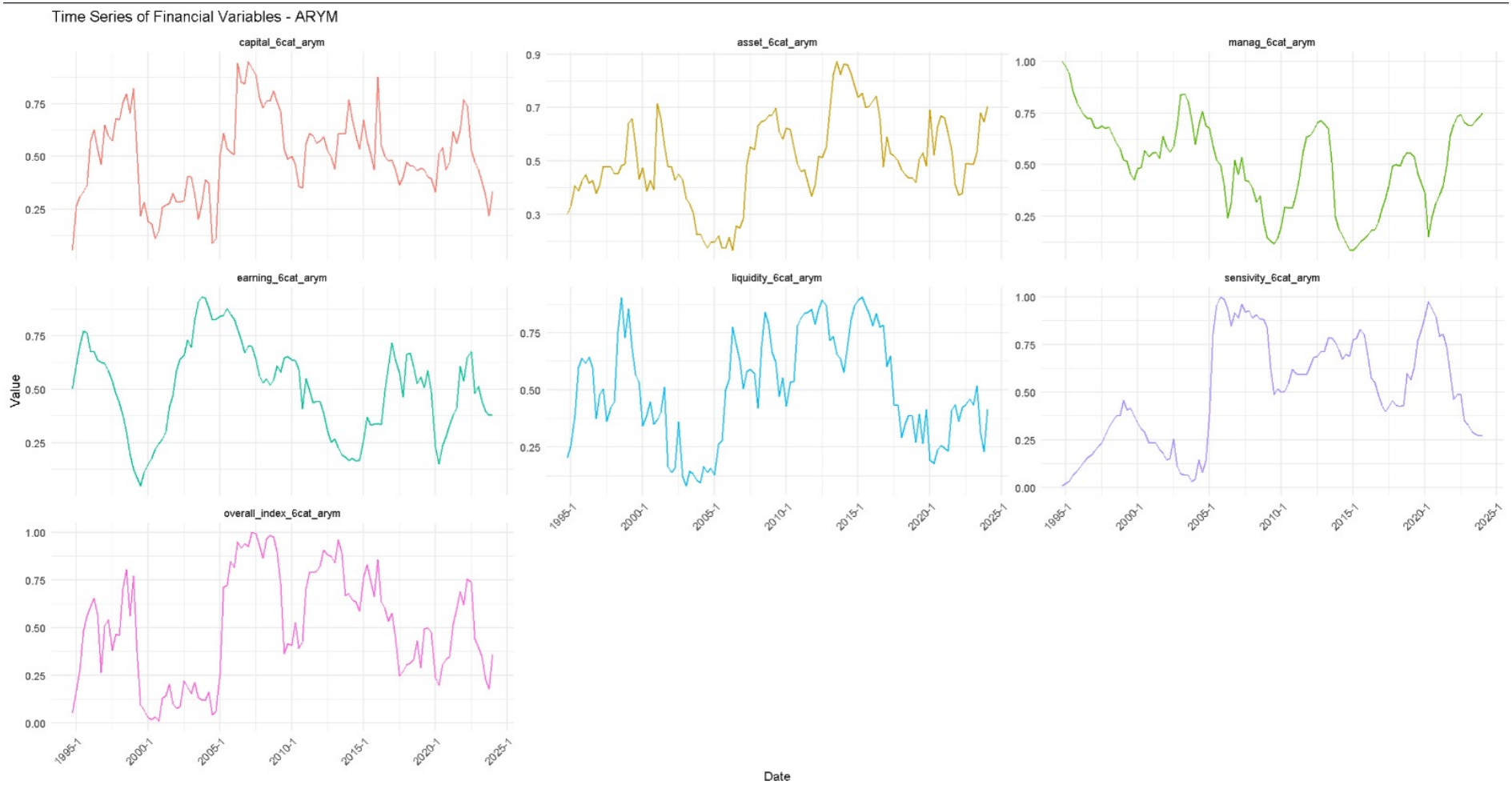


Figure: Aggregation Indexes

Section

Modelo Base- Continuo: Información Agregada-

$$GAP_{t+h} = \beta_0 + \beta_1 GAP_{t-1} + \beta_2 C_t + \beta_3 A_t + \beta_4 M_t + \beta_5 E_t + \beta_6 L_t + \beta_7 S_t + \epsilon_t$$

where:

- GAP_{t+h}: Represents the measure of financial distress (credit GDP gap), h periods ahead.
- C_t: Represents the capital adequacy indicator, in this case, the Equity over Assets ratio.
- A_t: Represents the asset quality indicator, in this case, the Cost to Risk ratio.
- M_t: Represents the management indicator, in this case, the Operative expenses over Assets.
- E_t: Represents the earnings indicator, in this case, the Earnings over Equity ratio (ROE).
- L_t: Represents the liquidity indicator, in this case, the liquidity ratio.
- S_t: Represents the sensitivity indicator, in this case, the natural logarithm of the total assets.

Modelo Base Continuo: Información Panel

$$GAP_{t+h} = \beta_0 + \beta_1 GAP_{t-1} + \beta_2 C_{it} + \beta_3 A_{it} + \beta_4 M_{it} + \beta_5 E_{it} + \beta_6 L_{it} + \beta_7 S_{it} + \epsilon_i t$$

where:

- GAP_{t+h}: Represents the measure of financial distress (credit GDP gap) , h periods ahead.
- C_t: Represents the capital adequacy indicator, in this case, the Equity over Assets ratio .
- A_t: Represents the asset quality indicator, in this case, the Cost to Risk ratio .
- M_t: Represents the management indicator, in this case , the Operative expenses over Assets .
- E_t: Represents the earnings indicator, in this case, the Earnings over Equity ratio (ROE).
- L_t: Represents the liquidity indicator, in this case, the liquidity ratio.
- S_t: Represents the sensitivity indicator, in this case, the natural logarithm of the total assets.

We controlled for fixed effects at the bank level.

Modelo Extendido

$$GAP_{t+h} = \beta_0 + \beta_1 GAP_{t-1} + \beta_2 IndexC_t + \beta_3 IndexA_t + \beta_4 IndexM_t + \beta_5 IndexE_t + \beta_6 IndexL_t + \beta_7 IndexS_t + \epsilon_t$$

where:

- GAP_{t+h}: Represents the measure of financial distress (credit GDP gap) h periods ahead.
- $IndexC$: Represents the Aggregated index of capital adequacy category.
- $IndexA$: Represents the Aggregated index of Asset Quality.
- $IndexM$: Represents the Aggregated index of Management.
- $IndexE$: Represents the Aggregated index of Earnings.
- $IndexL$: Represents the Aggregated index of Liquidity.
- $IndexS$: Represents the Aggregated index of Sensitivity.

Ejercicio de Pronóstico

- Periodo de Estimación: 1994Q4 to 2013Q4
- Periodo de Pronóstico: 2014Q1 to 2023Q4
- Criterio de Evaluación: Error cuadratico medio (RMSE)

Metodología Heatmap

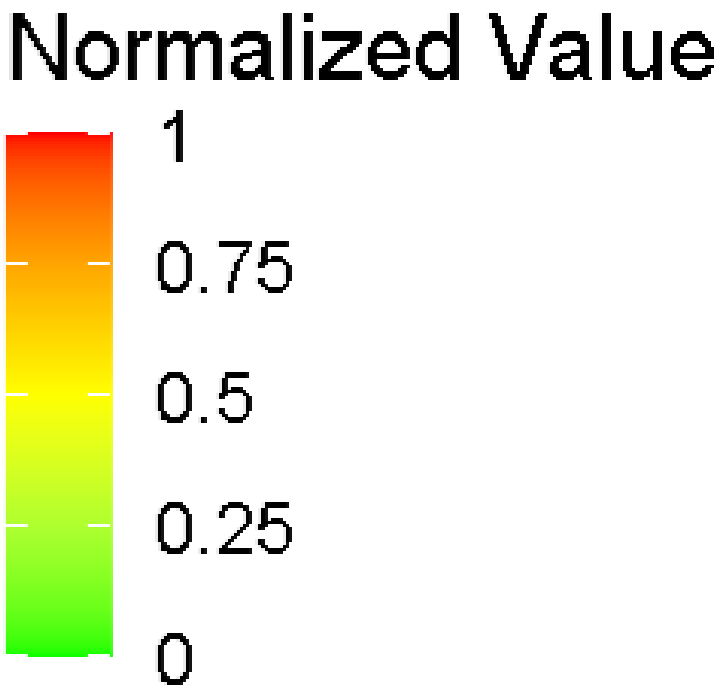


Figure: Color Scale for the heatmap

Modelo discreto: Modelo Logistico

$$D_t = \begin{cases} 0 & \text{if credit\_gdp\_gap}_t \leq \text{sd(credit\_gdp\_gap)} \\ 1 & \text{if credit\_gdp\_gap}_t > \text{sd(credit\_gdp\_gap)} \end{cases}$$

Figure: Financial Distress period definition

- **Logistic Model:**

$$P(D_t = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \ldots + \beta_p X_{pt})}} \tag{5}$$

- Predictive accuracy: Area Under the ROC Curve (AUC)

Section

Results: Base Model

Table 5.1: Regression Results

	Dependent variable: Credit-GDP Gap				
	Gap	Gap Lead 1	Gap Lead 2	Gap Lead 3	Gap Lead 4
	(1)	(2)	(3)	(4)	(5)
Capital Ratio	0.010***	0.014***	0.016***	0.017***	0.014**
	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)
Cost to Risk	0.007**	0.010**	0.012**	0.010*	0.009
	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)
Operative Assets	−0.0003	−0.001	0.001	0.005	0.013
	(0.004)	(0.006)	(0.008)	(0.009)	(0.009)
ROE	−0.006**	−0.008*	−0.010*	−0.012**	−0.013**
	(0.003)	(0.004)	(0.005)	(0.006)	(0.006)
Liquidity Ratio	0.001	0.001	0.003	0.004	0.004
	(0.002)	(0.004)	(0.004)	(0.005)	(0.005)
Total Assets	−0.002	−0.003	−0.004	−0.002	−0.0001
	(0.004)	(0.005)	(0.007)	(0.007)	(0.008)
Credit GDP Gap Lag	0.654***	0.376***	0.094	−0.020	−0.124
	(0.069)	(0.099)	(0.122)	(0.133)	(0.140)
Constant	0.006	0.008	0.012	0.016*	0.021**
	(0.005)	(0.007)	(0.009)	(0.009)	(0.010)
Observations	116	115	114	113	112
R^2	0.788	0.566	0.348	0.224	0.145
Adjusted R^2	0.774	0.537	0.305	0.172	0.088
Note:					*p<0.1; **p<0.05; ***p<0.01

Figure: Base model- Database: Bank system level

Results:Base Model

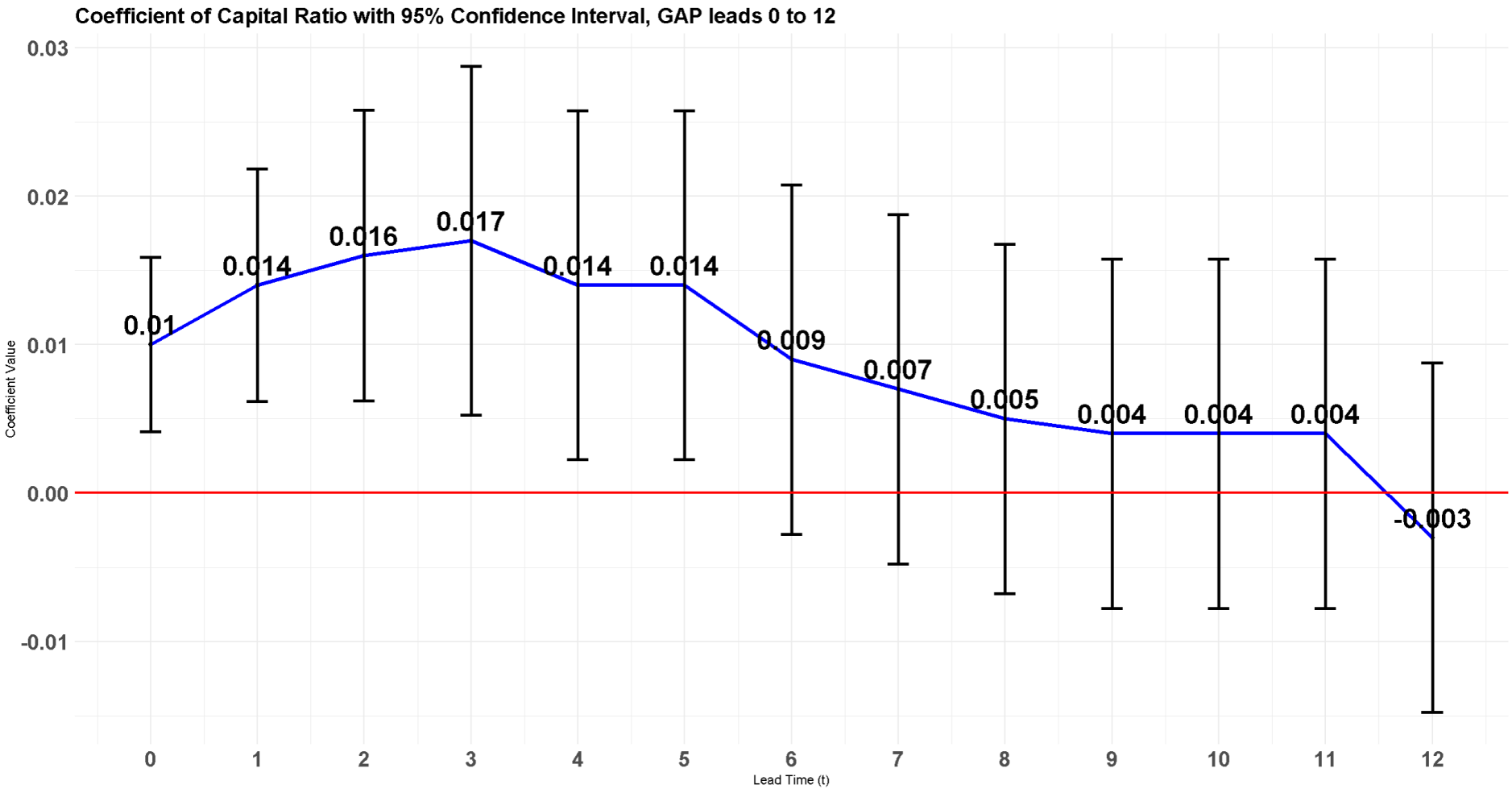


Figure: Capital ratio coefficients-Confidence Interval 95%

Results:Base Model

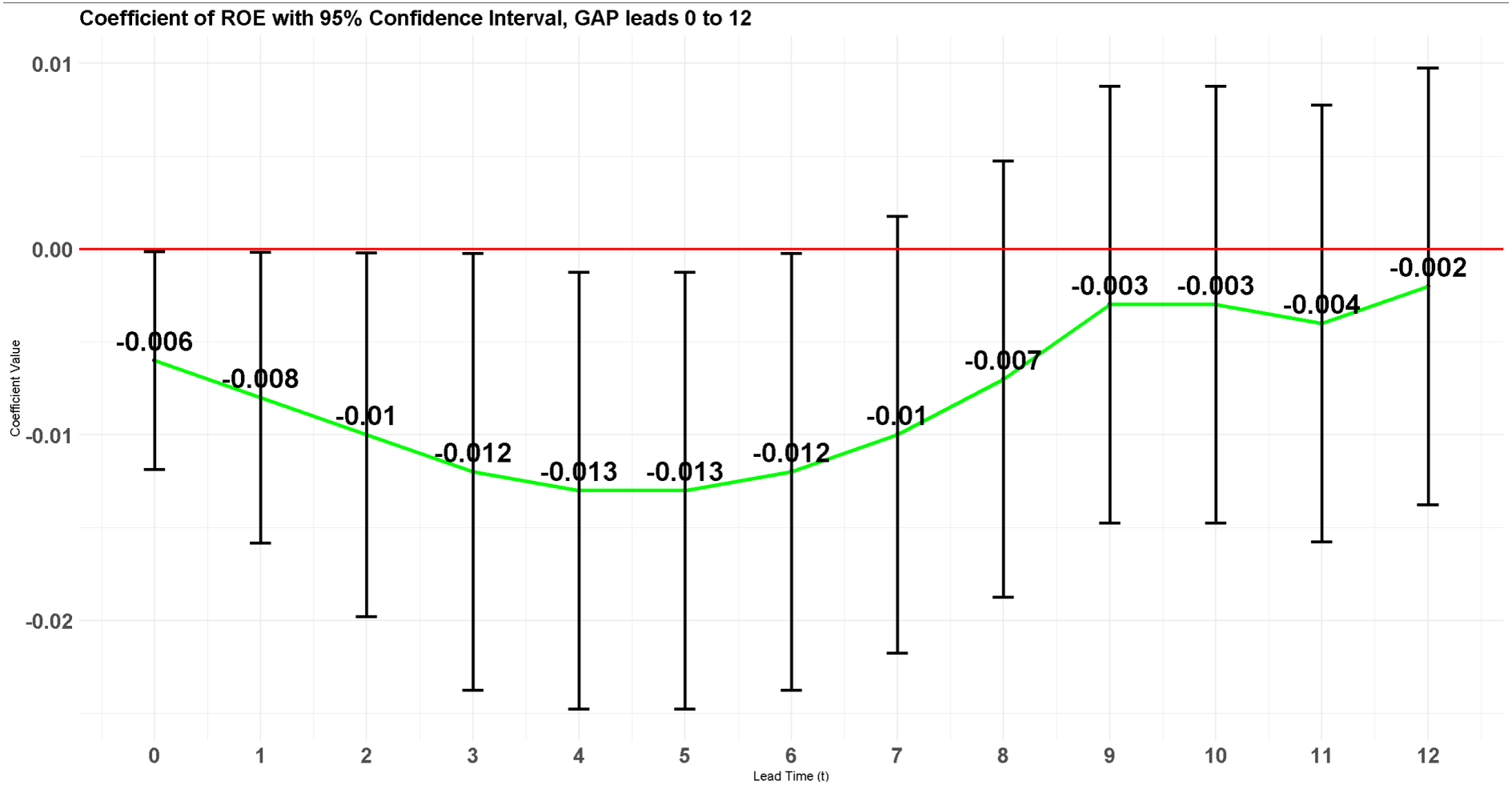


Figure: ROE coefficients-Confidence Interval 95%

Results:Base Model

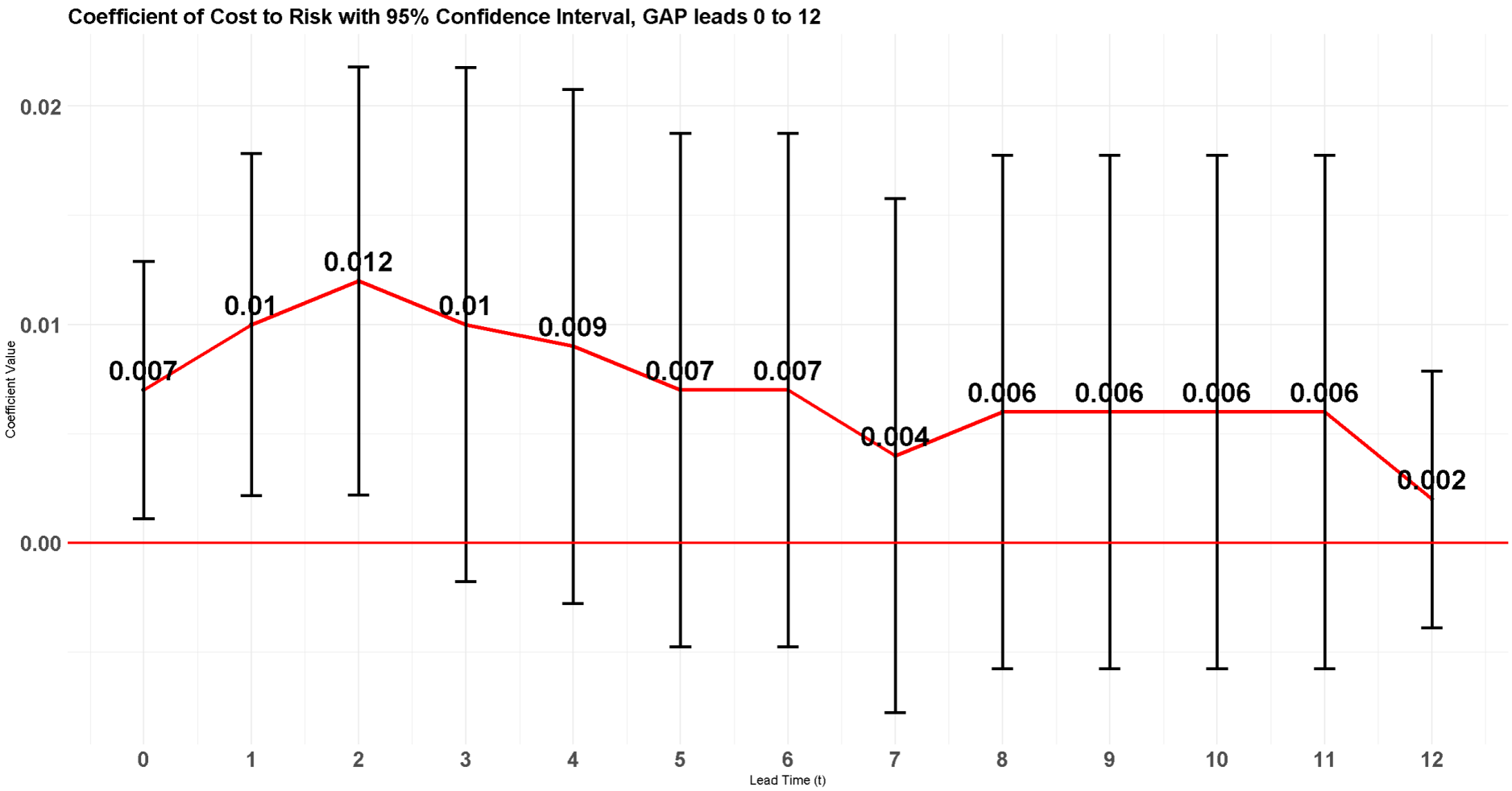


Figure: Cost to Risk coefficients-Confidence Interval 95%

Results:Panel data model

Table 5.2: Regression Results-Panel Model- Fixed Effects

	Dependent variable: GAP				
	Lead 0	Lead 1	Lead 2	Lead 3	Lead 4
Capital Ratio	0.004***	0.006***	0.006***	0.007***	0.006**
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Cost to Risk	0.004***	0.005***	0.005**	0.004	0.003
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Operative Assets	0.0001	−0.0001	0.0001	0.002	0.004
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)
ROE	−0.001	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Liquidity Ratio	0.002	0.003	0.004*	0.004	0.004
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
Total Assets	0.004**	0.006**	0.006**	0.005	0.003
	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)
Lag 1	0.787***	0.575***	0.335***	0.194***	0.056
	(0.028)	(0.040)	(0.049)	(0.053)	(0.055)
Observations	464	460	456	452	448
R^2	0.754	0.490	0.237	0.109	0.039
Adjusted R^2	0.748	0.479	0.220	0.089	0.017
Note:					*p<0.1; **p<0.05; ***p<0.01

Figure: Base Model- Individual bank data level

Results: Extended Model-regressions Lead 0

Table 5.3: Regression Results for GAP t

	Dependent variable: GAP lead 0			
	Arym	Geom	RMS	PCA
Capital	0.061***	0.044***	0.057***	0.025**
	(0.020)	(0.016)	(0.021)	(0.010)
Asset Quality	0.012	−0.002	0.018	−0.024*
	(0.024)	(0.019)	(0.025)	(0.014)
Management	−0.004	−0.008	−0.003	−0.008
	(0.018)	(0.018)	(0.017)	(0.015)
Earnings	−0.030	−0.022	−0.029	−0.031**
	(0.018)	(0.015)	(0.018)	(0.014)
Liquidity	−0.018	−0.010	−0.015	0.017
	(0.015)	(0.013)	(0.015)	(0.011)
Sensitivity	−0.004	0.0003	−0.003	0.023*
	(0.015)	(0.016)	(0.014)	(0.013)
Gap Lag 1	0.756***	0.788***	0.749***	0.825***
	(0.057)	(0.056)	(0.059)	(0.062)
Constant	−0.008	−0.0003	−0.013	−0.001
	(0.027)	(0.019)	(0.029)	(0.017)
Observations	116	116	116	116
R^2	0.769	0.765	0.766	0.770
Adjusted R^2	0.754	0.750	0.751	0.755
Note:				*p<0.1; **p<0.05; ***p<0.01

Figure: Extended Model- Indexes per category- Aggregated data level

Results: Extended Model-regressions Lead 1

Table 5.4: Regression Results for GAP t+1

	Dependent variable: GAP lead 1			
	Arym	Geom	RMS	PCA
Capital	0.102***	0.073***	0.092***	0.037**
	(0.028)	(0.022)	(0.030)	(0.015)
Asset Quality	0.037	0.036	0.023	−0.037*
	(0.034)	(0.026)	(0.035)	(0.021)
Management	−0.005	−0.0003	−0.016	−0.009
	(0.026)	(0.024)	(0.025)	(0.022)
Earnings	−0.053**	−0.036*	−0.061**	−0.048**
	(0.025)	(0.021)	(0.026)	(0.021)
Liquidity	−0.044**	−0.038**	−0.040*	0.019
	(0.020)	(0.018)	(0.022)	(0.016)
Sensitivity	−0.009	0.006	−0.007	0.037*
	(0.021)	(0.022)	(0.019)	(0.019)
Gap Lag 1	0.492***	0.561***	0.489***	0.624***
	(0.080)	(0.078)	(0.083)	(0.089)
Constant	−0.014	−0.016	0.004	0.001
	(0.037)	(0.027)	(0.041)	(0.025)
Observations	115	115	115	115
R^2	0.555	0.556	0.539	0.531
Adjusted R^2	0.526	0.527	0.509	0.501
Note:				*p<0.1; **p<0.05; ***p<0.01

Figure: Extended Model- Indexes per category- Aggregated data level

Results: Extended Model - Forecasting Exercise

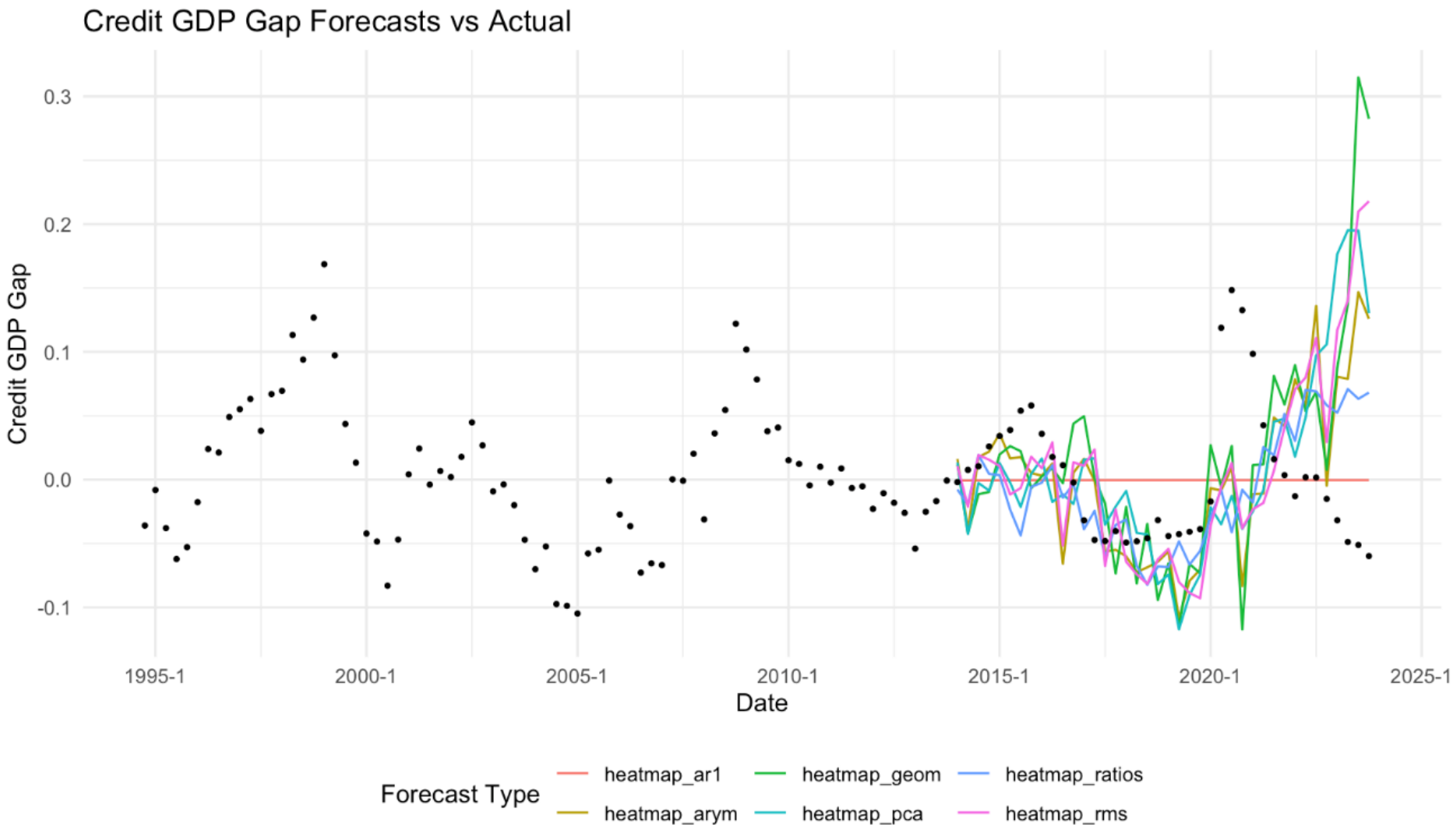


Figure: Forecasting for 2014Q1-2023Q4

Results: Extended Model - RMSE comparison

Horizon	GEOM	ARYM	RMS	PCA	RATIOS	AR(1)
4	0.0332	0.0255	0.0171	0.0321	0.0181	0.0149
8	0.0353	0.0300	0.0345	0.0430	0.0496	0.0354
16	0.0391	0.0345	0.0372	0.0388	0.0376	0.0343
40	0.1080	0.0806	0.0929	0.0955	0.0676	0.0523

Table 5.5: RMSE for Different Forecast Horizons

Figure: RMSE for different models and different horizon

Results: Heatmap Geometric average

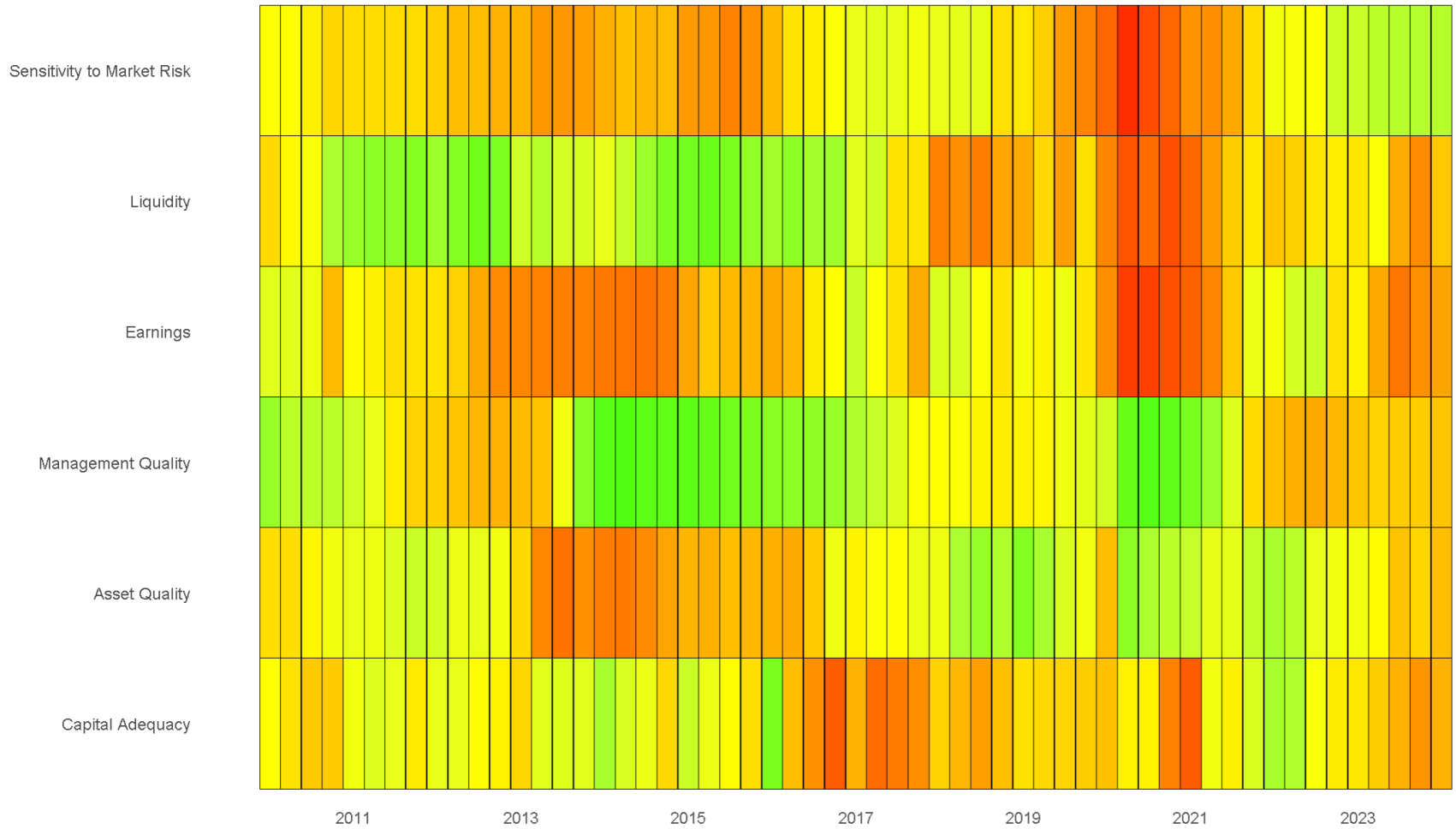


Figure: CAMELS category - 2011Q1-2023Q4

Results: Overall Banking Conditions Index

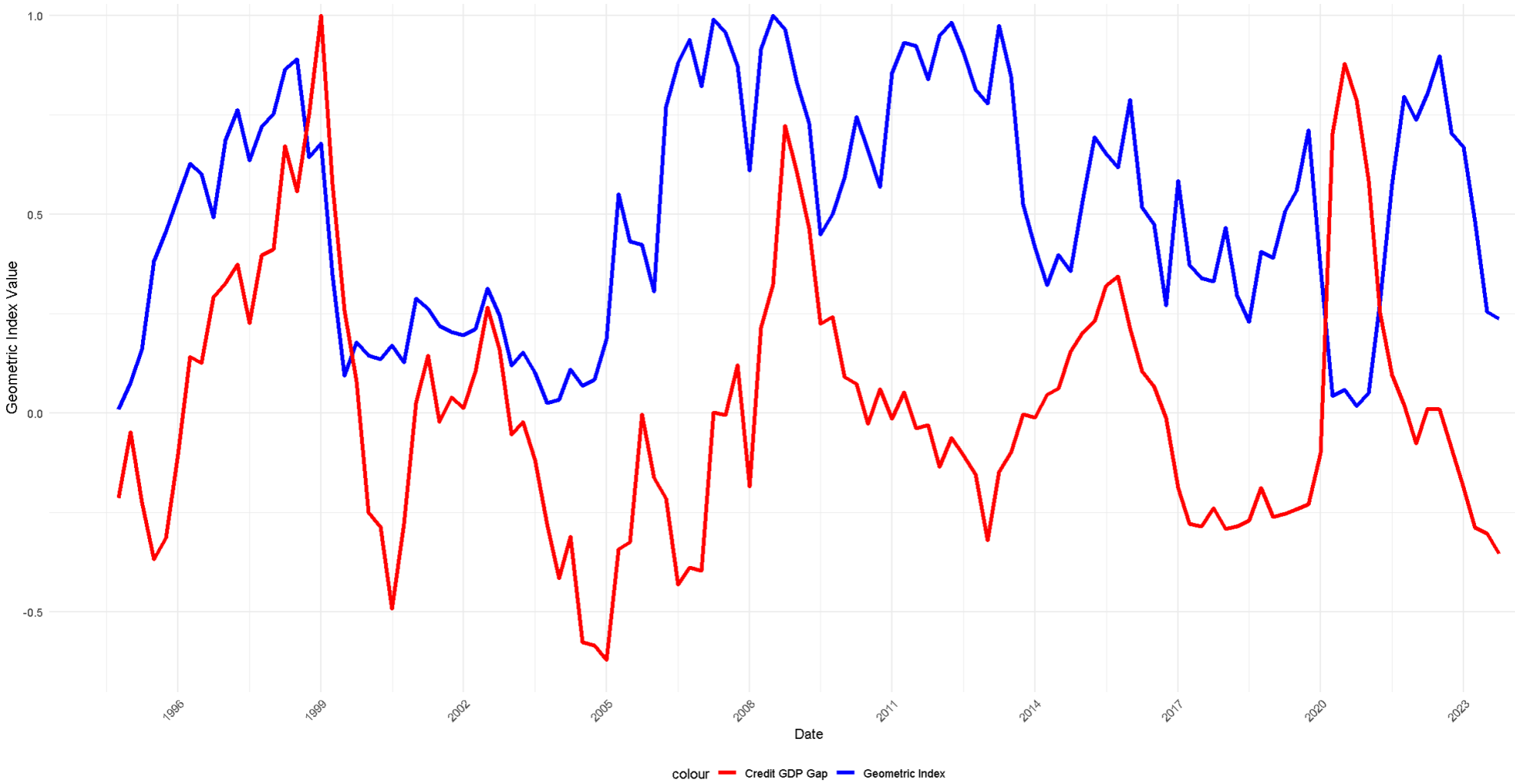


Figure: Two axis time series graph

Results: Overall Index- Individual regressions

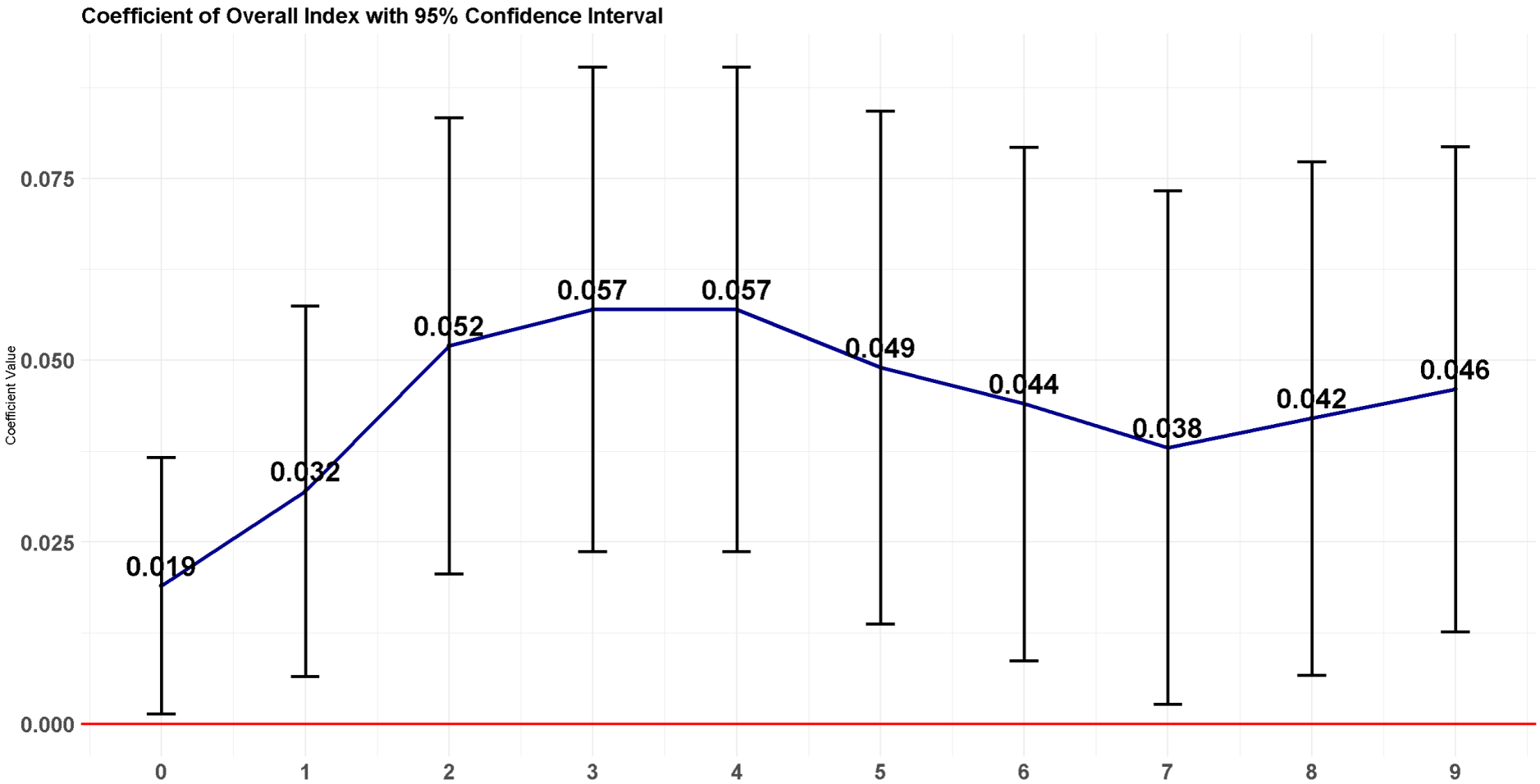


Figure: Individual regressions coefficients- lead 0 to 9

Results: Heatmap-2011Q1-2023Q4

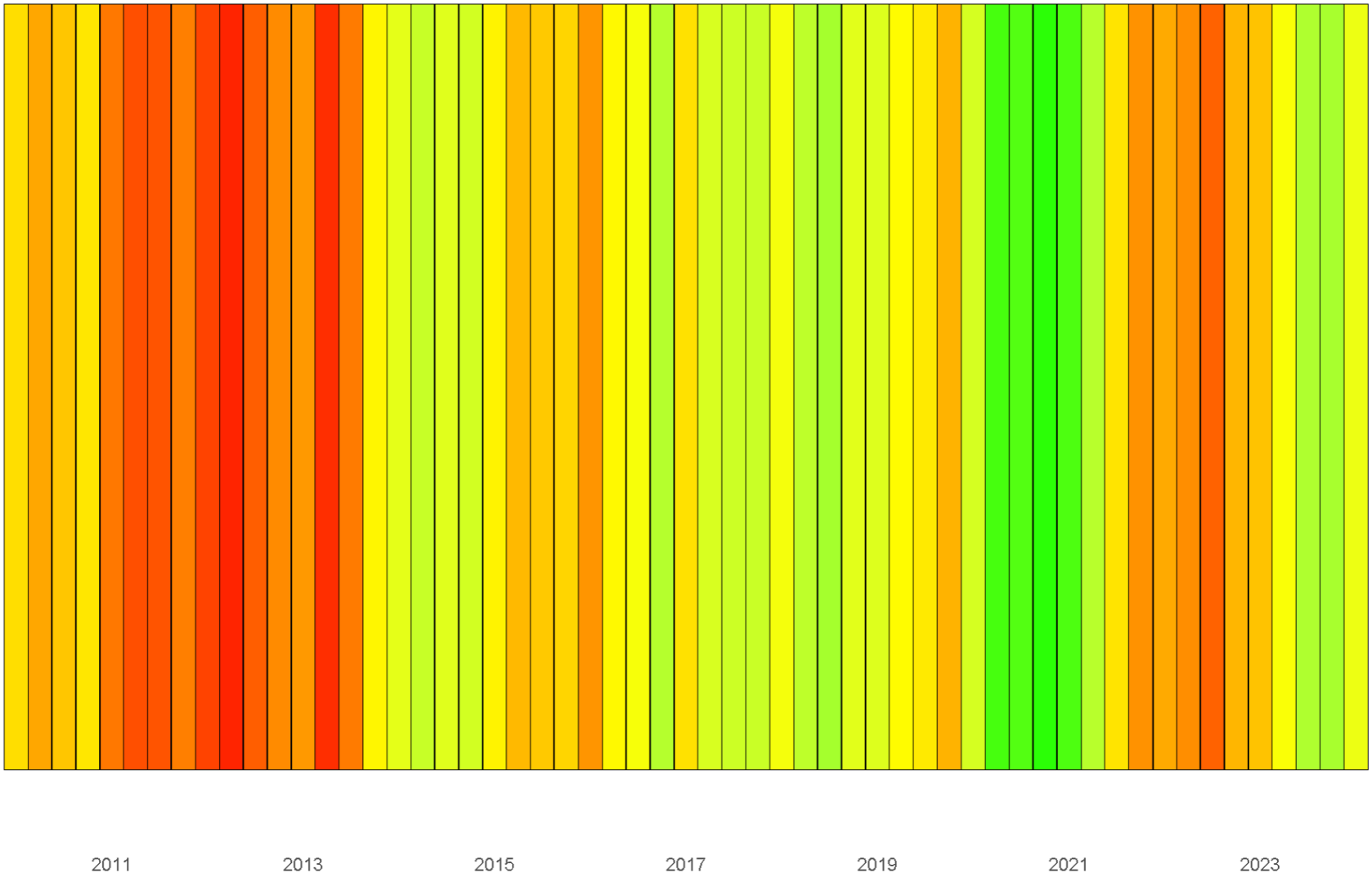


Figure: Overall Index-Geom

Results: Logistic Model

Table 19: Regression Results

	Dependent variable:				
	Credit GDP Gap Lead				
	Benchmark	Arym	Geom	RMS	PCA
	(1)	(2)	(3)	(4)	(5)
Capital		6.913*	5.690*	7.033*	4.458*
		(3.539)	(3.062)	(3.754)	(2.424)
Asset Quaility		−3.409	−4.468	−4.048	1.076
		(4.791)	(4.034)	(4.459)	(3.557)
Management		1.051	1.821	−0.009	−2.832
		(3.590)	(3.711)	(3.077)	(3.403)
Earnings		−2.598	−1.250	−3.248	0.906
		(3.452)	(3.293)	(3.358)	(2.989)
Liquidity		0.457	1.125	−0.450	4.284*
		(2.757)	(2.445)	(3.219)	(2.461)
Sensitivity		0.524	1.150	0.644	1.168
		(2.591)	(3.378)	(2.245)	(3.427)
Gap Lag 1	48.203***	49.829***	55.358***	47.872***	61.154***
	(10.609)	(13.643)	(15.378)	(12.938)	(17.003)
Constant	−3.280***	−5.378	−6.094	−3.744	−9.075*
	(0.609)	(5.393)	(4.524)	(5.446)	(4.715)
Observations	116	116	116	116	116
Log Likelihood	−23.783	−19.854	−18.909	−20.660	−18.127
Akaike Inf. Crit.	51.566	55.708	53.818	57.321	52.254
Note:					*p<0.1; **p<0.05; ***p<0.01

Figure: Logistic Model- Results

Results: Logistic Model- Goodness of Fit

Model	AUROC	Sensitivity	Specificity	Accuracy
BenchMark Model	0.9416	0.5556	0.9694	0.9052
Arym Indexex	0.9569	0.6667	0.9796	0.9310
Geom Indexes	0.9524	0.6667	0.9796	0.9310
RMS Indexes	0.9643	0.6667	0.9694	0.9224
PCA Indexes	0.9257	0.7222	0.9184	0.8879

Table 5.8: Model Performance Metrics

Figure: Logistic Model

Results: Logit Model

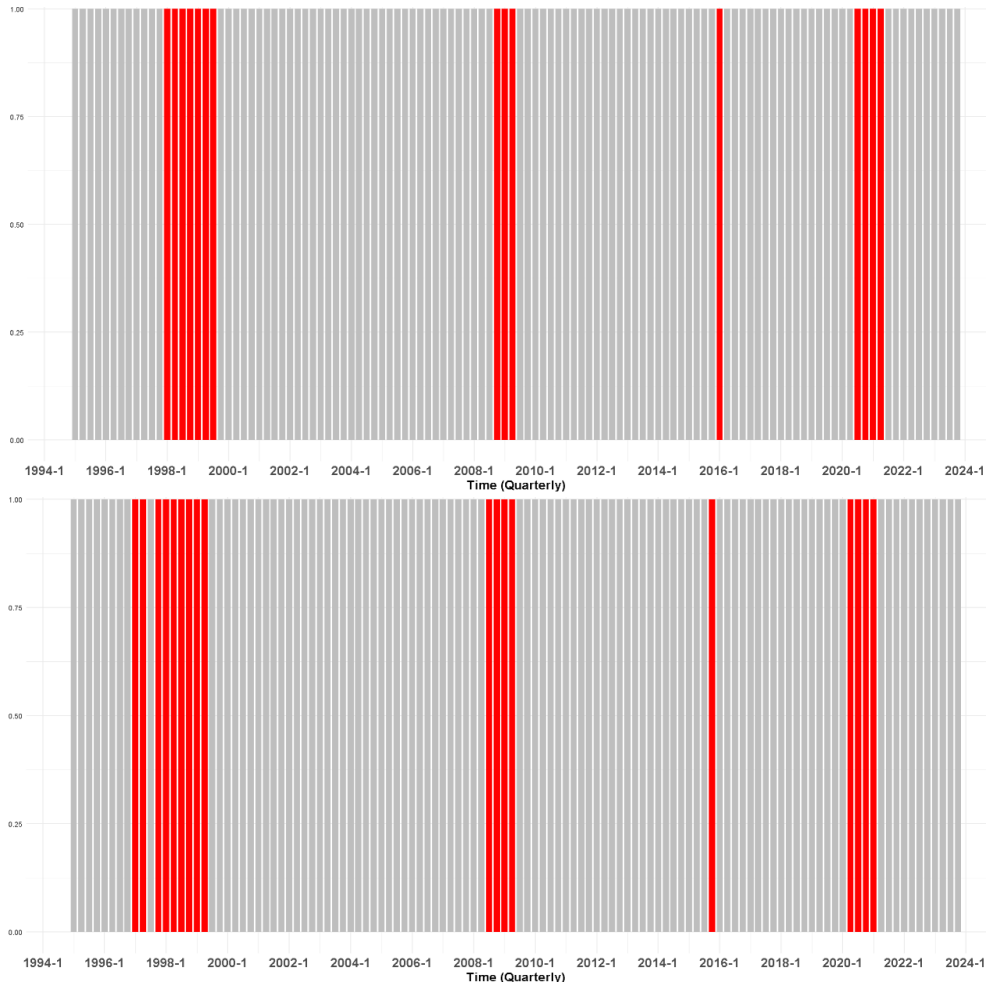


Figure: Above: Predicted episodes of financial distress-logit model, Below: Real episodes of Financial distress according to the threshold of Credit-GDP GAP

Results: Logit Model

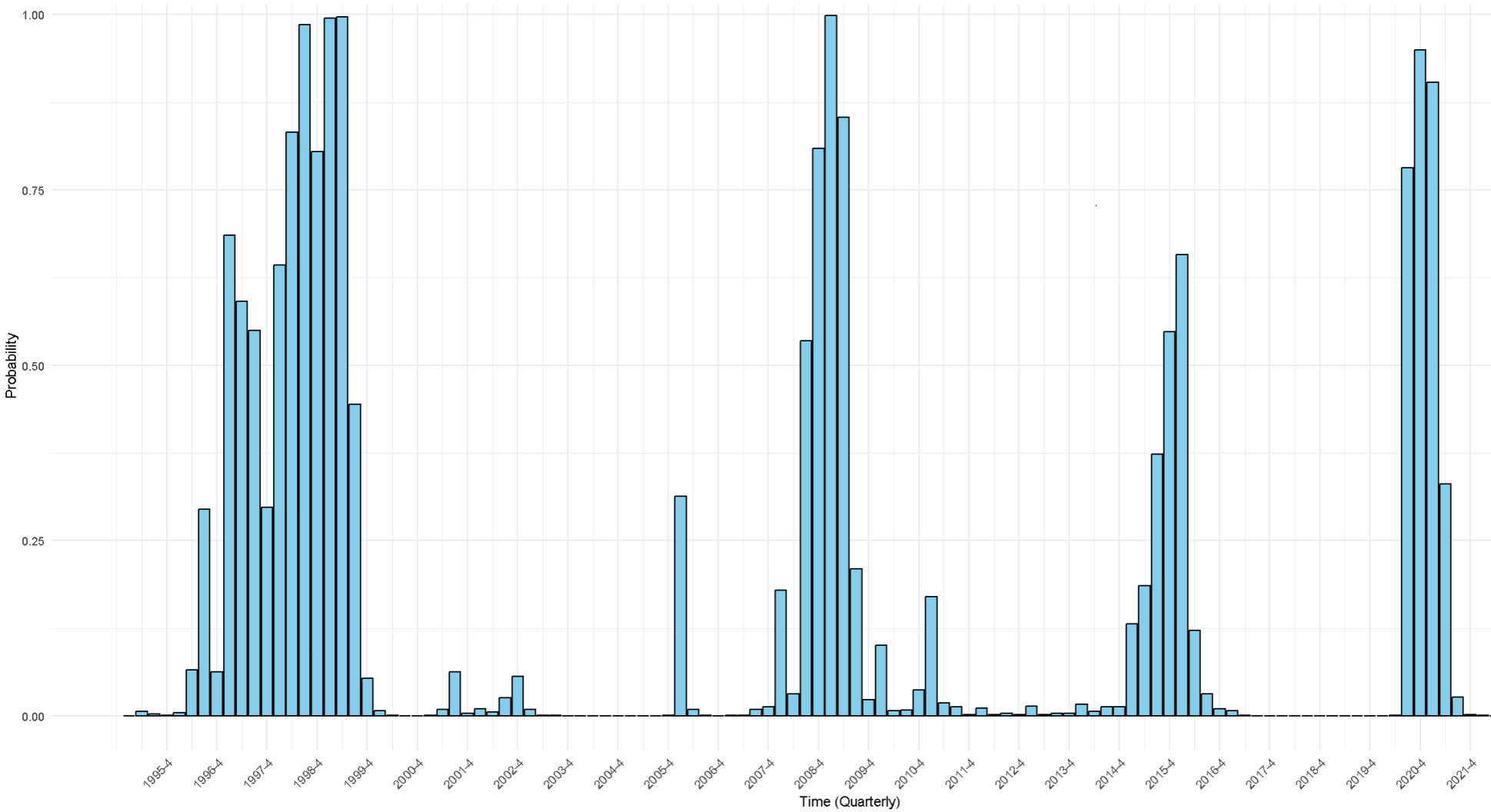


Figure: Probability of Financial Distress- Estimation

Results: Logit Model

Model	Probability-Percentages %
BenchMark Model	0.2101
Arym Indexex	0.0245
Geom Indexes	0.0099
RMS Indexes	0.0226
PCA Indexes	0.2190

Table 5.9: Estimation of the probability of Financial Distress for 2024Q1

Figure: Estimation of PFD-2024 Q1

Resumen de los resultados

- Los resultados del modelo básico, tanto en datos agregados como en panel, indican que las principales variables para predecir el GAP son los indicadores de suficiencia de capital, rentabilidad y calidad de los activos.
- Para dos de las tres categorías, los signos y la significancia se mantienen estables incluso cuando se consideran diferentes rezagos.
- El rendimiento del modelo extendido en el corto plazo es inferior al del modelo AR(1), pero lo supera en el mediano plazo.
- El modelo logit demuestra una alta precisión (aproximadamente 90%) al utilizar los índices por categoría.

Section

Conclusiones

- Los resultados sugieren que los ratios de Rentabilidad, Ajuste de Capital y Calidad de Activos son las principales variables para predecir la evolución de los episodios de stress financiero financiero, dado su significado y consistencia a través de diferentes especificaciones.
- En cuanto al ratio de Capital, el coeficiente se mantiene positivo y significativo; valores altos del ratio de capital, por encima de su valor de largo plazo o tendencia, podrían estar asociados con un mayor gap de crédito respecto al PIB y, en consecuencia, con mayor estrés financiero.
- Este resultado está en línea con estudios como los de Gambacorta y Mistrulli (2004) y Bridges et al. (2015).
- Para la calidad de los activos, nuestros resultados coinciden con el supuesto tradicional de que un mayor riesgo crediticio es perjudicial para la estabilidad del sector bancario.

Conclusiones

- El coeficiente negativo y la significancia asociados al indicador de Rentabilidad sugieren que niveles de rentabilidad por debajo del valor de largo plazo son perjudiciales para la salud del sistema bancario.
- El ejercicio de pronóstico sugiere que, en el corto y largo plazo, el modelo AR(1) predice mejor la evolución del gap. Sin embargo, en el mediano plazo, el modelo extendido supera al modelo de referencia.
- El mapa de calor y el índice general capturan de manera efectiva los principales escenarios de inestabilidad financiera durante el período desde el cuarto trimestre de 1994 hasta el cuarto trimestre de 2023.
- El modelo logístico identifica con éxito los principales episodios de estrés financiero.
- Los diversos modelos sugieren que los ratios de la metodología CAMELS pueden implementarse como indicadores de alerta temprana para la estabilidad financiera.

Limitaciones y Agenda pendiente

- Limitaciones de los datos
- Limitaciones de la definición de periodos de stress financiero
- Supuestos del modelo y restricciones metodológicas
- Direcciones para futuras investigaciones

Section

Q&A

Thank you for your attention!

Questions?