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HIGHER SCHOOL OF ECONOMICS

Fuad Aleskerov, Azamat Keskinbaev, Henry Penikas

A MULTIPLICATIVE MODEL OF COUNTERCYCLICAL CAPITAL BUFFER EVALUATION DIFFERENTIATED BY HOMOGENEOUS CLUSTERS OF COUNTRIES

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Fuad Aleskerov, Azamat Keskinbaev, Henry Penikas[1]

A MULTIPLICATIVE MODEL OF COUNTERCYCLICAL CAPITAL BUFFER EVALUATION DIFFERENTIATED BY HOMOGENEOUS CLUSTERS OF COUNTRIES[2]

The Basel Committee introduced countercyclical capital buffers in order to mitigate the effects of bank capital procyclicality, which is to say the decrease in the capital adequacy of banks in economic downturns. The ratio of loans to GDP was taken as the proxy for the economic cycle signaling variable.

Nevertheless, Repullo and Saurina (2011) have proven that the credit-to-GDP ratio is not as accurate at predicting the stage of economic cycle as the GDP growth rate. They proposed a theoretical framework for capital buffer calculations based on GDP growth rate dynamics.

We extend the countercyclical capital buffer analysis in two directions. First, empirical criteria to implement Repullo and Saurina's model are proposed and justified. Second, the countercyclical capital buffer parameter, α , is then differentiated according to clusters of countries that display homogeneous patterns of macroeconomic variables dynamics. Lastly, the countercyclical capital buffers based on the Basel Committee's approach and on the Repullo and Saurina model are then compared.

Keywords: Basel III, capital buffer, minimum capital requirements, credit-to-GDP, pattern cluster analysis.

JEL Codes: C38, C61, G20, G21, G28

[1] National Research University Higher School of Economics, International Laboratory of Decision Choice and Analysis

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1. Introduction

The main objective of any financial regulator is to maintain the stability of the banking system and to protect the interests of depositors and creditors. In order to achieve these objectives, the regulator has to intervene in financial cycles.

Basel III recommended the introduction of capital buffers and minimum capital requirements [BCBS, 2010a], [BCBS, 2010b]. The main goal of these is to protect the banking sector from economic cyclicality. This could be reached by introducing additional variable signaling for economic cycles and by dampening the negative effects of cyclicality. The Committee's Board suggests using a ratio of domestic credits – from the banking to the private sector – to GDP (credit-to-GDP ratio). On the base of this ratio, the value of the buffer is calculated following a procedure described in the annex of the Basel III Guidance [BCBS, 2010a]. This special capital buffer was intended to reduce the excessive cyclicality of a bank's capital; it would accumulate in periods of rising credit and then be spent during recessions, when there is a significant need for capital to cover incremental risks.

The Basel Committee released its Guidance in December 2010 and for a time opened it to feedback from researchers and national authorities. In their critical assessment, Repullo and Saurina (2011) present an estimation of the counter-cyclical effects from capital buffers. The authors point out that capital buffer does not behave as intended. In order to prove this, they estimate the correlation coefficient between GDP growth and the capital buffer as constructed in line with the Basel III Guidance. They observed a negative correlation between the capital buffer and GDP growth and between the credit-to-GDP gap and GDP growth. These results suggest that the credit-to-GDP gap tends to signal a reduction in capital requirements when GDP growth is high and, on the other hand, an increase in capital requirements when GDP growth is low. In other words, their research suggests that the opposite of Basel III's intensions will be observed.

Based on their assessment, Repullo and Saurina (2011) suggest an alternative way to recognize reference points in order to make capital decisions. Their proposal to directly tie the process of making capital decisions to GDP growth seems more efficient. To speak precisely, the idea was to adjust the point-in-time capital requirements with a multiplier μ_t, which is based on the GDP growth variable. This formula (6) below includes the constant α, which represents a sensitivity measure to GDP growth changes.

We estimate the intensity of parameter α in order to implement the multiplication model proposed by Repullo and Saurina (we denote this as **RSMM**). Moreover, this hypothesis is tested for the heterogeneity of countries according to macroeconomic indicators, which leads to different values of α for different clusters of countries. In other words, different approaches to build minimal capital requirements should be used for different clusters of countries unified by similar dynamics of macroeconomic indicators (such as GDP, inflation, unemployment, exports and imports, and others). This is reached by different values of α (rate of intensity to GDP growth) for clusters of countries.

The text is organized as follows: Section 2 presents a survey of previous research and currently developed models,Section 3 describes the data, Section 4 presents the methodology for the pattern cluster analysis and its outcome, while Section 5 addresses the estimation of the multiplicative model, and Section 6 concludes the paper.

2. Basel III Guidelines on Buffer Add-On: Pro et Contra

Basel III Guidance

The process of calculating capital buffers according to the Basel III Guidance [BCBS, 2010a, pp.12-14] consists of the following three steps:

- Calculation of the aggregate private sector credit-to-GDP ratio;
- Calculation of the credit-to-GDP gap (the difference between the ratio and its trend);
- Transforming the credit-to-GDP gap into the guide buffer add-on.

Let us describe this procedure in detail. First of all, the credit-to-GDP ratio for each country should be calculated

$$R_t = C_t / GDP_t . \tag{1}$$

Then, the credit-to-GDP gap is estimated according to the formula

$$G_t = R_t - T_t \ , \tag{2}$$

where a simple moving average or a linear time trend could be used as a needed trend.

Finally, the capital buffer is evaluated by the following rule

$$B_t = \begin{cases} 0, if\,(G_t < \mathrm{L}), \\ \dfrac{G_t - L}{H - L}, if\,(L \le G_t \le H), \\ 2.5,\ f\,(G_t > \mathrm{H}), \end{cases} \tag{3}$$

where *L* and *H* denote lower and upper threshold values for the gap. The lower and upper thresholds *L* and *H* play a key role in determining the timing and velocity of the adjustment of the guide buffer add-on to the underlying conditions. BCBS (Basel Committee on Banking Supervision) analysis has found that an adjustment factor based on *L=2* and *H=10* provides a reasonable and robust specification based on historical banking crises. However, this depends to some extent on the choice of the smoothing parameter, the length of the relevant credit and GDP data, and the exact setting of *L* and *H*.

In other words, the size of the buffer add-on (as a percentage of the risk-weighted assets) is zero when G_t is below a certain threshold (*L*). It then increases with G_t until the buffer reaches its maximum level where G_t exceeds an upper threshold (*H*).

Impact of new regulatory measures on economies

When discussing an output of new regulatory measures, a Basel working paper called "Long-term impact on economic performance and fluctuations" [Angelini et al., 2010] should be examined, in which the authors estimate the long-term impact of new regulatory capital requirements on the economy, as mentioned in Basel III guidance. They used DSGE family models (Dynamic Stochastic General Equilibrium models) for the assessment of steady state changes before and after the introduction of Basel III standards for different scenarios. The economy's output and welfare are taken as a measure of changes.

The article's results show that an increase of 1% to the minimum capital requirements leads to a loss in economic output equal to 0.09%. Likewise, the median effect of the new NSFR (Net Stable Funding Ratio) is 0.08%. Moreover, the prudential tightening of capital requirements leads to a decrease in the volatility of output. There are three major factors considered in this paper, including the tightening of liquidity standards, the increasing of minimum capital requirements, and stricter quality requirements for capital [Angelini et al., 2010, pp.9-12].

In detail, the authors estimate the effect on a state's long-term steadiness through an analysis of long-term indicators for liquidity by using a stochastic model for general dynamic equilibrium. The effect on the deviation of the resulting performance is evaluated in two ways. The first option, focused on unconditional volatility, involves an analysis of the unconditional standard deviation of key macroeconomic indicators. Alternatively, an autoregressive model might be introduced to estimate the optimal buffer value

$$v_t = (1-\rho_v)\bar{v} + (1-\rho_v)\chi_v X_t + \rho_v v_{t-1}, \quad (4)$$

where X_t is an explanatory variable (there might be more than one), χ_v is a sensitivity coefficient to the capital buffer of the explanatory variable, $\bar{v}$ is a steady state value of capital buffer, and v_{t-1} is a capital buffer in the previous period. All parameters are considered with appropriate weight coefficients ρ_v or $(1-\rho_v)$.

The impact of new regulatory measures on welfare is estimated using the Van den Heuvel formula for analysis of welfare losses caused by the tightening of capital requirements tightening [Angelini et al., 2010]

$$Cost = \frac{D}{C}(R^E - R^d - g_D)\frac{\Delta\bar{v}}{(1-\bar{v})} \quad (5)$$

Here, D is the total value of all deposits (aggregated over the economy's banking system), C is the aggregate consumption, R^E is the risk-adjusted return on equity, R^D is the (average) interest rate on total deposits, and g is the share of the non-interest cost, net of any fees, that is attributable to attracting and servicing deposits. This last item can be bound as $0 \le g_D \le g/D$, where g is operating expenses minus non-interest income (aggregated for the banking system). This leads to both an upper bound (when $g_D = 0$) and a lower bound (when $g_D = g/D$) on *Cost*. The key factor in the formula is the spread between the risk-adjusted return to equity and deposits. Intuitively, this reveals the value of liquidity creation by banks, which, in turn, allows banks to lend at lower rates to firms to the extent that the spread exceeds the cost of intermediation. Increasing the capital requirement reduces this boost to capital accumulation. The bank debt-to-consumption ratio concerns the importance of bank intermediated finance in the economy.

This long-term assessment paper ends with the following statements (cf. [Angelini et al., 2010], p. 20):

1. The response to changes in explanatory variables can be considered to be almost linear – a double tightening of regulatory measures leads to a double change in the outcome;
2. Segmentation by region (EU, US, UK...) does not reveal a significant difference in the effect of changes to minimum capital requirements;
3. In general for all models, a 1% change in the capital adequacy ratio leads to an average 0.09% loss in the new steady state;
4. The tightening of liquidity requirements (on 25%) leads to an additional output reduction by 0.08% and a 50% increase leads to a 0.15% reduction.

The authors conclude that they received significant values of output variance and welfare changes, with a 1% change in liquidity ratios leading to a 0.3-2.7% average decrease in output volatility (and with the addition of tightening minimum capital requirements, the decrease of output volatility reaches on average 3.4-10.2% depending on the scenario). Generally speaking, Basel III's new regulatory standards imply some losses in output and welfare (in terms of consumption).

2.3 Alternative approach to common reference point definition

The article called "The countercyclical capital buffer of Basel III. A critical assessment" by Repullo and Saurina (2011) deals with the problem of capital buffers and minimum capital requirements suggested by Basel III. The authors state that the implementation of this methodology implies decreasing capital requirements during an increase of GDP growth, and vice versa. According to Basel III, the main macroeconomic parameter that influences the size of the capital buffer is the credit-to-GDP gap (CGDP gap). The authors prove that this parameter is the main disadvantage of the methodology. For many countries this parameter is negatively correlated with GDP growth rate.

The authors consider the following time series: credit-to-GDP, credit-to-GDP gap, GDP growth, and capital buffer (calculated according Basel III) for different countries from the World Bank database. As a result they found out that the capital buffer value is negatively correlated with the credit-to-GDP gap. Moreover, the correlation strongly depends on the sample and time period, as well as the choice of a common reference point (credit-to-GDP or credit-to-GDP gap). Basel experts outline that this parameter works well in cases of economic growth, but that the regulator should use additional determinants in order to regulate the capital buffer during recessions.

The authors investigate whether the credit growth ratio is more efficient than the credit-to-GDP gap in capital buffer regulation. They made the same correlation calculation procedure using a new assumption. As a result, they discovered that this assumption is correct and that credit growth is a better signal for the size of systemic risk . It does not create additional constraints for minimum capital requirements and is positively corrected with GDP growth rate.

To support Repullo and Saurina’s statement, we consider macro data from Russia over the period of 1993 to 2009 (Table 1).

Table 1. Russia Macroeconomic Data with a Buffer Add-on Calculation

Year	C/GDP	trend	gap	buffer	growth
1993	25.92	30.21	-4.29	0.00	-0.05
1994	31.71	29.95	1.76	0.00	-0.09
1995	25.46	29.69	-4.23	0.00	0.00
1996	27.84	29.43	-1.59	0.00	-0.01
1997	29.49	29.17	0.32	0.00	0.03
1998	44.93	28.91	16.02	**2.50**	-0.33
1999	33.33	28.65	4.69	**0.84**	-0.28
2000	24.71	28.39	-3.67	0.00	0.33
2001	25.56	28.13	-2.57	0.00	0.18
2002	26.80	27.87	-1.06	0.00	0.13
2003	27.81	27.61	0.20	0.00	0.25
2004	25.65	27.35	-1.69	0.00	0.37
2005	22.09	27.09	-5.00	0.00	0.29
2006	22.44	26.83	-4.39	0.00	0.30
2007	25.47	26.57	-1.10	0.00	0.31
2008	25.11	26.31	-1.20	0.00	0.28
2009	33.85	26.05	7.80	**1.81**	-0.26

Source: World Development Indicators Database.

Correlation coefficients were estimated based on this data (all coefficients are significant at the 99% confidence level (Table 2)).

Table 2. Correlation Coefficients between Parameters

Corr.	*gap*	*buffer*	*growth*
gap	1		
buffer	0,92	1	
growth	-0,73	-0,72	1

These calculations also prove that the present capital buffer regulation contributes to an increasing of the buffer during recessions and to a decreasing of the buffer during credit booms. This contradicts the expectations of Basel experts.

Basel III presents an approach based on calculating the probability of default over a one-year time horizon. The use of this approach leads to the excessive volatility of minimum capital requirements during the economic cycle (the probability of default is estimated by considering such factors as the borrower's characteristics, credit features, and characteristics of the macroeconomic situation).

Instead of smoothing the output data, Repullo and Saurina (2011) suggest implementing risk sensitivity to the input data. This means that the minimum capital requirements are corrected with the multiplier (6), defined as

$$\mu(t) = 2N\left(\frac{\alpha(g_t - \bar{g})}{\sigma_g}\right), \qquad (6)$$

where g_t is the GDP growth rate, $\bar{g}$ is the long-term average, σ_g is the long-term standard deviation, $N(.)$ is the standard normal cumulative distribution function (the choice of normal distributional function is quite reasonable because we are dealing with normalized and detrended GDP growth rate and there is no need to consider more complex distributional functions), and α is a positive parameter to be estimated (in their paper [Repullo, Saurina, 2011] the authors did not solve the optimization problem). The multiplier μ_t is continuous and increasing in g_t, so capital requirements should increase in periods of increasing credit and decrease in recession periods. The multiplier μ_t is equal to 1 when $g_t = \bar{g}$, meaning that there are no adjustments at the midpoint of the business cycle, and it is bounded between 0 and 2, meaning that capital requirements will not increase beyond the bound or become negative. The normalization by σ_g allows us to express capital surcharges or reductions per standard deviation of GDP growth.

It is worth mentioning that the multiplier was not estimated in Repullo and Saurina (2011). We provide a solution to this problem.

3. Data Description

The method of cluster analysis has been used to construct a classification of countries based on key economic indicators. This method allows for the combining of 'similar' objects (in terms of selected measures) into separate homogeneous groups.

Key indicators characterizing the economy were considered, including unemployment as a percentage of the total workforce, GDP in U.S. dollars, GDP per capita in U.S. dollars, inflation rate based on consumer prices, and the exports of goods and services as a percentage of GDP. Nevertheless, only two indicators, specifically GDP growth and the credit-to-GDP ratio, enabled us to arrive at the appropriate breakdown of countries that resulted in statistically significant α values.

Data for the analysis came from an annual panel survey conducted by the World Bank (World Development Indicators Database). The sample consists of 67 countries, includes all rich countries. The database covers the period from 1998 to 2007. The sample includes all countries for which data exist for all indicators in the database and for at least nine years during the whole period of observation.

Descriptive statistics and correlation coefficients for the indicators used are presented below (see Tables 3 and 4):

Table 3. Summary of statistics

Descriptive statistics	Unempl. (%)	GDP (USD bln)	GDP per cap. (USD)	Infl. (%)	Exp. (%GDP)
min.	1	0.6	321	-4.0	6.9
max.	37.3	14061	106831	297.6	208.0
mean	8.7	540	15496	6.6	46.8
St. Dev.	5.6	1514	15954	16.1	29.0

Table 4. Correlation between parameters

Correlation	Unempl.	GDP	GDP per cap.	Infl.	Exp.
Unempl.	1	-0.14	-0.39	-0.03	-0.20
GDP		1	0.28	-0.08	-0.25
GDP per cap.			1	-0.22	0.39
Infl.				1	-0.04
Exp.					1

Thus it may be noted that the study covers a wide range of countries, the GDPs of which vary from USD 0.6 bln to USD 14,061 bln. The dispersion of other indicators is quite high as well.

4. Searching for Homogeneous Clusters of Countries

The values of each indicator were independently normalized for all observations according to formula (7) in order to use Euclidean metrics in cluster-analysis.

- Maximum and minimum values were identified for each indicator. In the new scale these values were equal to 10 and 0, respectively.
- All other values were displayed in the interval from minimum to maximum in the interval from 0 to 10 with a preservation of the relationship between distances and endpoints.

$$Xscaled = \frac{(X - X_{\min})}{(X_{\max} - X_{\min})} \cdot 10, \qquad (7)$$

where X is a parameter value, $X_{\min}$ and $X_{\max}$ are its minimum and maximum for all countries and periods.

To run **pattern cluster analysis**, 20 variables were used as inputs for k-means procedure, which is 2 macroeconomic indicators multiplied by 10 periods. The optimal number of clusters was chosen based on dendrogram analysis (cf. Figure 1). Thus, we decided to choose two clusters because they appeared to be significantly different in terms of values for the chosen macroeconomic variables.

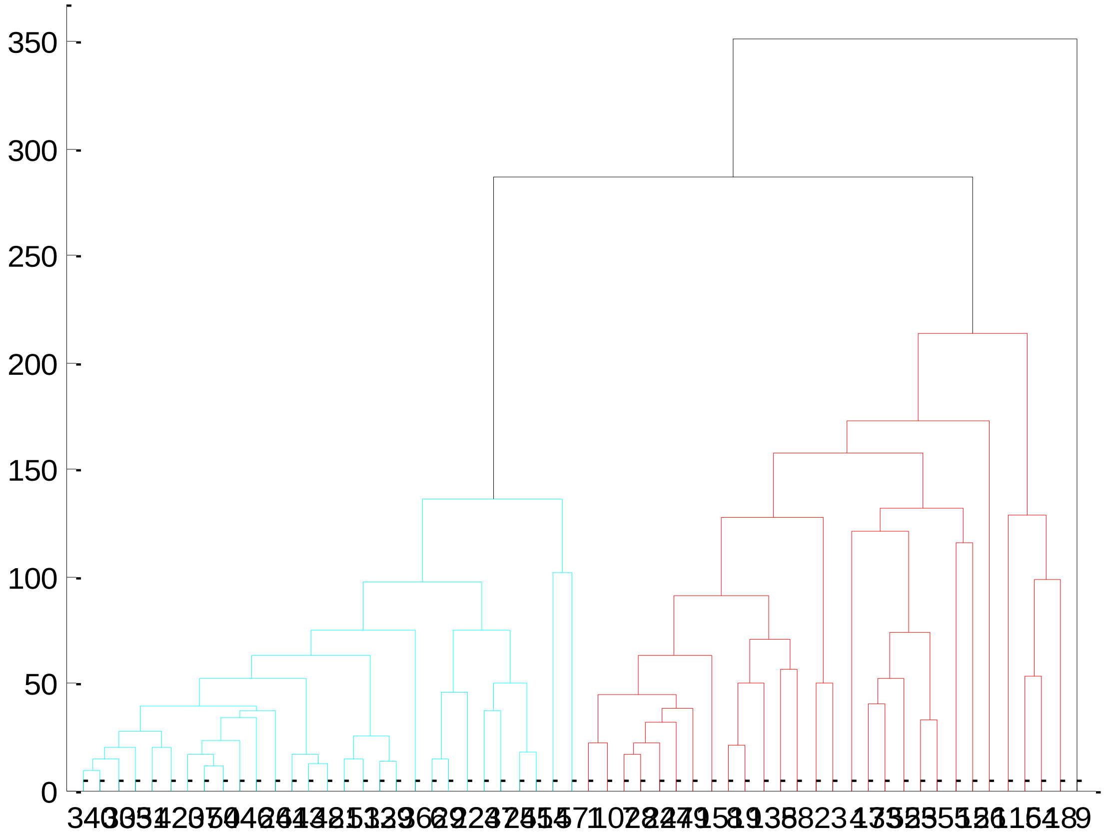

Figure 1. Dendrogram for Pattern Cluster Analysis

Note: Numbers on OX axis stand for ids of countries. OY axis presents the L2 dissimilarity measure.

The composition of the clusters is presented below.

Table 5. Cluster composition

	Cluster	
#	**1 (Highly Indebted)**	**2 (Low Indebted)**
1	Australia	Hong Kong
2	Bulgaria	Hungary
3	Canada	Indonesia
4	China	Israel
5	Colombia	Macao
6	Costa Rica	Mauritius
7	Croatia	Mexico
8	Denmark	Philippines
9	Estonia	Poland
10	Germany	Russia
11	Spain	Slovakia
12	Switzerland	South Africa
13	Thailand	Sri Lanka
14	Trinidad	United Kingdom
15	Ukraine	Czech
16	Argentina	Egypt
17	Austria	Iceland
18	Belgium	Italy

19	Dominican	Latvia
20	Finland	Lithuania
21	France	Luxemburg
22	Greece	Netherlands
23	Ireland	New Zealand
24	Japan	Panama
25	Korea	Peru
26	Malaysia	Portugal
27	Norway	Romania
28	Turkey	Slovenia
29	United States	Sweden

5. Multiplicative Model Estimation

In order to estimate α in (6), the criteria of its optimal value should be defined. We consider two assumptions: 1) minimum capital requirements μ_t should decrease during economic recessions (low rate of GDP growth) and increase when economic conditions improve; 2) μ_t should increase when the credit demand is high, and vice versa. That is why the dynamic of multiplier should replicate the behavior of both GDP growth rate (g_t) and credit-to-GDP (C_t / GDP_t). The respective dependence measures should be *maximized*. *Correlation* is not a proper dependence measure because the buffer value μ_t does not change as α approaches zero, resulting in zero standard deviation. Thus, the correlation is infinite and we arrive at the necessity to consider **covariances**.

Another important fact is that the dynamics of the indicators is not synchronized. The credit usually lags behind the business cycle, especially in downturns. However, studying this issue is beyond the scope of this paper.

It is thus necessary to maximize cov_2 with cov_1, which is positive. Thus

$$\begin{cases} \text{cov}_2 \xrightarrow[\alpha]{} \max \\ \text{cov}_1 > 0 \end{cases} \qquad (8)$$

where cov_1 is the covariance between multiplier μ_t and GDP growth rate (g_t), and cov_2 is the covariance between multiplier μ_t and the credit-to-GDP rate (C_t / GDP_t).

To validate the proposed approach, countries within the clusters were divided into training and testing sets for odd and even row numbers after sorting them by average GDP growth rate.

The figures illustrating the dynamics of cov_2 with respect to α values from training and testing subsets of clusters are below.

Training Set (α = 2.29)	Testing Set (α = 5.92)

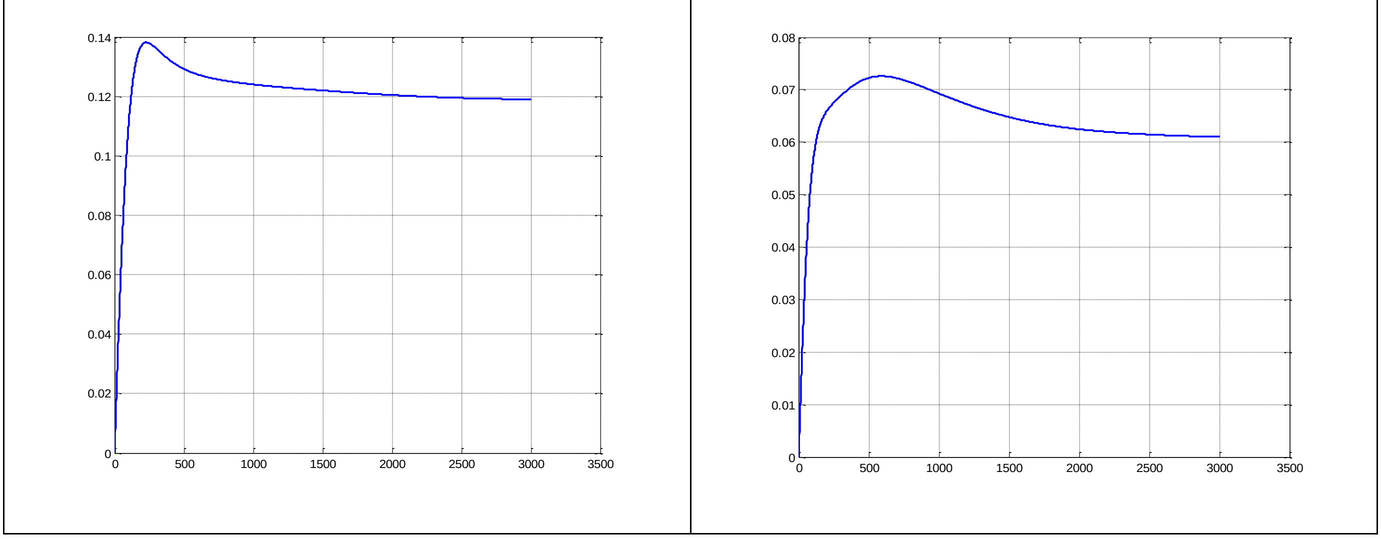

Figure 2. Correlation of capital buffers and credit-to-GDP for cluster 1

Note: α ranges from 0 to 10 on OX axis with the step 0.05.

Training Set (α = 18.23)	Testing Set (α =13.58)

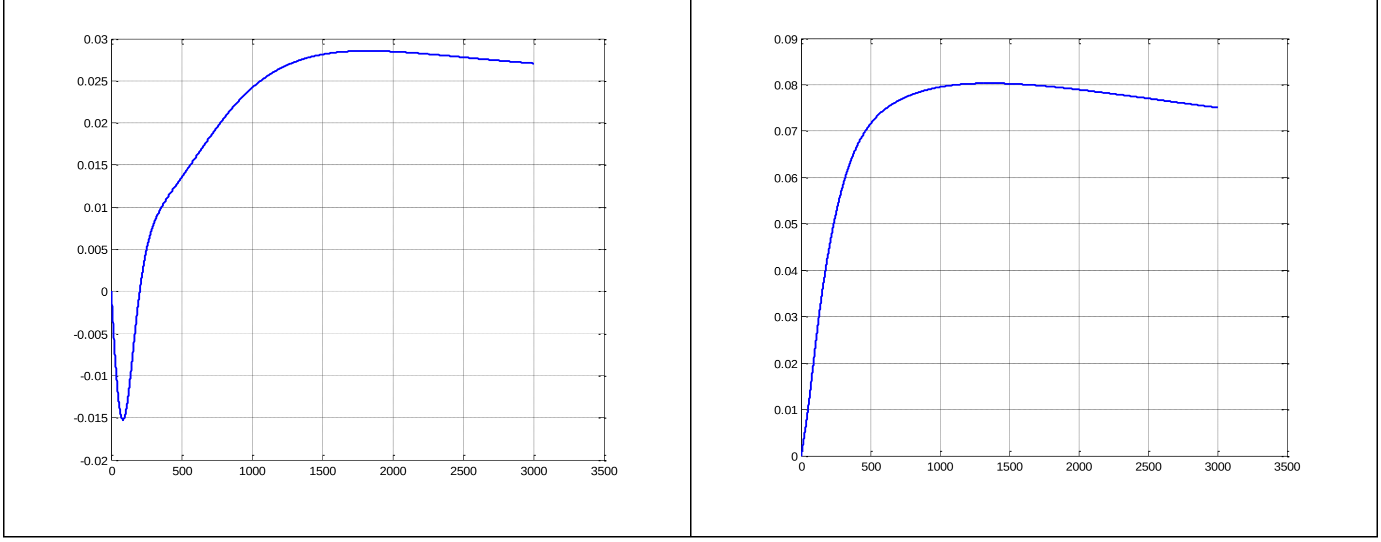

Figure 3. Correlation of capital buffer and credit-to-GDP for cluster 2

Note: α ranges from 0 to 10 on OX axis with the step 0.05.

Finally, the values of the α variable are presented below in Table 6 for all clusters.

Table 6. α Values by Clusters

		Set		
Cluster	**Name**	**Training**	**Test**	**Total**
1	Countries with high level of indebtedness	**2.29**	**5.92**	**4.10**
2	Countries with low level of indebtedness	**18.23**	**13.58**	**15.90**

Table 6 supports the key evidence that α differs by clusters. This means that applying the same α when calculating capital buffers for different countries is incorrect.

To finalize the research, values for countercyclical capital buffers according to the Basel Committee (BCBS) approach and **RSMM** are compared. Though the maximum values of countercyclical capital buffers may equal 2.5% within BCBS framework and 2.0% in MM case, on average the **RSMM** approach results in higher capital buffer values than does the Basel Committee (cf. Table 7 below for aggregate results and see Annex 1 for details).

Table 7. Buffer Values by Clusters

Cluster	Name		BCBS	RSMM
1	Countries with high level of indebtedness	Mean	0.6796	1.0146
		St.Dev.	0.4884	0.1319
2	Countries with high level of indebtedness	Mean	0.5145	1.0016
		St.Dev.	0.3630	0.1556

6. Conclusion

In general, the use of countercyclical capital buffers reduces the vulnerability of the banking sector in times of recession [Angelini et al., 2010].

BCBS analysts [BCBS, 2010a, p.13] mentioned the use of some 'smoothing parameter' in the procedure for estimating capital buffers. The proposed method of assessing the parameter α may be implemented when calibrating capital buffers for various countries by means of the credit-to-GDP ratio.

We show that there is a significant difference between α values for various clusters of countries. This leads to the rejection of a unified approach to applying countercyclical minimum capital requirements. It is advised that BCBS experts take this fact into account.

Annex 1. Countercyclical Capital Buffer Values By Clusters

	Cluster					
#	1 (High Level of Indebtedness)			2 (Low Level of Indebtedness)		
Model	Country	BCBS	RSMM	Country	BCBS	RSMM
1	Australia	0.88	0.97	Hong Kong	0.06	1.11
2	Bulgaria	0.91	1.05	Hungary	0.88	0.89
3	Canada	1.67	1.17	Indonesia	-	0.96
4	China	0.38	0.88	Israel	0.17	1.26
5	Colombia	0.10	1.04	Macao	0.65	0.90
6	Costa Rica	0.40	0.83	Mauritius	0.60	0.74
7	Croatia	0.66	1.10	Mexico	0.02	0.89
8	Denmark	1.55	0.97	Philippines	0.15	0.94
9	Estonia	0.90	1.07	Poland	0.31	1.05
10	Germany	0.08	0.94	Russia	0.59	1.34
11	Spain	0.86	0.95	Slovakia	0.38	0.96
12	Switzerland	0.43	0.99	South Africa	0.66	0.74
13	Thailand	0.28	1.22	Sri Lanka	0.05	1.23
14	Trinidad	0.09	0.96	United Kingdom	0.89	0.90
15	Ukraine	0.64	1.26	Czech	0.38	1.32
16	Argentina	0.18	1.21	Egypt	0.08	1.11
17	Austria	1.98	0.97	Iceland	0.83	1.10
18	Belgium	1.13	0.93	Italy	0.42	0.89
19	Dominican	0.44	0.75	Latvia	0.89	0.89
20	Finland	0.67	0.87	Lithuania	0.83	1.13
21	France	0.38	0.93	Luxemburg	1.11	1.00
22	Greece	0.67	0.93	Netherlands	1.44	0.89
23	Ireland	0.86	0.90	New Zealand	0.63	0.89
24	Japan	0.56	0.96	Panama	0.42	0.89
25	Korea	0.19	1.00	Peru	0.07	1.06
26	Malaysia	0.59	0.98	Portugal	0.72	0.89
27	Norway	1.39	1.20	Romania	0.32	1.11
28	Turkey	0.18	1.20	Slovenia	0.66	0.93
29	United States	0.69	1.22	Sweden	0.69	1.05
	Average	0.68	1.01	**Average**	0.51	1.00

Note: BCBS – Basel Committee approach; RSMM – multiplicative model of Repullo and Saurina (2011) with a common α for the total cluster applied; Countercyclical capital buffer values are expressed in percentage points to RWA (pp, %).

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Henry Penikas

Junior Research Fellow at International Laboratory of Decision Choice and Analysis, National Research University Higher School of Economics

E-mail: penikas@gmail.com