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NONLINEAR EFFECTS OF BANK REGULATION STRINGENCY ON BANK LENDING IN SELECTED SUB-SAHARAN AFRICAN COUNTRIES

Retselisitsoe I. Thamae[1] & Nicholas M. Odhiambo

Abstract

This paper investigates the nonlinear effects of bank regulation stringency on bank lending in 23 sub-Saharan African (SSA) countries over the period 1997-2017. It employs the dynamic panel threshold regression (PTR) model, which addresses endogeneity and heterogeneity problems within a nonlinear framework. It also uses indices of entry barriers, mixing of banking and commerce restrictions, activity restrictions, and capital regulatory requirements from the updated databases of the World Bank's Bank Regulation and Supervision Surveys as measures of bank regulation. The linearity test results support the existence of nonlinear effects in the relationship between bank lending and entry barriers or capital regulations in the selected SSA economies. The dynamic PTR estimation results reveal that bank lending responds positively when the stringency of entry barriers is below the threshold of 62.8%. However, once the stringency of entry barriers exceeds that threshold level, bank credit reacts negatively and significantly. By contrast, changes in capital regulation stringency do not affect bank lending, either below or above the obtained threshold value of 76.5%. These results can help policymakers design bank regulatory measures that will promote the resilience and safety of the banking system but at the same time not bring unintended effects to bank lending.

Keywords: Bank regulation; bank lending; nonlinear effects; dynamic panel threshold regression; sub-Saharan Africa

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1. Introduction

Most countries, including the ones in sub-Saharan Africa (SSA), have been facing pressure to increase the stringency of bank regulation since the aftermath of the 2007-2008 global financial crisis. Nevertheless, studies have shown that bank regulation has ambiguous effects on bank lending since it does not only come with benefits, but it also involves costs related to providing 'too much' (or 'too little') of it (Barth *et al*., 2004; Adesina, 2019; Thamae and Odhiambo, 2021). This implies that the effects of bank regulation stringency on bank lending could be nonlinear, depending on whether the benefits of adopting higher standards of bank regulation outweigh their costs, either below or above some threshold level (also see Figure 1). Thus, policymakers need to understand this nonlinear relationship to ensure that increasing the stringency of bank regulation, with the aim of promoting the resilience and safety of the banking system, will not lead to unintended effects on bank lending and be detrimental to bank development.

Previous theoretical and empirical studies on the effects of the stringency of various bank regulatory measures, such as bank entry barriers, restrictions on the mixing of banking and commerce, bank activity restrictions and capital regulatory requirements, on bank lending offer conflicting views. Firstly, the theory of market structure postulates that bank entry barriers reduce competition. These barriers can either increase the market power and profitability of banks and encourage prudent lending (Keeley, 1990) or result in inefficiencies that can cause banks to hike their costs of offering services and lead to a fall in demand for credit (Claessens and Klingebiel, 2001). Although the empirical evidence shows that increasing bank entry barriers limits bank lending (Merrouche and Nier, 2017), the effect is at times found to be positive (Amidu, 2014) or insignificant (Barth *et al*., 2004).

Secondly, the asymmetric information theory considers restrictions on the mixing of banking and commerce as well as on bank activities to minimize conflict of interest and moral hazard problems. This can limit banks' incentives to take excessive risks, thereby encouraging prudent lending (Boyd *et al.*, 1998). Contrarily, the theory of economies of scale and scope regards these restrictions as impediments that restrict banks' ability to provide more lending (Claessens and Klingebiel, 2001). While some empirical evidence exists supporting the argument that these restrictions prohibit bank lending (Barth *et al*., 2004), the other part of evidence indicates that they enhance bank lending (Amidu, 2014) or do not affect it (Merrouche and Nier, 2017).

Lastly, the risk-absorption theory indicates that capital regulatory requirements can encourage prudent lending by enhancing the risk-bearing capacity of banks, while the financial fragility-crowding out hypothesis points out that capital regulatory requirements can hamper prudent lending by forcing banks to rely more on equity than deposits and capital investors as equity providers are usually hesitant to give out lending (Kim and Sohn, 2017). The empirical findings on the effects of increasing capital requirements are heterogeneous as they are found to either restrict bank lending (Amidu, 2014; Bridges *et al.*, 2014) or have no effect on it (Barth *et al*., 2004; Bridges *et al.*, 2014; Fratzscher *et al.*, 2016). Nevertheless, all the above-mentioned empirical studies analyzed the effects of bank regulatory measures on bank lending using linear approaches to modelling.

This study, unlike the previous ones, aims to determine the nonlinear effects of bank regulation stringency on bank lending in a panel of 23 SSA countries during the period 1997-2017. The paper employs the dynamic panel threshold regression (PTR) model proposed by Kremer *et al.* (2013), which addresses both endogeneity and heterogeneity problems within a nonlinear framework. Furthermore, it uses indices on bank entry barriers, mixing of banking and commerce restrictions, bank activity restrictions and capital regulatory requirements from the updated databases of the World Bank (WB)'s Bank Regulation and Supervision Surveys (BRSS) as measures of bank regulation. To the best of our knowledge, this is the first study to use the preceding approaches and SSA context to examine the nonlinear effects of bank regulatory measures on bank lending.

With this analysis, the paper contributes to the literature on the effects of bank regulation on bank lending. There is a growing number of studies assessing how the following bank regulatory measures influence bank lending: bank entry barriers (see Barth *et al.*, 2004; Cottarelli *et al.*, 2005; Amidu, 2014; Merrouche and Nier, 2017), restrictions on the mixing of banking and commerce as well as on bank activities (see Barth *et al.*, 2004; Amidu, 2014; Sum, 2016; Merrouche and Nier, 2017; Ibrahim and Rizvi, 2018; Hsieh and Lee, 2020) and capital regulations (see Amidu, 2014; Bridges *et al.*, 2014; Košak *et al.*, 2015; Fratzscher *et al.*, 2016; Sum, 2016; Merrouche and Nier, 2017; Ibrahim and Rizvi, 2018; Temesvary; 2018; Hsieh and Lee, 2020)[2]. However, the evidence from these studies on how bank regulation affects bank lending is inconclusive. Moreover, none of these studies, to our knowledge, has given attention

[2] See Thamae and Odhiambo (2021) for a detailed review of these studies.

to the existence of threshold effects in the relationship between bank regulation and bank lending within a nonlinear framework. Therefore, this study expands the existing literature by considering bank regulation as a multifaceted phenomenon and assessing its threshold effects on bank lending.

The remainder of the paper is organised as follows: Section 2 presents a brief context on bank regulatory reforms in the SSA region and their effects on bank lending, while section 3 provides data sources and descriptive analysis. Section 4 discusses the econometric model and estimation techniques, while section 5 analyses the empirical results and offers a discussion of these. Section 6 concludes the paper and gives policy implications.

2. Context

SSA countries have adopted regulatory reforms in response to emerging challenges facing the banking sector. These reforms had a bearing on financial stability and banking development through the promotion of sustainable lending to the private sector. For example, prior to the 1990s, bank regulation in many SSA economies was lacking and, according to Le Gall *et al.* (2004), several factors were attributable to such inadequacy. First, the supervision of the banking sector was largely influenced by governments, instead of central banks, in favour of state-driven projects or state-owned businesses. As a result, central banks lacked enough authority over the supervision of banks and used outdated laws that limited their ability to enforce prudential regulatory requirements. Second, the limited availability of data and irregularity of prudential reports restricted the capacity of central banks to provide adequate monitoring and supervision of banks. Finally, bank regulations adopted by central banks at that time were not clearly defined in terms of important elements such as prudential limits on lending, exposures to risks, and capital requirements.

The highlighted drawbacks in bank regulation resulted in many banking crises across the SSA region. For instance, SSA had about 39 systemic banking crises from the 1970s till the mid-1990s relative to 51 banking crises experienced by the rest of the world (Laeven and Valencia, 2013). Thus, various SSA countries implemented measures to reform the financial sector since the late 1980s, including making significant adjustments to banking regulations as well as supervisory frameworks (Barth *et al.*, 2001, 2004, 2008, 2013; Cihak *et al.*, 2013; Enoch *et al.*, 2015; Mecagni *et al.*, 2015; Nyantakyi and Sy, 2015; Mlachila *et al.*, 2016; Anginer *et al.*,

2019). Such reforms included the adoption of the Basel I accord by almost all the countries, which aimed at limiting credit risk by imposing 8% of the risk-weighted assets as a minimum capital required ratio. Later, other countries such as Angola, Botswana, Malawi, and Mozambique implemented the Basel II accord (or certain elements of it), which accounted for operational risk in the determination of the minimum capital required ratio and improved risk monitoring and transparency. Lastly, various economies including Ghana, Kenya, Mauritius, Nigeria, Rwanda, Tanzania, West African Economic and Monetary Union (WAEMU)[3], and South Africa adopted the Basel II and III accords (or certain elements of the two), with the latter strengthening capital requirements from the Basel II accord and introducing macroprudential perspective to minimize systemic risk.

Concerned about the effects of some of these bank regulatory reforms on bank lending in the context of African countries, Amidu (2014) undertook a study focusing on 24 SSA economies during the period 2000-2007, which revealed that imposing stringent bank entry requirements and restricting banks to concentrate mainly on their central business of banking promoted bank credit delivery. However, the study established that the regulatory initiative characterised by stringent capital requirements prohibited the provision of bank credit to the private sector in the selected SSA countries. Alternatively, Adesina (2019) found that complying with the Basel III liquidity regulations could be beneficial for bank lending in the African continent as both liquidity coverage and net stable funding ratios had a positive impact on the growth rate of bank loans in 38 African countries over the period 2005-2015. Nevertheless, these studies did not determine the threshold effects of bank regulatory measures on bank lending within the SSA region, which is a gap this paper aims to fill.

3. Data Sources and Descriptive Analysis

3.1. Data Sources

This study uses averaged data over 3-year non-overlapping periods from 1997 to 2017 for a panel of 23 SSA economies, resulting in a maximum of seven observations under each variable per country. These countries were selected based on having data from at least three out of five WB's BRSS, including the last one completed in 2019. These BRSS surveys were finalized in 1999, 2003, 2007, 2011 and 2019 by Barth *et al.* (2001, 2004, 2008), Cihak *et al.* (2013) and Anginer *et al.* (2019), respectively. Barth *et al.* (2013) then compiled a database from the first

[3] WAEMU includes Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo.

four surveys and addressed their observed inconsistencies and missing values. Thus, Table V in the Appendix gives the available surveys for each of the selected SSA economies.

In the literature, bank lending is mainly proxied either by domestic bank credit to the private sector (see Barth *et al.*, 2004; Cottarelli *et al.*, 2005; Amidu, 2014; Fratzscher *et al.*, 2016; Cerutti *et al.*, 2017; Merrouche and Nier, 2017; Akinci and Olmstead-Rumsey, 2018; Revelo *et al.*, 2020) or total bank loans (see Košak *et al.*, 2015; Sum, 2016; Ibrahim and Rizvi, 2018; Klingelhöfer and Sun, 2019; Gómez *et al.*, 2020; Hsieh and Lee, 2020). However, this study follows Barth *et al.* (2004), Cottarelli *et al.* (2005) and Merrouche and Nier (2017) by using a more standard measure of bank lending, which is bank credit to the domestic private sector as a share of GDP. This proxy captures well domestic private credit expansion towards both short-term and long-term investments as a ratio of individual country's output.

The data on bank credit to the domestic private sector as a ratio of GDP are sourced from the WB Financial Development and Structure, the WB Global Financial Development, and the International Monetary Fund (IMF) International Financial Statistics databases. The study further uses the entry barrier, mixing of banking and commerce restriction, activity restriction and capital regulation stringency indices from the WB's BRSS as measures of bank regulation. The entry barrier index captures the degree of restrictions on bank licensing and foreign ownership, whereas the extent to which banks, non-financial firms, and non-bank financial firms can own and control each other is measured by the mixing of banking and commerce restriction index. The degree of restrictions on engagement in securities, insurance and real estate activities by banks is measured by the activity restriction index, while the capital regulation index is proxied by the stringency of bank regulatory requirements on bank capital. Additionally, the supervisory power index, which measures the extent to which bank supervisory authorities have the power to prevent, correct, and resolve problem banks, is used as an institutional control variable. Table VI in the Appendix gives the sub-components, qualification criteria and range for each of these indices.

The macroeconomic control variables that are common in the literature[4] are also employed in this study. The data on economic growth—captured by the log of real GDP (in purchasing

[4] Other control variables are not included due to patchy data availability in the selected SSA economies over the period under consideration.

power parity, 2011 international dollar), inflation—measured by the log of consumer price index, and current account balance as a ratio of GDP—indicating the net flow of capital, are obtained from the IMF World Economic Outlook and the WB World Development Indicators. Table VII in the Appendix presents the data sources and description of these variables used in this study.

3.2. Descriptive Analysis

Figure 1 portrays the relationship between average bank regulatory indices (normalized to one) and bank lending in all selected SSA economies from 1997 to 2017. On the one hand, one can impose linear relations between bank regulatory measures and bank lending. For example, bank credit to the domestic private sector as a share of GDP seems to have a negative relationship with the bank entry barrier as well as mixing of banking and commerce restriction indices, albeit the association is relatively weak in the case of the latter. In contrast, bank credit to the domestic private sector as a ratio of GDP appears to have a positive relationship with bank activity restriction and capital regulation indices, although these relations are not so pronounced.

On the other hand, one can argue that the depicted graphs show possible nonlinear relationships between bank regulatory measures and bank lending. For instance, bank credit to the domestic private sector as a share of GDP seems to have a positive association with bank entry barrier and mixing of banking and commerce restriction indices at lower levels of these indices. But beyond a certain point as the stringency of these indices increases, the relationship between these bank regulatory measures and bank lending tends to be negative. Similarly, bank credit to the domestic private sector as a ratio of GDP appears to have a negative relation with bank activity restriction and capital regulation indices at lower levels of these indices. However, beyond a certain point, as the stringency of these indices continues to rise, the association between these bank regulatory measures and bank lending becomes positive. Therefore, this underscores the importance of ascertaining whether the relationship between bank regulatory measures and bank lending is linear or nonlinear before any assumption can be imposed during the estimation process.

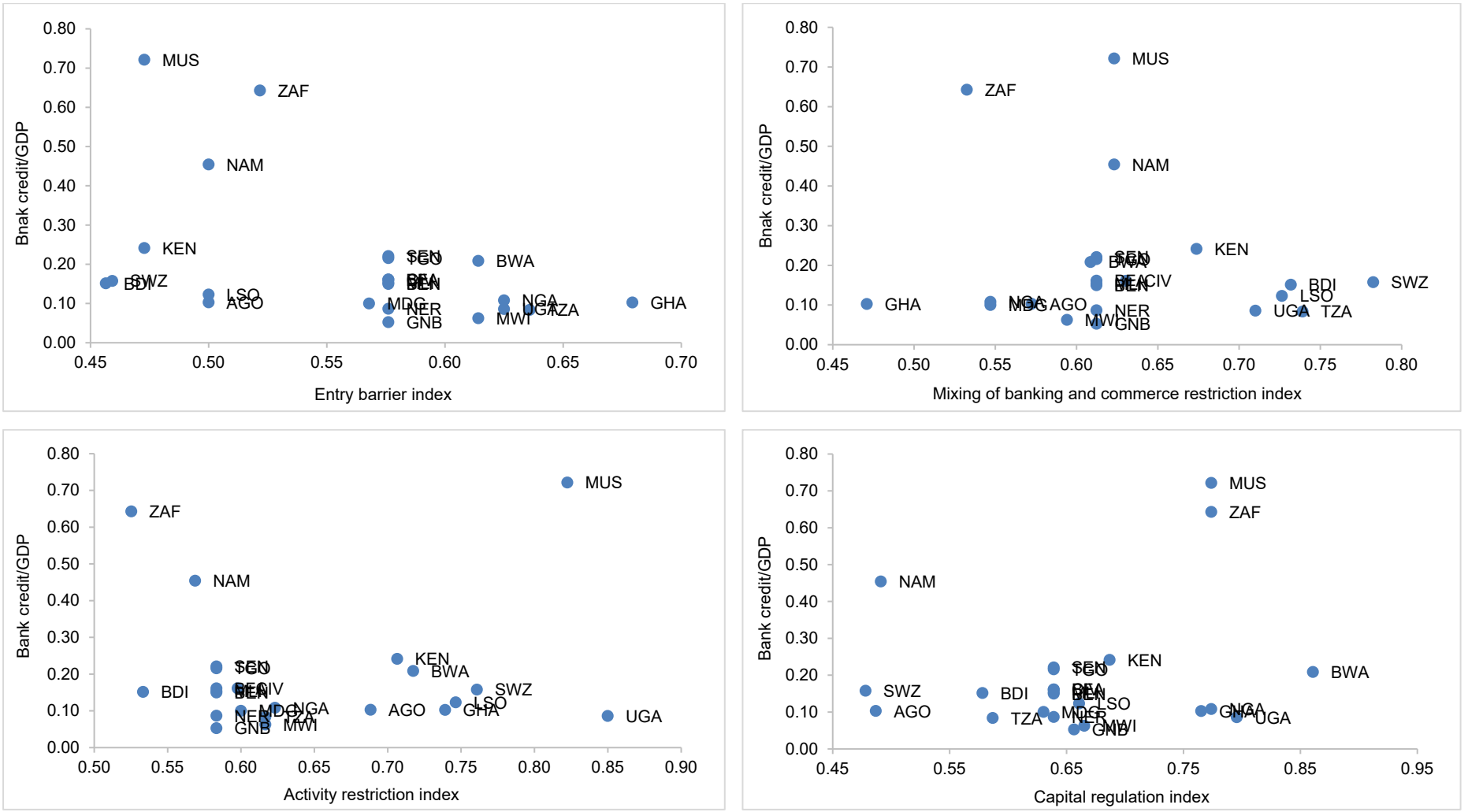

Figure 1 The relationship between bank regulation and bank lending in all selected SSA countries (averages from 1997 to 2017)

Note(s): Bank regulatory indices are normalized to one; AGO=Angola; BEN=Benin; BWA=Botswana; BFA=Burkina Faso; BDI=Burundi; CIV=Côte d'Ivoire; SWZ=Eswatini; GHA=Ghana; GNB=Guinea-Bissau; KEN=Kenya; LSO=Lesotho; MDG=Madagascar; MWI=Malawi; MLI=Mali; MUS=Mauritius; NAM=Namibia; NER=Niger; NGA=Nigeria; SEN=Senegal; ZAF=South Africa; TZA=Tanzania; TGO=Togo; UGA=Uganda.

Furthermore, Table I gives the summary statistics of all variables used in this study for all selected SSA economies. It shows that the mean of bank credit to the private sector as a share of GDP is 0.20, while the ones for bank regulatory and supervisory indices range from 0.56 to 0.71. The log of real GDP, the log of consumer price index and current account balance as a ratio of GDP averaged 24.04, 4.43 and -0.04, respectively. Real GDP and bank credit to the private sector as a ratio of GDP have higher variations in terms of standard deviation when compared to other variables, whereas current account balance as a share of GDP and bank entry barrier index have the lowest variations among the variables under consideration.

Table I Summary statistics

Variables	Obs.	Mean	Std. dev.	Min.	Max.
Bank lending variable					
Bank credit/GDP (L)	161	0.20	0.18	0.01	0.99
Bank regulatory and supervisory indices[a]					
Entry barrier (R_{EB})	161	0.56	0.08	0.38	0.75
Mixing of banking and commerce restriction (R_{BC})	161	0.63	0.11	0.33	0.89
Activity restriction (R_{AR})	161	0.66	0.12	0.42	1.00
Capital regulation (R_{CR})	161	0.66	0.16	0.30	1.00
Supervisory power (S)	161	0.71	0.17	0.29	1.00
Macroeconomic variables					
Real GDP[b] (in log form) (Y)	161	24.04	1.40	21.24	27.65
Inflation (log of consumer price index) (π)	161	4.43	0.81	-1.53	5.98
Current account (balance)/GDP (C)	161	-0.04	0.07	-0.25	0.19

Note(s): The sample comprises 23 selected SSA countries using averaged data over 3-year non-overlapping periods from 1997 to 2017; [a]normalized to one; [b]in purchasing power parity (2011 international dollar); Obs. is observations; Std. dev. is standard deviation; Min. is minimum; Max. is maximum.

Alternatively, Table II presents the correlation matrix of the variables employed in the analysis of this study. It indicates that there is a negative and significant association between bank credit to the private sector as a share of GDP and bank entry barrier index, while the mixing of banking and commerce restriction, activity restriction, capital regulation and supervisory power indices have no significant association with bank lending. Real GDP has a positive and significant association with bank credit to the private sector as a ratio of GDP, whereas inflation and current account balance as a ratio of GDP have an insignificant association with bank lending. Even though some significant negative or positive associations exist among bank regulatory and supervisory indices and macroeconomic variables, there is a low possibility of multicollinearity among these explanatory variables since none of them has a correlation coefficient of 0.80 or higher with other variables.

Table II Correlation matrix

Variables	L	R_{EB}	R_{BC}	R_{AR}	R_{CR}	S	Y	π	C
L	1.00								
R_{EB}	-0.34**	1.00							
R_{BC}	-0.06	-0.17**	1.00						
R_{AR}	-0.08	0.03	0.05	1.00					
R_{CR}	0.06	0.18**	0.07	0.19**	1.00				
S	-0.09	0.04	0.04	0.26**	0.28**	1.00			
Y	0.25**	0.21**	-0.21**	-0.14**	0.15	0.25**	1.00		
π	0.08	0.09	0.31**	-0.29**	0.03	-0.10	0.10	1.00	
C	0.05	-0.09	0.06	0.06	0.07	-0.02	0.21**	0.11	1.00

*Note(s): L = bank credit/GDP; R_{EB} = entry barrier index; R_{BC} = mixing of banking and commerce restriction index; R_{AR} = activity restriction index; R_{CR} = capital regulation index; S = supervisory power index; Y = real GDP; π = inflation; C = current account/GDP; ** indicates statistical significance at the 5% level or better.*

4. Econometric Model and Estimation Techniques

4.1. Dynamic Panel Threshold Regression (PTR) Model

This study adopts the dynamic PTR model to determine whether bank regulation stringency has any distortionary effects on bank lending if it is 'too high' (or 'too low'). This approach is more appropriate than the threshold model of Hansen (1999), which results in inconsistent estimates when applied to a dynamic model due to the endogeneity problem arising from the correlation between the lagged dependent variable and the disturbance term. Instead, the dynamic PTR model of Kremer *et al.* (2013) follows Arellano and Bover (1995) by using the future orthogonal deviations transformation to eliminate individual effects and avoid the problem of serial correlation arising from taking first differences. In addition, the dynamic PTR incorporates the generalized method of moments (GMM)-type estimators as suggested by Caner and Hansen (2004) and uses lagged values of the dependent variable as instruments to address the problem of endogeneity.

Following Kremer *et al.* (2013), the study specifies the dynamic PTR model indicating the relationship between bank regulation stringency and bank lending as follows:

$$L_{i,t} = \mu_i + \beta_1' \boldsymbol{x}_{i,t} I(q_{i,t} \leq \gamma) + \beta_2' \boldsymbol{x}_{i,t} I(q_{i,t} > \gamma) + \varepsilon_{i,t} \quad (1)$$

where $i = 1, \dots, N$ represents the country; $t = 1, \dots, T$ indexes the time; μ_i is a set of country-specific fixed effects; β is a k-dimensional vector of parameters to be estimated; $\varepsilon_{i,t}$ is an independently and normally distributed error term with mean zero and constant variance; $I(\cdot)$ is the indicator function taking the value of 1 if the specified argument holds, and 0 otherwise, indicating the regime defined by the threshold variable $q_{i,t}$ and the threshold level γ; $L_{i,t}$ is the dependent variable capturing bank credit to the domestic private sector as a share of GDP; $\boldsymbol{x}_{i,t}$ is a k-dimensional vector of explanatory variables, which includes a bank regulatory measure (either bank entry barrier, mixing of banking and commerce restriction, bank activity restriction or capital regulation index), the control variables ($S_{i,t}$ = bank supervisory power index, $Y_{i,t}$ = real GDP, $\pi_{i,t}$ = inflation, and $C_{i,t}$ = current account balance as a share of GDP), $L_{i,t-1}$ as a lagged value of the dependent variable, and other endogenous regressors.

The vector of explanatory regressors is divided into two main sub-components – $x_{1i,t}$ as a set of exogenous variables that are not correlated with $\varepsilon_{i,t}$, and $x_{2i,t}$ as a set of endogenous

variables that are correlated with $\varepsilon_{i,t}$. Furthermore, the model needs an appropriate set of $m \geq k$ instrumental variables $z_{i,t}$ including $x_{1i,t}$.

As mentioned in the introduction, bank regulatory indices are expected to either hamper or enhance bank lending. Moreover, the study includes institutional and macroeconomic control variables that are common in the literature in its model specification. The institutional control variable included is the bank supervisory power index, which is a measure for the bank supervisory environment. Merrouche and Nier (2017) indicate that strong supervisory power may be used to discipline banks and may reduce moral hazard problems ex ante. However, Barth *et al.* (2004) postulate that, although supervisory power can encourage prudent lending by minimizing the costs of monitoring banks, it may also discourage it through abuse of such power and lack of enforcement of regulations. Thus, the impact of the tightening of bank supervisory power on bank lending is expected to be either negative or positive.

As part of macroeconomic control variables, the study includes the log of real GDP, which is a proxy for economic growth. According to Cottarelli *et al.* (2005), Djankov *et al.* (2007) and Yi *et al.* (2022), countries with higher levels of income tend to have credit markets that are bigger and that comes with higher degrees of financial deepening as they enjoy economies of scale in the organization of the supporting institutions. Therefore, an increase in real GDP (or economic growth) is anticipated to enhance the demand for bank lending.

Another macroeconomic control variable included in the estimations of this study is inflation, which is a proxy for macroeconomic stability. A rise in inflation is expected to discourage customers from acquiring new loans (Djankov *et al.*, 2007). This is so because, in times of rising inflation, banks are more likely to increase rates, and this may lead to a fall in the demand for bank credit (Adesina, 2019; Yi *et al.*, 2022). Nonetheless, in line with Çatik and Karaçuka (2012), the response of bank credit to changes in inflation in a low-inflation environment may be different from the one in a high-inflation regime. Bank lending may increase following a rise in inflation because of the expectations of macroeconomic stability prevailing under a low-inflation environment. Hence, increases in inflation are anticipated to have ambiguous effects on bank lending.

The last macroeconomic variable controlled for is current account balance as a ratio of GDP, which is a measure of external imbalances or the net flow of capital. In line with Merrouche and Nier (2017), higher levels of current account deficits should be met by net inflows of capital, and this could lead to an increased supply of lending within the domestic banking sector. As a result, it is expected that current account balance as a share of GDP will have a negative relation with bank credit.

4.2. Linearity Test

Before estimating Equation 1, the study uses the Fischer Lagrange Multiplier (LM) test from Colletaz and Hurlin (2006) to test the null hypothesis of linearity. This test possesses better small-sample size properties than other asymptotic test statistics following the χ^2 distribution. The Fischer LM test is then specified as follows:

$$LM_F = \frac{NT(SSR_0 - SSR_1)/mk}{SSR_0/(NT - N - mk)} \tag{2}$$

where SSR_0 and SSR_1 are the panel sum of squared residuals under the null hypothesis (linear panel model with individual effects) and the alternative hypothesis (dynamic PTR model), respectively, and all other variables are as explained earlier. LM_F has an approximate $F(mk, NT - N - mk)$ distribution. If the null hypothesis is rejected, the study estimates the dynamic PTR model shown in Equation 1.

4.3. Generalised Method of Moments (GMM) Estimation Technique

In line with Kremer *et al.* (2013), the study follows Arellano and Bover (1995) by using the future orthogonal deviations transformation to eliminate individual effects from Equation 1, with the error term given by,

$$\varepsilon_{i,t}^{*} = \sqrt{\frac{T-t}{T-t+1}}\left[\varepsilon_{i,t} - \frac{1}{T-t}\left(\varepsilon_{i,t+1} + \cdots \varepsilon_{i,T}\right)\right] \tag{3}$$

As result, the error terms are uncorrelated, that is,

$$\mathrm{Var}(\varepsilon_i) = \sigma^2 I_T \Rightarrow \mathrm{Var}(\varepsilon_i^{*}) = \sigma^2 I_{T-1} \tag{4}$$

The lags of the dependent variable are included as instruments when estimating a reduced-form regression for the endogenous variables. Equation 1 is then estimated through least squares for a fixed threshold γ whereby the predicted values from the reduced-form regression are used to replace the endogenous variables. Finally, the estimator of the threshold value γ, which has the smallest sum of squared residuals, is chosen.

After determining the $\hat{\gamma}$, the GMM is used to estimate the slope coefficients. Given that one of the primary requirements of using GMM is to ensure that $N > T$ (Odhiambo, 2020), this study follows Osei and Kim (2020) and uses the averaged data over 3-year non-overlapping periods to remove cyclical fluctuations and determine the nonlinear effects of bank regulation stringency on bank lending in the longer term. It also limits the maximum lags of instruments to two in line with Law *et al.* (2021) to prevent the overfitting of instrumental variables.

5. Empirical Analysis

5.1. Linearity Test Results

The linearity test results are provided in Table III. The Fisher test statistics reject the null hypothesis of linearity in models with bank entry barrier and capital regulation indices but fail to reject the same null hypothesis in models with mixing of banking and commerce restriction and bank activity restriction indices. The rejection of the null hypothesis of linearity then supports the existence of nonlinear effects in the relationship between bank lending and bank entry barriers or bank capital regulations.

Table III Linearity test results

Model	Fisher (F-statistic)
$L = f(R_{EB}, S, Y, \pi, C)$	75.71***
$L = f(R_{BC}, S, Y, \pi, C)$	-5.26
$L = f(R_{AR}, S, Y, \pi, C)$	-57.92
$L = f(R_{CR}, S, Y, \pi, C)$	44.24***

*Note(s): L = bank credit/GDP; R_{EB} = entry barrier index; R_{BC} = mixing of banking and commerce restriction index; R_{AR} = activity restriction index; R_{CR} = capital regulation index; S = supervisory power index; Y = real GDP; π = inflation; C = current account/GDP; ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.*

5.2. Dynamic Panel Threshold Regression (PTR) Results

The study estimates the nonlinear impact of bank entry barriers and capital regulations on bank lending (plus controls) using the dynamic PTR model. The estimated results are presented in Table IV with bank entry barrier and capital regulation indices used as threshold variables,

while bank supervisory power index, real GDP, inflation, and current account balance as a ratio of GDP are included as covariates or control variables. Firstly, the table shows the estimated threshold levels for bank entry barrier and capital regulation indices and their corresponding 95% confidence intervals. Secondly, it gives the regime-dependent estimates of bank entry barrier and capital regulation indices on bank lending. Specifically, $\widehat{\beta_1}$ and $\widehat{\beta_2}$ capture the marginal coefficients of bank entry barrier index or capital regulation index on bank lending in the low and high regimes of bank regulation stringency, respectively. Lastly, it provides the estimated coefficients of the control variables.

The estimated threshold value of the stringency of bank entry barriers is 62.8% (or 0.628) with the 95% confidence interval of [49.9 – 62.8], while that of capital regulation stringency is 76.5% (or 0.765) with the 95% confidence interval of [40.0 – 79.8]. These confidence intervals indicate that the threshold estimate of the stringency of bank entry barriers is relatively more precise than that of capital regulation stringency. This implies that less uncertainty exists regarding the threshold level of bank entry barrier stringency. Nevertheless, even though the study does not argue that the determined thresholds give the optimal degrees of bank regulation stringency[5], they confirm the existence of a nonlinear relationship between bank regulatory measures and bank lending as portrayed in Figure 1. As was observed from those graphs, bank lending seemed to have a positive relationship with the stringency of bank entry barriers at lower levels of this index, which are values now found to be below 62.8%. However, beyond this threshold value, the association became negative. Alternatively, bank lending appeared to have a negative relation with the stringency of capital regulations at lower values of this index, which are the ones now found to be below 76.5%. But beyond this threshold level, the relationship seemed to be positive.

The study further uses the estimated coefficients of the two regimes of bank regulation stringency to confirm the significance of the observed nonlinear relationship between bank regulatory measures and bank lending. In the case of bank entry barrier index, both the low ($\widehat{\beta_1}$) and high ($\widehat{\beta_2}$) regime-dependent coefficients are statistically significant at the 10% and 1% levels, respectively, with the low regime-dependent coefficient having a positive sign, while the high regime-dependent coefficient has a negative sign. This suggests that when the stringency of bank entry barriers is below the threshold value of 62.8%, its effect on bank

[5] The optimal level of bank regulation stringency depends on other factors that are beyond the scope of this study.

lending is positive in the context of the selected SSA economies. Although this result is similar to the one found by Amidu (2014), it applies only when bank entry barrier stringency is below the threshold level of 62.8%. But when the stringency of bank entry barriers is above that threshold value, its impact on bank lending is negative.

The obtained results on the nonlinear effect of bank entry barriers on bank lending in the selected SSA economies are also consistent with the theory of market structure. As postulated by Keeley (1990), imposing bank entry barriers could increase the market power and profitability of banks through the reduction in competition, thereby encouraging more prudent lending. Although this argument is supported by the finding that increases in bank entry barriers affect bank lending positively in the case of the selected SSA countries, it occurs only when the stringency of bank entry barriers is below the 62.8% threshold level, that is, increasing from low to moderate levels. But once bank entry barrier stringency goes beyond that threshold level, that is, increasing from moderate to high, bank entry barriers affect bank lending negatively and significantly in the selected SSA economies. In line with Claessens and Klingebiel (2001), this could be explained by the possibility that excessive reduction in competition due to stringent bank entry barriers usually comes with inefficiencies that make banks raise the costs of their services, thereby discouraging the demand for credit.

When it comes to the model with capital regulation index, the low regime-dependent coefficient bears a negative sign for values below the threshold level of 76.5%, but a positive sign for values above that threshold level. Nevertheless, both coefficients are statistically insignificant, thereby neither supporting the risk-absorption theory nor the financial fragility-crowding out hypothesis (see Kim and Sohn, 2017). This is contrary to the finding by Amidu (2014), who found that stringent capital requirements prohibited bank lending in SSA countries. Thus, changes in bank capital regulatory requirements in the case of the selected SSA countries do not affect bank lending, regardless of whether their stringency is below or above the identified threshold level. Therefore, even after accounting for the existence of nonlinear effects, changes in the stringency of capital requirements do not affect bank lending just like in the studies that adopted linear approaches to modelling (see Barth *et al*., 2004; Bridges *et al.*, 2014; Fratzscher *et al.*, 2016).

As shown in Table IV, other results indicate that the impact of the stringency of bank supervisory power on bank lending is negative and significant at the 1% level. This finding is similar to the one obtained by Merrouche and Nier (2017) and indicates that even though strong supervisory powers minimize moral hazard problems through monitoring and enforcement of regulations, that comes with a cost of reducing bank lending in the selected SSA countries. The results further show that the effects of economic growth (proxied by the log of real GDP) and inflation (captured by the log of consumer price index) on bank lending are positive and significant at the 1% level. The former finding tallies with the expectation that countries with higher levels of income tend to have credit markets that are bigger, with higher degrees of financial deepening as they enjoy economies of scale in the organization of the supporting institutions (Cottarelli *et al.*, 2005; Djankov *et al.*, 2007). Consistent with Çatik and Karaçuka (2012), the latter result shows that the effect of an increase in inflation, which is expected to discourage customers from acquiring new loans (see Djankov *et al.*, 2007; Adesina, 2019), seems to be outweighed by that of the expectations of macroeconomic stability, which normally prevails under relatively low-inflation environments. Finally, the results reveal that the impact of current account balance as a ratio of GDP on bank lending is insignificant in the case of the selected SSA economies.

Table IV Dynamic panel threshold (PTR) regression results

	Model with	
	Entry barrier index	**Capital regulation index**
Threshold estimates and confidence intervals		
Threshold estimates	62.8%	76.5%
95% confidence interval	[49.9 – 62.8]	[40.0 - 79.8]
Impact of bank regulation		
$\widehat{\beta_1}$	0.52* (0.29)	-0.08 (0.12)
$\widehat{\beta_2}$	-2.70*** (0.27)	0.79 (0.57)
Impact of covariates		
Initial	-0.01 (0.06)	0.02 (0.05)
Supervisory power (S)	-0.33*** (0.11)	-0.32*** (0.11)
Real GDP (Y)	0.86*** (0.24)	0.82*** (0.21)
Inflation (π)	0.16*** (0.05)	0.14*** (0.05)
Current account/GDP (C)	-0.01 (0.005)	-0.01 (0.01)
Countries	23	23
Observations	161	161

*Note(s): The sample is based on averaged data over 3-year non-overlapping periods from 1997 to 2017; The dependent variable is bank credit/GDP (L); Standard errors are in parenthesis; ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.*

6. Conclusion And Policy Implications

The effects of bank regulation stringency on bank lending can be nonlinear, depending on whether the benefits of adopting higher standards of bank regulation outweigh their costs, either below or above some threshold level. This study examines the nonlinear effects of bank regulation stringency on bank lending in 23 selected SSA economies over the period spanning 1997 to 2017 using the dynamic PTR model proposed by Kremer *et al.* (2013) to address both endogeneity and heterogeneity problems within a nonlinear framework. The results for the linearity test provide evidence that the relationship between bank lending and the stringency of bank entry barriers or capital regulatory requirements in the context of the selected SSA countries is nonlinear, while that of bank credit and the restrictions on the mixing of banking and commerce or bank activities is not.

Although this study does not argue that the determined thresholds give the optimal degrees of bank regulation stringency, the empirical results from the PTR model reveal that when the stringency of bank entry barriers is below the threshold value of 62.8%, its effect on bank lending is positive in the selected SSA economies. But when the stringency of bank entry barriers is above that threshold value, its impact on bank lending is negative. This shows that imposing bank entry barriers encourages bank lending only when the stringency of bank entry barriers increases from low to moderate levels, possibly due to increases in market power and bank profitability (see Keeley, 1990). However, once bank entry barriers increase from moderate to high, bank entry barriers affect bank lending negatively since they are likely to result in inefficiencies that make banks raise the costs of their services, thereby discouraging the demand for credit (see Claessens and Klingebiel, 2001). Moreover, while the low regime-dependent coefficient for bank capital regulation stringency is negative for values below the threshold level of 76.5%, but positive for values above that threshold level, both coefficients are found to be statistically insignificant just as in the case of studies that employed linear approaches to modelling (see Barth *et al*., 2004; Bridges *et al.*, 2014; Fratzscher *et al.*, 2016).

In terms of policy implications, the findings of this study first show that regulators should take into consideration the existence of threshold effects in the relationship between bank lending and bank regulatory measures, when assessing the effectiveness of the latter on the former, since not doing so could lead to biased estimates and result in wrong conclusions. Secondly, policymakers should not introduce bank regulatory reforms for their own sake as too stringent regulations could have an adverse impact on bank credit. As a result, some level of balance should be maintained when determining the stringency of bank regulatory measures that will promote the resilience and safety of the banking system while at the same time not causing unintended effects on bank lending. These implications could also be useful to other regions that have introduced major reforms in bank regulation like in the case of SSA countries. In the future, it may be interesting to incorporate other factors that will help in determining the optimal levels of bank regulatory measures that are conducive for bank credit.

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Appendix

Table V World Bank's Bank Regulation and Supervision Surveys (BRSS) for selected SSA countries

Country name	Country code	Survey I (1999)	Survey II (2003)	Survey III (2007)	Survey IV (2011)	Survey V (2019)
1. Angola	AGO	-	-	✔	✔	✔
2. Benin	BEN	-	✔	✔	✔	✔
3. Botswana	BWA	✔	✔	✔	✔	✔
4. Burkina Faso	BFA	-	✔	✔	✔	✔
5. Burundi	BDI	✔	✔	✔	✔	✔
6. Cote d'Ivoire	CIV	-	✔	✔	✔	✔
7. Eswatini	SWZ	-	✔	-	✔	✔
8. Ghana	GHA	-	✔	✔	✔	✔
9. Guinea-Bissau	GNB	-	✔	✔	-	✔
10. Kenya	KEN	✔	✔	✔	✔	✔
11. Lesotho	LSO	✔	✔	✔	✔	✔
12. Madagascar	MDG	-	✔	-	✔	✔
13. Malawi	MWI	✔	-	✔	✔	✔
14. Mali	MLI	-	✔	✔	✔	✔
15. Mauritius	MUS	✔	✔	✔	✔	✔
16. Namibia	NAM	✔	✔	-	✔	✔
17. Niger	NER	-	✔	✔	✔	✔
18. Nigeria	NGA	✔	✔	✔	✔	✔
19. Senegal	SEN	-	✔	✔	-	✔
20. South Africa	ZAF	✔	✔	✔	✔	✔
21. Tanzania	TZA	-	-	✔	✔	✔
22. Togo	TGO	-	✔	✔	✔	✔
23. Uganda	UGA	-	-	✔	✔	✔

Source(s): Own computation using data from Barth et al. (2001, 2004, 2008, 2013), Cihak et al. (2013), and Anginer et al. (2019).

Note(s): The parenthesis gives the year of completion of the survey; A tick (✔) shows that the data is available; A dash (-) shows that the data is unavailable, and the previous or subsequent available survey data is used instead.

Table VI Measurement of bank regulatory and supervisory indices

Index	Sub-components	Qualification	Range
Entry barrier	Limitations on foreign bank ownership of domestic banks	Are foreign entities prohibited from entering through *a) Acquisition? b) Subsidiary? c) Branch? d) Joint Venture? [Yes = 1; No = 0; for each]*	0-4
	Entry into banking requirements	Are the following legal submissions required to obtain a banking license: *a) Draft bylaws? b) Intended organization chart? c) Financial projections? d) Financial information on main potential shareholders? e) Background/experience of future directors? f) Background/experience of future managers? g) Sources of funds to be disbursed in the capitalisation of a new bank? h) Market differentiation intended for the new bank? [Yes = 1; No = 0; for each]*	0-8
Mixing of banking and commerce restriction	Bank ownership of non-financial Firms	To what extent can banks own and control non-financial firms? *[Unrestricted=1=a bank may own 100 percent of the equity in any nonfinancial firm; Permitted=2=a bank may own 100 percent of the equity of a nonfinancial firm, but ownership is limited based on a bank's equity capital; Restricted=3=a bank can only acquire less than 100 percent of the equity in a nonfinancial firm; and Prohibited=4=a bank may not acquire any equity investment in a nonfinancial firm whatsoever]*	1-4
	Non-financial firm ownership of banks	To what extent can non-financial firms own and control banks? *[Unrestricted=1=a nonfinancial firm may own 100 percent of the equity in a bank; Permitted=2=unrestricted with prior authorization or approval; Restricted=3=limits are placed on ownership, such as a maximum percentage of a bank's capital or shares; and Prohibited=4=no equity investment in a bank]*	1-4
	Non-bank financial firms owning banks	The extent to which non-bank financial firms may own and control banks? *[Unrestricted=1=a nonbank financial firm may own 100 percent of the equity in a bank; Permitted=2=unrestricted with prior authorization or approval; Restricted=3=limits are placed on ownership, such as a maximum percentage of a bank's capital or shares; and Prohibited=4=no equity investment in a bank]*	1-4
Activity restriction	Securities Activities	To what extent can banks engage in the following activities: *a) Securities? b) Insurance? c) Real estate? [Unrestricted = 1 = full range of activities can be conducted directly in the bank; Permitted = 2 = full range of activities can be conducted, but some or all must be conducted in subsidiaries; Restricted = 3 = less than a full range of activities can be conducted in the bank or subsidiaries; and Prohibited = 4 = the activity cannot be conducted in either the bank or subsidiaries; for each]*	1-4
	Insurance Activities		1-4
	Real Estate Activities		1-4

Index	Sub-components	Qualification	Range
Capital regulation	Overall capital stringency	Overall capital requirement questions: *a) Is it risk-weighted in line with Basle guidelines? b) Does the ratio vary with a bank's credit risk? c) Does the ratio vary with market risk? d) Before minimum capital adequacy is determined, which items are deducted from capital: i) Market value of loan losses? ii) Unrealized securities losses? iii) Unrealized foreign exchange losses? [Yes = 1; No = 0; for each]*	0-6
	Initial capital stringency	Questions: *a) Are the sources of funds to be used as capital verified by authorities? [Yes = 1; No = 0] b) Can assets other than cash/government securities be used to increase capital? c) Can borrowed funds be used? [Yes = 0; No = 1; for b) and c)]*	0-3
Supervisory power	Official supervisory power	Questions: *a) Can supervisors meet external auditors to discuss report without bank approval? b) Are auditors legally required to report misconduct by managers/directors to supervisory agency? c) Can legal action against external auditors be taken by the supervisor for negligence? d) Can supervisors force banks to change the internal organizational structure? e) Are off-balance sheet items disclosed to supervisors? f) Can the supervisory agency order directors/management to constitute provisions to cover actual/potential losses? g) Can the supervisory agency suspend the director's decision to distribute: i) dividends? ii) bonuses? iii) management fees? h) Can the supervisory agency supersede bank shareholder rights and declare the bank insolvent? i) Does banking law allow the supervisory agency to suspend some or all ownership rights of a problem bank? j) Regarding bank restructuring and reorganisation, can supervisory agency or any government agency do the following: i) supersede shareholder rights? ii) remove and replace management? iii) remove and replace directors? [Yes = 1; No = 0; for each]*	0-14

Source(s): Barth et al. (2001, 2004, 2008, 2013), Cihak et al. (2013), and Anginer et al. (2019).

Table VII Data sources and definitions of variables

Variables	Sources	Definitions
Bank lending variable		
Bank credit/GDP	World Bank Financial Development and Structure Dataset; Global Financial Development Database; International Monetary Fund International Financial Statistics	Credit to the private sector from banks as a ratio of GDP
Bank regulatory and supervisory indices		
Entry barrier	World Bank's Bank Regulation and Supervision Surveys	Measures the degree of restrictions on bank licensing and foreign ownership
Mixing of banking and commerce restriction	World Bank's Bank Regulation and Supervision Surveys	Measures the extent to which banks, non-financial firms, and non-bank financial firms can own and control each other
Activity restriction	World Bank's Bank Regulation and Supervision Surveys	Measures the degree of restrictions on engagement in securities, insurance, and real estate activities by banks
Capital regulation	World Bank's Bank Regulation and Supervision Surveys	Measures the stringency of bank regulatory requirements regarding capital
Supervisory power	World Bank's Bank Regulation and Supervision Surveys	Measures the degree to which bank supervisory authorities have the power to prevent, correct and resolve problem banks
Macroeconomic variables		
Real GDP	International Monetary Fund World Economic Outlook / World Bank World Development Indicators	Real gross domestic product (in purchasing power parity, 2011 international dollar)
Inflation	International Monetary Fund World Economic Outlook / World Bank World Development Indicators	Consumer price index
Current account/GDP	International Monetary Fund World Economic Outlook / World Bank World Development Indicators	Current account balance as a ratio of GDP