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The Impact of Regulation and Supervision on Banking Efficiency: A Cross-Country Analysis

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Abstract

Regulatory and supervisory practices have immensely increased during the past years following the global financial crisis and several papers have investigated how these regulations have affected banking efficiency. However, due to the difficulty in measuring regulations, previous papers may not have fully captured the regulatory and supervisory environment. In this paper, we implement the Categorical Principal Components Analysis method for measuring regulations and supervision across countries. A multiple linear regression was performed with and without moderation based on country development level, as well as an instrumental variable analysis to address potential endogeneity issues. The results suggest that Deposit protection schemes are partially robustly relevant in explaining banking efficiency, while Asset diversification, Permissible banking activities, Capital adequacy requirements, Supervisor enforcement power, and Bank disclosure and resolution activities do not have any statistically significant explanatory power. We find that regulations and supervision have heterogeneous effects for countries at different stages of their development, although with statistically significant results only for low middle-income countries. The results demonstrate the necessity for policymakers to consider the impact that regulations and supervision has on banking efficiency in order to be able to appropriately adjust to the constantly evolving regulatory and supervisory landscape.

Keywords: Bank, Regulation, Supervision, Efficiency, Deposit Protection, Categorical Principal Component Analysis (CATPCA), Cross-country Analysis

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1. Introduction

The latest global financial crisis (2007-2009) resulted in banks around the world to incur heavy losses where millions of people lost their jobs which caused high unemployment rates and deep recessions, thus revealing several flaws in the banking system. Several studies have investigated the causes of the financial crisis, and the main consensus is that the underlying reasons included excessive risk-taking by financial institutions and minimal capital cushions to cover for unexpected financial losses. The critical elements of these underlying causes were attributed to a lack of capital regulations and holdings, market discipline, and banking supervision. To prevent such a situation from arising again, the global financial crisis was followed by an intense period of regulations and the establishment of institutions to better regulate the banking industry and thus address its flaws (Anginer et al., 2019). For instance, Basel III was endorsed by the Group of Twenty (G20) in November 2010, and the capital requirements regulations entered into force in January 2014 (on average, the level of regulatory capital held by banks was higher by the end of 2016 compared to the end of 2010 (Anginer et al., 2019)). Shortly thereafter, the single resolution mechanism regulation was also implemented in 2014 (EU Banking Law, 2024). Moreover, the European Banking Authority (EBA) was established in 2010 as a regulatory body to maintain financial stability throughout the EU banking industry (Majasaki, 2023). Even in low-income and transition countries, changes in the banking regulation have been implemented in the past decade with significant tightening in bank capital requirements (Djalilov & Piesse, 2019).

The high proliferation and intensity of the regulations is likely to have caused an effect on the efficiency and performance of banks. There have been studies investigating the effect of single regulatory practices, however, analyzing a particular regulation is not sufficient to measure a country's regulatory environment (Pereira Pedro et al., 2023). The World Bank has conducted extensive surveys, known as the Bank Regulation and Supervision Survey (BRSS), since the early 2000s to evaluate countries' regulatory and supervisory progress in the banking sector. Previous research papers have used the BRSS to construct partial variables or indices related to specific domains using dimension reduction techniques (Anginer et al., 2019; Barth et al., 2004, 2005, 2008, 2013). However, the use of partial indices might lead to conclusions that lack external validity due to the fragmented portrayal of the regulatory and supervisory practices (Pereira Pedro et al., 2023). There is thus limited valid knowledge on the association between regulatory and supervisory practices, and efficiency within the banking sector.

In this paper, we aim to investigate the impact of the stringency of regulations and the supervisory environment on the efficiency and performance of banks worldwide. To address the issue of using partial indices that has been used in previous methods, we employ the new method suggested by Pereira Pedro et al. (2023). In that method, the authors use Categorical Principal Components Analysis (CATPCA) to make use of the entire BRSS dataset and create full indices to represent the regulatory and supervisory environment across countries. As for the dependent variables, to measure banking efficiency, previous literature dictates the use of accounting measures such as net interest margin and

overhead costs (Chortareas et al., 2012; Demirgüç-Kunt et al., 2003). As far as we know, this is the first time using CATPCA to construct regulatory variables that will further be regressed on estimators of banking efficiency, and thus provide a more comprehensive and holistic understanding of how different aspects of banking regulations and supervision affect the efficiency of banks. Thus, we investigate the following research question: What is the association between the stringency of certain aspects of regulations and supervision, and net interest margin and overhead cost ratio respectively?

We implement a multiple linear regression model with variables controlling for other country-level indicators across countries. Moreover, we conduct a moderation analysis based on country development levels to analyze whether the heterogeneous effects exist in banking sector efficiency for countries at different stages of their development. Finally, an instrumental variable analysis is carried out in order for an attempt to determine causality in our regressions.

Our findings reveal that more stringent *Deposit protection schemes* have a significant effect in improving the banking sector efficiency across countries. The initial results show that other aspects of regulation and supervision do not significantly affect efficiency within the banking sector. Furthermore, when employing the moderation model, we find that the banking sector in the low middle-income countries are country subset that are affected by the regulations.

The rest of the paper is organized in the following order: Background, Literature Review, Data Collection and Processing, Methodology, Results, Discussion, and Conclusion.

2. Background

2.1. A Brief History of the Basel Committee

Towards the end of 1974, banking failures had impacted both the United States and Germany (specifically the failure of Bankhaus Herstatt in West Germany), prompting the central bank governors of the G10 countries (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, the United Kingdom, and the United States, with Switzerland playing a minority role) to establish a committee. This committee is now known as the Basel Committee on Banking Supervision (BCBS). The BCBS is intended to enhance financial stability by improving the quality of banking supervision worldwide and serving as a forum for regular cooperation between its member countries on matters concerning banking regulations and supervision (Basel Committee on Banking Supervision, 2013). The Basel Committee has since then expanded its membership from the G10 to 45 institutions from 28 jurisdictions. The Committee first published the Basel Concordat in 1975 and subsequently, a series of international standards for prudential banking regulations followed. Its most significant contributions have been in the realm of capital adequacy accords, commonly known as Basel I, Basel II, and the most recent Basel III accords (The Basel Committee - Overview, 2023). Basel I was brought forward in 1988 with the goal to stabilize international banking and prevent

competitive inequality caused by lack of common bank-capital regulations. Basel II subsequently built on Basel I, for example by taking operational risk into consideration, established supervision to ensure that sufficient capital requirements are met and improved standards for disclosure of capital and risk (Demirgüç-Kunt et al., 2008).

2.2. The Global Financial Crisis of 2007-2009

The financial market crisis in 2007-2009 had severe repercussions and brought several aspects of banking into light. One such example was the critique brought forward by the BCBS on the instruments used for assessing risk that were exclusively based on previously known relationships that were assumed to remain constant, thus underestimating interplay between different types of liquidity (ElBannan, 2017). Afterwards, regulations such as the Basel Accord III were published in 2010 as an update on previous versions of regulations that had been presented in 1988 (Basel I) and 2001 (Basel II) with the goal of addressing structural failures in banking worldwide. Basel III was focused on creating an improved regulatory capital framework, leverage, and liquidity (Demirgüç-Kunt et al., 2008).

2.3. The World Bank's Bank Regulation and Supervision Survey (BRSS)

Post-crisis, the EU and the BCBS increased the intensity at which it published and imposed regulations on the banking and financial services sector. As such, the regulations were accompanied by several regulatory documents along with interpretations of those regulations in the form of consultant whitepapers, academic articles, as well as in newspapers and trade journals. Despite the vast amount of textual data available, it is not necessarily suitable for an econometric analysis.

To analyze global progress and proliferation of the regulatory and supervisory reforms in the banking sector across countries, as well as over periods of time, the World Bank introduced the Bank Regulation and Supervision Survey (BRSS) in the early 2000s. In total, five surveys have been conducted with the latest version of the survey started in 2017 and completed in 2019 for 160 jurisdictions during the period 2011-2016 (see Table 1 for a summary of the different BRSS editions) (Pereira Pedro et al., 2023). To assess the impact of regulations on banking efficiency and development in the industry, we will use the latest edition published in 2019 (data collected from 2011-2016).

Table 1: Bank Regulation and Supervision Survey (BRSS) editions and details

Edition	Data Collection	No. of Countries	Publication Year	Related paper/book
BRSS2001	1997-1999	118	2001	(Barth et al., 2006)
BRSS2003	2001	151	2003	(Barth et al., 2004, 2006)
BRSS2007	2005-2006	142	2007	(Barth et al., 2008)
BRSS2011	2008-2010	142	2012	(Cihák et al., 2012)
BRSS2019	2011-2016	159	2019	(Anginer et al., 2019; Pereira Pedro et al., 2023)

Source: Pereira Pedro et al. (2023)

3. Literature Review

3.1. Measuring Regulation & Supervision

Barth et al. (2013) provide a database that consists of the BRSS that were created in collaboration with and sponsored by the World Bank (a global partnership consisting of 5 institutions that aim to find solutions to reduce poverty, increase prosperity in developing countries and promote sustainable development). The survey was constructed in agreement with bank supervisors, economists, and staff at the World Bank, whereupon regulatory officials finalized the survey. In many cases, multiple officials who represented the same country completed the survey to verify that the responses were consistent. The first three surveys were published in 2001, 2003 and 2007 respectively. For these surveys, the authors thoroughly oversaw and managed the construction of the questionnaire, implementation of the survey, as well as the data collection. For the fourth survey that was published in 2012 and conducted by the World Bank, the authors were less involved in management of the survey. Their final database contains data on bank regulatory and supervisory policies across 180 countries from 1999 to 2011. In the database that Barth, Lin, et al. (2013) provide, the researchers have made extensive efforts to review inconsistencies and obtain missing data by reviewing country documents and webpages as well as national publications and contacting regulatory officials. Furthermore, they have constructed summary indices using linear Principal Component Analysis (a dimension reduction technique) that represents the major categories of policies within regulation and supervision respectively. The indices belong to one of eight different categories, and each index is based on specific survey questions belonging to each respective category. The overarching topic of each index includes permissible bank activities, capital requirements, official supervisory power, information disclosure requirements, external governance mechanisms, deposit insurance protection schemes, barriers to entry, and loan provisioning.

Pereira Pedro et al. (2023), however, point out the shortcomings of this dimension reduction by using PCA on categorical data, and argue that Non-Linear PCA (NLPCA) would provide a more suitable analysis of the categories. (Meulman et al., 2011) present a way of conducting NLPCA by using

optimal scaling transformations where qualitative variables are converted into quantitative variables. This can be performed by using Categorical Principal Component Analysis (CATPCA) which analyzes data that includes different types of variables including nominal, ordinal and numerical ones. Different weights are assigned to different variables and by assigning a large weight for a specific variable, data points that are similar will be clustered together. Subsequently, individual observations will be depicted as members of subgroups which is useful if the number of observations is very large (further description about how to address potential issues with the dataset, such as how to regard open-ended questions or missing data is provided in Section 4.1). Subsequently, CATPCA is used to optimally scale and aggregate regulatory and supervisory practices. Based on the results, Pereira Pedro et al. (2023), found that certain indicators were more trustworthy to measure the stringency of regulations. They also determine which variables are more relevant to distinguish between regulatory and supervisory practices worldwide. Based on this, the 2011 BRSS dataset shows that deposit (savings) protection schemes, liquidity, diversification requirements, complementary banking activities and market discipline are deemed to be the most important regulatory components. As for supervision, resolution activities, mandate of the head of the supervisory agency and report of prudential regulation infractions are deemed to be the most relevant supervisory components.

3.2. Banking Efficiency

Several countries have implemented aspects of Basel II and III and post-crisis, regulations have increased in complexity which has resulted in lower transparency, increased regulatory arbitrage and increased supervision resources from taxes. In some cases, especially complex regulations may generate unnecessarily high costs of compliance, thus implying that less complicated regulations may be more beneficial (Anginer et al., 2019). There are two views considering the impact of regulation and supervision on banking efficiency: the public interest view and the private interest view. The public interest view states that the government aims to implement bank regulations that promote efficiency in banking by factoring in the public. This idea opposes the private interest view that claims that regulations are imposed to promote special interests for a few actors which inhibits banking efficiency (Barth et al., 2005).

A number of studies have investigated how efficiency within the banking sector has been affected post-implementation of a new framework from the Basel Accord (Basel II). Barth, Lin, et al. (2013) present their findings on how regulations, supervision and monitoring affect efficiency within the banking sector. They use data from the BankScope database to gather information on banking variables, while the Barth et al. (2004, 2005, 2008) datasets are used to assess bank regulation, as well as supervision and monitoring. Furthermore, they control for macroeconomic and institutional factors by using variables from the World Development Indicator and the World Governance Indicator. Subsequently, data envelopment analysis (DEA) was used to obtain measures of bank efficiency. They found a negative association between more stringent restrictions on permissible banking activities and operating efficiency but a suggested positive association between stringent capital

regulations and bank efficiency. Furthermore, Barth et al. (2008) found that greater stringency could result in fewer opportunities for banks to accomplish diversification, which in turn could lead to lower income streams and franchise value, thus causing operational inefficiency (Laeven & Levine, 2009). More specifically, capital stringency regulations are expected to increase efficiency since it decreases risk as well as spurs owners to manage risk more efficiently. On the other hand, agency theory suggests that greater capital regulation results in higher agency costs between shareholders and managers when managers are facing stricter repayment requirements. Through this, we construct the following hypotheses:

Hypothesis 1: Greater stringency in asset diversification has a significant and negative impact on banking sector efficiency

Hypothesis 2: Stringent restriction on permissible banking activities has a significant negative impact on banking sector efficiency

Hypothesis 3: Stringent capital adequacy regulations have a positive and significant effect on banking sector efficiency

Furthermore, deposit protection schemes received growing attention post-crisis as countries significantly increased the coverage of their financial safety nets to recover market confidence and improve banking sector stability (Anginer et al., 2014). Anginer et al. (2014) point out double-faced nature of deposit insurance schemes. On the one hand, during times of banking crises, deposit insurance schemes can lead to greater confidence in the banking sector, and thus have a stabilizing effect during financially turbulent periods. On the other hand, deposit insurance can increase moral hazard risks as banks can take on more risks due to greater protection, and thus lead to instability and inefficiency in the banking sector. Overall, Anginer et al. (2014) find that deposit protection schemes have a negative effect during the period they study (2006-2009). Additionally, Barth et al. (2004) also find that deposit insurance schemes have a significant negative impact on the performance of the banking sector. Thus, the following hypothesis was formulated:

Hypothesis 4: More stringent deposit protection schemes have a significant and negative impact on banking sector efficiency

As for supervision and monitoring, Beck et al. (2006) argues that a more powerful supervisory agency that has direct influence on the monitoring of banks can ameliorate corporate banking governance and boost efficiency. Barth, Lin, et al., 2013 find support for this and state that official supervisory power in the hands of independent supervisors tends to enhance banking efficiency. Moreover, they find support that increased monitoring of banks due to greater transparency through information disclosure leads to increased efficiency. More recently, Bace & Ferreira (2020) investigated how regulatory and supervisory policies affected banking efficiency in EU countries and concluded that private

monitoring was statistically significantly and positively correlated with efficiency, whereas no correlation was found between public policies of monitoring and efficiency. Following this, the hypotheses regarding supervision were formulated:

Hypothesis 5: Higher supervisory enforcement power results in a positive and significant effect on banking sector efficiency.

Hypothesis 6: Greater supervision regarding bank disclosure and resolution activities has a positive and significant effect on banking sector efficiency.

Despite a vast amount of research being conducted concerning this topic, a lot of the research has focused on advanced economies, with very few focusing on developing or transition economies (Casu et al., 2016; Djalilov & Piesse, 2019). Existing literature points out the differences between advanced and emerging economies. The Institutional Difference Hypothesis (IDH) states that advanced economies consist of institutions – that support the efficiency in product, capital and labor markets – that are absent in emerging economies. Therefore, it is highly likely that regulations affect countries differently depending on stage of development progress. Djalilov & Piesse (2019) find that only regulations on activity restrictions improve banking efficiency, while capital requirements regulations, market discipline and supervision have no significant impact in transition economies.

Another finding is that the majority of previous research papers have employed a standard multiple linear regression model. However, a limitation of this method is potential endogeneity issues through reverse causality with outcomes within the banking sector affecting regulations and supervision as opposed to just the other way around. Triki et al. (2017) suggest that banks could lobby for specific regulations that favor them in terms of growth and efficiency. High-performing banks could, for example, lobby for more stringent entry restrictions to prevent new competitors from entering which could hinder success. To address this issue, a number of papers have conducted an instrumental variable (IV) analysis. Barth, Lin, et al. (2013) include religious composition, latitude, legal origin and ethnic fractionalization as instruments based on theory and empirical research. Religious composition could affect governmental view on regulation and supervision, for example through the creation of hierarchical bonds of authority that affect governmental institutions, which has received support empirically as well (Barth et al., 2004). Subsequently, it has been theorized that during the colonization era, countries in tropical climates have experienced the development of political institutions that resulted in protection of a small elite while disfavoring others (Acemoglu et al., 2001; Barth et al., 2004). Beck et al. (2003) state that tropical climates are often argued to have a negative impact on economic development, and Easterly & Levine (2002) investigated this empirically and found that latitude, amongst other factors, seem to affect development within a country. Thus, countries geographically located at a higher latitude (further away from the equator) were able to set up better institutions, including better regulatory and supervisory bodies within the banking sector. Furthermore, Porta et al. (2002) found that legal origin affects economic outcomes. Common law has

been associated with the improvement of financial development, financial accessibility, and greater dispersion of ownership. Moreover, it has been associated with less stringent governmental ownership and regulation which was related to a lower degree of corruption and a more well-functioning labor market. An additional paper that has investigated banking efficiency and regulations, and has also conducted an instrumental variable analysis, included ethnic fractionalization, year of independence, and women participation in politics as instruments, apart from the instruments mentioned in Barth et al. (2004) (Triki et al., 2017). Ethnic fractionalization has been shown to explain differences in public policies and year of independence affects orientation of new policies. Moreover, women participation in politics has been suggested to have an impact on policy decisions and legislation (Triki et al., 2017).

4. Data Collection and Processing

Our dataset is compiled from two primary sources: (i) the Global Financial Development database for data on banking efficiency and (ii) the BRSS (from the World Bank) for data on the regulatory and supervisory variables.

4.1. Regulation and Supervision Variable Construction (using the BRSS)

This paper will use the new methodology for constructing banking regulatory variables presented by Pereira Pedro et al. (2023). This methodology applies NLPCA with optimal variable transformation, due to the qualitative and quantitative nature of the survey data. This summarizes regulatory variables into a smaller group of components that represent a majority of the information conveyed by the original BRSS data.

This paper has gathered and analyzed data on all the countries in the 2019 publication of the BRSS, wherein the data was collected from 2011 to 2016. Pereira Pedro et al. (2023) provide a list of survey questions concerning regulation from the 2011 version of the BRSS in their supplementary material, which consist of 83 variables in total. One of the questions on their list was missing from the 2019 BRSS (Q 2.6.1) whereupon data on 82 of those 83 variables in total were obtained from the 2019 BRSS. 30 of those variables were continuous and the remaining 52 questions were categorical, and thus had to be recoded for the statistical analysis. 21 of those 52 variables had a binary outcome (yes/no) and were recoded as 1 and 2.[1] The other 31 questions were multiple choice and thus required recoding according to a categorical scale. A table with a system for recoding those variables was provided in the supplementary material for 13 questions but not exist for the additional 18 questions which thus had to be converted to numerical categorical variables. Questions with the options “Yes”, “No”, and “Not Applicable” were recoded as 1, 2, and 3 respectively, whereas questions with several

[1] 1 for Yes; 2 for No. We did not use 0 for No as CATPCA interprets 0 as a missing value.

options were recoded according to the number of the option; option a) was recoded as 1, option b) as 2, and so on.

A number of additional modifications had to be undertaken to facilitate analysis of the data (see Appendix A). In some cases, a numerical category had to be added if countries hadn't chosen any of the provided options in the supplementary material. For example, for question 8.10, the option "none" that had been present in the 2011 version was no longer included in the 2019 version which meant that it had to be added as a category. Another example is question 9.3 ("Which criteria are taken into account to classify loans and advances as non-performing?") where one of the combinations of options that were present in the data had not been provided with a categorical number in the supplementary material whereupon the decision was made to recode that response as the closest option that the authors had provided (recoded as "all except collateral and other", instead of "all except breach, collateral and other"). For the cases where several options were missing from the supplementary material, categories were added to more accurately reflect the responses that the countries had provided. Observations with missing values were excluded from the analysis by the statistical software.

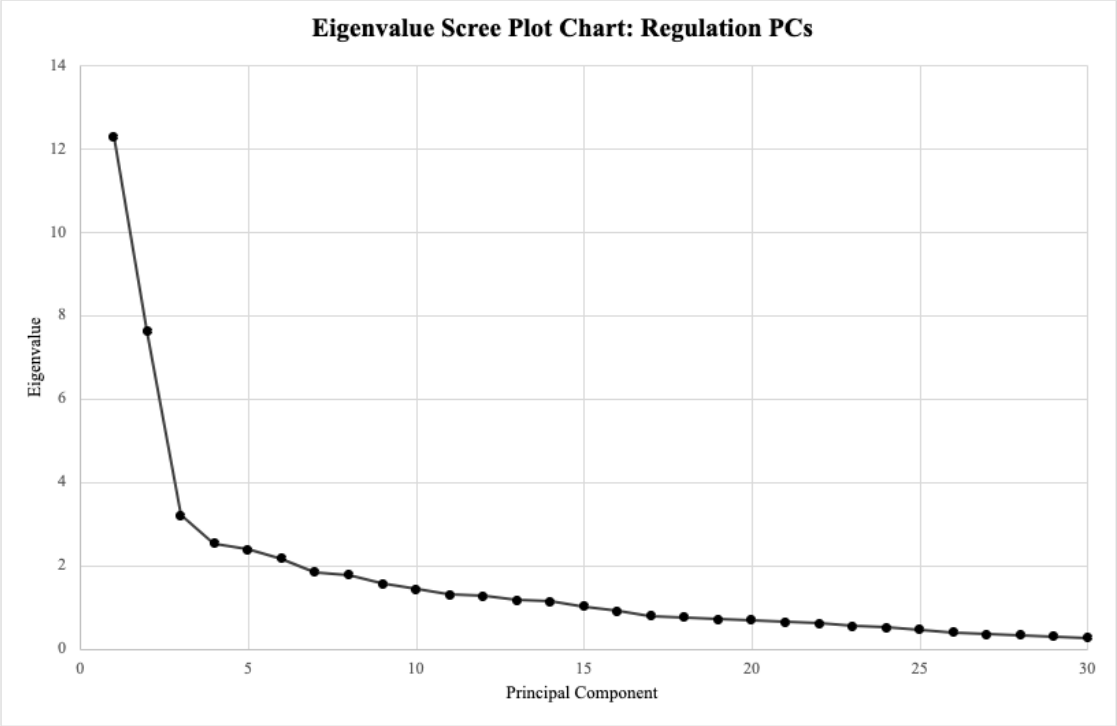
When it comes to handling missing data, there are a number of different ways that have been described in Barth, Lin, et al. (2013). The strategy used in their paper is imputation of the modal category which means that missing values are replaced with the most commonly chosen option for that variable. Other strategies include excluding objects where values are missing, using minimization of the loss function and ignoring missing data or adding a category that captures missing values for a certain variable. Pereira Pedro et al. (2023) use imputation of the same value for quantitative variables and added an additional class consisting of all countries that had missing values. We approached the missing value strategy in the same way as Pereira Pedro et al. (2023).

Upon completion of the BRSS data cleaning, IBM's Statistical Package for Social Sciences (SPSS) was used for carrying out the CATPCA. The first objective was to determine the number of dimensions (principal components) to extract in the analysis. We implemented the CATPCA script in SPSS. As PCA is sensitive to the scale of the variables, we first optimally scaled the data based on whether the variables were ordinal (multiple categories), nominal (dummy), or numerical (scale). The optimizing criterion is based on an iterative criterion called alternating least squares and after the current quantifications are used to find a solution, the quantifications are then updated using that solution, until some criterion is reached that signals the process to stop. A scree plot visual analysis could then be used to determine the number of principal components to extract (IBM SPSS Categories 28, 2021). The eigenvalues – the measure of how much variance is accounted for by each component - were plotted on the scree plot. The common practice is to look for an "elbow point", i.e. the point at which an abrupt change in the slope occurs, as the components in the shallow slope contribute with very little additional information to the solution.

4.1.1. Regulatory Variables

In Figure 1, the elbow point could occur at either 3 or 4 principal components, beyond which the components explain too little of the variation in the data to be considered valuable for our analysis. In order to maintain external consistency with Pereira Pedro et al. (2023), we extracted four principal components which, as seen in Table 2, approximately account for 53.04% of the BRSS (2019) data on regulatory survey questions.

Figure 1: Scree plot of Eigenvalues for each principal component for Regulations



Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Table 2: Eigenvalues and proportion of variance accounted for Regulation PCs

Dimension	**Variance Accounted For**	
(PC)	**Eigenvalue**	**% of Variance**
1	13.564	26.08
2	8.102	15.58
3	3.083	5.92
4	2.834	5.44
Total	27.583	53.04

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

There are two parts of the CATPCA output that were of particular importance to us: the component loadings and the object scores. The component loading is the correlation between the principal component and each original variable (the survey question). Squaring these correlation coefficients provide an amount of the variation explained by each question within a component. In other words,

the component loadings tell us how much of the variation in a variable (question) is explained by the component. The component loadings are thus important to understand which questions from the BRSS (and thus which aspects of banking regulation) belong to each principal component. The preferred method of Varimax Rotated Component Matrix with Kaiser Normalization is implemented to obtain the component loadings for each principal component and the object scores for each country (Principal Component Analysis, n.d.). This is because Varimax Rotation allows for clearer interpretation of which survey questions are explained by each principal component, as well as clearer interpretation of the relationships between countries. Tables 3 to 6 portray the component loadings for the survey questions that are meaningful to each principal component. Bold values represent values greater than 0.500 and are thus considered significant for the particular principal component (Pereira Pedro et al., 2023).

The output also provides us with rotated object scores within each principal component for each country (see Appendix B). These object scores have numerical (metric) properties (unlike the original categorical data) that are standardized, because of the optimal scaling, with near zero mean and unit standard deviation, thus allowing for comparisons across countries in the sample (Pereira Pedro et al., 2023).

Through the CATPCA, we found that PC1 was composed of questions related to the *Deposit protection schemes* (as was found by Pereira Pedro et al. (2023), see Table 3). *Deposit protection schemes* are usually set up by countries to protect bank depositors, either fully or partly, from the losses caused by a bank's inability to pay its debts when due. They provide a safety net that promotes financial stability. Since the global financial crisis, several countries have raised the regulatory requirements for deposit insurance to ensure greater financial stability and the prevention of bank runs and failures (Hon Chu, 2011). Shifting focus to the object scores, we find that Zimbabwe had the highest score (1.124), while The Gambia had the lowest score (-1.740) for PC1. Upon further inspection of Zimbabwe's responses in the BRSS and other documents, Zimbabwe possessed an explicit depositor protection scheme that has been established since 2003 and was further expanded in 2012 to include additional responsibilities. The deposit insurance authority (known as the Deposit Protection Corporation) in Zimbabwe has significant legal power to cancel or revoke deposit insurance for any participating bank, as well as taking legal actions against bank directors or officials for violations against the laws. Moreover, participation in the deposit protection scheme is mandatory for a majority of the banks. In contrast, there is no depositor protection scheme in The Gambia (even as of 2023), and thus they provide no further responses to the following questions in regard to depositor protection schemes (*The Gambia Country Diagnostic*, 2023). Therefore, a higher value of PC1 could be interpreted as a country possessing more stringent regulations regarding *Deposit protection schemes*.

Table 3: Component loadings for **PC1 regulatory** questions (values in bold are greater than 0.500 and are considered to be significant for that PC).

PC1 | Depositor (Savings) Protection Schemes				
	Component Loadings			
Question Wording	*PC1*	*PC2*	*PC3*	*PC4*
8.1 Is there an explicit deposit insurance protection system for banks?	**0.944**	0.028	0.060	0.071
8.5 Does the deposit insurance authority by itself have the legal power to cancel or revoke deposit insurance for any participating bank?	**0.932**	-0.007	0.020	0.084
8.6 Can the deposit insurance agency/fund take legal action for violations against laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials?	**0.906**	0.032	0.034	0.076
8.7 Has the deposit insurance agency/fund taken legal action for violations against laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials ...	**0.551**	0.070	-0.062	0.037
8.8 Is participation in the deposit insurance system compulsory for the following banking entities?	**0.952**	0.151	0.075	0.024
8.9 Are the following types of deposits excluded from deposit insurance coverage?	**0.906**	0.138	0.101	-0.024
8.10 The deposit insurance coverage type is (choose the most appropriate option):	**0.933**	-0.129	0.044	-0.010
8.13 Is there formal coinsurance, i.e. are ALL depositors explicitly insured for less than 100% of their deposits?	**0.866**	0.130	0.046	0.030
8.14 What percentage of the total deposits of participating banks was actually covered by the scheme as of end of ...? Note: please provide answer in percentage (e.g. 50 means 50%)… 2016	**-0.634**	-0.106	-0.078	-0.035
8.15 Is there an ex ante fund/reserve to cover deposit insurance claims in the event of the failure of a member bank?	**0.940**	0.146	0.085	0.026
8.15.1 Is funding provided by ...:	**0.854**	0.118	0.070	0.029
8.15.2 What is the ratio of accumulated funds to total insured deposits as of end of 2016? Note: please provide answer in percentage (e.g. 50 means 50%).	**-0.674**	-0.078	-0.059	-0.039
8.16 Do deposit insurance fees/premiums charged to banks vary based on some assessment of risk?	**0.919**	0.132	0.097	0.017
8.21 Were insured depositors wholly compensated (to the extent of legal protection) the last time a bank failed?	**0.618**	0.068	0.072	0.032
8.22 Were any deposits not explicitly covered by the deposit insurance scheme at the time of failure compensated the last time a bank failed (e1cluding funds later paid out in liquidation procedures)?	**0.574**	0.056	0.074	0.043

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

PC2 is primarily concerned with questions related to *Requirements on Asset diversification and non-performing loans* (see Table 4). The object scores reveal extreme values on the higher end – for the Democratic Republic of the Congo (7.524), Comoros (6.278), Montserrat (5.940), and Eswatini (3.209). It seemed that those were dominated by missing responses in relation to survey questions entailing PC2 and were thus considered to be outliers. Following this, the object scores further signified the subsequent highest score belonging to Zimbabwe (1.019), while Papua New Guinea scored the lowest (-1.407). Inspection of the BRSS revealed that Zimbabwe had more stringent regulations in place regarding asset diversification. Moreover, banks are prohibited from making loans abroad and thus do not hold foreign currency reserves in place. In terms of loans, banks in Zimbabwe are required to classify loans as non-performing for a customer, given that any other of the

customer's loans are non-performing. On the other hand, Papua New Guinea has a lack of guidelines regarding asset diversification (the first guidelines being established as late as 2023) (Yabom, 2023). Furthermore, banks are not prohibited from making loans abroad, and the rules are more lenient in terms of classifying loans as non-performing. As a result, we found that higher values of PC2 were associated with more stringent regulations concerning *Requirements on Asset diversification and non-performing loans*.

Table 4: Component loadings for **PC2 regulatory** questions (values in bold are greater than 0.500 and are considered to be significant for that PC).

PC2 | Requirements on Asset Diversification and Non-Performing Loans				
	Component Loadings			
Question Wording	*PC1*	*PC2*	*PC3*	*PC4*
3.3.1 What was the minimum required risk-based regulatory capital ratio (i.e., as percent of risk-weighted assets) as of end of ...? Note: please provide answer in percentage (e.g. 50 means 50%)… 2016	0.259	**0.524**	-0.004	0.348
3.4.1 What was the actual risk based capital ratio of the banking system (i.e., as percent of the banking system risk-weighted assets) as of end of ...? Note: please provide answer in percentage (e.g. 50 means 50%)… 2016	0.214	**0.530**	0.041	0.083
7.3 Are there any regulatory rules or supervisory guidelines regarding asset diversification?	0.096	**0.945**	0.148	0.135
7.4 Are banks prohibited from making loans abroad?	0.107	**0.793**	0.083	0.214
7.6.1 Are banks required to hold reserves in foreign currencies or other foreign-denominated instruments in order to fulfill the requirements listed in question 7.6?	0.275	**0.597**	0.109	0.109
9.1 Do you have an asset classification system under which banks have to report the quality of their loans and advances using a common regulatory scale?	0.047	**0.794**	0.122	-0.383
9.3 Which criteria are taken into account to classify loans and advances as non-performing …	0.094	**0.798**	0.004	0.051
9.5 Does accrued, though unpaid, interest/principal enter the bank's income statement while the loan is classified as non-performing?	0.029	**0.830**	0.091	0.091
9.7 If a customer has multiple loans and advances and one of them is classified as non-performing, are all the other exposures automatically classified as non-performing as well?	0.062	**0.689**	0.064	0.055
10.1 Are banks required to prepare consolidated accounts for accounting purposes?	0.108	**0.940**	0.055	0.073
10.4 Does accrued, though unpaid, interest/principal enter the income statement while the loan is still performing?	0.110	**0.941**	0.056	0.070
10.9 Are bank directors legally liable if information disclosed is erroneous or misleading?	0.042	**0.882**	0.058	0.057
10.11 Are banks required by supervisors to have external credit ratings?	0.054	**0.881**	0.062	0.058
10.12 What percentage of the top ten banks (in terms of total domestic assets) are rated by international credit rating agencies (e.g., Moody's, Standard and Poor)? Note: please provide answer also in the case there are less than 10 banks in the system.	-0.087	**-0.609**	-0.077	-0.050

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

PC3 then consisted of survey questions that cover regulations on *Permissible banking activities and capital ownership* (see Table 5). The highest value is for Papua New Guinea (10.393) which was considered an extreme value; thus, we used the second and third highest values for Djibouti (3.474) and the United States (2.885) respectively, while the lowest score was observed for Eswatini (-1.183). For countries with a higher score, the responses in BRSS implied that related parties, i.e., those entities or individuals with a close link to a bank through ownership, control, or substantial influence,

are not allowed to hold capital in the same bank (Chatain & Caruso, 2024). Moreover, limits are placed on the ownership of banks by non-financial, such as a maximum percentage of a commercial bank's capital or voting shares. In relation to all the complementary banking activities, it seems like these countries generally are more restrictive in terms of the ability of banks to participate in complementary banking activities such as securities, insurance, and real estate. In contrast, the BRSS response by Eswatini connotes that the country does not have any restrictions in terms of the ability of related parties to own capital in a bank, and non-financial firms may own equity with voting rights in a bank. Furthermore, there seemed to be lesser restrictions in place with regards to banks engaging in complementary activities. Overall, the analysis of PC3 seemed to suggest that higher object scores were associated with more stringent *Permissible banking activities and capital ownership*.

Table 5: Component loadings for **PC3 regulatory** questions (values in bold are greater than 0.500 and are considered to be significant for that PC).

PC3 | Permissible Banking Activities and Capital Ownership Requirements				
	Component Loadings			
Question Wording	*PC1*	*PC2*	*PC3*	*PC4*
1.4.2 Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities?	0.076	-0.113	**0.843**	0.015
1.6 Which of the following are legally required to be submitted before issuance of the banking license?	-0.056	-0.083	**0.654**	-0.165
2.6 Can related parties own capital in a bank?	-0.029	0.192	**0.516**	-0.025
2.8 Can Nonfinancial firms own equity with voting rights (i.e., voting shares) in banks? Please see options provided and select option that best characterizes your banking sector (choose the most appropriate option).	0.131	0.363	**0.672**	-0.293
4.1 What are the conditions under which banks can engage in securities activities (e.g., brokerage, dealing on own account, portfolio management, investment advice, underwriting, venture capital activities, securitization)? (choose the most appropriate option)	0.122	0.450	**0.636**	0.441
4.2 What are the conditions under which banks can engage in insurance activities (e.g., life and non-life insurance policies; reinsurance policies)? (choose the most appropriate option)	0.211	0.374	**0.546**	0.241
4.3 What are the conditions under which banks can engage in real estate activities (e.g., selling, offering, negotiating, listing of real estate)? (choose the most appropriate option)	0.067	**0.564**	**0.584**	0.183
4.5 Can banks own voting shares in nonfinancial firms? Please mark the option that best characterizes the situation in your jurisdiction	0.120	0.358	**0.546**	0.400

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Finally, PC4 was based on survey questions regarding *Capital adequacy and audit requirements* in a country (see Table 6). As done previously, removing extreme object scores, the highest score was for Djibouti (2.667), while the lowest score was for United States (-3.469). According to the BRSS, the United States employed the latest capital adequacy regime (Basel III), while Djibouti had been employing the older Basel capital adequacy regimes. Furthermore, the United States has regulations on the coverage of capital risks through minimal capital requirements in the jurisdiction, and requirements on central bank reserve and/or deposits. Djibouti, on the contrary, does not have any central bank reserve requirements stated in the jurisdiction. Hence, lower country scores of PC4 were associated with more stringent capital *Capital adequacy and audit requirements*.

Table 6: Component loadings for **PC4 regulatory** questions (values in bold are greater than 0.500 and are considered to be significant for that PC).

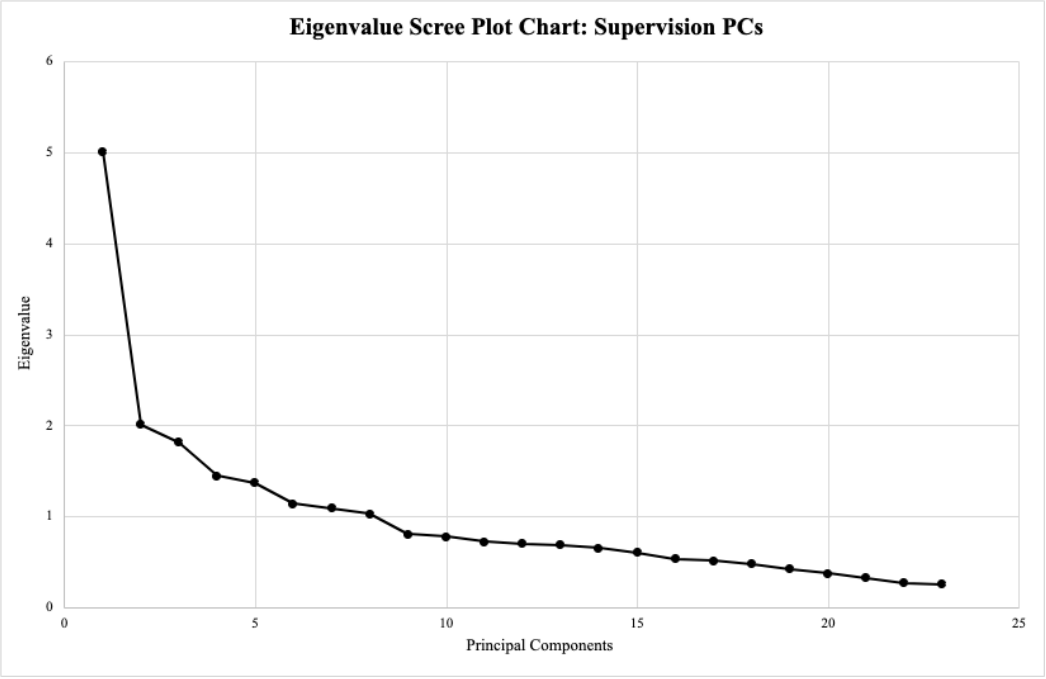
PC4 | Capital Adequacy and Audit Requirements				
	Component Loadings			
Question Wording	*PC1*	*PC2*	*PC3*	*PC4*
1.1 What body/agency grants banking licenses? Please include the name of licensing agency. If more than one, please describe their respective licensing roles.	-0.047	-0.483	-0.032	**-0.734**
3.1 Which regulatory capital adequacy regimes did you use as of end of 2016 and for which banks does each regime apply to (if using more than one regime, select all regimes currently in use)? In the space provided below each option please specify which bank types - commercial banks, state-owned commercioffal banks, state-owned development banks, mutual banks, foreign banks, bank-holding companies - fall under which regime.	-0.178	-0.286	0.003	**-0.565**
3.2 Which risks are covered by the current regulatory minimum capital requirements in your jurisdiction? Please select each risk that applies.	-0.169	-0.216	0.045	**-0.524**
5.1.2 Are specific requirements for the extent or nature of the audit spelled out?	0.068	0.361	0.194	**-0.513**
7.6 Are the following requirements in place in your jurisdiction? b. Central Bank reserve and/or deposit requirements	0.077	**0.527**	0.067	**0.728**

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

4.1.2. Supervisory Variables

We took the same approach to construct the principal components for the supervisory variables. According to Figure 2, we saw that the elbow point could occur at two principal components, beyond which the components could be considered to explain too little of the variation in the data to be considered valuable for our analysis. The two supervisory principal components, as seen in Table 7, approximately accounted for a sufficient 57.73% of the BRSS (2019) recoded data on supervision.

Figure 2: Scree plot of Eigenvalues for each Principal Component for Supervision



Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Table 7: Eigenvalues and proportion of variance accounted for Supervision PCs

Dimension	**Variance Accounted For**	
PC	**Eigenvalue**	**% of Variance**
1	11.372	49.45
2	1.904	8.28
Total	13.277	57.73

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Similarly to the regulatory variables, this output also provides rotated object scores within each principal component for each country (see Appendix C). The CATPCA analysis revealed component loadings that showed that PC1 was composed of survey questions related to the *Official Supervisory Enforcement Power* in a country (see Table 8, below). Countries with a higher object score indicated in the BRSS that the banking supervisory agency has significant power – the agency can force a bank to change its internal organizational structure and banks have a legal responsibility and accountability towards the agency, and there seem to be greater strictness in terms of mandatory actions to be taken and escalation of an issue to higher levels in case of breach of prudential regulations. Moreover, there seemed to be a structured process in place for the appointment of the head of the banking supervisory agency. On the other hand, countries' lower object scores indicated a lack of enforcement power provided to supervisory agency, and banks not having legal responsibility or accountability in reporting to the banking supervisory agency. Therefore, higher object scores for PC1 were associated with a more stringent supervisory environment in terms of official supervisory enforcement power.

As for PC2, the component loadings revealed that the principal component was primarily comprised of questions in the BRSS related to *Bank Disclosure and Resolution Activities, and Supervisory Frameworks* (see Table 8, below). The countries towards the higher end of the object scores responded a mandatory requirement for banks to disclose to supervisors, along with the bank supervisory agency having the power to take actions against the bank and/or the external auditor in case of an inadequate audit. Moreover, the supervisory agency in these countries operate an early intervention framework (e.g. prompt corrective action) that forces automatic action when certain regulatory thresholds are breached. These countries also seem to have a separate bank insolvency framework that is distinct from that of non-financial firms (including declaring insolvency, superseding shareholders' rights, removing and replacing bank senior management and directors, and appointing and overseeing a bank liquidator/receiver). On the contrary, the countries on the lower end of the object scores for PC2, have more lenient disclosure requirements to supervisors. Furthermore, there is no mention of supervisory authorities possessing powers to perform bank resolution activities. Thus, countries with higher object scores were considered as having more stringent supervisory frameworks and requirements on bank disclosure and resolution activities.

Table 8: Component loadings for the two extracted **supervisory** principal components (values in bold are greater than 0.500 and are considered to be significant for that PC).

PC1 | Official Supervisory Enforcement Power		
	Component Loadings	
Question Wording	*PC1*	*PC2*
11.1 Please indicate whether the following enforcement powers are available to the supervisory agency … a. Cease and desist-type orders for imprudent bank practices; f. Require banks to constitute provisions to cover actual or potential losses; j. Require banks to reduce or suspend dividends to shareholders; k. Require banks to reduce or suspend bonuses and other remuneration to bank directors and managers	**0.583**	0.224
11.2 Are bank regulators/supervisors required to make public formal enforcement actions, which include cease and desist orders and written agreements between a bank regulatory/supervisory body and a banking organization?	**0.532**	0.226
12.1 What body/agency supervises banks for prudential purposes …	**0.793**	0.493
12.5 Can the banking supervisory authority force a bank to change its internal organizational structure?	**0.664**	0.399
12.6 To whom is the banking supervisory agency legally responsible or accountable (mark all options that apply)?	**0.744**	0.453
12.7 How is the head of the banking supervisory agency appointed (mark all options that apply)?	**0.892**	0.331
12.9 Does the head of the banking supervisory agency have a fixed term?	**0.832**	0.261
12.10 Can the head of the banking supervisory agency be removed by…	**0.671**	0.436
12.12 Can individual banking supervisory staff be held personally liable for damages to a bank caused by their actions or omissions committed in the good faith exercise of their duties?	**0.577**	0.268
12.15 If an infraction of any prudential regulation is found in the course of supervision, must it be escalated (i.e., reported to higher levels)?	**0.813**	0.123
12.16 Are there mandatory actions that the banking supervisor must take if an infraction of any prudential regulation is found?	**0.893**	0.329

PC2 | Bank Disclosure and Resolution Activities, and Supervisory Frameworks§		
	Component Loadings	
Question Wording	*PC1*	*PC2*
5.14 In cases where the supervisor identifies that the bank has received an inadequate audit, does the supervisor have the powers to take actions against …	0.240	**0.690**
10.7 Do banks disclose to the supervisors …	0.404	**0.566**
11.4 Does the supervisory agency operate an early intervention framework (e.g. prompt corrective action) that forces automatic action when certain regulatory triggers/thresholds are breached?	0.470	**0.631**
11.8a Which authority has the powers to perform the following problem bank resolution activities?... - a. Declare insolvency	0.351	**0.866**
11.8b Which authority has the powers to perform the following problem bank resolution activities?... - b. Supersede shareholders' rights	0.112	**0.777**
11.8c Which authority has the powers to perform the following problem bank resolution activities?... - c. Remove and replace bank senior management and directors	0.191	**0.840**
11.8e Which authority has the powers to perform the following problem bank resolution activities?... - e. Appoint and oversee a bank liquidator/receiver	0.348	**0.869**

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Overall, the regulatory and supervisory variables across the PCs indicate that more positive (negative) values for the object scores are associated with greater (lower) stringency.

4.2. Banking Efficiency Data

Different measures can be used to estimate and evaluate the efficiency of banks. Two of the most well-known methods include: (i) traditional financial accounting measures based on financial statement analysis, and (ii) non-parametric methods such as the Data Envelopment Analysis (DEA) (Wozniewska, 2008). While there has been an apparent increase in the use of DEA to evaluate banking efficiency, Chortareas et al. (2012) used both, the DEA method and accounting measures, and found that both methods produced the same results. This paper will thus use financial accounting measures to estimate banking efficiency.

We used the World Bank's Global Financial Development Database to obtain the financial data for the banking sector of each country. More specifically, we collected data for the main dependent variables – net interest margin and overhead costs – that indicate a measure of efficiency. The data was collected at the country-level for 2016 since this is the year when the banking regulation and supervision data for the BRSS was collected (Bace & Ferreira, 2020; Demirgüç-Kunt et al., 2003).

Net interest margin was formulated as the interest income minus the interest expense divided by the interest-bearing assets. The interest-bearing assets include investment securities, loans, and leases. The net interest margin essentially measures the spread between what the bank pays to their lenders and what they receive from their borrowers while taking into account the size of the bank – a common size analysis. The net interest margin thus focuses on the traditional lending and borrowing operations of the bank. A higher value of the net interest margin variable is indicative of inefficiencies in the market, with banks possibly exploiting their customers by charging them higher interest rates (Demirgüç-Kunt et al., 2003). However, as Demirgüç-Kunt et al. (2003) point out, differences in net interest margins across jurisdictions might arise due to differences in bank activity, asset allocation, and risk preference of firms. For these measurement and interpretational issues, we included control variables which are outlined later in next sub-section (4.3).

It is however possible for bank inefficiencies to yield high overhead costs instead of high net interest margins. Thus, for the purpose of robustness, the overhead ratio margin was used separately as a dependent variable and was calculated by dividing the bank non-interest (operating) expenses by the total assets of the bank (again considering the bank size). A higher overhead cost ratio implies inefficiencies in the firm due to ineffective management as well as higher market power, thus indicating that higher overhead costs are associated with lower operational efficiency. It is expected that both net interest margin and overhead costs produce similar results (Bace & Ferreira, 2020; Demirgüç-Kunt et al., 2003).

4.3. Control Variables

Due to the problems outlined above in measuring and interpreting banking efficiency, we also controlled for the following variables: bank concentration, bank assets-to-GDP ratio, GDP per capita growth rate, political stability, and government-ownership structure.

While there was no data available for the direct measure of competition in the banking sector, the *bank concentration* variable could be represented as an indicator of market power by the top five banks in the country. Sapci & Miles (2019) present the Quiet Life Hypothesis (QLH) which states that if there is higher concentration in the banking sector, i.e., if there are fewer large banks having more of the market power, banks tend to be inefficient.

Banking sector size was formulated as the total assets of a country's banking system divided by the country's GDP. This variable thus takes into account the importance and contribution of a banking sector within a country's economy. One study found the size of the banking sector as a percentage of its GDP to be significantly correlated with most systemic risk measures, and thus is considered a good measure of the systemic risks in a country's banking sector (Kakes & Nijskens, 2018).

GDP growth rate is the annual growth rate of GDP per capita. Since business cycle fluctuations might determine monetary policy along with interest rates and banking conditions which ultimately might impact the level of net interest margin, GDP growth rate was included as a control variable (Demirgüç-Kunt et al., 2003).

A few studies have analyzed the impact of political stability on the banking sector. Unsurprisingly, these studies have found that political instability creates a significant adverse impact on the stability and efficiency of the banking sector, and thus is included as a control variable (Shabir et al., 2024; Venâncio de Vasconcelos, 2020).

The ownership structure, specifically government involvement in the ownership of banks might play an important role in determining a bank's efficiency. Two views exist regarding the impact of government-ownership of banks: the development view and the political view. While the development theory states that government ownership aids productivity growth and banking efficiency, Porta et al. (2002) find more support for the political view which states that government ownership is likely to lead to inefficiencies in the bank. Thus, we include another control variable: the proportion of government-owned banks. It is computed as the fraction of the banking system's assets that is held by banks with 50% or more government-ownership, and is included as a control variable: 1 if the

government holds 50% or more ownership of the country's banking system's assets, and 0 otherwise (Bace & Ferreira, 2020; Panizza & Eugène-Rigot, 2023.; Porta et al., 2002).[2]

Finally, we checked whether a country suffered a crisis during 2016. In our dataset, we found that only three countries – Moldova, Guinea-Bissau, and Ukraine – suffered from a banking crisis during 2016. Thus, we decided to remove these country observations from a dataset to avoid bias in the analysis.

4.4. Instrumental Variables

As previously mentioned, the multiple linear regression analysis could suffer from endogeneity issues and reverse causality bias. To mitigate this, a two-stage least-squares (2SLS) regression was conducted to isolate part of the variation in banking efficiency that could be attributed to the explanatory regulatory and supervisory variables.

Religious composition data was gathered from a report on "The Global Religious Landscape" published in 2012 by Pew Research Center, which provides data on religious composition by country. The major religion in each country that we had included was registered and recoded on a scale from 1-5 for the five different major religions Islam, Christianity, Buddhism, Hinduism and Judaism (Hackett & Grim, 2012). Latitude was obtained from a dataset published on Google developers with data on both latitude and longitude. For legal origin, the data was originally from The Quality of Government Institute which is a research institute that is part of the Department of Political Science at the University of Gothenburg. The different origins were English Common Law, French Commercial Code, Socialist/Communist Laws, German Commercial Code and Scandinavian Commercial Code. These options were recoded as 1-5.

Data on women participation was extracted from IPU Parline which is an open online source that provides data on national parliaments' structure and operations, including global monthly data and rankings on women participation in national parliaments. There was data on percentage of women both in lower house or single House and upper House or Senate. Given that Upper House or Senate was not applicable for most of countries and thus were missing a majority of the data points, we only used the available data on percentage of women in Lower House from December 2016 in our analyses. Year of independence was collected from The World Factbook which was published by The CIA under the U.S. Government. Continuous variables including latitude and women participation and national parliaments were standardized with a mean of 0 and a standard deviation of 1.

5. Methodology

The results from the principal component analysis (PCA) were used to capture the information about the regulations for each country based on the available data from the BRSS 2019. These were then used as the independent variables in the following regressions.

5.1. The Multiple Linear Regression Model

To estimate the causal effect of the regulations on the traditional borrowing and lending efficiency in the banking sector (using net interest margin), we first used the following model:

$$NIM_k = \alpha + \beta_1 Reg_k + \beta_2 Sup_k + \beta_3 C_k + \varepsilon_k \qquad \text{(Model 1)}$$

where *k* refers to country *k*, *Reg* is a vector of the regulatory variables constructed, while *Sup* is a vector of the supervisory variables constructed using the CATPCA of the BRSS (2016) dataset for each country, and *C* is a vector of the control variables.

Furthermore, overheads might measure cost efficiencies and market competition that are not captured by net interest margin (Demirgüç-Kunt et al., 2003), and thus, we used overhead costs as the dependent variable to formulate the following models:

$$OC_k = \alpha + \beta_1 Reg_k + \beta_2 Sup_k + \beta_3 C_k + \varepsilon_k \qquad \text{(Model 2)}$$

Since multicollinearity and heteroskedasticity would violate the MLR assumptions for determining causality, we conducted the Variance Inflation Factor (VIF) test for multicollinearity and the Breusch-Pagan test to investigate the presence of heteroskedasticity. The VIF test (see Appendix D) indicates no multicollinearity present in the models. As for the Breusch-Pagan test, the null hypothesis of the test refers to the presence of homoskedasticity. As can be seen in Appendix E, the p-value for all models was insignificant at the 5% level. Thus, we do not reject the null hypothesis and do not find a violation for the MLR assumption of homoskedasticity.

5.2. Country Development Level Moderation

Previous literature has rarely examined how countries at different stages of their development are impacted by regulations differently (exception being Djalilov & Piesse (2019) that looks specifically into transition countries). However, none have investigated the impact of regulations on banking efficiency across countries, based on development levels. To investigate this, we employed the following models:

$$\begin{aligned} NIM_k = \alpha + \beta_1 Reg_k + \beta_2 Sup_k + \beta_3 LM + \beta_4 UM + \beta_5 (Reg_k \cdot LM) + \\ \beta_6 (Sup_k \cdot LM) + \beta_7 (Reg_k \cdot UM) + \beta_8 (Sup_k \cdot UM) + \beta_9 C_k + \varepsilon_k \end{aligned} \qquad \text{(Model 3)}$$

$$OC_k = \alpha + \beta_1 Reg_k + \beta_2 Sup_k + \beta_3 LM + \beta_4 UM + \beta_5 (Reg_k \cdot LM) + \beta_6 (Sup_k \cdot LM) + \beta_7 (Reg_k \cdot UM) + \beta_8 (Sup_k \cdot UM) + \beta_9 C_k + \varepsilon_k \quad \text{(Model 4)}$$

here, LM refers to Low Middle-income countries, while UM refers to Upper Middle-income countries. Moreover, the coefficients for High income countries are represented in the coefficients for β_1 and β_2.

Note: Table 10 shows that there are only 7 observations for low-income countries. To maintain data that was balanced across country-levels, we removed the 7 observations containing low-income countries and conducted the moderation regression on the remaining three country-levels.

5.3. Instrumental Variable Analysis – Determining Causality

To determine causality of the estimates, a two-stage least-squares regression (2SLS) was conducted. In the first-stage regression, each endogenous variable was regressed on the five instrumental variables:

$$Reg_k \; or \; Sup_k = \alpha + \gamma_1 IV_k + \gamma_2 C_k + \varepsilon_k \quad \text{(Model 5)}$$

An F-statistic over 10 was considered to characterize a strong instrumental variable as the F-statistic indicates the variation explained by the instrument relative to the total variation by the explanatory variable. The second-stage regression was thereafter conducted for all the estimates of the explanatory variables with significant coefficients for at least one of the instruments in the first-stage regression. Both net interest margin and overhead costs respectively were regressed on those explanatory variables obtained in the first stage regressions:

$$NIM_k = \alpha + \beta_1 \widehat{Reg}_k + \beta_2 \widehat{Sup}_k + \beta_3 C_k + \varepsilon_k \quad \text{(Model 6)}$$

$$OC_k = \alpha + \beta_1 \widehat{Reg}_k + \beta_2 \widehat{Sup}_k + \beta_3 C_k + \varepsilon_k \quad \text{(Model 7)}$$

where $Reghat_k$ and $Suphat_k$ are the instrumented explanatory variables from the first-stage regression. Diagnostic tests were also performed including tests for Weak instruments, Wu-Hausman and Sargan tests.

6. Results

The regression results from models 1 and 2 are reported in Table 9, the regressions from the moderated models 3 and 4 are reported in Table 10, and the instrumental variable analysis models 6 and 7 are reported in Table 11.

6.1. Multiple Linear Regression

Table 9: Regression Table (Models 1 & 2), where NIM: Net Interest Margin; OC: Overhead Cost ratio

	Dependent Variables	
	NIM	OC
	(1)	(2)
Deposit Protection Scheme	-0.266 *	-0.092
	(0.108)	(0.107)
Asset Diversification and Non-Performing Loans	0.723	0.327
	(0.598)	(0.596)
Permissible Banking Activities and Capital Ownership	-0.075	-0.398
	(0.256)	(0.256)
Capital Adequacy and Audit Requirements	-0.185	-0.096
	(0.200)	(0.199)
Official Supervisory Enforcement Power	0.283	0.064
	(0.304)	(0.303)
Bank Disclosure and Resolution Activities	-0.152	-0.304
	(0.332)	(0.331)
Bank Concentration	-0.067	-0.058
	(0.084)	(0.084)
Assets to GDP ratio	-0.628***	-0.667***
	(0.086)	(0.086)
GDP per capita growth rate	-0.205**	-0.197**
	(0.074)	(0.073)
Political Stability	-0.125	-0.044
	(0.084)	(0.084)
Government Ownership	-0.178	-0.227
	(0.365)	(0.364)
Intercept	0.205	0.093
	(0.172)	(0.172)
Num. obs.	98	98
R^2	0.595	0.556
Adj. R^2	0.544	0.499
Residual Std. Error	0.678 (df = 86)	0.676 (df = 86)
F-Statistic	11.51*** (df = 11; 86)	9.791*** (df = 11; 86)

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$*

Source: Authors' rendition of Models 1 and 2 using R-Studio

As seen in Table 9, the regression results for models 1 and 2 show negative and statistically significant coefficients for Deposit Protection Schemes, suggesting that more stringent regulations on *Deposit protection schemes* lead to better financial efficiency (through net interest margin), but has no impact on managerial efficiency (represented by overhead cost ratio). However, the other regulatory and supervisory variables suggest no statistically significant effect on banking sector efficiency. Furthermore, the control variables for Assets-to-GDP ratio and GDP capita growth rate are negative and statistically significant, suggesting that a larger banking sector in a country and a larger growth rate are indicators of better efficiency in the banking sector.

6.2. Country Development Level Moderation

As it can be seen in Table 10, a clear distinction between Low- and High-income countries is apparent – low-income countries have poorer efficiency levels (in terms of both net interest margin and overhead costs ratio) and seem to generally have a lesser stringency of regulations (except for Reg_PC3: *Permissible banking activities* compared to High-income countries.

Table 10: Summary Statistics based on Country-Level subsets (standardized values)

Income Level	Count	Reg_ PC1	Reg_ PC2	Reg_ PC3	Reg_ PC4	Sup_ PC1	Sup_ PC2	NIM	OC
Low	7	-0.365	-0.196	-0.065	-0.134	0.091	0.262	1.275	1.190
Low Middle	22	0.242	-0.124	-0.080	0.045	0.112	0.177	0.457	0.231
Upper Middle	31	-0.006	-0.184	-0.223	-0.053	0.160	0.187	0.344	0.365
High	38	0.386	-0.160	-0.168	0.014	-0.046	0.306	-0.772	-0.693

Source: Authors' calculations using R-Studio

However, there is no clear difference among the supervisory variables between the two country-level subsets. Interestingly, there is no clear distinction between Low Middle- and Upper Middle-income countries, in terms of both types of the explanatory variables (regulations and supervision) and the efficiency margins.

Following this, Table 11 shows the regression results for models 3 and 4. According to this, the stringency of regulations (*Deposit protection schemes*, *Asset diversification*, and *Permissible banking activities*) only seems to significantly affect the operational efficiency (through overhead costs ratio) in Low Middle-income countries. While more stringent deposit protection schemes lead to increased operational efficiency, it seems that greater stringency in *Asset diversification* and *Permissible banking activities* lead to greater inefficiency in operations.

Table 11: Country-Level Moderation Regression Table (Models 3 & 4), where LM: Low Middle-Income countries; UM: Upper Middle-Income countries; NIM: Net Interest Margin; OC: Overhead Cost ratio

	Dependent Variable	
	NIM (3)	OC (4)
(Intercept)	-0.547	-0.535
	(0.275)	(0.276)
LM	1.314**	1.086*
	(0.421)	(0.423)
UM	0.524	0.853
	(0.492)	(0.494)
Deposit Protection Schemes	-0.192	0.036
	(0.171)	(0.172)
Asset Diversification and Non-Performing Loans	-0.420	-0.545
	(0.907)	(0.912)
Permissible Banking Activities and Capital Ownership	-0.126	-0.402
	(0.307)	(0.309)
Capital Adequacy and Audit Requirements	-0.448	0.255
	(0.571)	(0.574)
Official Supervisory Enforcement Power	0.011	-0.012
	(0.350)	(0.352)
Bank Disclosure and Resolution Activities	-0.137	-0.276
	(0.351)	(0.353)
LM : Deposit Protection Schemes	-0.732	-0.833*
	(0.406)	(0.408)
UM : Deposit Protection Schemes	0.329	0.102
	(0.252)	(0.254)
LM : Asset Diversification and Non-Performing Loans	3.948	4.385*
	(2.039)	(2.051)
UM : Asset Diversification and Non-Performing Loans	0.932	1.119
	(1.365)	(1.373)
LM : Permissible Banking Activities and Capital Ownership	1.453	1.660*
	(0.752)	(0.757)
UM : Permissible Banking Activities and Capital Ownership	-1.073	-0.567
	(0.796)	(0.801)
LM : Capital Adequacy and Audit Requirements	-0.534	-1.376
	(0.791)	(0.796)
UM : Capital Adequacy and Audit Requirements	0.195	-0.473
	(0.700)	(0.704)
LM : Official Supervisory Enforcement Power	1.839*	1.587
	(0.895)	(0.900)
UM : Official Supervisory Enforcement Power	0.392	-0.490
	(1.135)	(1.142)
LM : Bank Disclosure and Resolution Activities	1.696	1.712
	(1.335)	(1.343)
UM : Bank Disclosure and Resolution Activities	0.599	0.101
	(1.040)	(1.046)
Controls	Yes	Yes
Num. obs.	91	91
R^2	0.724	0.690
Adj. R^2	0.618	0.570

Note: *** p < 0.001; ** p < 0.01; * p < 0.05*

Source: Authors' rendition of Models 3 and 4 using R-Studio

6.3. Instrumental Variable Analysis

None of the first-stage regressions generated an F-statistic over 10 (see Appendix F for the first-stage regression results). Latitude is however statistically significant as an instrument for *Deposit protection scheme* and *Asset diversification* at the 0.1% and the 5% significance level respectively. For *Bank disclosure and resolution activities*, the coefficients for both Latitude and Year of Independence are statistically significant at the 5% level.

Subsequently, we proceeded to run the second-stage regression for both net interest margin and overhead costs, where both respective dependent variables were regressed on the three endogenous variables obtained from the first-stage regressions with statistically significant coefficients. Control variables were also included in the regressions and the coefficients for both *Deposit protection schemes* and *Asset diversification* are statistically significant at the 5% level (see Table 12). The results observed in the multiple linear regression for net interest margin are therefore robust for *Deposit protection scheme*. Interestingly, the statistical significance for the coefficients for *Deposit protection scheme* and for *Asset diversification* as regressors on overhead costs that is observed in the instrumental variable analysis, was not observed in the initial regressions presented in Table 9. The same observation is seen for *Asset diversification* as a regressor on net interest margin.

Table 12: Second-stage regression results from Instrumental Variable Analysis with confidence intervals reported in brackets. NIM: Net Interest Margin; OC: Overhead Cost ratio

	Dependent Variables	
	NIM	OC
	(6)	(7)
(Intercept)	2.384*	2.199*
	(0.952)	(0.914)
Deposit Protection Scheme	-1.867*	-1.702*
	(0.623)	(0.598)
Asset Diversification and Non-Performing Loans	11.294*	10.791*
	(5.094)	(4.892)
Bank Disclosure and Resolution Activities	-0.923	-0.693
	(1.424)	(1.368)
Num. obs.	98	98
R^2	-1.961	-2.016
Adj. R^2	-2.055	-2.112
RMSE	1.755	1.685

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$*

Source: Authors' rendition of Models 6 and 7 using R-Studio

The Weak instruments test is significant for *Deposit protection schemes*, as well as for *Bank disclosure and resolution activities*, but not for *Asset diversification* (see Table 13). This is observed both for net interest margin and overhead costs respectively. The Weak instruments values provide information on the correlation between the instruments and the endogenous variables. A weaker correlation between the instruments and one or more of the endogenous variables will result in lower precision of the estimated coefficients whereas a strong correlation will lead to greater accuracy in the estimation and also a larger test statistic and a smaller p-value (Fox et al., 2023). The results therefore indicate that the correlations are strong between the instruments and the explanatory variables of *Deposit protection schemes*, and *Bank disclosure and resolution activities* respectively, while the correlation is weak between those same instruments and *Asset diversification*.

The Wu-Hausman test is statistically significant for both regressions (see Table 13). The test compares the 2SLS estimators with those obtained from OLS. If at least one of the explanatory variables are endogenous, the OLS estimates will be inconsistent thus promoting usage of the IV estimators instead, which is illustrated by a larger value of the test and a decrease in p-value (Fox et al., 2023). The test is highly statistically significant in both regressions which confirms our concern that has previously been brought up that endogeneity issues with the explanatory variables may be present in our model.

Lastly, the Sargan test is not statistically significant for either one of the two regressions (see Table 13). The Sargan test detects overidentification where a greater test value with a small p-value indicates that the instruments are contributing with contradictory information to the estimates (Fox et al., 2023). Since the test is not statistically significant for either of the regressions, we do not have a strong reason to believe that overidentification issues are present that could cause biasedness and inconsistency of the estimators.

Table 13: Diagnostic tests on the estimated variables obtained from the first-stage regressions when applied in the second-stage regressions.

	Dependent Variables	
	NIM	OC
Weak instruments (Deposit Protection Schemes)	4.336***	4.336***
Weak instruments (Asset Diversification and Non-Performing Loans)	1.697	1.697
Weak instruments (Bank Disclosure and Resolution Activities)	1.799*	1.799*
Wu-Hausman Test	10.763***	9.634***
Sargan Test	9.113	8.542

Note: *** p < 0.001; ** p < 0.01; * p < 0.05*

Source: Authors' rendition of Diagnostic checks (from Models 5, 6 and 7) using R-Studio

7. Discussion

While studies have previously investigated the impact of deposit insurance schemes on stability (Anginer et al., 2014), the impact of deposit insurance regulation on banking sector efficiency has rarely been examined. In this study, we find that even after controlling for other factors, more stringent deposit insurance schemes lead to better financial efficiency. Therefore, not only do we reject H_4 (more stringent deposit protection schemes have a significant and negative impact on banking sector efficiency), but rather we find the opposite to be true: more stringent deposit protection schemes have a statistically significant and positive impact on banking sector efficiency. Anginer et al. (2014) mention the contradicting evidence of the impact of deposit protection schemes on banking sector efficiency. During stable periods, previous literature has mentioned the negative effect of the presence of deposit protection schemes on banking efficiency. In this paper, as previously mentioned, the countries that experienced a crisis during the sample period were removed from the analysis. We suggest a possible reason for the contradicting evidence due to the analysis being conducted for different time periods: (Anginer et al., 2014) carried out their analysis for the sample period 2006-2009, while this analysis was carried out for 2016. Moreover, (Anginer et al., 2014) showed that stronger supervision can help improve the effect of deposit protection schemes on banking efficiency. Thus, it is highly likely that while deposit protection schemes have been shown to be detrimental for the banking sector as it exacerbates moral hazard risks, this analysis shows that in more recent times, deposit protection schemes have been better implemented in the market, and perhaps through better supervision, have led to improvements in banking sector efficiency.

However, none of the other regulations nor supervision seem to affect banking efficiency, and thus we are unable to reject the other null hypotheses. As previous literature has pointed out the complex impact of regulations on efficiency (Barth, Lin, et al., 2013), this paper suggests that post-crisis, the continuous proliferation of regulations and supervision in recent times has created ambiguity on their impact on the banking sector.

The control variables seem to suggest that a larger banking sector in a country and a higher GDP per capita growth rate is more efficient (this was also found in Djalilov & Piesse (2019)). This is most likely because the banking industry is more established in the country and can thus operate at a higher efficiency level. Moreover, a country with higher GDP per capita growth rate, meaning a country that is growing faster has a more efficient banking sector.

The moderation allows for the investigation of countries at different levels of development. Interestingly, only the low middle-income countries show statistically significant results for managerial efficiency, but not for financial efficiency (see Table 11). While *Deposit protection schemes* seem to improve managerial efficiency (similar to what has been explained previously), greater stringency in other regulatory aspects of *Asset diversification* and *Permissible banking activities* seem to lead to significant managerial inefficiency. In comparison to Djalilov & Piesse

(2019), firstly, we find support that regulations do have different effects in countries at different levels of their development. Secondly, while Djalilov & Piesse (2019) investigate transition countries, our sample looks into low middle-income countries, where the two are not necessarily the same, although similarities exist. In our case, we find that regulations in low middle-income countries exhibit similar results to those that were hypothesized in H_1 and H_2. Thus, it is possible that while previous studies investigating advanced economies in earlier time periods showed support for H_1 and H_2 (Bace & Ferreira, 2020; Barth et al., 2008; Barth, Lin, et al., 2013; Laeven & Levine, 2009; Podpiera, 2004) it is the emerging economies that are now at that point of their growth.

As mentioned in the results of the instrumental variable regression, we observe that the statistically significant coefficient for *Deposit protection schemes* when used as a regressor on net interest margin is robust whereas the coefficient on that same regressor on overhead costs become statistically significant when adding instruments. The same applies for *Asset diversification* whose coefficients also become statistically significant both for net interest margin and overhead costs after adding instruments. This indicates that the implementation of the instruments has resulted in capturing a part of the explanatory power of the regressors, partially addressing the endogeneity issues. The validity of these results however needs to be further investigated through assessment of the results of the diagnostic tests as well as other checks that have been performed.

Firstly, the Weak instruments test suggests that the correlation is strong between the instruments and the two explanatory variables of *Deposit Protection Schemes*, and *Bank Disclosure and Resolution Activities* respectively but not for *Asset diversification*. The statistical significance that we observe for *Asset diversification* may therefore not be causal since the diagnostic test suggests that there is only a weak correlation between the instruments and that regressor. This indicates that the statistical significance observed for that coefficient cannot necessarily be attributed to the instruments. Furthermore, the results obtained for the Sargan test contradict the notion that the estimators may be biased and inconsistent. Based on these diagnostic tests, the application of these instruments seems reasonable in terms of explanatory power and identifying and capturing part of the causal relationship of the main regression between banking efficiency on the regulatory and supervisory variables. One study however argues that the results of the Sargan test can indicate that the instruments are valid even when they are not. In models such as the one presented in this paper with more instruments than regressors, this can occur if the instruments are similar in their degree of invalidity and strength thus falsely resulting in larger and insignificant test statistics which indicates that the issue of overidentification is not present (Kiviet & Kripfganz, 2021). For this reason, we further check the results of the Wu-Hausman test which indicates that since one or more of the explanatory variables are presumably endogenous, the instrumental variables estimators are favorable over OLS estimators.

We do observe that the coefficients are statistically significant for two of the regressors on both net interest margin and overhead costs thus implying that the instruments are relevant in capturing part of the explanatory power of the regressors. The value of the F-statistic is however not above 10 for any of

the first-stage regressions which indicates that the instruments used are weak since it suggests that they are not exogenous. The results that are observed in the second-stage regressions may therefore, although statistically significant, still suffer from endogeneity issues despite the addition of the instrumental variables.

Barth, Lin, et al. (2013) found that adding instrumental variables (legal origin, latitude, ethnic fractionalization and years of independence since 1776) did not affect the results of their main regressions. They also conducted tests to assess overidentification and suitability of the instruments and found that the null hypothesis that the instruments were valid could not be rejected. Triki et al. (2017) on the other hand observed that some of their results were robust in the instrumental variable regressions including the positive impact of entry restriction and the negative effect of restriction of banking activities, exit from banking, controls for price and greater stringency of transparency requirements. The authors do however also observe that restrictions on activity, liquidity and diversification requirements were not significant in the instrumental variable regression while availability of financial safety nets and overall capital stringency had a positive and significant impact on bank efficiency.

One reason for the discrepancy in the observed results in this study compared to the ones obtained in Barth, Lin, et al. (2013) and Triki et al. (2017) could be due to data collected at the bank-level and during a different time period (1999-2007) compared to the one covered in this paper. Furthermore, their regressors of regulations and supervision deviated from the ones obtained with the implementation of CATPCA in this paper since each of their regulatory variables are based on fewer questions from the BRSS. They used data envelopment analysis to assess banking efficiency which they argue enables them to focus on individual observations as opposed to population averages which is what has been done in this paper.

Furthermore, Triki et al. (2017) only investigated African countries and their dependent variable is a composite of different inputs, consisting of total costs, total fixed assets and deposits and short-term funding. Similar to Barth, Lin, et al. (2013), they also used the DEA method to estimate efficiency for individual banks as well as used other datasets that were constructed by African organizations.

Additional investigation and implementation of other potential instrumental variables is needed to gain further understanding of the complexity around endogeneity issues between regulatory and supervisory practices and banking efficiency. The widely adopted DEA method for assessing banking efficiency is something to consider for future papers, in combination with the application of CATPCA to assess regulatory and supervisory practices based on large survey data such as the BRSS. Other potential instrumental variables to consider are the ones applied in (Caselli & Reynaud, 2019) that investigates whether fiscal rules result in improved fiscal balances and uses the number of neighboring countries who have previously implemented a fiscal rule in the last years as an instrument. The authors argue that the adoption of a rule in a neighboring country can cause reforms to take place within the

domestic country and thus also a domestic rule, through social mechanisms such as economic competition, learning, mimicking and coercion (Caselli & Reynaud, 2019). In such a case, countries within the EU could potentially be compared with countries outside the EU that do not necessarily act under the same rules.

It is important to note that this study only had access to efficiency data for the entire banking sector of a country, while previous studies had access to data for each bank that allowed for the analysis of regulations at bank-specific level across countries. This is because BankScope (the previous data source on banking efficiency data) was terminated in 2015. The results obtained in this paper represent country aggregate statistics and trends that allows for a holistic comparison of the entire banking sector across countries, and the controls used at the country level possibly increases the generalizability to other settings.

For future research, the availability of bank-specific data could allow for a more granulated analysis, regarding the impact of regulations and supervision on bank efficiency as it would capture variations among individual banks, for example by using fixed effects and controlling for unobserved heterogeneity across countries. Moreover, it would allow for an investigation into differences among banks within a country based on factors such as bank size. Thus, in this paper, having access to only country-level data has proven to be a limitation due to the inability to analyze how regulations within a country affects the banks within the country, which could help understand bank-level performance, and the impact of specific regulations or supervision on banking efficiency.

This is the first time that a research paper has regressed banking efficiency data on regulatory and supervisory variables that have been constructed through CATPCA using data obtained from the World Bank's BRSS. Moreover, to the best of our knowledge, this is the only paper that has used the 2019 version of the BRSS to do so. In comparison to the PCs obtained by Pereira Pedro et al. (2023), the PCs obtained in this paper are largely similar and provide an adequate and reliable representation of the regulatory and supervisory environment across countries. However, we recognize that there are limitations to the recoding and variable construction process that might need to be addressed for future analyses.

As suggested by Pereira Pedro et al. (2023), we employ an active imputation strategy for missing values and impute the same value to all countries with missing value in each variable. This methodological option thus assumes that countries with missing values are equivalent to a random subsample of countries to which specific questions do not apply but should still be considered in the CATPCA for estimating the stringency of regulation and supervision. While this strategy enables consistency in the treatment of missing values across variables, there might be certain questions that call for the use of other imputation strategies. For instance, replacing the missing values with 0 ('zero') for scaled variables, taking the median value for the sample or a sub-sample of the observations, using machine learning for missing value imputation, or even gathering data from

external sources, agencies, or experts, for countries with missing values. In this way, the CATPCA could be used to obtain more accurate estimates for the stringency of regulatory and supervisory variables.

It might also be possible to examine/explore different methods to use the CATPCA to construct the regulatory/supervisory variables. For example, the questions could be grouped separately by grouping the questions based on the section they belong to, and then conducting the CATPCA to achieve one or two principal components for each section. Doing so should not only allow the comparison of regulations and supervision across countries, but also in different time periods of the BRSS, thus allowing the construction of a panel dataset.

8. Conclusion

In this paper, we apply CATPCA as a way of measuring and assessing banking regulation and supervision in order to investigate the impact on banking efficiency. The method has previously been presented and applied in Pereira Pedro et al. (2023), but the results of the analysis were not further applied in statistical analyses. We further the analysis in this paper where the potential impact of regulatory and supervisory practices on the financial metrics of banking efficiency were explored. Our results indicate that deposit protection schemes contribute to improved efficiency across banking sector. The size of the banking sector and GDP per capita growth rate seem to positively contribute to efficiency as well. Furthermore, we find high-income countries as having the most stringent regulations and supervision, while low-income countries being the least stringent during the sample period. The moderation analysis confirms the different effects of regulation and supervision on banking sector efficiency based on the stage of development a country is in.

To determine causality in our analysis, we use an instrumental variable analysis that suggests that the results are robust for *Deposit protection schemes* although the diagnostic tests indicate that the instruments may be weak and that endogeneity issues still need to be considered and addressed. For example, other instruments could potentially be used to capture some of the presumed variation to prove causality between regulatory and supervisory practices, and banking efficiency.

The results have implications for regulatory and supervisory bodies, as well as banks, around the world as they provide insights into the recent effects of the stringency of regulations and supervision on banking sector efficiency. In particular, the results imply that regulations on *Asset diversification, Permissible banking activities* and *Capital adequacy requirements*, and supervision concerning *Supervisor enforcement power* and *Bank disclosure and resolution activities* do not sufficiently impact banking sector efficiency. This suggests that policymakers need to consider weaknesses of the banking sector and consider the implementation of regulations that improve banking efficiency. While

doing so, they need to take into account the impact on other banking factors such as stability and bank runs, as well as the financial and economic environment.

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10. Appendix

Appendix A: Added numerical categories for the recoding of the BRSS survey responses for the categorical questions.

Question number	Recoded number	Description of chosen options
Q 1_6	9	All except h and i
	11	All except g and h
	12	All except a and j
	13	All except j
	14	All except d
	15	All except a, h and i
	16	All except c and f
	17	All except a, b and c
	18	All except b and j
	19	None except d
	20	All except a and i
Q 1_8	9	NA
	10	c and d
	11	b, c and d
	12	d
Q 1_9_1, Q_10_1 and Q1_11_1	21	a, b and d
	22	a, b, d and g
	23	b, c and e
	24	a, b, c, d, g and h
	25	c, d and e
	26	c, e, g and h
	27	a, b, d and h
	28	a, b and e
	29	g
	30	d and e
	31	b, d and h
	32	b and d
	33	b, c and d
Q 3_1c	1	Basel I
	2	Basel I + Basel II
	3	Basel II
	4	Basel III

	5	Basel III
	6	Basel II + Basel III
	7	Basel I + Basel III
	8	Basel I + II + III
	9	Basel III + leverage ratio
	10	Basel III + leverage ratio + other
	11	Basel II + leverage ratio
	12	Basel I + leverage ratio
	13	Basel I + II + II + leverage ratio
	14	Basel 1 + II + leverage ratio
	15	Basel II + III + leverage ratio + other
	16	Basel II + III + other
	17	Basel I + III + leverage ratio
	18	Other
	19	Basel II + III + leverage ratio
Q 3_2	4	a, b, c and d
	5	a, b and c
	6	a and c
	7	a, c and d
	8	a and c
	9	none
	10	a and d
	11	c
Q 8_9 and Q 8_6	1	a
	2	A + b
	3	B
	4	e
	5	f
	6	B + c + d
	7	B + c
	8	B + d
	9	A + b + c + d
	10	A + c + d
	11	C + d
	12	C
	13	D
	14	A + b + c

Q 9_3	25	all except g and h
	26	all except c and h
	27	all except c, d, f and h
	28	all except f, g and h
	29	all except c, e, f and h
	30	all except c, f, g and h
	31	b and e
	32	all except f and h
	32	all except f and h
	33	all except d, f, g and h
	34	all except a, f g and h
	35	a
	36	e and f
	37	b and e
	38	all except f and g
	39	a and d
	40	b, d, e and g
	41	b and h
	42	all except d, f and h
	43	all except f and g
	44	a, b and e
	45	a, c and e
	46	all except d and h
Q 10	1	A
	2	B
	3	C
	4	D
	5	E
Q 15_1	1	A
	2	B
	3	C
	4	D
	5	None
	6	Combination

Source: Pereira Pedro et al. (2023) and Authors' additional recoding

Appendix B: Country Object Scores obtained from CATPCA of questions related to Regulations

	Regulatory PCs			
Country	**PC1**	**PC2**	**PC3**	**PC4**
Albania	0.426	0.072	-0.457	0.104
Angola	-1.433	-0.477	0.200	0.091
Antigua and Barbuda	-1.630	0.075	0.379	-0.381
Argentina	0.944	-0.123	-0.319	-0.098
Armenia	0.501	-0.221	-0.299	-0.085
Aruba	-1.571	-0.347	-0.255	0.036
Australia	0.268	-0.173	0.169	0.244
Austria	0.634	-0.144	-0.372	-0.114
Azerbaijan	0.777	-0.194	0.614	-0.090
Bahrain	0.049	-0.124	-0.194	0.114
Bangladesh	0.409	-0.124	0.061	-0.157
Belarus	0.706	-0.126	-0.378	-0.045
Belgium	0.728	-0.131	-0.378	-0.046
Belize	-1.563	-0.296	-0.423	-0.072
Bermuda	0.415	-0.097	0.663	-0.042
Bhutan	-1.572	-0.412	0.256	0.280
Bolivia	-0.380	-0.028	-0.332	-0.069
Bosnia and Herzegovina	0.844	-0.167	0.008	-0.237
Botswana	-1.500	-0.420	-0.126	0.007
Brazil	0.878	-0.114	-0.259	-0.079
British Virgin Islands	-1.619	0.324	-0.291	0.491
Bulgaria	0.977	-0.147	-0.185	-0.066
Burundi	-1.559	-0.321	-0.120	-0.035
Cabo Verde	-0.009	-0.112	-0.442	-0.064
Canada	1.059	-0.145	-0.009	0.067
Cayman Islands	-1.550	-0.301	-0.100	0.170
Chile	-0.351	-0.246	-0.343	-0.148
China	-0.970	0.118	0.220	-0.410
Colombia	0.729	-0.208	-0.127	-0.299
Comoros	-0.122	6.278	1.249	0.976
Congo, Dem. Rep.	-0.633	7.524	0.859	5.678
Cook Islands	-1.726	0.262	-0.785	0.307
Costa Rica	-1.648	0.114	-0.719	1.157
Croatia	0.860	-0.131	-0.146	0.040
Curaçao	0.429	-0.223	0.158	-0.031
Cyprus	0.661	-0.142	-0.256	0.173
Czech Republic	0.823	-0.177	-0.364	-0.141
Denmark	-0.859	-0.273	-0.201	0.207
Djibouti	-1.269	-0.073	3.474	-2.667
Dominican Republic	0.660	0.080	-0.399	0.080
Ecuador	0.568	-0.226	0.201	-1.204
El Salvador	0.541	0.008	-0.361	-0.120

Estonia	0.500	-0.174	-0.293	0.040
Eswatini	-1.353	3.209	-1.183	0.545
Fiji	-1.622	-0.287	-0.534	0.155
Finland	0.922	-0.179	-0.209	-0.026
France	0.882	-0.144	-0.291	-0.043
Gambia, The	-1.740	0.086	0.395	1.742
Georgia	-1.614	-0.312	-0.460	0.327
Germany	0.942	-0.154	-0.082	0.075
Ghana	-1.518	0.052	-0.588	1.200
Gibraltar	0.812	-0.228	1.014	0.032
Greece	0.677	0.209	-0.321	0.013
Guatemala	0.680	0.136	-0.352	-0.024
Guernsey	0.211	0.191	-0.016	0.175
Guyana	-1.378	-0.425	-0.202	-0.194
Haiti	-1.681	-0.208	-0.076	0.258
Honduras	0.985	0.050	-0.334	0.250
Hong Kong SAR, China	0.629	-0.169	-0.294	-0.034
Hungary	0.837	-0.092	-0.403	-0.043
Iceland	0.989	-0.207	-0.104	-0.011
India	0.540	-0.141	0.285	0.082
Indonesia	0.747	-0.177	0.223	0.004
Ireland	0.770	0.495	-0.571	0.220
Israel	-1.563	-0.514	0.087	0.128
Italy	0.793	-0.225	0.038	0.062
Jamaica	0.625	-0.179	-0.012	-0.153
Japan	0.742	-0.259	-0.077	-0.029
Jersey	0.380	0.362	-0.447	0.234
Jordan	0.400	0.130	-0.319	0.633
Kenya	1.036	-0.262	0.394	-0.091
Korea, Rep.	0.934	-0.148	0.129	0.045
Kosovo	0.177	-0.138	-0.253	-0.151
Kuwait	-0.943	-0.328	-0.289	0.120
Kyrgyz Republic	0.407	-0.152	0.448	-0.534
Latvia	0.740	-0.136	-0.394	-0.149
Lebanon	1.034	-0.179	-0.096	-0.100
Lesotho	-1.644	-0.183	-0.851	-1.954
Liberia	-1.509	-0.375	-0.401	-0.078
Liechtenstein	0.400	-0.195	-0.063	0.094
Lithuania	0.803	-0.141	-0.141	-0.028
Luxembourg	0.908	-0.120	-0.171	0.041
Macao SAR, China	0.351	-0.161	-0.288	-0.096
Macedonia, FYR	0.583	-0.136	-0.329	0.011
Madagascar	-1.535	-0.272	-0.323	0.228
Malawi	-1.467	-0.276	-0.329	0.381
Malaysia	0.717	0.020	-0.127	0.330
Maldives	0.058	-0.146	-0.383	-0.218

Malta	0.503	-0.197	-0.203	-0.023
Marshall Islands	-1.484	-0.062	0.413	-0.577
Mauritania	-0.672	0.392	-0.792	0.012
Mauritius	-1.537	-0.196	-0.462	-0.348
Mexico	0.923	-0.020	-0.085	0.067
Moldova	0.792	-0.169	-0.365	-0.320
Montenegro	0.391	-0.187	-0.033	-0.198
Montserrat	-0.350	5.940	0.431	-8.968
Morocco	0.953	-0.021	-0.286	0.321
Mozambique	0.412	-0.233	0.122	-0.180
Namibia	-1.486	-0.621	-0.099	-0.372
Nepal	0.633	-0.001	0.315	0.045
Netherlands	0.913	-0.204	-0.126	-0.046
New Zealand	-1.474	-0.427	-0.483	0.140
Nicaragua	0.714	-0.125	0.109	-0.189
Nigeria	0.536	-0.162	-0.140	0.062
Norway	0.907	-0.184	-0.093	0.025
Oman	0.680	-0.160	0.168	0.069
Pakistan	-1.467	-0.364	-0.435	0.141
Palau	-1.631	-0.439	-0.173	0.112
Panama	-1.477	-0.420	-0.485	-0.032
Papua New Guinea	-0.941	-1.407	10.393	-0.189
Paraguay	0.613	0.289	-0.087	-0.002
Peru	0.829	-0.118	-0.385	-0.056
Philippines	0.782	0.137	0.041	0.858
Poland	0.703	-0.134	-0.166	0.060
Portugal	0.780	-0.023	-0.493	0.258
Qatar	-1.530	-0.431	-0.227	0.141
Romania	0.766	-0.167	-0.327	-0.053
Russian Federation	0.913	-0.145	-0.158	0.023
Rwanda	0.414	-0.096	-0.102	-0.065
Samoa	-1.633	-0.344	-0.175	0.081
San Marino	0.495	-0.198	-0.150	-0.234
São Tomé and Principe	-1.660	-0.662	0.226	-0.286
Saudi Arabia	0.342	-0.218	-0.013	-0.030
Serbia	0.397	-0.145	-0.282	-0.067
Seychelles	-1.540	-0.338	-0.556	-0.763
Singapore	0.345	-0.202	-0.220	-0.016
Slovak Republic	0.711	-0.218	-0.153	-0.148
Slovenia	0.704	-0.104	-0.196	0.271
South Africa	-1.488	-0.400	-0.476	0.203
Spain	0.868	-0.128	-0.292	-0.050
Sri Lanka	0.549	-0.360	1.205	0.476
Suriname	-1.567	-0.306	-0.193	0.260
Sweden	0.091	-0.200	-0.342	0.136
Switzerland	0.732	-0.186	0.017	0.174

Taiwan, China	1.009	-0.177	-0.026	0.060
Tajikistan	0.608	-0.143	0.041	-0.159
Tanzania	0.224	-0.142	-0.066	-0.158
Thailand	0.646	-0.175	-0.127	0.000
Tonga	-1.631	-0.431	-0.010	0.077
Trinidad and Tobago	0.903	-0.158	-0.241	-0.159
Tunisia	0.647	-0.178	0.066	-0.004
Turkey	1.008	-0.039	0.427	0.498
Turks and Caicos Islands	-1.617	-0.471	-0.190	0.065
Uganda	0.695	-0.116	0.021	-1.428
Ukraine	0.893	0.070	-0.472	0.257
United Kingdom	0.805	-0.147	-0.139	-0.035
United States	0.939	0.027	2.885	3.469
Uruguay	0.878	0.007	1.427	-0.530
Vanuatu	-1.571	-0.364	-0.390	-0.054
Vietnam	0.571	-0.224	1.427	0.303
WAEMU Countries	0.268	-0.153	-0.143	0.053
West Bank and Gaza	0.581	-0.167	-0.173	-0.197
Zimbabwe	1.124	1.019	0.221	0.226

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Appendix C: Country Object Scores obtained from CATPCA of questions related to Supervision

	Supervision PCs	
Country	**PC1**	**PC2**
Albania	0.103	0.400
Angola	-0.805	0.363
Antigua and Barbuda	0.136	0.201
Argentina	0.121	0.272
Armenia	0.174	0.231
Aruba	0.748	-1.125
Australia	0.222	0.190
Austria	0.188	0.150
Azerbaijan	0.219	0.208
Bahrain	0.132	0.269
Bangladesh	-0.323	0.338
Belarus	0.682	-0.640
Belgium	0.218	0.170
Belize	0.105	0.202
Bermuda	0.193	0.154
Bhutan	1.515	-4.084
Bolivia	0.104	0.150
Bosnia and Herzegovina	0.152	0.358
Botswana	0.308	-0.161
Brazil	0.195	0.261
British Virgin Islands	0.165	0.191
Bulgaria	0.111	0.364
Burundi	0.100	0.206
Cabo Verde	-0.227	0.387
Canada	0.195	0.209
Cayman Islands	0.218	0.177
Chile	0.087	0.199
China	-4.910	2.250
Colombia	0.195	0.247
Comoros	-5.036	-3.376
Congo, Dem. Rep.	-6.116	-4.421
Cook Islands	0.108	0.127
Costa Rica	-0.391	0.484
Croatia	0.186	0.184
Curaçao	0.130	0.118
Cyprus	-0.186	0.313
Czech Republic	0.170	0.225
Denmark	-0.326	-0.945
Djibouti	-0.235	-0.044
Dominican Republic	0.139	0.265

Ecuador	-0.447	0.645
El Salvador	0.234	-0.127
Estonia	-0.370	0.512
Eswatini	-5.807	-2.500
Fiji	-0.258	0.380
Finland	0.113	0.162
France	0.206	0.204
Gambia, The	0.228	-0.128
Georgia	0.284	-0.272
Germany	0.175	0.218
Ghana	0.208	0.238
Gibraltar	0.205	-0.227
Greece	-0.360	0.638
Guatemala	0.134	0.189
Guernsey	0.732	-0.882
Guinea-Bissau	0.124	0.281
Guyana	0.222	0.172
Haiti	0.217	0.229
Honduras	0.192	0.255
Hong Kong SAR, China	1.255	-1.805
Hungary	0.214	0.179
Iceland	0.196	0.208
India	0.145	0.071
Indonesia	0.142	0.265
Ireland	-1.692	1.844
Israel	0.231	0.218
Italy	0.067	0.189
Jamaica	0.287	-0.159
Japan	1.232	-1.666
Jersey	0.724	-0.724
Jordan	0.195	0.210
Kenya	0.182	0.250
Korea, Rep.	0.130	0.268
Kosovo	0.177	0.255
Kuwait	0.190	0.165
Kyrgyz Republic	0.095	0.189
Latvia	0.164	0.217
Lebanon	0.109	0.248
Lesotho	0.191	-0.800
Liberia	-0.246	0.333
Liechtenstein	-0.744	0.867
Lithuania	0.169	0.256
Luxembourg	0.121	0.359

Macao SAR, China	0.183	0.039
Macedonia, FYR	0.238	0.123
Madagascar	0.159	0.271
Malawi	-0.306	0.404
Malaysia	0.177	0.276
Maldives	0.135	0.156
Malta	0.246	-0.363
Marshall Islands	0.321	-0.315
Mauritania	0.705	-0.639
Mauritius	0.172	0.243
Mexico	0.191	0.226
Moldova	0.182	0.238
Montenegro	0.177	0.255
Montserrat	2.995	-7.110
Morocco	0.170	0.227
Mozambique	0.215	0.173
Namibia	0.240	0.187
Nepal	0.142	0.247
Netherlands	0.219	0.228
New Zealand	-0.288	0.427
Nicaragua	0.180	0.242
Nigeria	0.197	0.243
Norway	-0.525	0.849
Oman	0.164	0.163
Pakistan	0.223	0.211
Palau	0.231	0.224
Panama	0.153	0.241
Papua New Guinea	-0.158	-0.004
Paraguay	0.206	0.252
Peru	0.081	0.193
Philippines	0.201	0.241
Poland	-0.169	0.365
Portugal	0.176	0.245
Qatar	0.211	0.236
Romania	0.263	0.151
Russian Federation	0.223	0.149
Rwanda	-0.749	0.758
Samoa	0.143	0.186
San Marino	0.096	0.171
São Tomé and Principe	0.235	0.142
Saudi Arabia	0.202	0.172
Serbia	0.178	0.252
Seychelles	0.223	0.153

Singapore	0.215	0.244
Slovak Republic	-0.054	0.650
Slovenia	-1.681	1.182
South Africa	0.218	0.226
Spain	0.398	-0.300
Sri Lanka	0.137	0.123
Suriname	0.285	-0.140
Sweden	0.163	0.270
Switzerland	0.181	0.260
Taiwan, China	0.215	0.239
Tajikistan	0.207	0.224
Tanzania	0.239	0.207
Thailand	0.131	0.180
Tonga	0.158	0.203
Trinidad and Tobago	0.207	0.189
Tunisia	0.112	0.381
Turkey	0.139	0.255
Turks and Caicos Islands	1.700	-4.088
Uganda	0.206	0.255
Ukraine	0.133	0.272
United Kingdom	-0.542	0.982
United States	0.161	0.249
Uruguay	0.210	0.207
Vanuatu	0.232	0.107
Vietnam	-0.274	-0.029
WAEMU Countries	0.124	0.281
West Bank and Gaza	0.195	0.257
Zimbabwe	-0.008	-0.506

Source: Authors' rendition of the BRSS (World Bank) CATPCA Output

Appendix D: Test of multicollinearity

	Dependent Variables	
	NIM	OC
	(1)	(2)
Deposit Protection Scheme	2.191	2.191
Asset Diversification and Non-Performing Loans	2.069	2.069
Permissible Banking Activities and Capital Ownership	1.320	1.320
Capital Adequacy and Audit Requirements	1.247	1.247
Official Supervisory Enforcement Power	2.311	2.311
Bank Disclosure and Resolution Activities	2.416	2.416
Bank Concentration	1.378	1.378
Assets to GDP ratio	1.384	1.384
GDP per capita growth rate	1.112	1.112
Political Stability	1.486	1.486
Government Ownership	1.112	1.112

Source: Authors' rendition using R-Studio

Appendix E: Breusch-Pagan Test for Heteroskedasticity

	Dependent Variables	
	NIM	OC
	(1)	(2)
Breusch-Pagan	17.859	13.502
df	11	11
p-value	0.08491	0.2618

Source: Authors' rendition using R-Studio

Appendix F: Results for the first-stage regressions of the two-stage least-squares regression model. Each endogenous variable was regressed on all five instruments with control variables included in the regressions according to Model 5.

	Reg_1	**Reg_2**	**Reg_3**	**Reg_4**	**Sup_1**	**Sup_2**
(Intercept)	0.373	-0.098	-0.316*	0.012	-0.058	0.415**
	(0.413)	(0.080)	(0.158)	(0.193)	(0.171)	(0.155)
Legal Origin	0.101	0.005	0.008	-0.008	0.046	-0.080
	(0.136)	(0.026)	(0.052)	(0.063)	(0.056)	(0.051)
Latitude	0.390***	0.041*	-0.029	0.062	-0.061	0.081*
	(0.101)	(0.020)	(0.039)	(0.047)	(0.042)	(0.038)
Women Participation in Politics	0.097	-0.006	-0.004	-0.065	-0.048	0.025
	(0.105)	(0.020)	(0.040)	(0.049)	(0.044)	(0.040)
Year of Independence	-0.128	-0.037	0.005	-0.006	-0.008	0.080*
	(0.098)	(0.019)	(0.038)	(0.046)	(0.041)	(0.037)
Religion	-0.205	-0.037	0.073	-0.004	0.014	-0.007
	(0.144)	(0.028)	(0.055)	(0.067)	(0.060)	(0.054)
Bank Concentration	-0.153	-0.035	-0.021	-0.009	0.029	-0.033
	(0.103)	(0.020)	(0.039)	(0.048)	(0.043)	(0.039)
Assets-to-GDP Ratio	-0.045	-0.040	0.011	0.068	0.024	0.005
	(0.117)	(0.023)	(0.045)	(0.054)	(0.048)	(0.044)
Political Stability	-0.083	0.001	-0.019	-0.004	-0.085	0.053
	(0.105)	(0.020)	(0.040)	(0.049)	(0.043)	(0.039)
Government Ownership	0.362	0.003	-0.051	-0.051	0.212	-0.353*
	(0.440)	(0.085)	(0.168)	(0.205)	(0.182)	(0.165)
GDP capita growth	0.012	-0.003	0.013	-0.011	0.029	-0.021
	(0.093)	(0.018)	(0.036)	(0.043)	(0.038)	(0.035)
R^2	0.307	0.148	0.045	0.085	0.104	0.159
Adj. R^2	0.228	0.050	-0.065	-0.020	0.001	0.062
Num. obs.	98	98	98	98	98	98
F-statistic	3.861	1.514	0.4061	0.8078	1.013	1.642

Source: Authors' rendition using R-Studio