ERASMUS UNIVERSITY ROTTERDAM
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Bachelor Thesis Financial Economics

Governments, their credit, and its consequences:

Sovereign credit risk and its effects on commercial bank risk and returns

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Abstract

The following study aims to investigate the effects sovereign credit risk has upon the financial health of their domestic commercial banks. Analysing a sample of 37 OECD countries over the period 1999-2021, this investigation provides a more current alongside a comprehensive look at multiple financial factors of banks and how they are effects by the creditworthiness of the sovereigns which they are situated within. Using time-fixed effects OLS models, the results highlight the creditworthiness of the sovereign to play a significant role in the ability of banks to generate returns alongside control for their risk.

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Introduction

The role financial intermediaries play in the smooth running of today's modern and complicated financial sectors cannot be understated. There are several reasons for the collapse of the global financial system in 2008, yet most can be traced back to the financial risks taken by established financial institutions in the US related to sub-prime mortgages, eventually initiating an international financial and debt crisis and a near worldwide recession. This, and several other such examples leave no doubt about the effect financial intermediaries and institutions can have upon even the largest of global economies.

However, financial intermediaries are also slaves to the sovereigns they are situated within, for reasons of policy, regulation, and freedom of credit. In the same way banks affect the economies of the sovereigns they are situated in, the macroeconomic situation of those sovereigns can also affect commercial banks and their ability to lend and borrow money.
Furthermore, sovereign risk concerns may surge, as government debt levels may increase following the aftermath of the coronavirus, alongside rising healthcare and welfare costs leading to higher fiscal deficits being run by governments of advanced economies. This can be seen as the average debt-to-gdp ratio in the OECD countries has increased from 52% in 2007 to 94.7% in 2020, an increase of 42.7%.

This increase of sovereign credit risk since 2009 has also been at a similar time period following an increase in the bank funding costs especially within the euro area, with the dimensions of the impact being roughly similar to the decline in the credit ratings – and therefore the creditworthiness – of their home sovereigns. This post-crises period highlighted several flaws within the international financial system, and exposed their vulnerabilities towards credit risk, and led to an increase in the average non-performing loans(NPLs) of banks across the international financial system. An indicator of an increase in credit risk is an increase in non-performing loans, and this can be logically derived from the fact that a non-performing loan represents a loan with past due interest payments of over 90 days (ECB, 2015). Therefore it can be implied that a bank with an increase in non-performing loans has likely also undergone an increase in its risk taking activities to justify the increase in NPL's. Furthermore, the

period following the crisis also highlighted that the most serious risks posed towards commercial banks was that of liquidity risk and credit risk (Anastasiou, Louri, and Tsionas, 2019), primarily down to the excessive lending to subprime lenders creating extraordinary levels of credit risk; as the realisation of those loans defaulting led to several liquidity risks faced by banks in the USA, rippling towards banks throughout the world.

These increases in the perceived riskiness of sovereign credit risk may be therefore affecting their home banks negatively, and through various mechanisms. One of the most substantial channels that this may occur is through a reduction in the value of collateral which commercial banks can use to raise funding. This is the case as sovereign credit worsening generally leads to lower ratings for the relevant domestic banks, which therefore can lead to an increase in the costs of funding for those banks, and can therefore weaken their ability to access the market. Furthermore, a weaker sovereign may also be unable to provide any level of implicit or explicit guarantees which may further weaken the funding abilities of banks. This can also be seen as from 2008, the value of guarantees has declined for several OECD countries, correlated with a decline in their bank funding conditions. (Denk, 2015)

Furthermore, it is likely that a fall in sovereign credit may also lead to banks of neighboring/interconnected sovereigns also suffering a worsening of funding conditions as a result, in cases of direct or indirect cross-country bank exposures.
These dependencies of banks upon the creditworthiness of their sovereigns highlighted this, as the ability to secure funding for banks situated in Europe was significantly curtailed (Stanga, 2011). Therefore, it is important to analyze the macroeconomic factors which affect the decision making of banks within different countries. Therefore, one question which is highly relevant in modern financial contexts is “To what extent do sovereign credit risks affect risk taking in commercial banks?”

Theoretical Framework

Literature review

Following the 2008 recession, sovereign credit ratings significantly decreased in almost all sovereigns in the world, with their effects being especially evident within the developed western and euro area countries. The effects of this drop in sovereign credit ratings upon their respective domestic banks has been documented by CGFS (2011). In their paper, the authors find the deterioration in sovereign credit risks to adversely affect bank funding conditions, and suggests that a full insulation of bank risk from sovereign risk is likely never going to be a sustained feature of the financial landscape.

Furthermore, Stanga (2011) highlighted the effects government measures have upon bank risk shocks and sovereign credit risk. In particular, it emphasized how, during periods of financial crises, government measures to create bank rescue packages and bailouts led to a temporary decrease in the risk level of the respective banks. However, it was also seen that the same measures led to an increase in the sovereign default risk of the economy.

Following this, a study by Juntilla and Nguyen(2022) discussed the implications of the impact sovereign credit ratings have upon bank profitability within the euro area. Their primary findings are similar to the literature discussed above, i.e. that an increase in sovereign credit risk negatively affects bank profitability. However the study also highlights how widening sovereign risk premiums, in particular those based on government bond yields, would force the ECB into keeping extremely low interest rates, alongside being compelled to actively intervene in government bond markets, and may therefore lead to a change in the banking landscape over longer terms than simply when a credit crisis is going on, and identifies the low interest rates seen in the euro area over the last decade as detrimental to banks in the long term.

The paper by Das, Oliver and Tsuda (2012) also discusses the implications of heightened sovereign credit risks, and highlights how worsened sovereign credit ratings may lead to primary dealers being limited in their ability to stockpile sovereign

debt securities, which may directly lead to financial institutions being forced to reassess dealing with volatile sovereign debt assets, which may therefore result in government bond auctions having large yield concessions and poor bid distributions. This therefore also creates a potential for a negative cycle, as this can further lead to worsening sovereign lines of credit.

It is important to identify that most of the notable literature analyses the time period immediately following the 2008 global financial crisis, and therefore does not take into account the post-crisis period, nor the implications of Covid-19 and its ensuing lockdowns had upon sovereign credit risks. This suggests a lack in contemporary literature for the time period following the financial crisis, especially the implications upon banks and their funding conditions when sovereign credit ratings started rising again in the euro areas after economies began recovering from the crisis.

Empirical Review

The pre-existing literature with regards to sovereign credit risk affecting commercial banks has been extensively scrutinized over the past few decades. Breckenfelder (2018) highlights how this risk gets spilled over in primarily two channels:- a fiscal and a financial channel, and that the companies most affected are those with close business ties to their governments or a larger public sector ownership. Furthermore, Panetta and Davies (2011) also highlights how downgrades in a sovereign's risk perception lead to a reduction in the collateral commercial banks can use to secure wholesale and central bank financing, as in repo markets sovereign debt accounts for a large share of total collateral, and therefore an increase in the sovereign's risk perception leads to negative effects for the ability of commercial banks to gain funding. The impact of sovereign credit risk rippling down upon the banking sector are highlighted in the findings published by Valenzuela et al (2019), which primarily states the significance of a strong banking sector to insulate commercial banks from being exposed to sovereign risks, and finds a positive correlation between financial fragility and sovereign credit spreads.

In the majority of studies tackling the issue of sovereign credit risk, the understanding that the stability of the national economy as a whole plays a major factor in understanding the extent of the spillover effects of a sovereign debt crisis upon the

banking sector has been widely seen; and therefore a study failing to include macroeconomic variables separate from a country's sovereign credit risk may provide less reliable results. These correlations between other key macroeconomic variables and the risks faced by the banking sector are highlighted by Foglia (2022), which finds evidence of a strong positive correlation between public debt and the level of NPL's faced by banks, alongside a positive relationship between unemployment and the NPL levels.

Hypothesis development

Over the past 20 years, especially during the post-2008 period of financial crisis, significant flaws in commercial banks worldwide were exposed, especially that of risky loans. Intuitively, an increase in NPLs and hence an increase in loan defaults faced by commercial banks would be indicative of higher credit risks faced by those commercial banks, alongside an increase in debt (and therefore leverage) for those commercial banks. Therefore, the impact a sovereign's credit risk can have upon the credit risks faced by a commercial bank can be proxied via the usage of NPL's as an indicator for commercial bank risk. As mentioned by Panetta and Davies (2011), the degradation of a sovereign's creditworthiness leads to reduced collateral banks can use to secure financing, and therefore lower the ability of commercial banks to gain funding. One consequence of that could therefore be an increasing amount of risk banks have to undertake to retain a similar amount of funding, and therefore an increase in their NPL's. Alongside this, a weakening of the funding climate for banks might therefore also increase the amount of leverage they are exposed to, as suggested by Xu et al. (2021)

However, as Scott (2009) highlights, periods of financial crises have often led to instances of government-sponsored bank bailouts, leading to the creation of moral hazards in the banking sector. As elaborated on by Schizor et al. (2018), this is due to banks accepting riskier investments due to expectations of government bailouts in cases of the investments failing, and therefore stronger implicit government guarantees may lead to increases in bank risks.

Therefore, we can develop our hypothesis as followed:-

H1a: Sovereign credit risks are positively correlated with commercial bank credit risks
H1b: Sovereign credit risks are negatively correlated with commercial bank credit risks.

H2a: Sovereign credit risks are positively correlated with the leverage of the banking sector
H2b: Sovereign credit risks are negatively correlated with the leverage of the banking sector

Even though a higher rate of nonperforming loans might imply a higher rate of credit risk, there is a likelihood of a structural shift for commercial banks towards accepting greater risks in pursuit of higher returns. As most commercial banks tend to pursue their financial return as their bottom line, one must test for the correlation between sovereign credit risks and commercial bank profitability metrics. However, similar to the aforementioned 'moral hazard' hypothesis, and as suggested in the paper by Marques et al. (2012), the possibility expected bank bailouts alongside an increase in volatility during periods of financial crises may lead to an increase in bank risk taking cannot be ruled out. This may lead to expected profits yielded by banks in these higher volatility periods, with banks accepting the tradeoff towards greater solvency risk with the knowledge of implicit government guarantees. This may possibly lead to the creation of increased short-term profits by banks in periods of financial turmoil over a one-year period, at the expense of greater solvency risks.
Therefore, our hypothesis can be formulated as:-

H3a: Sovereign credit risks are negatively correlated with commercial bank returns on equity.
H3b: Sovereign credit risks are positively correlated with commercial bank returns on equity.

H4a: Sovereign credit risks are negatively correlated with commercial bank returns on assets.
H4b: Sovereign credit risks are positively correlated with commercial bank returns on assets.

Over time, as the economic and financial climate changes, alongside differences in regulation, the risk-reward portfolios of banks also keeps changing. The largest shift in economic and regulatory climate seen within the scope of this analysis has been during the 2008 financial crisis. This is as the effects of the crisis led to significant changes in both the global macroeconomic climate alongside leading to large changes in financial regulation throughout the world, as highlighted by Tropeano (2018). Therefore, this poses a question towards whether these changes also have led to significant changes towards banks and their ability to generate profits, alongside their risk profiles. This would be as one of the major causes of the financial crisis was that of extremely risky sub-par loans posited by banks preceding the crisis in search for higher returns creating huge financial exposures faced by banks (Krivogorsky, 2019) and therefore several regulations succeeding these events were put in place specifically in order to reduce the level of nonperforming loans endured by commercial banks. Within the scope of this study, this also poses questions towards whether there has been a significant change between the relationship sovereign creditworthiness has with bank risk and returns. Therefore, our hypothesis can be formulated as:-

H5a: There is a significant change in the effect sovereign creditworthiness has on commercial bank return on assets following the 2008 financial crisis.

H5b: There are no significant changes in the effect sovereign creditworthiness has on commercial bank return on assets following the 2008 financial crisis.

H6a: There is a significant change in the effect sovereign creditworthiness has on commercial nonperforming loans following the 2008 financial crisis.

H6b: There are no significant changes in the effect sovereign creditworthiness has on commercial bank nonperforming loans following the 2008 financial crisis.

Data

The sample includes yearly data from 37 of the 38 countries in the OECD from 1999 till 2021 as part of the overall analysis. The reason why these OECD countries were selected was due to the extensive availability of data within several of these countries, and the fact that OECD countries are spread throughout the world across multiple different continents rather than being concentrated simply within North America or Europe. Furthermore, a significant number of countries included within the OECD, and therefore this dataset, contain developed banking sectors, and therefore an analysis of commercial banks upon these countries also intuitively leads to more relevant conclusions being derived from this study. As the OECD countries combine to amount to roughly 62% of global GDP, it signifies the economic strength of these countries upon the global economy, and therefore the importance of their respective sovereign's economic influence. Therefore, these countries are worth examining due to their major influence on the global economy.

The reason why such a long time period has been taken is to ensure a large enough sample size of data to retain significance of conclusions, as the data selected is yearly and not quarterly or monthly. Furthermore, the time period from 1999 to 2021 2021 has been chosen to also account for the effects before, leading up to, and following the 2008 financial crisis, alongside including the economic effects of the Covid-19 pandemic upon the OECD countries. This therefore provides a comprehensive overview to understand the correlations between sovereign credit risk and bank fundamentals over a long run period inclusive of 'black swan' macroeconomic events.

This study consists of two types of data with respect to the dependent variables:- Bank profitability indicators and bank risk indicators. As indicated by Grier (2007), common indicators for analyzing bank credit risks are profitability indicators. In this scenario, the two primary indicators used to analyze bank profitability are its Return on Equity(ROE) and Return on Assets(ROA). ROE is an indicator which highlights the ability of a bank to generate profits based on the amount of equity capital that stockholders have invested in a bank. It is calculated using commercial banks' pre-tax income to yearly averaged equity. This is done by first aggregating both the numerator

and the denominator on a country level before division. This data was sampled by gathering unconsolidated banking metrics from Bankscope and Moody's.

ROA is an indicator which highlights the ability of a bank to generate profits based on the amount of assets the bank holds. This indicator is regarded as the most important indicator, which provides 'high-quality' information about a bank's performance (IMF, 2002). It is calculated using commercial banks' pre-tax income to yearly averaged total equity. This is done by first aggregating both the numerator and the denominator on a country level before division. This data was sampled by gathering unconsolidated banking metrics from Bankscope and Moody's.

Both ROE and ROA have been widely used in several studies requiring bank profitability metrics, such as those by Kayode et al. (1992), Louzis et al. (2012) and Ghosh (2015). Therefore, these variables are used as profitability metrics to understand the impact credit shocks upon their sovereigns may have on bank profitability. As different sovereigns would have different financial climates, banking sector coverages and banking regulations, it would naturally lead to different levels of financial leverage faced by banks in different sovereigns. Therefore, a stark difference in ROE and ROA would also indicate higher levels of financial leverage in banks, on average.

Therefore, to understand how sovereign creditworthiness and the general macroeconomic climate impact the credit risks faced by banks, this study will also consist of two variables to serve as indicators for bank risk. The two primary indicators used will be the Nonperforming loans ratio (NPLR) and the leverage of the banking sector. The NPLR is derived from calculating the ratio Nonperforming loans to the total value of a bank's loan portfolio. The data used to calculate the NPLR for all the OECD countries was derived from the metrics provided by the World Bank library. International guidelines recommend that loans be classified as nonperforming when payments of principal and interest are 90 days or more past due or when future payments are not expected to be received in full (World Bank, 2022). Furthermore, an NPL can be defined as a loan in which the payments are overdue by less than 90 days but they are not expected to be paid, or more than 90 days' of interest has been capitalized, refinanced, or delayed after negotiations have taken place (IMF, 2009). Due to this, the NPLR can be used to understand a bank's credit risk, as the ratio realises loans that have either defaulted or are close to default relative to their total

outstanding loans. Therefore, it can be intuitively understood by analysing this derivation that the NPLR can serve as an indicator of bank health and its underlying credit risks, as it identifies problems regarding the asset quality within a bank's loan portfolio. Therefore, in this study, NPLR will be used as a proxy for credit risks faced by a bank.

The other metric used as a proxy for credit risk is the banking sector leverage (LOBS). This is calculated as the ratio between the total financial assets of the banking sector and their total equity, also known as the equity multiplier ratio. The data used to calculate these equity multiplier ratios for all the OECD countries was derived from the OECD database. The rationale behind the utilization of this variable is that banks will engage in this kind of leverage, with the aim of increasing their return on equity. But a higher equity multiplier indicates a higher financial leverage, which is a potential source of financial fragility as it may increase a financial institution's exposure to risk and cyclical downturns and may mean that the sector is relying more on debt to finance its assets (OECD, 2014). A higher equity ratio does not directly implicate failure of a bank in times of crises; however it does imply greater financial fragility and risk exposure faced by banks on average, and therefore implies higher solvency risks for banks when faced with a negative financial scenario. Therefore, this metric will also be used as a proxy for credit risks faced by banks.

The primary independent variable used in this paper are the individual sovereign credit ratings of all 37 OECD countries from 1999-2021. These ratings were sourced from the Standard and Poor's (S&P) rating agency, and are letter grades providing as indicators of a sovereign's creditworthiness with respect to their ability to raise debt. These letter grades were split into ordinal categorical variables ranging from 1-24; with 1 being the lowest credit rating provided and 24 being the highest. The table below highlights the calculation of the data transformation:-

Table 0

Data transformation of Standard and Poor's Sovereign credit ratings into categorical variables

Description	Sovereign Credit Rating	Associated Credit Value
Prime	AAA	24
High Medium Grade	AA+	23
	AA	22
	AA-	21
Upper Medium Grade	A+	20
	A	19
	A-	18
Lower Medium Grade	BBB+	17
	BBB	16
	BBB-	15
Speculative	BB+	14
	BB	13
	BB-	12
Highly Speculative	B+	11
	B	10
	B-	9
Substantial Risk	CCC+	8
	CCC	7
	CCC-	6
Extremely Speculative	CC	5
	C	4
In Default	RD	3
	SD	2
	D.NR	1

The table above highlights the values associated with different credit ratings, with sovereigns with ratings ranging from AAA to BBB- (24 to 15) classified as investment grade, with ratings ranging at BB+ and below (14 to 1) classified as speculative grade investments.

This variable will be used as the primary indicator of sovereign credit risk, as it directly highlights the creditworthiness of the sovereign, and its ability to externally raise funds. Alongside the usage of sovereign credit ratings, there are 3 other macroeconomic exogenous variables used in the following research, to act as additional proxies for the economic health of the sovereign.

The macroeconomic variables most often used in the aforementioned literature are that of the Gross domestic product (GDP) growth rate and the Consumer Price Index (CPI). The GDP growth rate is primarily used to capture the effects posed by the

business cycle alongside other severe macroeconomic shocks such as that of Covid-19. This is a significant indicator of a country's economic cycle, as an increase in GDP would imply an increase in income, and therefore an increase in spending alongside an increase in a borrower's ability to pay off loans, alongside an expansion in financial corporations ability to raise and invest funds, as suggested by several pieces of literature such as Fiordelisi et al. (2011), Naceur and Kandil (2009) and Khan et al. (2017). Hence, there is an expectation that GDP growth rate is positively affiliated with a bank's profitability and creditworthiness. The data regarding GDP growth rate was derived from the OECD database.

Alongside this, the Consumer Price Index (CPI), or the inflation rate, is used as another exogenous control variable. As highlighted by Revell (1979), there may be a significant influence inflation may have upon a bank's performance, primarily reliant upon whether operating expenses and wages increase at a pace faster than the inflation rate. Furthermore, inflation may also directly impact banks nominal revenue generation, as the expectation of higher or lower inflation may lead to a subsequent adjustment in interest rates offered by commercial banks. The data regarding CPI was derived from the OECD database.

The final exogenous independent variable used for the purposes of this paper is that of a sovereign's Debt-to-GDP ratio. This variable is calculated by dividing the total debt of a sovereign by its annual GDP. This variable is used as another indirect indicator of a sovereign's credit risk, as a higher Debt-to-GDP ratio implies a higher level of financial leverage faced by a sovereign. However this is not a perfect indicator of credit risk, as each sovereign may have different national budget/GDP ratios, alongside different debt structures and future growth prospects. Therefore this variable will be used as an exogenous control variable for sovereign credit risk rather than as a primary indicator of risk. The data regarding Debt-to-GDP ratios was derived from the OECD database.

Methodology

Table 1

Definition of the variables employed in the study

	Measurement	Description
Independent variables		
Sovereign Credit Rating	Credit Rating provided by S&P	CRE
Debt-to-GDP ratio	Total Sovereign debt/Annual GDP	DGR
GDP growth rate	% increase in GDP from previous year	GDP
Inflation	Annual % change in consumer price index	CPI
Unemployment rate	% of total labour force unemployed	UNR
Dependent variables		
Return on Assets	Net Income/Total Assets	ROA
Return on Equity	Net Income/Total Equity Capital	ROE
Non-performing loans ratio	Non-performing loans/Total loans	NPLR
Leverage of the banking sector	Total Assets/Total Equity of the banking sector	LOBS

Table 1 above presents the variables this research uses. The calculation of the ratios is done by collecting individual data for all 37 countries with respect to average return on assets and equity of banks, alongside the nonperforming loans ratio and the leverage ratios of the banking sector. Alongside this, data was compiled for all the individual countries during the past 23 years to obtain 37 separate time-series datasets with respect to the respective Sovereign credit ratings, GDP measurements, Inflation and unemployment rates, and total government debt. These values were then transformed to obtain the variables highlighted above.

To construct this database, several data sources were used, including Thomson Reuters Eikon, World Bank, Bank Scope, Moody's, World Bank data, and OECD data. This therefore comes with minor limitations regarding some datasets, as not every variable was available for data collection for all the sovereigns over the entire observed duration of the study. In order to ensure that the data was consistent, there were

several comparisons of data, primarily between the data gathered by World Bank and OECD, and the data obtained from Bank Scope, Moody's. and Thomas Reuters Eikon. This was done in order to ensure the legitimacy of the dataset.

Empirical model construction

A significant majority of the aforementioned literature reviewed highlight that the linear functional form is the optimal function to apply for the subject of this analysis. Therefore, this study also employs a linear functional methodology and hence uses the ordinary least squares (OLS) method. Due to there being multiple sovereigns over a significant time span in the analysis, this study uses a panel data analysis.

In order to ensure that the model is appropriately constructed, there are several diagnostic tests which will be conducted before testing for any regressions. These tests will be based upon the five key assumptions required for the running of a successful OLS regression, following which if the tests are successful, will allow the creation of a model which can provide us with definitive and reliable conclusions.
The five assumptions include zero mean errors, homoskedasticity, independence between the explanatory variables and the error, autocorrelation, and the normality assumption. As the sample size of this database is large, the normality assumption is not required to hold. In this scenario, the first 4 assumptions are required to be fulfilled for the OLS estimator to be considered the best linear unbiased estimator; and for the estimators to be considered unbiased, consistent and efficient. (Brooks, 2019). In order to ensure that this model does not have explanatory variables correlated with one another, a multicollinearity test will also be conducted.

As the independent variables are sovereign-specific and macroeconomic variables, with the dependent variables being bank specific variables, there is an inherent unlikeliness of significant reverse causality being caused between these variables, and therefore all the explanatory variables will be contemporaneous in nature, rather than adding lagged effects in the regression models. There will, however be time fixed effects included as part of the regression equation. Therefore, the format the model will be set up in the regressions is as follows:-

1. $ROA_{it} = \alpha + \beta_1 CRE_{it} + \beta_2 DGR_{it} + \beta_3 GDP_{it} + \beta_4 CPI_{it} + \beta_5 UNR_{it} + \delta_2 Y_{2000} + \delta_3 Y_{2001} + \cdots + \delta_{23} Y_{2021} + \mu_{it}$
2. $ROE_{it} = \alpha + \beta_1 CRE_{it} + \beta_2 DGR_{it} + \beta_3 GDP_{it} + \beta_4 CPI_{it} + \beta_5 UNR_{it} + \delta_2 Y_{2000} + \delta_3 Y_{2001} + \cdots + \delta_{23} Y_{2021} + \mu_{it}$
3. $NPLR_{it} = \alpha + \beta_1 CRE_{it} + \beta_2 DGR_{it} + \beta_3 GDP_{it} + \beta_4 CPI_{it} + \beta_5 UNR_{it} + \delta_2 Y_{2000} + \delta_3 Y_{2001} + \cdots + \delta_{23} Y_{2021} + \mu_{it}$
4. $LOBS_{it} = \alpha + \beta_1 CRE_{it} + \beta_2 DGR_{it} + \beta_3 GDP_{it} + \beta_4 CPI_{it} + \beta_5 UNR_{it} + \delta_2 Y_{2000} + \delta_3 Y_{2001} + \cdots + \delta_{23} Y_{2021} + \mu_{it}$

Where i = country, such that i = 1,2,3…37; t = time period, such that t = 1999,2000,2001….2021. α is the constant term; while β is the coefficient estimate which highlights the degree of change the independent variable contributes to the dependent variable. For the fixed effects, Y is the Year with respect to the time fixed effects in use, while δ indicates the coefficient estimate for the fixed effects.

Several studies in the past such suggest that the optimal method of dealing with panel data is to estimate a pooled regression; via pooling all the data together in towards a singular model and regressing this on a single dependent variable (Brooks, 2019). One significant roadblock to this, however, is that such a regression model relies on the assumption of no heterogeneity between the data throughout the entirety of the sample. As this sample set contains several countries over a timespan lasting decades, this assumption is untenable as there is likely to be some heterogeneity between the samples. Therefore, a fixed effects or a random effects model would likely provide a more efficient estimate of the model.

In order to understand which model is better to use, a Hausman test will be used on equations 1, 2, 3 and 4.

Empirical Results

Descriptive statistics model

The descriptive statistics of the model is presented in Table 2. As highlighted in the table, from 1999 to 2021, on average, the total assets of commercial banks were able to generate a 0.76% return annually, while the total equity of commercial banks were able to generate annual returns of 9.83%. However, the minimum and maximum value of -116.93% and 43.56% indicate a large difference between different bank's ability to generate returns over different countries.

The average Nonperforming loan ratio of 4.14% over 1999-2018 does not paint the full picture regarding this metric, as its high standard deviation highlights. Furthermore, we can see how there are large differences between the credit risks banks face in different countries, as seen by the lowest average being 0.08% with the highest being 45.57%. Similarly, we can see large differences in the average banking sector leverage throughout countries, as the average value of 20.51 is lower than its own standard deviation being presented at 37.06, with the maximum of this metric being 611.49. On average the unemployment rate remained more stable across countries, averaging to 7.66%, while the CPI's higher standard deviation from its mean of 2.78% indicated larger differences in inflation among different countries relative to differences in unemployment. Furthermore, due to the diverse sample of countries in the dataset, there were significant differences in GDP growth rates among the countries from 1999-2021, averaging at 2.4%. The average Debt-to-GDP ratio sits at 73%, however a clear increase in this ratio could be seen following the 2008 financial crisis and the following eurozone debt crisis, predominantly in the GIIPS countries, being Greece, Italy, Ireland, Portugal and Spain. Finally, the average credit ratings of countries sits at 20.4, or roughly in between A+ and AA- on S&P's ratings scale. Several countries such as Germany, Switzerland and Luxembourg remained at the maximum credit rating throughout the time period of this sample, whereas less economically stable countries such as Greece and Turkey suffered significant downgrades to their credit ratings during the timespan of this data, especially following the 2008 recession.

Table 2

Summary statistics of the regression variables. The variables concern the macroeconomic and commercial bank data of 37 OECD countries during 1999-2021. All observations excluding CRE and LOBS are presented in percentage format.

Variable	Mean	St. Deviation	Min	Max
ROA	0.76404494	1.687046934	-19.3	12.92
ROE	9.83029536	14.81137756	-116.93	43.56
NPLR	4.13901958	5.664000552	0.0818078	45.5723196
LOBS	20.5123193	37.06148491	2.876225	611.4924
UNR	7.659	3.99067577	1.900	27.825
CPI	2.78453915	4.398484232	-4.478103	64.86748
GDP	2.4	3.451168946	-14.8	24.4
DGR	73.0102968	42.95557573	6.65372	257.7505
CRE	20.4077556	3.682631542	5	24

The correlation matrix of the utilized variables is highlighted in Appendix 1. A high correlation between variables is not found, alongside a VIF value of 1.52 indicates that multicollinearity is not a significant issue in this model.

Alongside the multicollinearity tests, other tests for the OLS assumptions of heteroskedasticity and normality were also conducted (See appendices 2 and 3). Those tests concluded problems of heteroskedasticity in the data, which we solve by employing robust standard errors on a country level. Furthermore, the normality tests highlight that the residuals are not normally distributed. However, due to the size of the sample data used in this analysis, normally distributed residuals are not required for the purpose of this analysis. Therefore, this does not pose as a violation to the developed model. Furthermore, the Hausman test shows the time-dependent fixed effects model to be the most appropriate model for regressing ROE, ROA and NPLR, while suggesting the random effects model as the most appropriate for regressing LOBS.

Table 3
Fixed effects regression results for Return on Equity (ROE) as the dependent variable. The regression includes yearly fixed effects.

Return on Equity (%)

Variable	Coefficient	Std. Err.	P>t
cpi	1.351655	.3259041	0.000
unr	-.6889496	.2512065	0.006
gdp	1.352905	.2160387	0.000
cre	2.434048	.4606570	0.000
dgr	.1051182	.0434483	0.016
Year			
2001	-.4155078	3.077661	0.893
2002	.1266455	3.109459	0.968
2003	1.475017	3.100098	0.634
2004	4.709144	3.104939	0.130
2005	4.926873	3.060735	0.108
2006	6.137080	3.017696	0.042
2007	2.892850	3.003491	0.336
2008	-9.045138	3.159533	0.004
2009	-1.125507	3.742326	0.764
2010	-4.904122	3.114041	0.116
2011	-4.660565	3.034464	0.125
2012	-3.115604	3.186496	0.329
2013	-2.291435	3.233418	0.479
2014	-1.739256	3.305770	0.599
2015	-1.667164	3.339871	0.618
2016	-2.416062	3.355626	0.472
2017	-7.271552	3.245159	0.025
2018	-3.540937	3.257391	0.277
2019	-3.692242	3.319710	0.266
2020	2.374939	4.131898	0.566

Regression Statistics

Constant	-48.1359
Number of observations	666
Number of groups	37
R^2	0.1852
F-Statistic	0.0000
corr(u_i, Xb)	-0.5296

Table 4
Fixed effects regression results for Return on Assets (ROA) as the dependent variable. The regression includes yearly fixed effects.

Return on Assets (%)

Variable	Coefficient	Std. Err.	P>t
cpi	-.0369315	.0406502	0.364
unr	-.0090181	.0320169	0.778
gdp	.1583017	.0275196	0.000
cre	.3057289	.0585115	0.000
dgr	.0056490	.0055258	0.307
Year			
2001	.1090952	.3924306	0.781
2002	.1025833	.396374	0.796
2003	.2198078	.3951045	0.578
2004	.3092359	.3957459	0.435
2005	.1991123	.3900714	0.610
2006	.2478798	.3846210	0.520
2007	.1152193	.3828579	0.764
2008	-.1074793	.4026859	0.790
2009	-.3438726	.4735338	0.468
2010	-.4253998	.3969835	0.284
2011	-.0864075	.3868429	0.823
2012	.4251042	.4062063	0.296
2013	-.0441862	.4121268	0.915
2014	-.1869663	.4209467	0.657
2015	-.7806901	.4251773	0.067
2016	-.0398475	.4294111	0.926
2017	-.2581632	.4158125	0.535
2018	.0745442	.4134790	0.857
2019	.1612440	.4217396	0.702
2020	.7077321	.5259545	0.179

Regression Statistics

Constant	-6.2389
Number of observations	667
Number of groups	37
R^2	0.0589
F-Statistic	0.0000
corr(u_i, Xb)	-0.6701

Table 3 and 4 highlight the empirical results for our bank profitability indicators ROE and ROA respectively.

The regression model in Table 3 produces a positive and significant impact the sovereign credit ratings have upon a bank's return on equity within that sovereign. Therefore, this implies that a bank's ROE is directly tied to the credit risk its sovereign faces, and a creditworthy sovereign therefore implies a higher level of return on equity for the banks within that sovereign. This result was expected, as the several aforementioned literature pieces also indicated a correlation between the creditworthiness of the sovereign and the ability of its banks to generate significant profits. As sovereign creditworthiness gets weaker, their ability to raise funds weakens in the process, which therefore also reduces the ability of collateral commercial banks can use to be able to raise funds themselves, and may therefore create less than optimal scenarios for commercial banks to navigate, therefore reducing their profitability metrics. This can also be seen in table 4, where sovereign credit ratings have a positive and significant impact upon commercial bank return on assets (ROA). These results were consistent with the results posited by Panetta (2011). The time fixed effects also capture several large shocks on bank profitability posed by external macroeconomic events, especially observable in 2008 in table 3 during the shock of the 2008 crisis, and 2009 and 2010 in table 4 when the global economy was still reeling from its consequences.

When looking at the macroeconomic control variables, all the variables are significant with the exception of Debt-to-GDP ratio in table 3; however in the regression analysis of ROA, the unemployment rate and inflation are also seen as insignificant coefficients. However, the implications of the results of the control variable coefficients are all as expected, with positive relationships observed between ROE towards both GDP growth rate and inflation, and a negative relationship observed between the unemployment rate and ROE.

The results obtained in tables 3 and 4 can therefore have several key economic implications. This is as an increase in a sovereign's credit rating by 1, on average, leads to a 2.43% increase in the ROE generated by its banks and a 0.31% increase in their average ROA. These results intuitively follow along similar lines as those found be Panetta (2011), in which it was realized that worsening sovereign credit lines affect their banking sector to a higher margin than other sectors, leading to an increase in

their wholesale funding costs, resulting in a decrease in their returns on equity due to a diminishing market access. Due to this, sovereigns which have a larger share of their economic development tied to the growth of their banking sector will have a greater incentive to be perceived as a reliable debtor, as a decrease in its creditworthiness and therefore a decrease in its domestic bank returns can lead to a significant decrease in its economic potential relative to those sovereigns with a lower dependence on its commercial banking sector. Therefore, sovereigns likely to have credit rating downgrades in the future as a consequence of their economic condition or fiscal policies can consider regulations designed to reduce the dependance of financial intermediaries in their economy to attempt to reduce the negative consequences of credit rating downgrades.

Alongside this, the results also indicate how high GDP growth rates within sovereigns translate to higher returns for their domestic commercial banks. This has key implications for both institutional and non-institutional investors when conducting commercial bank valuations, as the expected growth rate of a sovereign can directly impact the growth potential of banks situated within that sovereign.

Table 5
Fixed effects regression results for Nonperforming loans (NPLR) as the dependent variable. The regression includes yearly fixed effects.

Nonperforming loans ratio (%)

Variable	Coefficient	Std. Err.	P>t
cpi	-.0721934	.1053495	0.494
unr	.6579167	.0767230	0.000
gdp	.2353492	.0584165	0.000
cre	-.5096808	.1355970	0.000
dgr	.1206498	.0134716	0.000
Year			
2004	-.7181643	3.476029	0.836
2005	3.910703	2.646645	0.140
2006	3.381927	2.652991	0.203
2007	4.264236	2.651652	0.109
2008	4.382907	2.620666	0.095
2009	4.907087	2.625326	0.062
2010	2.714188	2.579973	0.293
2011	2.675842	2.579043	0.300
2012	2.313582	2.581461	0.371
2013	2.616255	2.577013	0.311
2014	2.157885	2.579468	0.403
2015	2.467642	2.578423	0.339
2016	2.615166	2.577554	0.311
2017	3.002622	2.576672	0.245
2018	2.953693	2.578505	0.253
2019	2.730342	2.581949	0.291
2020	1.143752	2.646412	0.666
2021	.4476496	2.816830	0.874

Regression Statistics

Constant	-2.71546
Number of observations	426
Number of groups	34
R^2	0.5816
F-Statistic	0.0000
corr(u_i, Xb)	-0.6823

Table 6
Random effects regression results for Leverage of the banking sector (LOBS) as the dependent variable. The regression includes yearly random effects.

Leverage of the Banking Sector

Variable	Coefficient	Std. Err.	P>z
cpi	.610465	.7968383	0.444
unr	.678121	.5849740	0.246
gdp	.5825898	.5380108	0.279
cre	-.798631	.8614384	0.354
dgr	.0053367	.0694686	0.939
Year			
2000	-.132956	8.355883	0.987
2001	2.284729	8.189413	0.780
2002	3.598727	8.165520	0.659
2003	3.372527	8.041992	0.675
2004	.7545575	8.056520	0.925
2005	19.56973	8.043474	0.015
2006	19.07617	8.076189	0.018
2007	3.331265	8.100744	0.681
2008	11.93544	8.326408	0.152
2009	10.06236	9.128404	0.270
2010	4.390724	8.009782	0.584
2011	6.428326	8.019926	0.423
2012	3.305955	8.166458	0.686
2013	1.977664	8.185951	0.809
2014	1.975250	8.184667	0.809
2015	2.301089	8.193946	0.779
2016	2.892215	8.205278	0.724
2017	1.756058	8.112839	0.829
2018	3.508053	8.157701	0.667
2019	4.122243	8.224453	0.616
2020	9.779801	9.343753	0.295
2021	3.278665	10.23431	0.749

Regression Statistics

Constant	23.3324
Number of observations	722
Number of groups	35
R^2	0.0221
F-Statistic	0.4918
corr(u_i, X)	0

Table 5 and 6 highlight the empirical results for our bank risk indicators Nonperforming loans and Banking sector leverage respectively.

As expected, table 5 highlights a negative and significant relationship between sovereign creditworthiness and the nonperforming loans within the sovereign's commercial banks. This implies that an increase in a country's creditworthiness leads to a decrease in the risk its commercial banks take in the form of risky loans, and therefore reduce the amount of nonperforming loans commercial banks have to write off. As highlighted by Stanga (2011), this can also be as a result of more credible sovereigns being able to provide implicit and explicit funding guarantees to its commercial banks, with a stable financial sector leading to commercial banks engaging in a reduction of risky lending. This reduction in nonperforming loans therefore can be seen as an overall decrease in the risks undertaken by the financial sector as bank feel less compelled to take on significant risks in their lending processes. This goes hand-in-hand with the results obtained in Table 3 and 4, as this leads to an overall increase in the returns on equity and returns on assets produced by the banking sector on average.

Furthermore, the unemployment rate, GDP growth rate, and Debt-to-gdp ratio are all share a significant positive relationship with the nonperforming loans. The results make intuitive sense with respect to the unemployment rate, as higher unemployment would suggest a worse macroeconomic climate as a whole for banks to work within, alongside fewer sources of income to provide creditworthy loans to. Similarly, the positive relationship with the Debt-to-GDP ratio suggests an increase in sovereign debt leading to an increase in credit risk faced by commercial banks, which is in line with the stipulations of existing literature. However, the positive relationship between GDP growth rate and nonperforming loans was unexpected. One possible explanation is that a high gdp growth rate suggests significant investment opportunities for commercial banks to exploit, where the total returns on equity are prioritized by banks over failure of its loans; and therefore banks may be willing to undertake the extra risk in exchange for a larger return on equity. The results in Table 3 and 4 highlight this, as GDP growth rate is significantly positively correlated with both ROE and ROA. Therefore in a booming economy, an increase in risk may be accepted by commercial banks in exchange for an increase in returns.

The results in table 6 highlight an insignificant relationship between banking sector leverage and any of the exogenous variables used in the regression model, including credit risk. Alongside this, the extremely low R^2 of the regression model suggests that there are other major factors which affect the leverage of the banking sector significantly more than the exogenous variables used in this regression.

The results obtained in table 5 implies a direct relationship between sovereign credit risk and commercial bank risk, with an increase in a sovereign's credit rating by 1 leading to an average decrease in the nonperforming loans faced by its domestic banks by 0.51%. The paper by Panetta (2011) yields similar results when looking at the relationship between sovereign Credit default swap (CDS) spreads and bank risk conditions, and posits that one likely cause of this is due to increases in sovereign financing needs lead to a 'crowding out' of commercial bank debt issuance, thereby forcing banks to obtain riskier debt securities. One major implication of this can be seen in scenarios of sovereign credit crises, where a substantial increase in sovereign credit risks can also lead to substantial increases in risks faced by its domestic banks. This therefore especially needs to be taken into account by economies which can face economic disaster due to the failure of its domestic banks. This is as sovereigns with domestic banks facing inherently higher credit risks can be brought towards solvency risks in the case of its sovereign facing further credit rating downgrades. Therefore policymakers need to keep in account the implications of its sovereign debt undertakings, and an expectation of increased sovereign credit risks in the future may have to be met with an increase in solvency regulations faced by its domestic banks to ensure that a sovereign debt crisis does not lead to a credit crisis faced by its banking sector.

Table 7
Fixed effects regression results for Return on Assets (ROA) from 1999-2008 as the dependent variable. The regression includes yearly fixed effects.

Return on Assets (%)			
Variable	Coefficient	Std. Err.	P>t
cpi	-.0469425	.0299802	0.119
unr	-.1193339	.0304054	0.000
gdp	.0081856	.0273959	0.765
dgr	-.0009491	.0071715	0.895
cre	-.0950118	.0740419	0.201
Year			
2001	-.1521774	.1697728	0.371
2002	-.1318011	.1776863	0.459
2003	.0603983	.1776323	0.734
2004	.4708933	.1723290	0.007
2005	.2785298	.1724619	0.108
2006	.3519619	.1658100	0.035
2007	.1285499	.1693904	0.449
2008	-.6446042	.2022061	0.002
2009	-.0910634	.6865921	0.895

Regression Statistics	
Constant	4.089096
Number of observations	265
Number of groups	32
R^2	0.2120
F-Statistic	0.0000
corr(u_i, Xb)	-0.1385

Table 8
Fixed effects regression results for Return on Assets (ROA) from 2009-2021 as the dependent variable. The regression includes yearly fixed effects.

Return on Assets (%)

Variable	Coefficient	Std. Err.	P>t
cpi	- .2623348	.0814191	0.001
unr	.0216525	.0601086	0.719
gdp	.1496712	.0427996	0.001
dgr	.0136806	.0112323	0.224
cre	.4825128	.1124533	0.000
Year			
2010	.0810964	.5378413	0.880
2011	.7411464	.5621284	0.188
2012	1.098897	.5343371	0.040
2013	.3770738	.5354196	0.482
2014	.1194751	.5676992	0.833
2015	-.5576332	.5851766	0.341
2016	.2680655	.5724406	0.640
2017	.3237342	.5991380	0.589
2018	.7397054	.5921118	0.212
2019	.7413045	.5744294	0.198
2020	.8832366	.5712082	0.123

Regression Statistics

Constant	-10.73171
Number of observations	402
Number of groups	37
R^2	0.0318
F-Statistic	0.0000
corr(u_i, Xb)	-0.8319

Table 7 and 8 highlight the differences in the effect sovereign creditworthiness has had on the return on assets of commercial banks preceding and following the 2008 financial crisis. Surprisingly, the results from table 7 show a negative relationship between sovereign creditworthiness and commercial bank return on assets from 1999 to 2008. However, it is important to keep in mind that the magnitude of the coefficient

for is relatively small and is also not significant. However, the results of table 8 are more in line with the results found in table 4, with a positive and significant coefficient.

Table 9
Fixed effects regression results for Nonperforming loans (NPLR) from 1999-2008 as the dependent variable. The regression includes yearly fixed effects.

Nonperforming loans ratio (%)

Variable	Coefficient	Std. Err.	P>t
cpi	-.0307161	.0815744	0.710
unr	.4305694	.0705066	0.000
gdp	-.0408684	.0495793	0.419
dgr	-.0069834	.0214849	0.748
cre	.1770529	.2118006	0.412
Year			
2004	-.7594699	.5512255	0.182
2005	-.4123088	.4551958	0.375
2006	-.4155079	.4356750	0.351
2007	-.4002778	.4645064	0.398
2008	-.0162583	.4767791	0.973
2009	.3519232	.6211227	0.577

Regression Statistics	
Constant	-3.833434
Number of observations	57
Number of groups	24
R^2	0.0268
F-Statistic	0.0000
corr(u_i, Xb)	-0.4380

Table 10
Fixed effects regression results for Nonperforming loans (NPLR) from 2009-2021 as the dependent variable. The regression includes yearly fixed effects.

Nonperforming loans ratio (%)

Variable	Coefficient	Std. Err.	P>|t|
cpi	.0287587	.1280404	0.822
unr	.6701799	.0863023	0.000
gdp	.2723918	.0634305	0.000
dgr	.1485979	.0152455	0.000
cre	-.4428850	.1618854	0.007
Year			
2010	-2.572957	.8398418	0.002
2011	-2.715179	.8814264	0.002
2012	-3.159457	.8409254	0.000
2013	-2.783609	.8189050	0.001
2014	-3.338424	.8561489	0.000
2015	-2.962938	.8689737	0.001
2016	-2.831682	.8406958	0.001
2017	-2.516399	.8961797	0.005
2018	-2.533559	.8930469	0.005
2019	-2.729982	.8676162	0.002
2020	-4.442722	.8435196	0.000
2021	-5.403747	1.513562	0.000

Regression Statistics	
Constant	-1.165701
Number of observations	369
Number of groups	34
R^2	0.5537
F-Statistic	0.0000
corr(u_i, Xb)	-0.7416

The results seen in table 9 and 10 show the differences in the effect sovereign creditworthiness has had on the nonperforming loan ratios of commercial banks preceding and following the 2008 financial crisis. The results in table 9 indicate a positive, albeit insignificant relationship between sovereign creditworthiness and commercial bank nonperforming loans between 1999 and 2008. However, the results

in table 10 are similar to those seen in table 5, with a negative and significant relationship between sovereign credit and nonperforming loans between 2009 and 2021.

Therefore, the results derived from tables 7 through 10 indicate a significant difference in the relationship sovereign creditworthiness has on commercial bank risk and returns following the 2008 financial crisis, as compared to preceding the crisis.

As hypothesized previously, significant changes in regulation alongside a large difference in the overall macroeconomic climate could be the reason as to why commercial bank performance became more closely related to sovereign creditworthiness. As several nations with extremely high credit ratings had commercial taking huge amounts of subprime loans preceding the 2008 recession Tropeano (2018), the large changes in regulation following the crisis would therefore partly explain the difference in results preceding and proceeding the 2008 financial crisis. This may have also led to commercial banks being more tied to their sovereign with regards to their ability to take risks, and therefore indirectly also their ability to generate returns. The results derived from the paper by Sironi (2018) also highlighted how regulation changes following the 2008 crisis led to significantly reduced risk taking by banks, alongside greater accountability towards their governments due to increases in regulation, and therefore a closer correlation between bank risk taking and sovereign risk taking following 2008. The results derived in the regression models above intuitively follows along similar lines.

A key implication that can be derived from the results posited by tables 7-10, is that the increased correlation between sovereign credit risks and bank risk and returns following 2008 suggests that the financial health of commercial banks are more closely tied to the creditworthiness of its sovereign. This can be seen in how an increase in a sovereign's credit rating by 1 following the 2008 crisis leads to an average increase in its domestic bank's ROA by 0.48%, while also decreasing the average nonperforming loans faced by banks by 0.44%. Therefore, policymakers may need to adjust for this shift following the 2008 crisis due to changes in both regulation and the macroeconomic state of the world. This may be in the form of more prudent fiscal policies and undertaking less government debt, as worsening sovereign credit may have larger downstream implications towards its financial sector following 2008 than the same changes in sovereign risk may see prior to the 2008 crisis.

Conclusion and Discussion

This study employs a panel dataset of 37 countries within the OECD from 1999-2021 to study the impact of sovereign credit risk on commercial bank profitability and risk conditions. This is done through approximating bank profitability by banks return on equity and return on assets, and find significant evidence that sovereigns with higher creditworthiness have, on average, banks with higher profitability. Furthermore, the nonperforming loans ratio was used as a proxy for commercial bank credit risk, in which there was also significant evidence suggesting that sovereigns with higher creditworthiness have, on average, banks with lower risks.

Following this, there was a further analysis on several macroeconomic control variables. Within that, the regression analyses provide evidence of higher GDP growth rates leading to higher profitability for commercial banks, alongside simultaneously leading to higher risks undertaken by banks, possibly in the chase of the aforementioned higher returns. Furthermore, the results provided also indicated a significant change in the relationship sovereign creditworthiness has on commercial bank risk and returns following the events of the 2008 financial crisis.

To conclude, the findings of this research can be used for further research and analysis on the spillover effects of changes in sovereign credit risk, alongside the causes of changes in commercial bank profitability and risk taking. Furthermore, one might investigate the causes which change the banking sector leverage (equity multiplier ratios) within the financial system of a sovereign, which this paper was unable to accomplish. Future research could also investigate the causes for why the relationship between sovereign credit and bank risks and returns changed following the events of the 2008 financial crisis.

Alongside this, future research could be conducted with country-sensitive fixed effects rather than time fixed effects, to account for the institutional differences which commercial banks face when operating in different sovereigns across the world, due to issues of culture, regulation, and internal financial and political climates. Furthermore, future research could also be conducted to investigate the effects sovereign credit risks may have upon the economic climate of the sovereign as a whole, rather than focusing upon the effects it has upon the financial climate of a sovereign.

The results posited by this research indicate a significant effect sovereign credit risks have upon commercial bank risk and returns. This therefore can lead to several policy implications for sovereigns due to the consequences their borrowing practices can have upon the health of their banking sector. Increases in government debt, especially without an increase in the sovereign's ability to raise funds to reliably pay off debts can create a sovereign credit crisis, which directly has the ability to harm the domestic banking sector. Therefore sovereigns with a greater reliance on their domestic commercial banks for the functioning of their overall economy may need to be more weary when issuing debt, with the knowledge that an increase in their perceived credit risk can lead to consequences far greater than having to pay higher interest rates on their debts.

Therefore, as this study does not include the dependance of a sovereign's economy on its domestic banks, future research could include variables such as financial intermediation ratios (the level of dependance on financial intermediaries on the total economy). Alongside this, future research can also analyze the reasons for a change in a sovereign's perceived credit risk, such as the difference foreign debt has compared to domestic debt upon a sovereign's creditworthiness.

This research primarily uses broad macroeconomic measures as its independent variables, and does not take into account political factors such as internal political stability indexes or the geopolitical scenarios faced by the sovereign. The factors may directly affect a sovereign's credit risk, and indirectly also affect the health of its banking sector. Therefore, future research could utilize a political lens to understand the impact which internal and external political stability might have upon a sovereign's banking sector.

Finally, future research could expand the scope of the study by taking into account non-OECD countries as well, as the OECD database excludes several large Asian and African economies such India, China, Nigeria etc. Including these nations could broaden the scope of this research to include sovereigns facing a different economic climate and credibility, alongside having different banking sector regulations, and therefore may affect the results of this research.

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Appendix

Appendix 1:- Multicollinearity test

	lobs	unr	cpi	dgr	gdp	cre
lobs	1.0000					
unr	0.0007	1.0000				
cpi	0.0727	0.0132	1.0000			
dgr	0.0116	0.1530	-0.3474	1.0000		
gdp	-0.0058	-0.0988	0.1933	-0.2887	1.0000	
cre	-0.0979	-0.5708	-0.2830	-0.1269	-0.0016	1.0000

	nplr	unr	cpi	dgr	gdp	cre
nplr	1.0000					
unr	0.6825	1.0000				
cpi	-0.1789	-0.0854	1.0000			
dgr	0.5337	0.4239	-0.3304	1.0000		
gdp	-0.1252	-0.2088	0.1327	-0.2757	1.0000	
cre	-0.6300	-0.5897	-0.2664	-0.2385	0.0751	1.0000

	roe	unr	cpi	dgr	gdp	cre
roe	1.0000					
unr	-0.3270	1.0000				
cpi	0.1935	0.0487	1.0000			
dgr	-0.2489	0.0848	-0.3427	1.0000		
gdp	0.3912	-0.0785	0.1874	-0.3183	1.0000	
cre	0.1920	-0.5328	-0.3342	-0.0780	-0.0294	1.0000

	roa	unr	cpi	dgr	gdp	cre
roa	1.0000					
unr	-0.2274	1.0000				
cpi	0.1214	0.0480	1.0000			
dgr	-0.2259	0.0850	-0.3326	1.0000		
gdp	0.3610	-0.0783	0.1650	-0.3200	1.0000	
cre	0.1015	-0.5307	-0.3398	-0.0785	-0.0227	1.0000

Variable	VIF	1/VIF
unr	1.85	0.540124
cre	1.85	0.541051
dgr	1.44	0.695371
cpi	1.36	0.736550
gdp	1.10	0.909621
Mean VIF	1.52	

Appendix 2:- Heteroskedasticity tests

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of lobs

         chi2(1)      =     3.14
         Prob > chi2  =   0.0764

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of nplr

         chi2(1)      =   756.48
         Prob > chi2  =   0.0000
```

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of roa

         chi2(1)      =   403.58
         Prob > chi2  =   0.0000

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of roe

         chi2(1)      =   347.64
         Prob > chi2  =   0.0000
```

Appendix 3:- Normality tests

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
lobs	723	0.28733	334.663	14.202	0.00000
unr	822	0.86077	73.467	10.555	0.00000
cre	851	0.95302	25.583	7.975	0.00000
dgr	763	0.91303	42.884	9.203	0.00000
cpi	851	0.43970	305.113	14.073	0.00000
gdp	850	0.91870	44.225	9.321	0.00000

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
nplr	460	0.56679	135.193	11.751	0.00000
unr	822	0.86077	73.467	10.555	0.00000
cre	851	0.95302	25.583	7.975	0.00000
dgr	763	0.91303	42.884	9.203	0.00000
cpi	851	0.43970	305.113	14.073	0.00000
gdp	850	0.91870	44.225	9.321	0.00000

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
roa	712	0.58583	191.802	12.834	0.00000
unr	822	0.86077	73.467	10.555	0.00000
cre	851	0.95302	25.583	7.975	0.00000
dgr	763	0.91303	42.884	9.203	0.00000
cpi	851	0.43970	305.113	14.073	0.00000
gdp	850	0.91870	44.225	9.321	0.00000

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
roe	711	0.70774	135.173	11.978	0.00000
unr	822	0.86077	73.467	10.555	0.00000
cre	851	0.95302	25.583	7.975	0.00000
dgr	763	0.91303	42.884	9.203	0.00000
cpi	851	0.43970	305.113	14.073	0.00000
gdp	850	0.91870	44.225	9.321	0.00000

Appendix 4:- Hausman tests

	ROE	ROA	NPLR	LOBS
chi2	25.28	39.74	53.55	6.49
Prob>chi2	0.0001	0	0	0.2618