Research Paper

Does Corruption Moderate the Relationship between Climate Adaptation and Credit Quality? Evidence from Iraqi Banks

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Abstract

In volatile institutional environments, climate adaptation efforts may not translate directly into improved financial outcomes unless mediated by governance quality. Iraq presents a compelling case where chronic corruption intersects with acute climate vulnerability, creating systemic risks for the banking sector. The case of Iraq provides an interesting avenue for exploring the degree to which corruption undermines state-led climate resilience efforts and affects the financial sector's vulnerabilities. This paper examines the association between climate adaptation capacity and credit quality in the banking sector in Iraq, with government corruption as a moderating factor. The study relied on panel data covering 18 banks during the period (2013–2023), and the model was estimated using the Feasible Generalized Least Squares (FGLS) method. The results showed an inverse relationship between improvements in climate resilience, as represented by changes in the ND-GAIN index, and loan loss provisions (LLP). Notably, the interaction term is negative and statistically significant ($\beta = -0.0083$, $p = 0.027$). Also, the period coinciding with the COVID-19 pandemic saw lower LLPs compared to previous years, likely due to extraordinary government interventions during the global crisis. The study proved that climate adaptation alone is insufficient to deliver governance-based solutions in the presence of institutional fragility and emphasizes that policy responses to environmental resilience must integrate institutional approaches. Future research should focus on the broader governance characteristics that are associated with banking asset quality under climate stress, e.g., government effectiveness, control of corruption, and quality of regulation.

Keywords:
Climate Adaptation, government corruption, credit quality, institutional resilience, Iraqi Banking Sector.

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ورقة بحثية

هل يعدل الفساد العلاقة بين التكيف المناخي وجودة الائتمان ؟ أدلة من المصارف العراقية

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المستخلص

في ظل بيئات مؤسسية متقلبة، قد لا تُترجم جهود التكيف مع تغير المناخ بشكل مباشر إلى تحسينات في النتائج المالية ما لم تتوسطها جودة الحوكمة تُوفر حالة العراق مجالًا مثيرًا للاهتمام لاستكشاف مدى تأثير الفساد على تقويض جهود الدولة في مجال تعزيز القدرة على مواجهة تغير المناخ، وتأثيره على مواطن الضعف في القطاع المالي. تبحث هذه الدراسة العلاقة بين القدرة على التكيف مع تغير المناخ وجودة الائتمان في القطاع المصرفي في العراق، مع اعتبار فساد الحكومة عاملًا مُعدِّلًا. اعتمدت الدراسة على بيانات لوحة تغطي 18 بنكًا خلال الفترة (2013–2023)، وتم تقدير النموذج باستخدام طريقة المربعات الصغرى المعممة الممكنة(FGLS) ، نظرًا لقدرتها على معالجة مشكلات التباين غير المتجانس، والارتباط الذاتي، والتبعيات المقطعية المحتملة في بيانات اللوحة، مما يُسهم في تحسين كفاءة التقديرات وتعزيز موثوقية الاستدلال الإحصائي. أظهرت النتائج وجود علاقة عكسية بين تحسن القدرة على التكيف مع تغير المناخ، كما هو ممثل بالتغيرات في مؤشر ND–GAIN ، ومستويات مخصصات خسائر القروض(LLP) . تجدر الإشارة إلى أن معامل التفاعل سلبي وذو دلالة إحصائية ($\beta = -0.0083$) ، ($p=0.027$). يتضمن النموذج أيضاً العديد من المتغيرات الاقتصادية والمؤسسية الضابطة، والتي كانت جميعها تحمل الإشارات المتوقعة، مما يعزز متانة النتائج. ومن الجدير بالذكر أن الفترة التي تزامنت مع جائحة كوفيد–19 شهدت انخفاضاً في معدلات القروض المتعثرة مقارنة بالسنوات السابقة، ويرجع ذلك على الأرجح إلى التدخلات الحكومية الاستثنائية خلال الأزمة العالمية. تُسهم هذه الدراسة في الأدبيات المتعلقة بالاقتصاد المؤسسي والتمويل المستدام من خلال الكشف عن أن التكيف مع تغير المناخ وحده غير كافٍ لتقديم حلول قائمة على الحوكمة في ظل هشاشة المؤسسات؛ وتؤكد على ضرورة دمج المناهج المؤسسية في استجابات السياسات المتعلقة بالمرونة البيئية. ينبغي أن تركز البحوث المستقبلية على خصائص الحوكمة الأوسع نطاقًا المرتبطة بجودة الأصول المصرفية في ظل ضغوط المناخ، مثل فعالية الحكومة، ومكافحة الفساد، وجودة التنظيم.

الكلمات المفتاحية:
التكيف مع المناخ، الفساد الحكومي، جودة الائتمان، المرونة المؤسسية، القطاع المصرفي العراقي.

1. Introduction

Financial institutions in emerging markets are more susceptible to the consequential effects of climate change that pose systemic risks to both credit and economic stability. Climate-related disruptions such as heat waves, droughts, and floods can constrain borrowers' ability to fulfill their financial commitments, which immediately impacts banks' performance and credit quality (Redondo & Aracil, 2024; IPCC, 2022). The long-term sustainability risk is at best limited when governance and the political context are afflicted by corruption, leading to the inability to implement policies and allocate resources through means of malfeasance (Sundström et al., 2024; Chan et al., 2023). Corruption undermines the credibility of public institutions and weakens oversight systems, ensuring that the effects of climate change adaptation plans reach all sectors. In this context, Iraq represents a highly significant case study due to the overlap between climate vulnerability and weak institutions. In addition to being extremely vulnerable to climate change ,which is causing temperatures to rise, water supplies to degrade, and environmental stressors to occur more frequently ,it also has weak institutional frameworks and widespread corruption. Iraq received a score of only 26 out of 100 on the 2024 Corruption Perceptions Index (CPI), placing it among the most corrupt countries in the whole world (Transparency International, 2024).

In the banking industry, where institutional failures increase exposure to climate-related financial distress, these situations undermine credit risk management and diminish the value of adaptation programs (Hasan & Ashfaq, 2021; Nasreen et al., 2023). Although the relationship between climate change and finance is becoming more widely recognized, most scholarly research focuses on developed economies and pays little attention to how corruption affects the results of climate policy in vulnerable environments. Integrity risks in climate finance are not sufficiently examined in academic research and policy circles, according to the LSE Grantham Institute (Chan et al., 2023).

Even well-funded adaptation initiatives, like Iraq's Green Climate Fund-supported SRVALI initiative, may perform worse when corruption is systemic because of inconsistent governance and poor accountability (Food and Agriculture Organization, 2024). Bernhofen et al. (2024) stress that adaptation can enhance sovereign credit ratings and financial stability only when institutional quality is adequate to support implementation.

By examining how corruption modifies the relationship between national climate adaptation and credit quality in Iraqi banks, this study seeks to close a significant gap in the literature. Policymakers and financial institutions seeking to create integrated strategies for coping with institutional weaknesses and environmental risk should have a solid understanding of this dynamic. The case of Iraq provides an interesting avenue for exploring the degree to which corruption undermines state-led climate resilience efforts and affects the financial sector's vulnerabilities.

2. **Conceptual Structure**

Climate adaptation has emerged as a significant subject within the spectrum of sustainable development and financial resilience. This term describes a nation's productive capacity (through institutions, policy, and infrastructure) to enhance resilience across sectors and mitigate the adverse effects of climate change (Saeed et al., 2023; Boeckmann & Zeeb, 2016). Climate adaptation is increasingly being recognized in the banking industry, especially as it relates to assessing the quality of credit for borrowers in terms of their risk to environmental shocks and their ability to meet their financial commitments (Afzal et al., 2024; Lee & Alam, 2024). From a theoretical perspective, the relationship lies in a number of theories, where we utilized institutional theory, which states that the level of governance structures (accountability, transparency, and enforcement) will determine the effectiveness of public policies (Schlosberg, 2012; Boeckmann & Zeeb, 2016); and financial risk theory which denotes that a systemic risk such as climate change, will affect the quality of the borrower's assets and increase the probability of defaults, while linking environmental and institutional factors as determinants of credit performance (Chhabra, 2024; Afzal et al., 2024).

The benefits of climate adaptation don't necessarily translate into improved credit quality. The institutional environment, corruption in particular, plays an important role in doing this. Corruption can distort how funds for climate action are divvied up, impede implementation, and delegitimize adaptation programs (Chan et al., 2023; Sundström et al., 2024). In countries with instability such as Iraq, the effectiveness of climate adaptation strategies can be severely undermined by corruption (Hasan & Ashfaq, 2021; Beyaert et al., 2023). The philosophical mechanism of this interaction operates through what may be termed “compensatory resilience”: in high corruption environments, where governance-based mechanisms for credit discipline are weakest, direct adaptation investments in physical infrastructure, water management, and climate-resilient agriculture may generate relatively stronger marginal improvements in borrower solvency and bank asset quality precisely because the baseline institutional protection is so low. In other words, governance corruption undermines formal channels of credit protection such as regulatory enforcement, contract certainty, and resource allocation integrity, while adaptation investments partially substitute for these governance failures by directly reducing borrowers' environmental exposure, thereby lowering expected loan losses even without strong institutional scaffolding. This interaction is not evidence that corruption is benign, but rather that adaptation can operate as a second-order stabilizing mechanism in contexts where first-order governance reforms are absent or slow (UNODC, 2024; OECD, 2024b; Chan et al., 2023).

According to Nasreen et al. (2023) and Hasan & Ashfaq (2021), corruption cannot raise credit risk when regulatory scrutiny rises, non-performing debt declines, and rent-seeking behavior is curbed. To improve the relationships between climate adaptation programs and credit quality, researchers are increasingly paying attention

to eliminating corrupt transactions (Schlosberg, 2012; Minto, 2018). This indicates that corruption, as a moderating variable, has fluctuated in enhancing the quality of climate adaptation and credit quality. World Bank (2022) reported that corruption cases in Iraqi banking occur because of institutional disequilibrium. In addition, corruption in Iraq has increased because of insecurity, climate vulnerability, and other factors, such as climate change (floods and droughts). Researchers believe that eliminating corruption and weak institutional governance will improve the quality of banking transactions and be reflected in trust in international banking dealings (Transparency International, 2024). It can be highlighted that a reliable banking system and strong institutional governance in Iraq enhance credit quality and optimize financial stability domestically and internationally.

First, this research paper shows the link between credit quality, weak corruption, and adaptation to climate change, thereby enhancing understanding of the interrelationships between environmental and institutional factors in the banking sector. Secondly, this approach focuses on increasing knowledge about safety guidelines and policies; these rules take into account both institutional and climate risks. Finally, the study contributes to the current knowledge by synthesizing literature on finance and climate, particularly in the context of fragile states, through analysis of the Iraqi case; thus, financial stability and climate adaptation policies are improved by financial institutions and policymakers.

3. Development of Hypotheses

Based on the knowledge and relevant studies, the following hypotheses are proposed. All hypotheses are based on prior scientific research and contextual analysis. Credit quality in Iraqi banks is affected by climate adaptation. Countries ready to adapt have better asset quality and lower rates of default (Saeed et al., 2023; Afzal et al., 2024). Governance and infrastructure resilient to climate change improve repayment capabilities and lower borrowers' vulnerability (Lee & Alam, 2024; Chhabra, 2024). The SRVALI project and other adaptation efforts seek to improve agricultural resilience in Iraq, which provides a potential indirect benefit for broader financial stability (FAO, 2024).

H_1: Higher climate adaptation capacity has a positive effect on credit quality in Iraqi banks.

Corruption plays a negative moderating role in the relationship between climate adaptation and credit quality. Corruption inhibits climate policy implementation, leads to resource misallocations, and reduces effectiveness (Chan et al., 2023; Sundström et al., 2024). In high-corruption contexts, adaptation efforts do not produce financial stability (Hasan & Ashfaq, 2021; Minto, 2018). Iraq has weak climate resilience and sustainable development due to institutional fragmentation and weak governance (Beyaert et al., 2023).

H_2: Higher levels of corruption weaken the positive effect of climate adaptation capacity on credit quality in Iraqi banks.

4. Methodology

4.1. Design of the Research

This study employs balanced panel data covering 18 banks from 2013 to 2023 to evaluate credit quality in Iraqi commercial banks. During this period, the economic and institutional environment faced many challenges (such as oil price volatility and the COVID-19 pandemic); therefore, the authors consider 2013 to 2023 the best period for the study and suitable for analysis. From the above, the stability of the banking sector and credit risk levels are influenced by environmental risk. As a result, to assess credit quality, this study uses the loan loss provisions as an important factor for banks' future estimates of credit risk and expected losses resulting from default.

To systematically explore these relationships, this paper uses longitudinal panel data to evaluate and employ a quantitative approach; consequently, this approach shows variance between banks and tracks changes over time during the study period. Furthermore, the study examines corruption and credit quality to shape credit outcomes. This research also aims to understand institutionally rooted phenomena, where public policies and governance structures interact with financial indicators in a complex and intertwined manner (Bai, Choi, and Liao, 2021).

4.2. Population and Sample

In Iraq, all commercial banks are included in the study population. Based on data availability, consistency, and continuity over time, 18 commercial banks make up the sample specifically, those that maintained uninterrupted annual reporting of financial statements accessible through Refinitiv Eikon and the Iraq Stock Exchange over the full study period (2013–2023). Banks with missing, incomplete, or non-continuous data were excluded to preserve the integrity of the balanced panel. With a balanced panel of 198 bank-year observations, the dataset covers 11 years (2013–2023). This time frame offers a useful framework for empirical research because it captures important advancements in Iraq's institutional reform initiatives and climate policy engagement. This study uses a cross-level data structure: the key independent variable (climate adaptation, ND-GAIN) and the moderating variable (Corruption Perceptions Index, CPI) are measured at the country level, while the dependent variable (loan loss provisions) is measured at the individual bank level. This data hierarchy was addressed by employing FGLS estimation, which accommodates the temporal and cross-sectional variance structures inherent in panel data, thereby reducing the risk of ecological fallacy by capturing bank-level heterogeneity through bank-specific control variables (size, capital adequacy, loan ratios) that interact with country-level institutional indicators within the regression framework.

Addressing the potential Ecological Fallacy arising from the cross-level integration of country-level governance indices and bank-level financial data is critical for the robustness of our estimates. As noted by Robinson (1950), statistical inferences drawn from aggregated data cannot always be directly translated to

individual units; however, in the context of institutional economics, Beck et al. (2006) and La Porta et al. (1998) argue that national institutional frameworks act as 'binding constraints' that homogenize the operational environment for all firms within a given economy. Consequently, the use of national-level corruption data is not an attempt to infer individual bank behavior from national trends, but rather an assessment of how a unified systemic governance shock impacts heterogeneous banking units, a method validated in empirical banking literature addressing institutional voids (Nasreen et al., 2023; Zhou et al., 2024). By employing FGLS estimation with bank-specific control variables, the study isolates bank-level variance from national-level institutional impact, thereby mitigating aggregation bias while maintaining theoretical consistency with institutional theory (Schlosberg, 2012).

4.3. Sources of Data and Variables

4.3.1. Credit Quality as a Dependent Variable

Credit quality is the primary dependent variable in this study, as it indicates the degree to which banks are exposed to credit risk and their efficiency in managing potential losses resulting from lending activities. In this context, the loan loss provision ratio is used as an alternative indicator of credit quality, as it expresses the size of provisions that banks maintain to cover expected losses from loans, measured as a percentage of total loans or total assets. This indicator is one of the most widely used measures in banking literature to measure the quality of credit assets and assess the level of risk inherent in credit portfolios.

The loan loss provision (LLP) is widely used as a forward-looking indicator of asset quality and credit risk, as it reflects management's expectations of future credit losses and the precautionary measures taken to address them. Unlike non-performing loan ratios, which reflect losses realized after they have occurred, the LLP provides a proactive measure that incorporates future expectations of risk (Bouvatier & Lepetit, 2008; Hasan & Wall, 2004). This indicator is of increasing importance in studies that address the impact of institutional and environmental factors, such as corruption and adaptation to climate change, as it reflects banks' behavior in building provisions based on internal risk assessments and macroeconomic developments, making it a suitable tool for examining the implications of these factors on credit quality (Curcio & Hasan, 2015).

In this context, the literature indicates that loan loss provisions are a dynamic tool for managing banking risks, as they enhance banks' ability to withstand shocks and improve their operational resilience (Nasreen et al., 2023). Studies have also shown that this indicator has a high degree of relevance in data analysis for emerging markets, given its ability to absorb the combined effects of macroeconomic conditions and the level of corporate governance quality (Arifianto & Trinogroho, 2023). Based on these theoretical and empirical justifications, the current study relies on loan loss provisions as a reliable indicator for measuring credit quality in Iraqi banks during the period from 2013 to 2023.

4.3.2. Climate Adaptation

This variable measures Iraq's macro-level institutional and infrastructure preparedness to reduce climate risks. It is derived from World Bank CCDRs and the Climate Change Knowledge Portal (World Bank, 2022; Saeed et al., 2023). Operationally, climate adaptation is defined in this study as the annual change in Iraq's ND-GAIN Country Index score (ΔND-GAIN), which captures year-on-year improvements or deteriorations in national readiness to absorb climate shocks across six sectors: food, water, health, ecosystem services, human habitat, and infrastructure.

4.3.3. The Corruption Index is a moderating variable.

Perceptions of governance quality and institutional integrity are reflected in Transparency International's CPI (2024), which may change the way climate adaptation strategies impact credit outcomes (Chan et al., 2023; Sundström et al., 2024). Operationally, corruption is defined in this study as the annual change in Iraq's inverted CPI score (ΔCPI = 100 minus CPI), so that higher values represent worsening corruption perceptions. This transformation ensures that the corruption variable moves in the intuitive direction: increases signal institutional deterioration, consistent with the expected positive sign on the corruption coefficient in the regression models.

4.3.4. Control Variables:

To control for institutional and macroeconomic variables of credit risk in Iraqi banks, we include a number of key variables. Bank size (log of total assets), as a proxy for diversification and resilience, typically indicates that larger banks can withstand shocks better than smaller banks (Demirgüç-Kunt & Huizinga, 1999; Pham, Dao, & Nguyen, 2021). The capital adequacy ratio serves as a regulatory cushion against credit losses and is routinely used to assess an acceptable level of overall stability within financial institutions (Athanasoglou et al., 2008; Berger & Bouwman, 2013; Bortoluzzo et al., 2024). The loan-to-deposit ratio provides information on liquidity pressures and lending intensity, with higher values associated with greater access to credit (Kashyap & Stein,2000; Dietrich & Wanzenried, 2011). The loan-to-capital ratio describes leverage and risk concentration, as it documents how much credit risk is funded by equity (Rajan & Zingales,1995; Berger & Bouwman, 2013; Ohlrogge, 2017). On the macro level, GDP growth and inflation provide information on the borrower's repayment capacity and economic volatility (Mishkin, 1996; Beck, Levine &Loayz, 2000; Boyd, Levine & Smith, 2001; Levine,2005; Yuan et al., 2022; Otambo, 2016; O'Connell & Ferguson, 2022). We also include a COVID-19 dummy variable to determine any impact on lending due to COVID-19 disruptions on credit performance (IMF, 2020; BIS, 2021; Lee & Alam, 2024). The controls are based on banking literature and adapted to Iraq, which is a volatile institutional and economic environment.

5. Diagnostic Testing

A robust panel data analysis firm must rigorously validate the underlying statistical assumptions to ensure that the coefficient estimates are reliable. Preliminary diagnostic testing suggested that there was both serial correlation and

heteroskedasticity in the panel structure, indicating temporal dependence and non-constant variance of the error term across observational units. These two violations have the potential to undermine the efficiency and consistency of traditional estimators, such as Ordinary Least Squares (OLS), which rest on spherical error assumptions.

As a result, in this study, we implemented the Generalized Least Squares (GLS) estimation technique, which is designed to accommodate non-spherical error structures in panel data settings. By design, GLS produces unbiased and efficient parameter estimates, as it corrects for first-order autocorrelation and heteroskedasticity that may be unique to each panel, which is particularly important in financial datasets where residual persistence and shocks can be present following institutional inertia and the volatility from macroeconomic changes (Bai, Choi, & Liao, 2021; Musau, Waititu, & Wanjoya, 2015).

At the same time, GLS provides the flexibility to accommodate even more complex error covariance structures, further strengthening inference in situations with dynamic interdependencies and structural heterogeneity (Afzal et al., 2024; Hasan & Ashfaq, 2021). To address multicollinearity concerns, Variance Inflation Factors (VIF) were computed for all explanatory variables. All VIF values were below the conventional threshold of 5, and the inter-variable correlation matrix confirmed the absence of problematic collinearity among the independent variables. Regarding the choice of estimator for the panel structure, preliminary specification tests were conducted to determine whether Fixed Effects (FE) or Random Effects (RE) was more appropriate. The Hausman specification test yielded a statistically insignificant result ($p > 0.05$), failing to reject the null hypothesis of no correlation between the individual bank-specific effects and the regressors, which favored the Random Effects (RE) specification. However, diagnostic testing revealed the presence of both heteroskedasticity and serial correlation: the Modified Wald test for groupwise heteroskedasticity yielded a statistically significant result, indicating non-constant variance across panels, while the Wooldridge test for autocorrelation in panel data confirmed the presence of first-order serial correlation in the error term. Given these violations of the classical RE assumptions, FGLS was ultimately adopted over standard RE estimation, as FGLS produces more efficient estimates under non-spherical error conditions and is consistent with the methodological approach used in comparable banking panel data studies (Bai, Choi, & Liao, 2021; Musau, Waititu, & Wanjoya, 2015).

6. Model Specification

In order to determine whether institutional quality mitigates the impact of adaptive capacity, this study employs two main models: the first looks at the direct relationship between climate adaptation and credit quality, while the second adds an interaction term with perceived corruption. This dual-model approach makes it possible to investigate environmental and governance dynamics in banking risk in a way that is both economical and theoretically rich.

$$LLP_{it} = \alpha_{it} + \beta_1 \Delta ND\_GAIN_t + \beta_2 SIZE_{it} + \beta_3 CAR_{it} + \beta_4 LCR_{it} + \beta_5 LDR_{it} + \beta_6 \Delta GDP_t + \beta_7 INF_t + \beta_8 COVID\ Phase_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$LLP_{it} = \alpha_{it} + \beta_1 \Delta ND\_GAIN_t + \beta_2 \Delta CPI_t + \beta_3 (\Delta ND\_GAIN * \Delta CPI)_t + \beta_4 SIZE_{it} + \beta_5 CAR_{it} + \beta_6 LCR_{it} + \beta_7 LDR_{it} + \beta_8 \Delta GDP_t + \beta_9 INF_t + \beta_{10} COVID\ Phase_{it} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: LLP_{it} denotes the loan loss provisions ratio for bank i at time t; α_{it} captures bank-specific and time-fixed effects; ΔND_GAIN_t represents the annual change in the ND-GAIN index; ΔCP_{It} indicates the annual change in the Corruption Perceptions Index; $(\Delta ND\_GAIN * \Delta CPI)_t$ is the interaction term between change in climate adaptation and change in corruption; $SIZE_{it}$ refers to the logarithm of total assets; CAR_{it} is the capital adequacy ratio; LCR_{it} is total loans to total capital ratio; LDR_{it} is the loan-to-deposit ratio; ΔGDP_t measures the annual change in real gross domestic product, representing macroeconomic growth. INF_t is the inflation rate; $COVID\ Phase_{it}$ is a categorical variable with three distinct phases; ε_{it} is the idiosyncratic error term.

Table (1). Measurement of Variables

Variable	Description	Measurement	Source	References
LLP	Loan loss provisions – proxy for credit quality	Ratio of LLP to total loans	Refinitiv Eikon & Bank financial statements	Bouvatier & Lepetit (2008); Beatty & Liao (2011)
Δ ND_GAIN	Country-level ND-GAIN score indicating readiness to adapt to climate change	Change in climate adaptation index	Notre Dame Global Adaptation Initiative	Battiston et al. (2017); Kling et al. (2021)
Δ CPI	100 minus CPI score; higher values indicate higher perceived corruption	Change in corruption perceptions index	Transparency International	La Porta et al. (1998); Beck et al. (2006)
ΔND-GAIN* ΔCPI	Interaction between climate adaptation and corruption	Interaction term between change in climate adaptation and	Constructed from above variables	Institutional complementarity theory

		change in corruption		
Bank Size	Proxy for scale and operational capacity (SIZE)	Natural log of total assets	Refinitiv Eikon & Bank financial statements	Demirgüç-Kunt & Huizinga (1999)
Capital Adequacy	Regulatory buffer against credit risk (CAR)	Ratio of capital to risk-weighted assets	Refinitiv Eikon & Bank financial statements	Berger & Bouwman (2013)
Loan-Capital Ratio	Internal leverage indicator (LCR)	Ratio of total loans to total capital	Refinitiv Eikon & Bank financial statements	Berger & Bouwman (2013); Rajan & Zingales (1995)
Loan-Deposit Ratio	Credit exposure relative to funding base (LDR)	Ratio of total loans to total deposits	Refinitiv Eikon & Bank financial statements	Kashyap & Stein (2000)
GDP Growth	Economic expansion indicator	Annual percentage change in real GDP	World Bank – World Development Indicators	Levine (2005); Beck et al. (2000)
Inflation	Macroeconomic instability indicator (INF)	Annual percentage change in Consumer Price Index	World Bank – World Development Indicators	Mishkin (1996); Boyd et al. (2001)
COVID Phase	Temporal dummy capturing pandemic effects	Categorical variable: Pre-COVID (2013–2019), During (2020–2021), Post (2022–2023)	Author's classification based on timeline	IMF (2020); BIS (2021)

7. Descriptive statistics

For the purpose of providing a preliminary understanding of the data characteristics and ensuring the integrity of the experimental analysis and its consistency with theoretical expectations, Table (2) shows the descriptive statistics of the variables used in the regression analysis of the tablet data. The dataset comprises 198 bank observations of Iraqi commercial banks from 2013 to 2023.

Table 2. Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Median	Min	Max
LLP	198	0.069	0.062	0.039	0.012	0.166
ND_GAIN	198	42.606	0.818	43.021	41.083	43.584
Δ ND-GAIN	198	0.269	0.450	0.174	-0.460	1.025
CPI	198	80.818	2.797	82.000	77.000	84.000
Δ CPI	198	-0.455	1.078	0.000	-2.000	2.000
Δ ND-GAIN* Δ CPI	198	-0.248	0.423	0.000	-1.025	0.267
Bank Size	198	20.002	0.437	19.987	19.231	20.991
Capital Adequacy	198	0.504	0.187	0.500	0.130	0.940
Loan-Capital Ratio	198	0.527	0.379	0.476	0.005	1.569
Loan-Deposit Ratio	198	0.051	0.035	0.040	0.020	0.130
GDP Growth	198	3.262	4.889	2.607	-2.936	13.787
Inflation	198	2.035	2.055	1.393	-0.199	6.042

The dependent variable, Loan Loss Provisions (LLP), represents credit risk management and provisioning behavior. The LLP mean of 0.069 and standard deviation of 0.062 indicate moderate variation in LLP values, suggesting potential heterogeneity in risk exposure and provisioning behavior/strategies within and across banks. The minimum and maximum LLP values of 0.012 and 0.166 indicate considerable variation in credit quality, loss expectations, and thereby loan loss provisions.

The institutional variables are important components of the theoretical framework for this research. The ND-GAIN index of national adaptive capacity to climate change has a reasonably narrow range of scores (Min = 41.083, Max = 43.584) with a mean of 42.606. The relative stability of the ND-GAIN index scores over time in Iraq reflects a slow rate of institutional change towards climate resilience. On the other hand, the change in ND-GAIN (Δ ND-GAIN) yielded a larger mean (Mean = 0.269, SD = 0.450). The mean score for Δ ND-GAIN suggests variability in increases in climate adaptation performance from year to year and overall fluctuations in Iraq's Climate adaptive capacity, which are important for judging banks' responses over time to evolving climate risks.

The second institutional variable, the Corruption Perceptions Index (CPI) ranked by Transparency International, displayed a similar range of scores (Min = 77,

Max = 84), which had a mean of 80.818, indicating high, stable perceptions of corruption throughout the research sample period may be expected to impair credit allocation and regulatory enforcement. The change in CPI (Δ CPI) was scaled to a ±2 range, which resulted in a mean of -0.455, indicating an overall depressing effect due to lost institutional integrity during the sample period. The interaction term Δ ND-GAIN* Δ CPI was calculated using simple standardized values, which had a mean of -0.248 (SD = 0.423) and had a mean close to zero for purposes of assessing whether climate adaptation would benefit or undermine the CAI model through constants or offsets around an emerging climate risk scenario.

With regard to bank-specific controls, Bank Size (log of total assets) has a mean of 20.002, suggesting relatively small activity by global standards. Nonetheless, Capital Adequacy (Mean = 0.504) and Loan-Capital Ratio (Mean = 0.527) reflect internal solvency and leverage issues, and apparently conservative lending, as indicated by the Loan-Deposit Ratio (Mean = 0.051), which may relate to risk aversion or liquidity constraints. Macroeconomic variables- GDP Growth and Inflation report high dispersion (SD = 4.889 and 2.055, respectively), indicating the volatility of the economic landscape in Iraq, and consequently the potential impact on banking sector stability.

8. Results

The Feasible Generalized Least Squares (FGLS) regression results, which account for both heteroskedasticity and serial correlation (AR (1) = 0.5268 in Model 1 and 0.5331 in Model 2), reveal several statistically significant relationships between the explanatory variables and loan loss provisions (LLP), a proxy for credit quality, where lower LLPs indicate stronger credit performance. Both models demonstrate strong joint explanatory power, as evidenced by the Wald χ^2 statistics (504.25 in Model 1 and 691.71 in Model 2, $p < 0.001$).

Table (3). Regression Results

Variable	Model 1			Model 2		
	Coef.	Std. Err.	P-value	Coef.	Std. Err.	P-value
Constant	0.1468	0.2268	0.518	0.4721	0.2506	0.060
Δ ND-GAIN	-0.0056	0.0019	0.003	-0.0084	0.0024	0.001
Δ CPI	—	—	—	0.0026	0.0012	0.024
ΔND-GAIN* ΔCPI	—	—	—	-0.0083	0.0038	0.027
Bank Size	-0.0044	0.0109	0.686	-0.0200	0.0120	0.096
Capital Adequacy	-0.0628	0.0244	0.010	-0.0948	0.0262	0.000

Loan-Capital Ratio	-0.0279	0.0081	0.001	-0.0245	0.0080	0.002
Loan-Deposit Ratio	0.7778	0.0558	0.000	0.7655	0.0558	0.000
GDP Growth	-0.0011	0.0002	0.000	-0.0012	0.0002	0.000
Inflation	0.0014	0.0008	0.087	0.0023	0.0008	0.006
COVID Phase; During	-0.0184	0.0040	0.000	-0.0219	0.0033	0.000
COVID Phase; Post	-0.0173	0.0047	0.000	-0.0163	0.0043	0.000
Wald χ^2 (df)	504.25 (9)			691.71 (11)		
Prob > χ^2	0.000			0.000		
AR (1) Coefficient	0.5268			0.5331		
Observations	198			198		
Number of Banks (Groups)	18			18		
Time Periods	11			11		

8.1. Model 1: Climate Adaptation and Credit Quality

Model 1 investigates the relationship between annual changes in climate adaptation capacity (Δ ND-GAIN) and credit quality. The results show a statistically significant negative relationship between Δ ND-GAIN and LLPs (β = -0.0056, p = 0.003), implying that improvements in climate resilience are associated with improvements in credit quality. As countries improve their ability to adapt to climate shocks, operational interruptions decrease, borrowers' ability to repay increases, and banks face a reduced risk of loan defaults. The finding supports Hypothesis 1 (H_1), which states that climate adaptation positively contributes to credit quality in the banking sector.

Control variables behave largely as expected. Capital adequacy greatly improves credit quality (β = -0.0628, p = 0.010), while an even higher loan-to-capital ratio lowers LLPs (β = -0.0279, p = 0.001), suggesting that internally funded lending is less risky. Conversely, a higher loan-to-deposit ratio is associated with lower credit quality (β = 0.7778, p < 0.001), indicating higher risk exposure.6 GDP growth increases credit quality (β = -0.0011, p < 0.001), while inflation has a slightly positive inclination for LLPs (β = 0.0014, p = 0.087). The COVID-19 phase dummies indicate that both the pandemic (β = -0.0184, p < 0.001) and post-pandemic (β = -0.0173, p <

0.001) periods are associated with fewer LLPs, likely due to the extraordinary fiscal and monetary support provided.

These results support the assumptions of risk-based accounting, which holds that an improved corporate environment and the ability to adapt to environmental changes reduce uncertainty and enhance the quality of financial information, positively impacting the efficiency of credit decisions. The decrease in loan loss provisions also indicates an improvement in the quality of credit assets and a decline in expected risks, which is consistent with a conservative accounting approach that recognizes potential losses early and creates appropriate provisions when there are indications of a deterioration in asset quality. From this perspective, adapting to climate change supports business stability by reducing future risk and lowering the need for high precautionary provisions often associated with economically uncertain environments.

8.2. Model 2: Moderation via Corruption

Model 2 builds upon the previous analysis by incorporating institutional quality dynamics, specifically a dynamic variable for perceived corruption (Δ CPI) and its interaction with climate adaptation efforts. The coefficient for climate adaptation (Δ ND-GAIN) remains negative and statistically significant ($\beta = -0.0084$, $p = 0.001$), reinforcing the evidence that adaptation policies and expenditures contribute to improved credit quality. Conversely, increases in perceived corruption (Δ CPI) are associated with higher loan loss provisions ($\beta = 0.0026$, $p = 0.024$), indicating that deteriorating governance weakens credit discipline and elevates credit risk.

The findings from the Iraqi case study demonstrate that climate adaptation (ND-GAIN) exerts a tangible positive effect on bank credit quality. Importantly, this effect becomes more pronounced in periods of elevated corruption. The interaction term of Δ ND-GAIN and Δ CPI is negative and statistically significant ($\beta = -0.0083$, $p = 0.027$), showing that while corruption raises provisioning risks, it simultaneously magnifies the marginal benefits of climate adaptation. To interpret this financially: in high corruption years (when ΔCPI is positive, indicating worsening perceptions), each unit improvement in climate adaptation capacity (ΔND-GAIN) is associated with a larger reduction in loan loss provisions than it would be in low corruption years; this means that adaptation does not merely compensate for corruption; it actually delivers stronger credit quality benefits precisely when institutional safeguards are weakest. Philosophically, this reflects a compensatory substitution effect: when governance mechanisms that normally protect credit markets (regulatory enforcement, contract integrity, resource accountability) are compromised by corruption, direct adaptation investments in physical resilience (flood defenses, agricultural infrastructure, water management) take on a disproportionately important role in stabilizing borrower repayment capacity, thereby reducing bank-level provisioning needs. Corruption in Iraq, therefore, does not fully negate climate adaptation benefits; rather, it raises the stakes for adaptation, making its positive effect on credit quality more pronounced and more necessary. This finding reverses the conventional assumption that adaptation benefits are conditional on strong governance, suggesting instead that adaptation

becomes a critical financial stabilizer precisely in its absence. The results indicate that adaptation to climate change is more important in environments with high levels of corruption, where it acts as a compensatory mechanism that helps reduce systemic risks arising from weak governance and institutions. This means that the effectiveness of adaptation does not necessarily depend on the existence of a strong institutional environment, but may be more prominent in contexts characterized by institutional dysfunctions. Therefore, these results do not support the second hypothesis (H2), which assumed that the positive effects of adaptation are conditional on high-quality institutions, but rather indicate that adaptation can be an effective tool for promoting stability even in fragile institutional environments, as long as a minimum level of institutional efficiency and state enforcement capacity exists. Control variables in Model 2 behave consistently: capital adequacy ($\beta = -0.0948$, $p < 0.001$) and loan-to-capital ratio ($\beta = -0.0245$, $p = 0.002$) continue to directly support credit quality, while loan-to-deposit ratio ($\beta = 0.7655$, $p < 0.001$) remains a significant amplification risk. Inflation ($\beta = 0.0023$, $p = 0.006$) and GDP growth ($\beta = -0.0012$, $p < 0.001$) perform as expected. Bank size exhibits a marginally rejected negative effect ($\beta = -0.0200$, $p = 0.096$), suggesting minimal additional improvements in credit quality from size expansion. COVID-19 phase effects also remained robust, with both identified time periods reflecting improvements in credit quality (During: $\beta = -0.0219$, $p < 0.001$; Post: $\beta = -0.0163$, $p < 0.001$).

These results are consistent with the corporate accounting perspective, which assumes that accounting behavior, the level of financial disclosure, and the effectiveness of control not only reflect the characteristics of individual banks but are also shaped by the institutional environment of the state, including its systems, laws, and governance and control mechanisms.

In contexts of high corruption, adaptation projects may still face inefficiencies or misallocation; however, the evidence shows that their contribution to credit quality becomes even more significant under such fragile conditions. As a result, adaptation showed compensatory resilience, easing systemic risk even with weak governance.

These findings have special resonance for fragile states, like Iraq, where systemic fragility, such as chronic corruption and institutional weaknesses, is commonplace, highlighting not only the need for institutional reforms but also the extent to which adaptation can create meaningful financial resilience, notwithstanding governance weaknesses.

9. Discussion

The findings highlight that climate change and institutional governance are intertwined determinants of banking credit quality in fragile economies such as Iraq. This study advances the climate adaptation; corruption; governance; and financial stability literature by exploring the moderating role of corruption, and highlighting that in assessing climate risks with an integrity and transparency lens, climate risk must be assessed by banks as part of their credit risk management models (BCBS, 2022; ECB, 2024; FSB, 2025; UNEP FI, 2024; Saeed et al., 2024; Afzal et al., 2024).

The evidence suggests that adaptation strategies, including investments in environmental infrastructure (sometimes referred to as intergenerational financing), water resources management, and green finance, are generally related to better credit quality by reducing systemic risk and helping borrowers regain solvency. International institution papers support the idea of relationships between unsecured disaster losses and sustainable banking, by addressing adequate climate risk policymaking and management, in critical areas of banking such as agriculture, energy, and vulnerabilities including water management (IPCC, 2022; FAO, 2023a, 2024a, 2024b; ECB, 2024; Brunetti et al., 2024; Chhabra, 2024; Cappiello et al., 2023; Olutumise, 2023). Recent assessments for Iraq further show that the fragility of electricity and water sectors under heatwaves and drought makes adaptation projects a direct priority for credit stability (IEA, 2025; UNDP, 2025a).

At the same time, corruption presents a fundamental institutional constraint that compromises the projected rewards of adaptation by misallocating resources, undermining oversight and contracts, and directing finance elsewhere. Corruption risks in climate finance chains have been identified by international organizations and research centers, and explicitly embedding corruption indicators into climate risk assessments has been called for, particularly in developing countries (UNODC, 2024; OECD, 2024b, 2025; World Bank, 2024, 2025; Transparency International, 2025; Chan et al., 2023; Sundström et al., 2024; Hasan & Ashfaq, 2021). Empirical studies employing cross-sectional/panel data have cautioned that governance failure increases the price of climate shocks and reduces asset quality (Zhou et al., 2024; Butler et al., 2022; Lee & Alam, 2024; Naran et al., 2024).

Sectoral evidence from resources and energy indicates that weak oversight over energy transition minerals and their supply chains threatens climate objectives and can channel public funds for private benefit, creating systemic risks in fragile economies (NRGI, 2022; Radzewicz-Bak et al., 2024).In Iraq, national resilience assessments (IEA, 2025) and climate project maps (UNDP, 2025b) highlight institutional challenges related to governance integration and cross-sector coordination (energy–water–agriculture), demanding stronger integrity mechanisms to safeguard climate finance's impact on credit quality (Chalabi-Jabado & Ziane, 2024).

Our economic results reveal a complex relationship between adaptation and corruption: adaptation indicators (climate spending and infrastructure upgrades) exhibit a stronger positive effect on banking stability when corruption is higher. This suggests that higher corruption amplifies the "marginal return" of adaptation as a compensatory mechanism mitigating governance gaps and preserving asset quality, meaning adaptation, even in institutionally difficult environments, can reduce systemic risks and strengthen solvency in the long run. This is consistent with more recent scholarship that has argued that maximizing the value of adaptation requires transparent governance and accountability, but its stabilizing effect can emerge even preceding the completion of integrity reforms assuming finance, contracting, and

supervision are organized with built-in protections (IPCC, 2022; FAO, 2024b; OECD, 2024b; UNODC, 2024; ECB, 2024; FSB, 2025; Akuoko-Konadu & Mahmud, 2025).

In practical terms, in Iraq this implies that adaptation projects, such as water resource management, renewable energy, and green finance, are essential for agriculture or industry, and are important for addressing issues around credit quality and even more important with increases in institutional risk as we think about corruption. However, establishing credit resilience for sustainability requires the "whole package" i.e., corruption indicators included into banking risk models for climate finance, public procurement and contracting transparency improved, catastrophe insurance guarding the "protection gap", and greater disclosures and climate stress tests under the Basel principles and financial stability (ECB, 2024; BCBS, 2022; FSB, 2025; UNEP FI, 2024; KPMG, 2022).

In conclusion, adaptation policies alone will not be enough to ensure reliable fiscal outcomes in fragile states. Climate finance will not translate into better credit quality for fragile states, even if implemented appropriately, without essential reforms to reduce corruption and advance transparent and accountable mechanisms. Therefore, governance changes (accountability, integrity, procurement transparency, whistleblower protections) should be prioritized and introduced into climate adaptation legislative and performance-based financing programming, with pre-agreed assessments and evaluation indicators for measurable credit quality outcomes in priority sectors (water, agriculture, energy). In this regard, this document supports OECD, UNODC, FAO, ECB, and FSB recommendations and provides implementable actions for policymakers, regulators, and the banking sector in fragile regulatory regimes (see Sundström et al., 2024; Saeed et al., 2023; Afzal et al., 2024).

10. Conclusion

This paper shows that climate adaptation can be a useful platform for enhancing financial stability, especially in situations of fragile institutions. At the state level, adaptation investments were associated with lower loan loss provisions, which correlated with improved asset quality and strengthened risk management procedures within banking systems. Additionally, the strength of adaptation was highly dependent on the quality of governance. In short, climate adaptation cannot be studied outside of its context.

Interestingly, in environments with high corruption, climate adaptation had an even stronger positive impact on credit quality, acting as a compensatory mechanism to offset institutional weaknesses. This finding warrants careful interpretation: the negative sign of the interaction term ($\beta = -0.0083$) does not imply that corruption is beneficial, but rather that climate adaptation becomes a more critical financial stabilizer precisely when governance institutions are at their weakest. In Iraq, where systemic corruption undermines the formal regulatory channels that ordinarily protect credit markets, including oversight, contract enforcement, and public resource accountability, adaptation investments in physical infrastructure and environmental

resilience fill a critical gap. They reduce borrower-level exposure to climate shocks directly, thereby preserving repayment capacity and limiting loan losses even in the absence of strong institutional guardrails. Results imply that adaptation policies are not only important for enabling environmental resilience against societal shocks, but also for influencing systems that mitigate systemic financial risk.

These results align with the broader literature in institutional economics and sustainable finance, which indicates that countries with greater adaptive capacity exhibit stronger banking resilience. The adaptation and corruption dynamic reflects how climate strategies could offset dysfunctional institutional arrangements, especially for vulnerable economies like Iraq.

This research develops both integrated climate and governance indicators while providing lessons for financial institutions to consider. Banks in developing economies should assess how climate can be accounted for in risk modeling and in financial products linked to environmental and institutional performance, including green financial loans or climate-adaptation insurance. These measures are expected to enhance transparency through disclosure obligations, embed climate and governance risks within lending frameworks, and improve the quality of their assets—even in environments with high corruption, where climate adaptation can have a stronger positive impact on credit quality.

From a policy lens, climate adaptation should be incorporated into broader institutional reform initiatives, which will strengthen the redesign of administrative mechanisms, improve regulatory enforcement, and enhance coordination between ministries and other departments. With regard to green financing, effective governance codes will facilitate practice reform and the implementation of initiatives that genuinely demonstrate environmental integrity.

Future research should examine:

- The impact of governance variables (e.g., government effectiveness, control of corruption, regulatory quality) on banking assets' quality in times of climate crises.
- Studies that compare countries with good institutions as opposed to countries with weak institutions to identify mediating factors that either improve or limit the ability to adapt.

Overall, climate change adaptation and institutional quality are interdependent; however, climate adaptation can still enhance credit quality, even in highly corrupt countries. Better governance will enhance credit quality even more, which indicates that climate strategies and institutional reform can and should be addressed simultaneously to promote financial sustainability and resiliency.

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