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The Transmission of Climate Shocks to Financial Risk in Morocco: A Macro-Financial Perspective Using Bayesian VAR Modeling

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Abstract. Global warming reached unprecedented levels in 2024 since records began in 1850, suggesting that climate change is worsening. This article considers the impact of climate shocks on the real economy and financial stability, particularly focusing on temperature and precipitation variations. We assess climate change by estimating a Bayesian Vector Autoregression (BVAR) for the period 2007Q1–2022Q1 and examining the dynamic responses of GDP and non-performing loans (NPLs) to it. Our results indicate that precipitation shocks positively affect economic activity, while temperature shocks have adverse and damaging effects on both economic production and the financial sector. We find evidence of and suggest an indirect transmission channel between climate and financial risk through GDP. Our findings clearly indicate the need for climate dynamics to be modeled in macroeconomic and financial models to appropriately capture the risks associated with climate variability.

Keywords: *Climate change, Bayesian Vector Autoregression, Financial risk, NPLs, Precipitation.*

1. Introduction

The National Oceanic and Atmospheric Administration (NOAA) has stated that, according to records kept since 1850, 2024 was the warmest year on record, with average global temperatures 1.29°C above the 20th-century average of 13.9° (NOAA 2025). While this single statistic may not be alarming in isolation, it is more concerning given that all of the ten hottest years on record occurred between 2015 and 2024. Overall, this trend is highly worrisome. Human activity is strongly dependent on climate, and if temperatures continue to rise over an extended period, serious economic and financial consequences may result. It is therefore important to assess each dimension of these effects. Doing so will both improve our understanding of the mechanisms by which climate impacts the economy and offer opportunities to propose measures to mitigate these effects, such as corrective or preventative interventions.

The African continent cannot be dissociated from this threat. Indeed, the relevant data suggest that the temperature is 1.65°C above average. In fact, 2024 is to date the fortieth consecutive year of above-average temperatures. In Morocco, unprecedented heat waves occurred, with temperatures reaching 41°C in July of this year. As a backdrop to the upward trajectory of temperatures, the structure of the Moroccan economy is amplifying the economic and financial effects of climate change. Agricultural activity predominates the Moroccan economy. Although the added value of agriculture contributes around 10% of GDP, it also indirectly makes additional contributions through other sectors such as transport and agri-food. Any perturbation in agricultural activity has the potential to extend to the rest of the economy, either directly or indirectly. With this in mind, and given the presence of climate change, added value in the agricultural sector declined by 4.8% in 2024 (HCP 2024). Although household final consumption expenditure and non-agricultural activity were on a positive trend, the agricultural sector experienced a decline that cannot be explained by economic conditions. One possible explanation, however, is the climate data presented above.

Furthermore, it's interesting to note that economic implications can be transmitted to the financial sphere through the macro-financial linkage. In essence, the deterioration in agricultural activity has repercussions on gross domestic product (GDP), which in turn has a negative impact on corporate cash flows. As a result, their ability to honor their financial commitments deteriorates (Achmakou and Hachimi Alaoui 2024). In sum, financial risk is growing in magnitude. In this respect, it is essential to examine the evolution of data related to the financial sphere. Considered to be a representative indicator of the financial system's resilience, non-performing loans have shown a remarkable rise over the past decade. They rose from 44 232 MDH in December 2013 to 97 160 MDH in December 2024 (Bank Al-Maghrib 2013, 2024).

These observations can be presented as potential implications of climate change. In this sense, climate change is not just an environmental issue, but also has a profound impact on the economic and financial sectors. Indeed, the persistence of extreme climatic conditions and the deterioration of agricultural activities weakens macroeconomic equilibrium, increases the probability of corporate default, and heightens the vulnerability of the financial system. Formally, these are the founding hypotheses of this paper, represented by the culpability of climate change in financial risk. To our knowledge, there is no study that has dealt with, in an integrated framework, the way in which changes in temperature could affect not only precipitation, but also the economic sphere, i.e., the GDP, and consequently the default probability of companies. The few studies that have tackled the subject in the Moroccan context, such as (Abdelmajid et al., 2021; Benkachchach and El Issaoui 2024; En-Nia, Liouaeddine, and Mansouri 2025), are limited to studying the effect of climate change on agricultural GDP, but do not analyze the effect on financial risk, nor do they exploit the mechanism that unites climate variables with financial figures. In this respect, we consider our current study to be justified.

To verify this and highlight the potential mechanisms through which climate change affects financial risk, we employ a Bayesian Vector Autoregression (BVAR) model. The main reason for choosing this approach is its robustness and superior performance compared with the standard VAR model (Doan, Litterman, and Sims 1984; Litterman 1986). The analysis uses data covering the period 2007Q1–2022Q1, a period marked by increasing global climate stress. In addition to quantifying the direct impacts of climate fluctuations on precipitation, this approach allows us to assess their effects on key economic indicators, such as the GDP gap and non-performing loans (NPLs). NPLs are considered early warning indicators of corporate default risk and are therefore a relevant measure of financial vulnerability.

Existing studies generally follow two separate strands. The first examines the impact of climate change on agricultural production and economic activity without considering financial stability (Ouraich and Economy 2014) (Amiri et al. 2021) and (Houria and Fatima 2021). The second investigates the implications of climate risks for the financial sector, yet typically treats climate risk as an exogenous driver of financial instability without explicitly modelling its transmission through the real economy. This study bridges these two strands by empirically tracing the transmission of climate shocks from agricultural production to macroeconomic activity and ultimately to banking sector vulnerability, using a Bayesian VAR framework.

The rest of the paper is structured as follows. Section 2 presents a brief literature review. Section 3 explains the data selection and presents the descriptive statistics. Also, it introduces the method that we applied. We present and discuss the empirical results in Section 4. Finally, Section 5 concludes.

2. Literature Review

The literature relating to the effect of climate change on the financial sphere can be decomposed into two main parts. The first takes a narrow view, focusing on the impact of climate conditions on the probability of corporate default and the quality of banking assets. The second takes a systemic approach, studying the implications of climate change for the financial system as a whole.

a. Climatic impact on financial risk

In the Chinese context, (Fan et al. 2024) highlighted the effect of climate change on financial risk, as represented by non-performing loans (NPLs). They noted that rising temperatures reduce worker productivity. As a result, individual and corporate incomes decline, and the ability of economic agents, households and corporations, to honor their financial commitments diminishes. Consequently, outstanding debts increase, which in turn reduces the quality of banks' assets and their resilience. In summary, temperature fluctuations increase financial risk. These conclusions were confirmed in the same context by (Brik 2024) using quantile regression. Similarly, in Africa, (Bell and van Vuuren 2022) point out that climate shocks increase default probabilities and default losses.

Following the same line, (Mirza et al. 2024; Nguyen, Diaz-Rainey, and Kuruppuarachchi 2023; Turnbull 2023) highlight the effect of climate change on financial risk through two channels: transitional and physical. The first refers to the negative implications of the transition to a low-carbon economy on companies' probability of repayment, often linked to changes in policies, regulations, or consumer preferences. The second refers to the consequences of direct damage caused by extreme climatic events, such as floods, droughts, and storms, on the probability of default (Gao, Ju, and Yang 2023). In this regard, and using a dynamic credit rating model based on survival analysis, (Zanin, Calabrese, and Thorburn 2024) demonstrated that in U.S. regions exposed to extreme events, the probability of default increases by around nine percentage points compared to unexposed regions.

However, (Mirza et al. 2024) note the heterogeneity of this effect across companies depending on their compliance with environmental rules. In fact, those with the best environmental ratings, i.e., scores reflecting stronger environmental management practices, show some resilience to such risks (Bandyopadhyay and Kashyap 2023; Kabir et al. 2021). Another dimension of heterogeneity was identified by (Lee, Zhang, and Lee 2024), who found that small banks, regional banks, and banks with lower levels of liquidity are most exposed to climate shocks.

b. Climate change and systemic risk

While some studies emphasize the impact of climate change on firms' ability to repay their debts and on the quality of banks' assets, its repercussions can also be observed on a broader scale. An increasing number of papers have examined the implications of climate change for systemic risk and the stability of the financial system as a whole (Basher and Sadorsky 2024; Heo 2024). In this regard, (Dafermos, Nikolaidi, and Galanis 2017) illustrate, using a macroeconomic ecological stock-flow-fund model, how climate change can undermine financial stability. The mechanism is similar to the macro-financial channel: worsening climatic conditions reduce firms' profitability and liquidity, increase the likelihood of default (Capasso, Gianfrate, and Spinelli 2020), and cause bond prices to collapse. At this point, access to financing, i.e. credit, slows down. In effect, the climatic recession gains in amplitude and the loop becomes tighter.

Beyond the macro-financial channel, (Wu et al. 2023) analyse the impact of climate change on financial risk through the lens of volatility. From this perspective, climate conditions affect asset price volatility (Penzin, Isah, and Salisu 2025; Zhou and Ma 2025), thereby heightening credit and systemic risks. (Basher and Sadorsky 2024; Heo 2024) identify similar patterns via the channel of global warming concerns and international climate-related meetings. They find that heightened concern over global warming tends to increase systemic risk in bear and normal markets, whereas such meetings tend to reduce systemic risk in normal market conditions. The latter result aligns with the view that increased media coverage of climate change and its associated dangers can mitigate systemic financial risk.

The literature also examines climate change and financial stability through the prism of transition risk. In both the stock and flow perspectives, the transition effect is more severe for sectors with high carbon exposure, those responsible for significant greenhouse gas emissions (Penzin, Isah, and Salisu 2025; Wang et al. 2025; Zhang, Li, and Liang 2025). In such cases, increased exposure to carbon-intensive assets heightens systemic risk in proportion to the pace of transition. Climate policies (e.g., carbon taxes) and restrictions on specific activities erode the profitability and asset quality of firms and banks linked to high emissions, thereby increasing the vulnerability of the financial system.

3. Methodology: Data and Econometric Model

This section presents both the econometric model and a description of the related variables.

a. Model Variables

As this paper aims to address the question of the effect of climate change on financial risk, it is necessary to identify the different variables to be analyzed for this purpose. In this respect, we consider precipitation and temperature as representative of climatic conditions. Financial stability is proxied by NPLs, while the GDP gap represents the business cycle. In fact, the latter constitutes a channel for transmitting climate shocks to the financial sector. It includes the added value of the agricultural sector, enabling us to capture the impact of climate warming on the business cycle. In other words, our econometric model assumes that altered climatic conditions affect agricultural yields, which in turn influence the economic cycle and, consequently, determine the financial cycle.

The following table describes the different variables involved in the model.

Table 1:Description des variables

Variable	Definition	Source
Precipitation	Observed annual precipitation in mm	Climate change information portal (World Bank)
Temperature	Average annual observed surface temperature (°C)	Climate change information portal (World Bank)
Gdp	Gross Domestic Product in volume	International Monetary Fund (IMF)
NPLs	Non-performing loans	Bank AL Maghreb

Source: Authors development

To capture the effect of climate change on the economic and financial cycle, the related variables are considered in their cyclical component. In other words, for each of the variables GDP and NPLs, HP filters are used to extract the cyclical component that will be incorporated into the model. In this sense, the lambda parameter value is set at 1600.

To set up the Bayesian VAR (BVAR) model using quarterly data for the period from 2007Q1 to 2022Q1, it was necessary to homogenize the frequency of all the time series making up the model. While the economic and financial variables were quarterly, the two climate variables, surface temperature and precipitation volume, were only available at an annual frequency. To achieve temporal homogeneity, we applied linear interpolation to these two-climate series to transform them into a quarterly frequency. This choice is justified along two dimensions, balancing statistical constraints with conceptual focus.

On the one hand, from a statistical perspective, this homogeneity within the model ensures the consistency of the dynamic estimates required by the BVAR, while expanding the sample size to 61 observations. This approach maintains the degrees of freedom necessary for stable Bayesian inferences and valid impulse response functions (IRFs), which a strictly annual sample (N=15) would fail to guarantee. On the other hand, from a conceptual perspective, this transformation aligns with the objective of our study, which focuses on the macroeconomic impacts of long-term climate trends (i.e., structural climate change) rather than high-frequency, intra-annual weather volatility or seasonal shocks. Although linear interpolation assumes a smooth intra-annual evolution, accepting the risk of altering the short-term dynamic structure, this smoothing acts as a filter that isolates the underlying transitional climate trends. While it is not a technique designed to eliminate seasonality in the traditional statistical sense, the linear interpolation guarantees strict temporal consistency and synchronized co-movements with the quarterly economic and financial variables, ultimately ensuring the robust identification of macro-climatic transmissions

Table 2 shows the descriptive statistics of the four variables composing the econometric model: the cyclical GDP gap, NPLs, temperature, and precipitation.

Table 2: descriptive statistics

	gdp	**NPLs**	**Precipitation**	**Temperature**
Mean	0.001768	-4.5E-10	315.1948	18.36571
Median	0.003761	-1070.38	296.1100	18.35000
Maximum	0.030778	9548.656	489.1200	19.10000
Minimum	-0.064189	-7022.02	221.9800	17.68000
Standard deviation	0.019251	4548.132	70.69025	0.348978
Asymmetry	-1.808219	0.263353	0.733927	0.193999
Kurtosis	7.719031	2.298688	2.890968	2.665447
Jarque-Bera	30.92939	0.673100	1.895672	0.229659
Probability	0.000000	0.714230	0.387579	0.891518
Nombre d’observations	61	61	61	61

Source : Authors development

b. Econometric Model

To examine the macroeconomic effects of climate change, we opted for a Bayesian Vector Autoregression (BVAR) model. This choice is primarily motivated by the inherent limitations of traditional VAR models, especially when dealing with limited available data or complex interactions between macroeconomic variables that benefit from the further estimation flexibility and shrinkage priors provided by the BVAR framework.

The choice of a Bayesian Vector Autoregressive (BVAR) model over a classical VAR is dictated by the empirical necessity to overcome the "curse of dimensionality" inherent to our sample size, 61 observations spanning the period 2007Q1–2022Q1. In an unrestricted frequentist VAR with two lags $(p = 2)$ and four variables (k=4), the number of parameters to be estimated amounts to 36 $(k(kp + 1))$. Therefore, for high-dimensional time series, estimating the parameters of a VAR model becomes complicated or even unfeasible (Pavlyuk 2019).This excessively high ratio of parameters relative to available observations leads to severe overfitting, excessive coefficient variance, and numerical instability when faced with the local collinearity induced by climate data interpolations. The Bayesian approach resolves this constraint by introducing mathematical regularization via prior probability distributions. Rather than arbitrarily forcing certain coefficients to zero at the risk of introducing omitted-variable bias, the BVAR model preserves the entire dynamic structure while shrinking superfluous parameters toward zero, thereby guaranteeing the robustness of the impulse response functions (IRFs).

Within this framework, structural climate shocks are extracted using a Cholesky decomposition based on the following ordering of the system's variables: $y_t = (Temperature_t, Precipitation_t, gdp_t, NPLs_t)^T$, where y_t is a k×1 vector of time series at time t. This specific recursive ordering is strictly grounded in physical and economic rationale. First, the climate variables $(Temperature_t, Precipitation_t)$ are placed at the top of the ordering because they are contemporaneously exogenous to the economic system; while weather anomalies can instantly disrupt human and economic activity, macroeconomic aggregates cannot exert a contemporaneous feedback effect on regional climate conditions within the same period. Second, within the economic block, a climate shock is assumed to affect aggregate output (gdp_t) first, through immediate channels such as agricultural losses, infrastructure damage, or labor productivity drops. This macroeconomic contraction subsequently transmits to the financial sector with a lag, ultimately reflecting in the accumulation of Non-Performing Loans $(NPLs_t)$ in the banking system.

Our BVAR (Bayesian Vector Autoregressive) model can be mathematically formulated as follows:

$$y_t = A_0 + \sum_{i=1}^{p} A_i y_{t-i} + u_t \tag{1}$$

Where the variables are the series: surface temperature, precipitation, gross domestic product (gdp) and non-performing loans (NPLs). We will assume that there are k variables in the model, here k=4. We note that:

- $y_t = (Temperature_t, Precipitation_t, gdp_t, NPLs_t)^T$ is a $k \times 1$ vector of time series at time t.
- A_0 is a $k \times 1$ vector of constants or intercepts.
- A_i is $k \times k$ matrix of coefficients for the i-th delay, for $i = 1,2, \dots, p$.
- u_t is $k \times 1$ vector of error terms or shocks (innovations) with covariance Σ_u, $u_t \sim i.i.d.\mathcal{N}(0, \Sigma)$.

Since standard (non-Bayesian) VARs suffer from overparameterization as long as the number of variables is large. The Minnesota prior makes it possible to reduce uncertainty on coefficients by injecting economic information on lags. Under this condition, forecast accuracy is improved, the model complexity is controlled and VAR estimates are stabilized. In other words, the Litterman-Minnesota prior is used to regularize the coefficients by introducing certain constraints to account for the temporal structure of the data. The objective is to give greater weight to coefficients associated with lags close to time t, whereas those of more distant lags receive less weight. In addition, prioritization favors low coefficients for variables with low correlation, allowing them to be distributed around zero.

According to Litterman–Minnesota prior, coefficients in the matrix A_i follow a normal distribution, with mean zero and inverse variance proportional to the distance between variables and lags. The variance of each coefficient is thus expressed as $\frac{\lambda}{(1+i)^2}$, where λ is a hyperparameter that controls the intensity of the regularization, and i represents the lag. For errors u_t, it is supposed to follow a normal distribution with covariance Σ_u, which can be estimated from the data or by a specific prior. This Bayesian framework enables us to model the relationships between the different variables in a flexible way, while avoiding overlearning. We can present the Minnesota Moments as follows:

$$\mathbb{E}\left[(A_\ell)_{ij} \mid \Sigma\right] = \begin{cases} \delta_i & \text{if } i = j, \ell = 1 \\ 0 & \text{else} \end{cases}$$

$$\text{Var}\left[(A_\ell)_{ij} \mid \Sigma\right] = \begin{cases} \dfrac{\lambda_1^2}{f(\ell)} & \text{if } i = j \\ \dfrac{\lambda_1^2}{f(\ell)} \cdot \dfrac{\Sigma_{ij}}{w_j^2} & \text{if } i \neq j \end{cases}$$

Where :

- $\delta_i = 1$: this reflects the expectation that the own-lag coefficient at lag 1 is close to 1, consistent with a random walk behaviour.
- λ_1 : global tightness of the prior. The smaller it is, the stronger the prior (i.e., more weight is given to the prior relative to the data).
- $f(\ell)$: lag decay function. A common choice is $f(\ell) = \ell^2$, which implies that more distant lags are considered less important.
- ω_j^2 : scale factor of variable j, typically estimated as the variance from a univariate autoregression. It adjusts for differences in the magnitude of the variables.

4. Results and Discussion

In this section, we estimate a BVAR model, present simulations of climate shocks and discuss the results. To this end, we use quarterly data on temperature, precipitation, GDP and non-performing loans. Table 4 shows the estimation results. We note that according to the Akaike (AIC), Schwarz-Bayesian (SC) and Hannan-Quinn (HQ) criteria, we choose two lags as the optimal lag.

The results of the BVAR model provide insight into three dynamic relationships between climate variables and economic and financial components. First, temperature has a delayed effect on precipitation, indicating a gradual instability in weather conditions. Second, climate variations have a direct impact on economic activity, i.e., gross domestic product, implying that the economic cycle is exposed to climate risk. Finally, and most importantly, climate change affects financial risk. In fact, high temperatures lead to an upward trend in non-performing loans, illustrating the relationship between climate stress, weakened economic performance, and, consequently, the risk of financial stress. We illustrate these dynamic results below in terms of the model's impulse responses.

Table 3: Estimation Results

	Precipitation	Temperature	gdp	NPLs
Precipitation (-1)	0.807234 (0.04921)	-0.000399 (0.00021)	0.003136 (0.00652)	-0.004579 (0.00581)
Precipitation (-2)	0.017053 (0.04194)	0.000170 (0.00018)	0.002898 (0.00554)	-0.004826 (0.00494)
Temperature (-1)	-9.384431 (11.1385)	0.830593 (0.04856)	-1.467932 (1.48378)	1.759763 (1.32269)
Temperature (-2)	13.90402 (9.46116)	-0.021582 (0.04135)	0.081047 (1.26031)	0.450563 (1.12353)
gdp(-1)	0.590765 (0.54319)	-0.002875 (0.00236)	0.323348 (0.07278)	-0.032732 (0.06451)
gdp(-2)	0.070774 (0.34300)	-0.000761 (0.00149)	0.040954 (0.04610)	-0.005626 (0.04073)
NPLs(-1)	-0.335402 (0.52553)	0.000494 (0.00228)	0.043818 (0.07000)	0.484162 (0.06275)
NPLs(-2)	0.127601 (0.36641)	-0.000546 (0.00159)	0.033072 (0.04881)	0.086157 (0.04389)
C	-27.36093 (157.374)	3.606659 (0.68301)	23.33073 (20.9657)	-37.93439 (18.6891)

() Values in brackets correspond to the respective standard errors. *Source: Authors development*

The impulse response functions (IRFs) estimated from the BVAR model allow for an analysis of the dynamics between climatic variables (temperature and precipitation) and economic variables (GDP and NPLs). These analyses reveal the effects of climatic shocks on the Moroccan economy and financial system, highlighting complex interaction mechanisms. Graphs 1 and 2 show that the responses vary in both intensity and duration depending on the variable and type of climate shock. The BVAR IRFs highlight two key dynamics. First, they capture the interactions among climate variables, particularly between precipitation and temperature. Second, they trace the transmission of climatic shocks to the real economy and, subsequently, to the financial system via GDP and non-performing loans (NPLs).

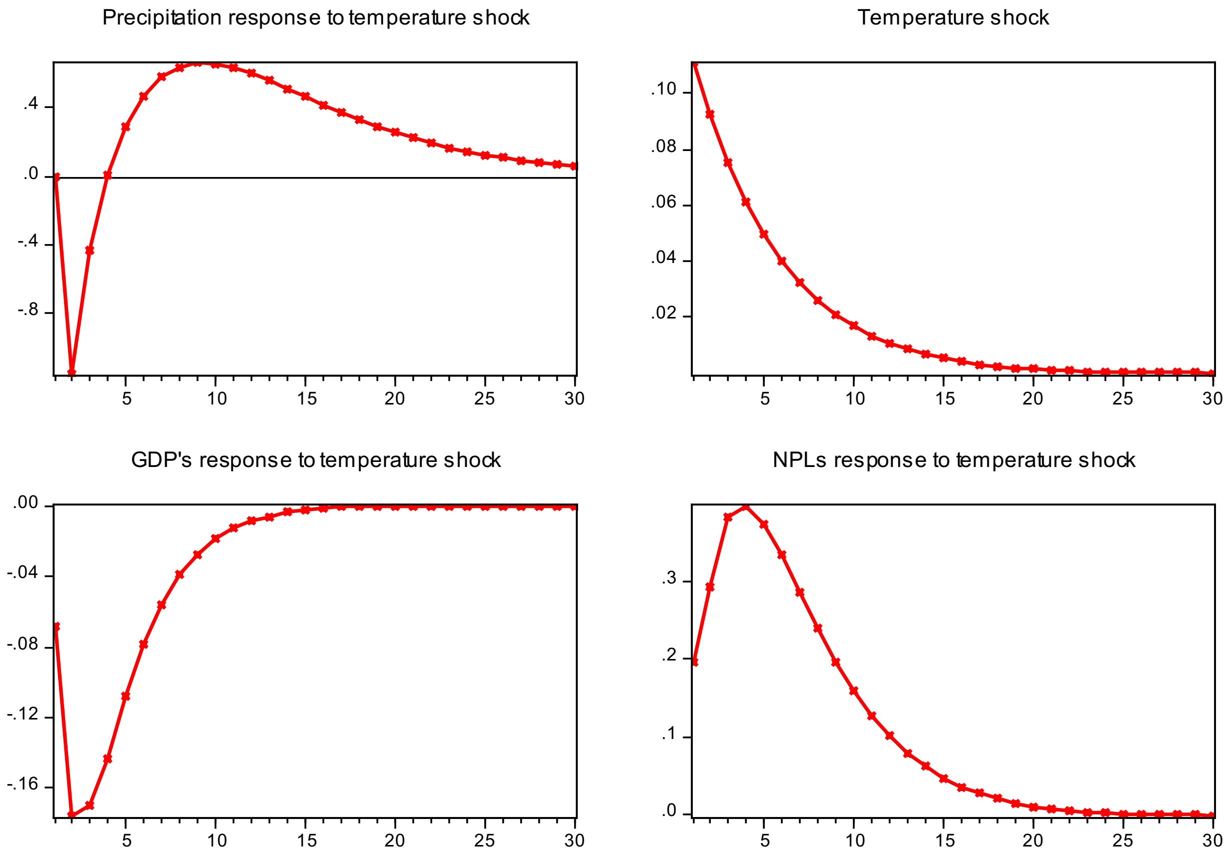
As economists, our main focus is on the economic and financial effects of climate disruption. However, it is justified to take into account the interactions between climate variables, not for their intrinsic interpretation, but to reinforce the robustness of the modeling. Integrating the effects of temperature and precipitation simultaneously, as well as the interactions between these two dimensions, makes it easier to identify the overall climatic impact on economic indicators. This helps limit omission biases and more realistically reflect the mechanisms by which climate influences the business and financial cycle.

Regarding climate dynamics, the effect of temperature on rainfall patterns is well documented in the scientific literature. There are several studies showing that an increase in temperature tends to reduce precipitation and thereby reinforce drought conditions (Khodayar, Kalthoff, and Kottmeier 2018; Martin-Vide et al. 2022; Serra et al. 2014). This rise in temperature is taking place as global warming, leading to drier conditions and a progression towards increased drought (Arellano, Zheng, and Roca 2025). Conversely, precipitation events can locally modify surface temperature, according to results from climate models (Acero et al. 2024; Kollet et al. 2009; Wei et al. 2014). These bidirectional interactions testify to the complexity of climate systems and justify their simultaneous consideration in the econometric models studied. The impulse responses to a precipitation shock, represented in graphs 1 and 2, confirm these dynamics. The first shows that the precipitation shock is transitory, fading progressively over some 15 periods, indicating a damped response. The temperature reacts negatively to this shock, with a sharp drop followed by a slow return to equilibrium. This reverse reaction illustrates physical mechanisms well established in the literature, where increased humidity in the atmosphere favors more moderate temperatures.

More directly, the analysis of the economic variables reveals that the temperature shock leads to a substantial contraction in GDP, persisting over several periods. This dynamic illustrates the high sensitivity of the Moroccan economy to climatic disturbances. This can be explained by the agricultural channel. In fact, the decline in agricultural production is transmitted to the rest of the economy, generating a deterioration in overall activity. The transmission of the climatic effect to GDP through agriculture is not limited to a direct accounting effect, i.e. the simple inclusion of agricultural value added in the calculation of GDP. It also includes indirect effects, affecting non-agricultural activities dependent on agriculture, such as agri-food, transport and rural business. Further, the financial consequences are also underlined. The negative response of GDP leads to a significant increase in non-performing loans. This reflects the transmission of economic pressures to the banking sector, notably via the deterioration of firms' cash flow and the increase in payment defaults.

The impulse responses to a precipitation shock, shown graphically in Figure 2, confirm the above dynamics. Temperature reacts negatively to an increase in precipitation. This inverse reaction illustrates physical mechanisms well documented in the literature, where increased humidity in the atmosphere leads to more moderate temperatures. In economic terms, the GDP response to a positive precipitation shock is positive. This suggests that more favorable climatic conditions improve production, particularly in the agricultural sector, which is highly exposed to rainfall variations. Downstream, we observe a reduction in non-performing loans (NPLs), following the improvement in agricultural income and economic agents' cash flow. This indicates a temporary easing of financial pressure on the banking system. Moreover, Figure 2 shows that the rainfall shock is transitory, diminishing gradually over around thirty quarters. The long amortization delay can be explained by the considerable water storage capacity. Morocco has 145 large dams with a storage capacity of 18.67 billion m3. This asset makes it possible to extend the benefits of a positive precipitation shock.

Figure 1: Business and financial cycle response to positive temperature shock

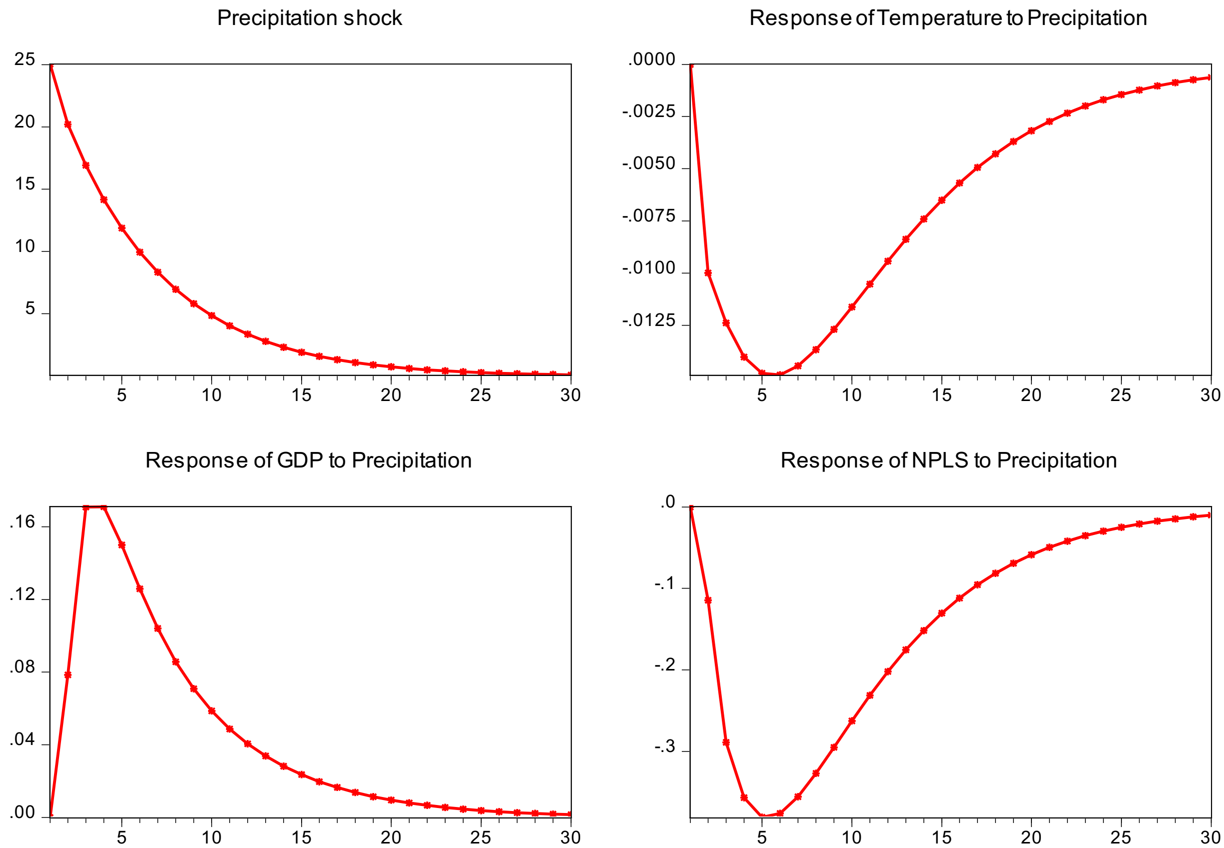


Source: Authors development

Overall, the results show that climate shocks have a significant and differentiated, impact on the various economic dimensions. The economic and financial spheres appear particularly vulnerable. These complex interactions underline the need to anticipate climate impacts and integrate adaptation and resilience strategies into economic policies. In other words, climate change represents a serious challenge for the Moroccan economy, particularly given the country's dependence on its agricultural sector, which contributes significantly to GDP and employment. Variations in temperature and precipitation, amplified by climate change, have a direct impact on agricultural production, influencing crop yields and the availability of water resources. These disruptions are transmitted to the rest of the Moroccan economy, notably through the volatility of agricultural incomes and pressures on foreign trade, given the role played by agricultural exports.

In financial respects, these climatic shocks also affect the quality of banking assets. A drop in agricultural production or weather-related economic instability can reduce the ability of households and agricultural businesses to honor their financial obligations, leading to an increase in non-performing loans (NPLs). Furthermore, financial and economic infrastructure can be undermined by extreme climatic events, amplifying systemic risks for the Moroccan financial sector. These results underline the urgent need for Morocco to adopt adaptation and resilience measures, such as more efficient irrigation, the development of crops resistant to extreme weather conditions, and the introduction of innovative financial instruments, such as climate insurance, to mitigate the risks associated with climate change.

Figure 2: Business and financial cycle response to positive precipitation shock



Source: Authors development

The results from the BVAR model reinforce several dynamics identified in the literature relating to the economic impact of climate change. Firstly, the interaction noted between temperature and precipitation emphasizes the need to integrate these two climatic dimensions into econometric models. Indeed, although these connections are not the direct object of our economic analysis, taking them into account helps to enhance the model's robustness and better identify climate transmission channels. This approach is consistent with the work of (Khodayar, Kalthoff, and Kottmeier 2018; Martin-Vide et al. 2022; Serra et al. 2014), who demonstrate that rising temperatures lead to a reduction in rainfall, thereby accentuating drought episodes. Conversely, some studies also point out that precipitation can lead to local temperature moderation (Acero et al. 2024; Kollet et al. 2009; Wei et al. 2014), which is confirmed by the impulse responses to rainfall shocks in our model.

From an economic perspective, the results highlight the vulnerability of Morocco's gross domestic product to weather-related shocks, particularly through the agricultural channel. In particular, high temperatures lead to a significant and persistent contraction in GDP. This result reflects the Moroccan economy's high dependence on agriculture, a sector particularly exposed to climatic conditions. This dependence is not limited to a direct accounting relationship, in which the fall in agricultural value added mechanically affects GDP, but extends to indirect effects affecting downstream sectors such as agri-food, transport, and rural trade. This dynamic confirms the work of (Fan et al. 2024) and (Bell and van Vuuren 2022), who emphasize that losses in heat-related productivity reduce incomes, with repercussions for the real economy as a whole.

Another impact of climate change is seen in the financial sector. The increase in NPLs in response to temperature shocks is explained by the contraction in economic activity and the decline in the ability of households and companies to honor their financial commitments. This transmission, from the climate to the real economy and then to the financial sector, is in line with the findings of (Brik 2024; Mirza et al. 2024; Zanin, Calabrese, and Thorburn 2024), who underline the link between physical climate risks and deterioration in the quality of banking assets. Conversely, positive precipitation shocks improve economic conditions and reduce NPLs, due in particular to higher agricultural incomes and improved cash flow. This trend is all the more pronounced given Morocco's substantial water storage capacity, via its dams, thus prolonging the beneficial effects of rainfall shocks over several periods.

Finally, while the model focuses on macro-financial variables, the dynamics observed suggest a risk of systemic propagation. GDP decline, combined with rising non-performing loans, can activate an unfavorable macro-financial cycle, similar to that described by (Capasso, Gianfrate, and Spinelli 2020; Dafermos, Nikolaidi, and Galanis 2017). This cycle, in which climate degradation affects corporate profitability, limits access to credit and reinforces economic tensions, is particularly worrying in a country where economic diversification remains limited. These findings underline the importance of integrating climate risk into economic and financial policies, through adaptation instruments such as climate insurance, support for resilient crops, or macroprudential mechanisms integrating environmental risks.

5. Conclusion

In the present study, we examine the impact of climate change - namely, temperature and rainfall variations - on Morocco's financial stability. Using a BVAR (Bayesian VAR) model, the results indicate that climate shocks are transmitted to the real economy, initially affecting agricultural production, and hence GDP, before degrading financial stability via an increase in non-performing loans. The results of the impulse response function analyses show that temperature shocks have a more destabilizing impact on financial stability, being more persistent than precipitation shocks.

These findings raise three key implications for public policy. Firstly, climate risks should be systematically considered in macroeconomic forecasts and integrated into financial prudential tools, particularly in climate-sensitive economies. Secondly, agricultural resilience policies should be synchronized with financial sector resilience programs to minimize contagion risks. Thirdly, climate-related risks could be incorporated into the calibration of monetary and macroprudential tools to contribute to financial stability.

In future research, it would be relevant to assess regional differences in climate vulnerability within the country, analyze the non-linear implications of climate shocks and evaluate green adaptation instruments such as climate insurance or sustainability-linked credits. In future research, it would be relevant to assess regional differences in climate vulnerability within the country, analyze the non-linear implications of climate shocks and evaluate green adaptation instruments such as climate insurance or sustainability-linked credits.

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