# Essays on Climate, Output, Inflation and Monetary Policy

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## Introduction

It is now clear that climate change-related shocks have impacts on the macroeconomy and financial stability (Dell et al., 2012; Dafermoset al., 2018). A vast body of work has determined that central banks face physical and transition risks to their mandates (Batten et al., 2016). The African continent is vulnerable to physical climate risks, and therefore it is vital to study how these risks interact with the macroeconomy and, in turn, monetary policy and its effectiveness. This is the premise of this thesis.

Paper 1 takes a broad view to understand the impacts of climate shocks on inflation in African economies. I use this work to determine what drives heterogenieties in results within countries on the continent. In particular, I focus on the weights of food and energy-related inflation (which differ across African countries) in driving overall inflationary outcomes. With the motivation that countries' climate shocks differ, I focus the rest of this thesis on the case of South Africa in subsequent work. The focus on South Africa in Papers 2-4 enables me to utilise granular, country-specific data, which is not otherwise available for other countries on the continent. This approach allows this work to present nuanced insights that can lead to actionable policy.

Although work has been done on understanding climate impacts on inflation and output, separately, there is little analysis on the potential inflation-output trade-off brought about by climate change. Moreover, much of the literature focuses on aggregates, whereas I will decompose inflation and output components in Paper 2.

It follows that if climate shocks are inflationary, central banks ought to use monetary policy to address this. However, climate-induced inflation, when accompanied with output losses, poses a potentially complex scenario for monetary policy to deal with. While the response of

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central banks to various shocks has been studied, the literature on climate shock responses is scant. Paper 3 addresses this.

Finally, I seek to understand how climate shocks alter monetary policy transmission through the credit channel - the channel that largely governs financial stability. While there exists a large body of literature that seeks to understand the credit transmission channel, much less work considers how climate shocks can yield additional frictions within the credit channel. Hence, Paper 4 will produce evidence of whether and to what extent climate shocks act as credit channel transmission frictions.

# Variables and Data

**Climate Variables and Data.** The climate shock explanatory variable used in each paper consists of temperature and precipitation anomalies, as well as the extremes of precipitation anomalies. I will use the European Centre for Medium-Range Weather Forecasts Reanalysis (ERA-5) data on global temperature and precipitation spanning from 1979 to date, in line with Usman et al. (2024), Kotz et al.(2022) and Kotz et al. (2021). Temperature is computed in Kelvin and will be transformed to degrees Celsius by subtracting 273.15. Precipitation is measured in millilitres. Each climate shock will be weighted by population for ease of interpretation (Hersbach, et al., 2023; Copernicus Climate Change Service, 2021).

To devise temperature and precipitation shock variables, I compute the deviation from each climate variable's long-run monthly mean, as done by Usman et al. (2024) and Kabundi, et al. (2022). Where relevant for a given paper, quarterly aggregates will also be calculated from monthly data. The climate shock variables are devised as follows:

$$\text{shock}_{i,j,t} = \frac{x_{i,j,t} - \bar{x}_{i,j,t}}{\sigma_{i,j,t}} \tag{1}$$

Where:

$x_{i,j,t}$ represents the climate variable $i$ (either temperature or precipitation) in country $j$ at time $t$.

$\bar{x}_{i,j,t}$ denotes the long-run average climate variable value for climate variable $i$ in country $j$ at time $t$. The dates used to compute the long-run average climate shock will differ in each paper according to each analysis period. In general, the long run average will be computed from the same quarter or month's average temperature or precipitation in the preceding 10-30 [1] years.

$\sigma_{i,j,t}$ is the standard deviation of each climate variable $i$ in country $j$ in quarter or month $t$.

To enrich this analysis, I will devise two extreme variables using the precipitation data. In line with Felbermayr & Gröschl (2014), I construct an extreme dry dummy variable as an

[1]The sample period used in Paper 2 will be relatively shorter than the other paper's sample periods. As such, Paper 2 will have the longest historical mean period due to the availability of more data to devise a historical mean.

occurrence where, in at least three consecutive months, precipitation falls below half of $\bar{x}_{i,j,t}$. Similarly, I denote an extreme wet dummy variable as the occurrence of a positive change in monthly precipitation.[2] [3] Therefore, the climate shock variable encompasses a temperature shock, a precipitation shock, an extreme dry event and an extreme wet event variable.

To conduct sensitivity analysis in each paper, I will deploy the Weighted Climate Data. This dataset houses both temperature and precipitation data measured in the same units as the ERA-5 data, but available between 1940 and 2022 only (Gortan, et al., 2024).

**Economic Variables and Data.** Table 1 denotes the main economic variables used in this thesis. Each dataset is either freely available online or through the South African Reserve Bank (SARB), which I have full access to because I am an employee of the Bank. The analysis in each paper will include a sample period of the longest available horizon of available data. The frequency of analysis for Papers 3, 4, and 5 is quarterly, where monthly data are aggregated. Papers 1 and 2's analyses are conducted using a monthly frequency, where relevant quarterly economic data will be linearly interpolated.

**Table 1: Economic Data**

| **Variable Name** | **Date Range** | **Frequency** | **Source** | **Use** |
|---|---|---|---|---|
| Global Consumer Price Index (CPI) [4] | 2000-2025 | Monthly | SARB | Paper 1 |
| Global Food and Non-Alcoholic Beverages Weight in Headline Inflation | 2000-2025 | Monthly | IMF | Paper 1 |
| Global Housing, Water, Electricity, Gas and Other Fuels Weight in Headline Inflation | 2000-2025 | Monthly | IMF | Paper 1 |
| South African CPI [5] | 2008-2025 | Monthly | SARB | Paper 2,3,4 |

[2] The time-frame rationale is that drought-like occurrences (proxied by the extreme dry variable) happen over an elongated time period. In contrast, flood-like incidents (proxied by the extreme wet variable) are much shorter-lived.

[3] Africa is most vulnerable to floods and droughts (Kunawotor, et al., 2022). Additionally, floods, droughts and storms make up 80% of South Africa's natural disaster events, hence the emphasis on extreme dry and wet events (EM-DAT, 2025).

[4] Including global country-level CPI for the following categories: Headline, Food and Non-Alcoholic Beverages, Alcoholic Beverages, Clothing, Housing, Household Goods, Health, Transport, Communication, Recreation and Culture, Education, Hotels, Other, Energy.

[5] Including South African CPI for the following categories: Headline, Processed Food, Unprocessed Food, Food and Non-Alcoholic Beverages, Food, Cereal Products, Meat, Fish and Other Seafood, Milk, Other Dairy

| | | | | |
|---|---|---|---|---|
| South African Gross Value Added (GVA) [6] | 1960-2025 | Quarterly | SARB | Paper 2 |
| South African Employment Rate [7] | 2000-2025 | Quarterly | SARB | Paper 2 |
| South African Industrial Production [8] | 1998-2025 | Monthly | SARB | Paper 2 |
| South African Output Gap | 1990-2025 | Quarterly | SARB | Paper 3, 4 |
| South African Repurchase Rate | 2000-2025 | Quarterly | SARB | Paper 3 |
| Euro- and US-Rand Exchange rates | 1960-2025 | Monthly | SARB | Paper 3 |
| Forecast of the South African Repurchase Rate | 2000-2025 | Quarterly | Reuters Econometer, available through the SARB | Paper 4 |

Products and Eggs, Oils and Fats, Fruits and Nuts, Vegetables, Sugar, Confectionery and Desserts, Other Food, Non-Alcoholic Beverages, Hot Beverages, Cold Beverages, Alcoholic Beverages and Tobacco, Alcoholic Beverages, Spirits and Liqueurs, Wine, Beer, Tobacco, Clothing and Footwear, Clothing, Footwear, Housing and Utilities, Actual Rentals for Housing, Owners Equivalent Rent, Maintenance and Repair, Water Supply and Miscellaneous Services, Electricity, Gas and Other Fuels, Furnishings, Household Equipment and Routine Maintenance, Furniture, Furnishings and Loose Carpets, Household Textiles, appliances, Tableware and Equipment, Goods and Services for Routine Household Maintenance, Domestic Services, Health, Medicines and Health Products, Health Services, Transport, Purchase of Vehicles, Operation of Personal Transport Equipment, Fuel, Other Services, Passenger Transport Services, Transport Services of Goods, Information and Communication, Information and Communication Equipment, Information and Communication Services, Recreation, Sport and Culture, Recreational Goods, Recreational and Cultural Services, Newspapers, Books and Stationery, Package Holidays, Education, Primary and Secondary Education, Tertiary Education, Restaurants and Accommodation Services, Restaurants, Accommodation Services, Insurance and Financial Services, Insurance, Financial Services, Personal Care and Miscellaneous Services, Personal Care, Other Services.

[6]Including South African GVA for the following categories: Agriculture, Forestry and Fishing, Mining, Industry (which includes individual data for subcategories: Manufacturing, Electricity, Gas and Water Supply, and construction) and Services (which includes individual data for subcategories: Wholesale and Retail Trade, Transport, Storage and Communications, Finance, Real Estate and Business Services, Community, Social and Personal Services (which includes individual data for sub-sub-categories: Government Administration and Defense, Personal and Other Services)).

[7]Including the South African Employment Rate for the following categories: Agriculture, Mining, Manufacturing, Utilities, Construction, Trade, Transport, and Finance.

[8]Including South African Industrial Production for the following categories: Manufacturing, Food, Beverages and Tobacco, Textile, Clothing and Footwear, Vehicles, Mining, and Electricity, Gas and Water Supply.

| | | | | |
|---|---|---|---|---|
| Forecast of the South African Gross Domestic Product (GDP) | 2000-2025 | Quarterly | Reuters Econometer, available through the SARB | Paper 4 |
| Forecast of the South African CPI | 2000-2025 | Quarterly | Reuters Econometer, available through the SARB | Paper 4 |
| South African GDP | 1960-2025 | Quarterly | SARB | Paper 4 |
| South African Unemployment Rate | 2000-2025 | Quarterly | Statistics South Africa | Paper 4 |
| Bank Loan-to-Deposit Ratio | 1997-2025 | Quarterly | SARB | Paper 4 |

# Paper 1: Climate Shocks and Prices in African Economies: What is driving the heterogeneity?

*What drives differences in climate shock-induced inflation in African countries?*

The literature has established that climate change has economic consequences. One of these is inflation. Two of the most studied channels through which climate change can impact headline inflation are food and energy inflation. Food and energy inflation can be affected by climate change through both supply and demand channels (Liet al., 2023). On the supply side, a changing climate can put pressure on food production supply chains. In addition, climate change can reduce energy supply because of its impact on the productivity of energy supply-related inputs (Mukherjee & Ouattara, 2021; Atalla et al., 2018). Moreover, mitigation efforts against climate change, like the introduction of cleaner energy sources, also cause energy price volatility (Akan, 2023; Diawuo, et al., 2020). The demand side pertains to energy prices and adaptive behaviour. That is, to adapt to extreme weather, households may use more energy for heating and cooling, which raises energy demand (Zhang, et al., 2022).

Consequently, much of the existing literature on the climate shock-inflation nexus has also analysed food and energy inflation. Cevik and Jalles (2024) estimate the impact of climate on food prices and find that, for a panel of 173 countries, food inflation exhibits heterogeneous outcomes across income groups. Both droughts and floods exert positive pressure on food prices in a sample of African countries, and only extreme weather events impact headline inflation (Kunawotor, et al., 2022). While this work provides insights into food and headline inflation for the continent, there is no account of country-specific heterogeneities, including the role that the share of food prices in the calculation of headline inflation may play in driving heterogeneous country-level results. Energy inflation studies for the African context are scant. In Europe, temperature variability dampens energy prices and has small impacts on headline inflation (Lucidi, et al., 2024). Another study finds that in cold European countries, extreme low temperatures lead to higher energy prices in both warmer and colder countries. However, colder countries have lower extreme thresholds that yield equivalent energy price increments (Mosquera-Lopez, et al., 2024). These impacts on energy prices could have an impact on headline inflation for the African case, depending on the weight of energy-related components in the headline inflation basket, which are heterogeneous across African countries over time.

Baleyte et al. (2024) report that consumer prices have become less susceptible to extreme temperatures in recent decades compared to pre-COVID decades. They cite lower food price weights in today's consumer prices as a potential reason why consumer prices are more resilient to temperature extremes. I use this work to test this hypothesis directly. In particular, I investigate whether the weights of food and energy-related prices (proxied by the weight of housing, water, electricity, gas and other fuels in headline inflation) in headline consumer prices have a bearing on the inflationary impacts of climate shocks. While literature investigating the impact that the weighting of inflation components has exists[9], to my knowledge, this will be the first study to directly test and understand the role that these weights play in a climate shock context. As is commonplace in the literature, I also split the African sample according to monetary policy framework (Kabundi et al., 2022) and income group (Cevik & Jalles, 2024) to understand a holistic set of potential heterogeneity drivers.

I rely on impulse response function analysis using local projections in a panel setting, first put forward by Jorda et al. (Jordà, 2005) and then later used throughout the literature (Baleyte, et al., 2024; Cevik & Jalles, 2024; Kabundi et al., 2022). The advantage of local projections is their flexibility without compromising efficiency when samples are sufficiently large (Plagborg-Møller & Wolf, 2021). For each forecast horizon, h, the following baseline regression is estimated:

$$y_{i,t+h} = \alpha_i + \delta_t + \phi_h(L)y_{i,t-1} + \beta_h \,\text{Climate}^k_{i,t} + \varepsilon_{i,t+h} \tag{2}$$

Where $y_{i,t+h}$ is headline inflation in country $i$ during month $t$ at horizon $h$ such that $0 \leq h \leq H$.

$\alpha_i$ are country fixed effects.

$\delta_t$ are time fixed effects to account for seasonality.

[9]Knetsch, et al. (2025) show that the weighting of components in the inflation basket has pronounced impacts on inflation rates in European economies. Similarly, Gelos & Ustyugova (2017) find that countries with larger food and transport inflation weights are more likely to endure sustained upward inflationary pressure in response to commodity shocks. In addition, larger food and transport shares in CPI are associated with larger second-round inflationary effects following shocks.

$\phi_h(L)$ represents the polynomial lag operator.

$\text{Climate}^k_{i,t}$ represents a vector of exogenous climate shocks, $k$, including temperature and precipitation shocks, as well as extreme wet and dry events.

$\varepsilon_{i,t+h}$ are residuals.

In addition to studying the response of headline inflation to climate shocks, I augment this initial regression equation to understand which characteristics in African countries are driving results. To do this, I include the following variables in the regression to form interaction terms with the climate shock variables: a) Monetary policy regime (inflation versus non-inflation targeting) b) Low-income versus middle-income countries c) Share of food inflation in headline inflation and d) Share of housing, water, electricity, gas and other fuels in headline inflation.

As such, I estimate equations of the following form:

$$\begin{aligned} y_{i,t+h} = {} & \alpha_i + \delta_t + \phi_h(L)y_{i,t-1} + \beta_{0h}\text{Climate}^k_{i,t} + \beta_{1h}(\text{Climate}^k_{i,t} \times \text{Differentiator}^j_{i,t}) \\ & + \beta_{2h}\text{Differentiator}^j_{i,t} + \varepsilon_{i,t+h} \end{aligned} \tag{3}$$

Where $\text{Differentiator}^j_{i,t}$ denotes the variables, $j$, described in (a)-(d).

# Paper 2: Toward Understanding How Climate Change Impacts the Inflation-Output Trade-Off

*How do climate shocks impact the sectoral inflation-output trade-off?*

South Africa's vulnerability to weather-water-related shocks and temperature changes subsequently opens up the economy to potential inflationary and negative output pressures. The relationship between output and inflation has been studied extensively using New Classical and New Keynesian theories (see Chong Yang, 2021 for a review). The Phillips curve lens posits that an output-inflation trade-off exists in the short run. Shocks such as oil supply shocks represent one type of shock that is stagflationary (Kilian, 2009). Climate shocks – which yield supply and demand pressures – thus present interesting implications for the output-inflation trade-off, especially since these shocks occur more frequently and with larger intensities.

Although work has emerged on understanding macroeconomic impacts of climate shocks, this has generally been localised to either output or inflation. There is consensus in the literature on the existence of a negative climate-output relationship for climate variables including temperature and disasters (Kotz, et al., 2024; Colacito, et al., 2019; Felbermayr & Gröschl, 2014; Dell, et al., 2012). It is also now clear that these effects are disproportionately pronounced in developing countries (Cevik & Jalles, 2024; Cavallo, et al., 2021). Given the known impacts of climate shocks on inflation and output, it is vital to study these impacts in one framework to accurately assess the inflation-output tradeoff.

Climate shocks and temperature changes can have various implications for supply and demand, which stem from impacts on agricultural production, supply chain disturbances, tourism, and energy supply channels (Cevik & Gwon, 2024; Cevik & Jalles, 2024; Yuan, et al., 2024; Bartos & Chester, 2015; Scott, et al., 2012). These effects, in turn, can alter inflation. Therefore, a growing body of literature has begun to investigate the impact of climate shocks on inflation, including in African countries (Qi, et al., 2025; Cevik & Jalles, 2024; Kabundi, et al., 2022; Kunawotor, et al., 2022; Mukherjee & Ouattara, 2021). Much of this work has found that climate shocks[10] are inflationary. Moreover, recently, sector-specific price effects have been examined for Europe (Ciccarelli, et al., 2023).

Despite the growing body of literature that has sought to understand the growth and inflationary impacts of climate change, especially from a cross-country perspective, considerable room remains for evidence that quantifies these impacts for the South African case, in particular within CPI and GVA categories which represent sector-level insights. Moreover, much of the work that has been done includes little to no analysis of the potential stagflationary pressures that climate shocks could bring. This paper addresses this gap by quantifying climate-induced output and inflation impacts, decomposed by sector. Particular attention will be paid to the inflation-output relationship per sector, should one exist. The sectors to be studied include the food, energy, insurance, and tourism sectors.

The literature purports that the agricultural sector is the most vulnerable sector to the impacts of climate change (Bandara & Cai, 2014). Hence, I expect the contemporaneous impacts of climate-related shocks on agricultural-related sector prices and agricultural output to be the most pronounced. It is much less obvious how the effects in other sectors, especially in the South African context, compare. This evidence will provide a climate shock permeation framework that allows for nuanced and actionable policy recommendations to ameliorate climate-related macroeconomic impacts.

To undertake this work, I will use a Structural Vector Autoregression (SVAR). SVARs have been used to analyse the interaction between the environment and the macroeconomy in recent literature (Kim, et al., 2022; Mukherjee & Ouattara, 2021). I deploy an SVAR in this analysis because of the ability to impose a block exogeneity restriction, as done first by Cushman and Zha (1977) and later by others (Ozdemir & Obekcan, 2020; Allegret, et al., 2012; Mackowiak, 2007). This restriction allows for the climate block, $y_t^c$, to influence the economic block, $y_t^e$, contemporaneously and with a lag, without the reciprocal influence of $y_t^e$ on $y_t^c$ (Sosa & Cashin,

[10] Qi, et al., (2025) use the Climate Risk index (CRI) as a measure of a country's exposure and vulnerability to climate shocks. Cevik & Jalles (2024) use the EM-DAT database to compute climate-related natural disasters. Kabundi, et al. (2022) devise temperature and precipitation shocks in the same way as this thesis. Separately, they use floods, droughts and storms classified by the EM-DAT database. They assign the intensity of disasters from insights on the number of people affected by each disaster. Similarly, Kunawotor, et al. (2022) rely on the EM-DAT database to classify floods and droughts, and their intensity using number of people affected by each disaster. Mukherjee & Ouattara (2021) use temperature shocks.

2009).

To this end, the SVAR vector of endogenous variables is made up of two blocks as follows:

$$y_t = \begin{bmatrix} y_t^c \\ y_t^e \end{bmatrix} \tag{4}$$

Such that:

$$y_t^c = \begin{bmatrix} T_t, P_t, EW_t, ED_t \end{bmatrix} \tag{5}$$

$$y_t^e = \begin{bmatrix} \pi_t^i, X_t^j \end{bmatrix} \tag{6}$$

Where:
$T_t$ is a temperature shock variable
$P_t$ is a precipitation shock variable.
$EW_t$ denotes extreme wet events.
$ED_t$ denotes extreme dry events.
$\pi_t^i$ represents CPI, including CPI categories.
$X_t^j$ represents GVA, including GVA categories.

To assess the inflation-output trade-off through the Phillips curve lens, and as a robustness mechanism, I will also estimate employment by sector within the $y_t^e$ vector. Moreover, I will proxy $X_t^j$ with industrial production per sector (which is aggregated monthly, rather than quarterly) as a sensitivity test (Baleyte, et al., 2024).

The general structural model equation is given by:

$$Ay_t = By_{t-1} + \varepsilon_t \tag{7}$$

Where:
$A$ captures contemporaneous relationships within the system.
$B$ captures lagged relationships within the system.
$\varepsilon_t$ are structural shocks.

As done by Cevik & Jalles (2024), Kabundi et al. (2022), and Mukherjee & Ouattara (2020), I will also estimate impulse response functions to understand the evolution of these climate-economic dynamics.

# Paper 3: The Response of Monetary Policy to Climate-Induced Inflation

*What has the monetary policy response been to climate shocks over time?*

In the face of climate-driven inflation shocks, central banks face a policy trade-off conundrum. Monetary policy inaction following the occurrence of a climate shock risks undermining the anchoring of inflation expectations. On the other hand, monetary policy tightening could hinder economic recovery from a climate shock. Climate change has brought and will continue to bring about recurrent and more severe shocks, which central banks must manage in the context of the inflation-output trade-off. For the South African case, the adoption of an inflation targeting regime also complicates the Bank's response to output-inflation trade-off enhancing shocks.

Jordà et al. (2020) find that wars, which are disasters that destroy capital and are thus comparable to natural disasters, elevate the natural interest rate. Theoretically, this would necessitate an increase in the repurchase rate in response. According to Cantelmo et al. (2024), central banks respond to climate shocks, while Fratzscher et al. (2020) find that inflation targeting regimes withstand climate shocks better due to their strong response to these shocks. For the United States case, Kara (2017) finds that monetary policy does not ignore food price changes, which are sensitive to climate shocks.

While the response of the SARB to shocks has been studied before, this work has omitted the rigorous analysis of climate shock responses (Aye, et al., 2017). This paper will fill this gap. I will adopt a Time-Varying Parameter Vector Autoregression (TVP-VAR) to assess the monetary policy response to climate shocks over time, as initially done by Primiceri (2005). This model is suitable because it allows for the evolution of the coefficients and covariance as random walks over time. The TVP-VAR model is as follows:

$$y_t = A_t y_{t-1} + B_t x_t + \varepsilon_t \tag{8}$$

Where:

$y_t$ is a vector of macroeconomic variables including inflation, the output gap, the repurchase rate, and the exchange rate (in this order) at time $t$.

$A_t$ contains the coefficients of lagged dependent variables within this system.

$x_t$ is a vector of exogenous climate shocks including temperature and precipitation shocks, as well as extreme wet and dry events.

$B_t$ are time-varying coefficients of exogenous shocks.

$\varepsilon_t$ is a vector of error terms.

Finally, as done in Paper 2, impulse response functions will be computed to understand the evolution of the variables in this system.

# Paper 4: Climate Shocks and the Credit Market: A Monetary Policy Transmission Lens

*How do the effects of climate change impact credit markets and, in turn, monetary policy transmission through the credit channel?*

According to Bernanke and Gertler (1995), the credit channel is one of the key monetary policy transmission channels. Monetary policy affects the credit channel through its impact on the external finance premium [11]. Two linkages underscore monetary policy impacts on this premium: the balance sheet and the bank lending channel. The balance sheet channel stems from dynamics in the balance sheet and the incomes of borrowers, while the lending channel deals with how interest rates could impact lenders' loan supply volumes (Hall, 2001). The balance sheet channel has been well established as a significant monetary policy transmission channel (Altavilla, et al., 2024; Aysun & Hepp, 2013; Ashcraft & Campello, 2007). Notwithstanding, there remains room to provide empirical estimations of the credit channel's strength due to recent developments in the identification of monetary policy shocks. This is especially true for emerging economies where this work is scant (Pirozhkova & Viegi, 2024). This paper hones in on the balance sheet channel by estimating how climate shocks can reduce (or indeed enhance) the effectiveness of unanticipated monetary policy decisions on the behaviour of borrowers.

The main motivation of this paper is that like monetary policy shocks, climate shocks – because of their impacts on capital and labour inputs and, in turn, their erosion of firm profitability – can cause frictions within the credit market and have consequential financial stability ramifications (Dafermos, et al., 2018; Aglietta & Espagne, 2016). In so doing, climate shocks could widen the external finance premium and, in turn, stymie the efficacy of monetary policy pass-through. While this seems a likely course, there is also the potential for monetary policy to mute the deleterious climate shock effects on the credit market, in line with the literature that that studies how monetary policy can be used as a tool to tackle climate change (Roy, 2024; Boneva, et al., 2021; Monasterolo & Raberto, 2018). In either case, climate shocks play a role in the functioning of the credit market and, consequently, the credit market monetary transmission channel.

I will investigate to what extent the manifestation of climate shocks act as a credit market friction and how this (potential) friction impacts monetary policy transmission. This involves three parts. First, I will compute the monetary policy shock variable. Second, I will estimate the causal relationships of interest in this work using a panel regression. Finally, I will use a

[11] The external finance premium is governed by credit-market frictions which cause departures from lenders expected return and potential borrowers' expected costs.

quantile regression procedure to nuance these results.

**Step 1. Defining a monetary policy shock.** I use a monetary policy shock, rather than the monetary policy rate itself, as an indicator for monetary policy to ensure exogeneity within the regression framework (Miyajima, 2024). To this end, I replicate a shock variable devised by Merrino (2021) for the South African case based on a simplification of the work of Romer and Romer (2004) as follows:

$$\Delta r_t = \alpha + \tilde{r}_t + \sum_{t=0}^{2} \beta_t \Delta \tilde{y}_t + \sum_{t=0}^{2} \delta_t \tilde{\pi}_t + \varepsilon_t \tag{9}$$

Where: $\Delta r_t$ is the change in the forecast of the repurchase rate.
$\tilde{r}_t$ is the forecasted repo rate in levels.
$\tilde{y}_t$ is the forecasted real GDP growth rate.
$\tilde{\pi}_t$ is the forecasted consumer price index inflation rate.

The residuals from Equation 6, $\varepsilon_t$, are used as the $\text{MPShock}_t$ explanatory variable that follows in the panel regression estimation.

**Step 2. Panel Regression.** I use a panel regression to primarily test whether monetary policy shocks, when augmented with climate shocks, yield heightened or muted impacts on the credit market as follows:

$$\text{Credit}_{i,t} = \beta_0 + \beta_1 \text{Climate}_t^k + \beta_2 \text{MPShock}_t + \beta_3 (\text{Climate}_t^k \times \text{MPShock}_t) + \Gamma X_t + \gamma_s + \delta_t + \varepsilon_{i,t} \tag{10}$$

Where:

$\text{Credit}_{i,t}$ is the growth rate of credit extended to agent $s$ (households or corporates) at time $t$.

$\text{Climate}_t^k$ is the climate shock variable, including temperature and precipitation shocks, as well as extreme wet and dry events, which are each denoted by $k$.

The $\text{Climate}_t^k \times \text{MPShock}_t$ term tests whether the frictions introduced by climate change shocks are significant enough to modify the pass-through of monetary policy through the credit channel.

$X_t$ is a vector of control variables that includes GDP growth, the US Dollar-Rand exchange rate, the loan-to-deposit ratio and the unemployment rate.

$\gamma_s$ are agent, time-invariant fixed effects.

$\delta_t$ are time fixed effects.

$\varepsilon_{i,t}$ is the error term.

**Step 3. Quantile Regression.** I will deploy a quantile regression framework to ascertain whether weak, median or strong credit growth periods have differential effects. I expect that weak growth periods will yield the largest response to climate-augmented monetary policy shocks.

## Conclusion

This thesis will be made up of four papers, which will each contribute towards advancing knowledge on how climate change has and can impact output, inflation and monetary policy. To date, while more work is being done at the intersection of climate change and the economy, there remain important gaps in our understanding of the relations between climate shocks and heterogeneous inflationary responses on the African continent, the inflation-output trade-off (especially at sector-specific levels), how monetary policy responds to climate shocks; and whether climate shocks hamper the transmission of monetary policy through the credit channel, which is a channel vulnerable to the impacts of climate change. The latter three gaps are particularly pronounced for emerging market economies. In its entirety, this work contributes towards narrowing these gaps.

## Research Plan

I plan to complete this PhD in 5 years. I am an Associate Economist (in the research unit) at the SARB. Therefore, I am based in South Africa. I will overlap my PhD and work deliverables. I can do this because my job primarily involves producing research papers. The SARB will cover all expenses related to the programme. Moreover, in the third or fourth year of my PhD, I plan to visit Utrecht University for a minimum of three months. During this time, I plan to present my ongoing and completed work, participate in in-person seminars and conferences, and take any relevant classes to refine the thesis, if need be. I will also come to Utrecht in person to defend the thesis. The SARB will cover any costs related to these visits. During the duration of the PhD, I plan to meet with my supervisors at least twice a month. Table 2 lays out the sequencing of PhD activities for the duration of the program.

**Table 2: Research Plan**

| **Year** | **Quarter** | **Goals** | **Actions or Deliverables** |
|---|---|---|---|
| **1: Paper 1** | Q1 | Paper 1 literature review, define research questions | Literature review, defined research questions |
| | Q2 | Data collection and cleaning, data section documentation | Cleaned data file, data write up |
| | Q3 | Econometric analysis including robustness tests | Paper results |
| | Q4 | Complete paper 1 write-up, presentation of paper | Paper 1 draft |
| **2: Paper 2** | Q1 | Paper 2 literature review, define research questions | Literature review, defined research questions |
| | Q2 | Data collection and cleaning, data section documentation, preparation of go-no-go material | Cleaned data file, data write up |
| | Q3 | Econometric analysis including robustness tests, finalising of go-no-go material | Paper results |
| | Q4 | Complete paper 2 write-up, presentation of paper | Paper 2 draft, go-no-go discussion |
| **3: Paper 3** | Q1 | Paper 3 literature review, define research questions | Literature review, defined research questions |
| | Q2 | Visit to Utrecht, Data collection and cleaning, data section documentation, presentation of paper | Cleaned data file, data write up |
| | Q3 | Econometric analysis including robustness tests | Paper results |
| | Q4 | Complete paper 3 write-up, presentation of paper | Paper 3 draft |
| **4: Paper 4** | Q1 | Paper 4 literature review, define research questions | Literature review, defined research questions |
| | Q2 | Data collection and cleaning, data section documentation | Cleaned data file, data write up |
| | Q3 | Econometric analysis including robustness tests | Paper results |

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| | Q4 | Complete paper 4 write-up, presentation of paper | Paper 4 draft |
| **5: Thesis** | Q1 | Combining of papers into one thesis, including formulating an overall thesis introduction, literature review and conclusion | Thesis draft |
| | Q2 | Final review of thesis by supervisors, addressing supervisor comments | Thesis ready for submission |
| | Q3 | Submission and addressing committee comments | Final thesis |
| | Q4 | Submission and defense | Completion |

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