

South African Reserve Bank

Working Paper Series

WP/25/19

**Climate risk, climate policy and international capital flows:
evidence from SADC countries**

Tesfaye T. Lemma, Michael Machokoto and Marvelous Kadzima

Authorised for publication by Konstantin Makrelov

6 November 2025



SOUTH AFRICAN RESERVE BANK

© South African Reserve Bank

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means without fully acknowledging the author(s) and this Working Paper as the source.

South African Reserve Bank Working Papers are written by staff members of the South African Reserve Bank and, on occasion, by consultants under the auspices of the South African Reserve Bank. The papers deal with topical issues and describe preliminary research findings and develop new analytical or empirical approaches in their analyses. They are solely intended to elicit comments and stimulate debate.

The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the South African Reserve Bank or South African Reserve Bank policy. While every precaution is taken to ensure the accuracy of information, the South African Reserve Bank shall not be liable to any person for inaccurate information, omissions or opinions contained herein.

South African Reserve Bank Working Papers are externally refereed.

Information on South African Reserve Bank Working Papers can be found at <https://www.resbank.co.za/en/home/publications/Papers/working-papers>.

Enquiries relating to the Working Paper Series can be addressed to:

Head: Economic Research Department
South African Reserve Bank
P O Box 427
Pretoria 0001

Tel. +27 12 313 3911

Climate risk, climate policy and international capital flows: evidence from SADC countries

Tesfaye T. Lemma,^{*} Michael Machokoto[†] and Marvelous Kadzima[‡]

Abstract

This study examines the impact of climate risk and climate policies on capital flows in Southern African Development Community (SADC) countries. Using data from 10 SADC countries spanning 2000 to 2022, we find that climate risk – proxied by extreme weather and climatic events – negatively affects aggregate international capital flows and their individual components: direct investments, portfolio investments and other investments. Similarly, the extensiveness of climate policies is associated with a decline in capital flows across all three categories. These inverse relationships persist whether international capital inflows or outflows are used as the dependent variable. The findings remain robust after addressing potential biases related to omitted variables, measurement issues, endogeneity and self-selection. This study offers important policy insights for SADC economies – a region highly vulnerable to climate change yet relatively under-researched.

JEL classification

Q54, Q56, F21, F36, O55

Keywords

Climate risk, climate policy, capital flows, SADC countries

^{*} College of Business and Economics, Towson University, Maryland, United States. Email: tlemma@towson.edu

[†] School of Economics and Finance, University of the Witwatersrand, Johannesburg, South Africa.

[‡] Department of Financial Management, University of Pretoria, Pretoria, South Africa.

1. Introduction

Climate change has become a complex and existential threat to our well-being, making it the subject of increasing interest for regulators, policymakers, researchers and practitioners (Lemma et al. 2023). The incidence of extreme weather events and natural disasters has increased due to global warming, leading to considerable socio-economic losses (Chen et al. 2022). Climate shocks, along with extreme weather events and natural disasters, can impact a country's foreign capital flows through infrastructure damage, resource shortages and supply chain disruptions – these are examples of *physical risks* (Batten 2018; Pachauri et al. 2014). The disruptions due to extreme weather and climatic events could increase the cost of business and the associated financial risks, which tend to have a strong effect on international capital flows (Koepke 2019). These risks could also undermine a country's creditworthiness, market stability, liquidity, reputation and overall standing, thereby significantly influencing foreign investors' decisions (Chen et al. 2022). Similarly, the financial risk associated with disruptions due to extreme weather and climatic events could also encourage domestic investors to divest and reallocate funds elsewhere (Cooper 2020). On the other hand, climate-related crises could result in the collapse and retrenchment of both inflows by foreigners and outflows by domestic agents (Broner et al. 2013).

The urgent need to address climate change has introduced a new dimension in global governance, with climate policies increasingly focused on mitigating climate risks (Fourné and Li 2024). National climate policies have gained prominence in political agendas worldwide (Schmidt and Fleig 2018; Gu and Hale 2023). Over the past decades, not only has policy activity intensified, but the scope and diversity of climate policies have also expanded significantly (Schmidt and Fleig 2018). However, the adoption of climate-related regulatory policies presents a double-edged sword, yielding both positive and negative macroeconomic effects. Such policies may increase the regulatory burden of doing business, potentially altering a country's comparative advantage in attracting international capital flows (Chen et al. 2022). But, at the same time, effective climate policies can lead to reductions in greenhouse gas emissions and mitigate extreme weather events, which may help to retain existing capital or attract new capital into a country (Fourné and Li 2024).

Given the import of international capital flows as catalysts for economic growth (Prasad, Rajan and Subramanian 2007), an emerging strand of studies demonstrates a link between aspects of climate risk and international capital flows. In line with the contention that heightened climate risk in a country could increase the financial risk perceived by international investors (Soussane et al. 2023; Chen et al. 2022; Gopalan, Gupta and Rajan 2023), numerous studies highlight the adverse impact of climate risk on foreign direct investment (FDI) (Chen et al. 2022; Chen and Fang 2024; Gopalan, Gupta and Rajan 2023; Shear, Ashraf and Butt 2023; Soussane et al. 2023; Li, Lu and Xie 2024), while others fail to find consistent evidence supporting a relationship between the two variables (Gu and Hale 2023). Still others provide evidence supporting a positive association between climate risk and FDI (Jorgenson et al. 2022; Xing and Wang 2023).

We observe four key gaps in the existing literature. First, international capital flows are typically categorised into three main components: FDI, portfolio investments and other investments (including bank loans and trade credits). However, most studies examining the relationship between climate risk and international capital flows focus on FDI, largely overlooking portfolio and other investments (Cole, Elliott and Zhang 2017; Fourné and Li 2024). This is a significant omission, considering that portfolios and other investments account for approximately 50–60% of international capital flows, and the determinants of one category may not necessarily apply to others (Fourné and Li 2024).

Second, while the relationship between climate risk and international capital inflows reflects foreign investors' responses, their impact on capital outflows captures domestic investors' reactions. However, prior research has primarily focused on inflows, largely neglecting outflows (see, for instance, Chen and Fang 2024; Gopalan, Gupta and Rajan 2023; Gu and Hale 2023; Ni et al. 2022). While these studies enhance our understanding of how foreign investors respond to climate risk and regulatory policies, they provide little, if any, insight into domestic investors' reactions. This research gap is also significant, as foreign and domestic investors may respond differently to economic shocks and policy changes (Forbes and Warnock 2012; Broner et al. 2013).

Third, while climate risk is widely recognised as an existential threat, governments face concerns that climate-related regulations may deter capital flows (Schmidt and Fleig 2018). Emerging and developing economies in particular fear the capital withdrawal effects of adopting climate-related regulatory policies (Brewer 2008; Contractor et al. 2020; Chen et al. 2022). The literature offers conflicting evidence: Fourné and Li (2024) find that stringency of climate policy is positively associated with the inflow of portfolio and bank investments, whereas Gu and Hale (2023) and Ni et al. (2022) report a negative relationship. Fourné and Li (2024) further highlight that the effect of climate policies on FDI inflows is statistically insignificant. The conflicting findings underscore the need for a closer examination of how international capital flows respond to climate risk and the adoption of climate policies.

Fourth, while emerging and developing economies are more vulnerable to climate shocks and experience greater damage from extreme weather events and natural disasters (Chen et al. 2022), existing research presents mixed findings on the relationship between climate risk and international capital flows in these economies. Soussane et al. (2023), for example, suggest that climate risk may have a stronger deterrent effect on FDI in less developed countries. Conversely, Shear, Ashraf and Butt (2023) find that FDI inflows are sensitive to climate-related risks in high- and middle-income countries but not low-income countries. Opoku et al. (2022) show environmental degradation increases FDI flows to low- and lower-middle-income countries while reducing them in upper-middle-income countries. Similarly, Barua, Colombage and Valenzuela (2020) demonstrate that, in the long term, rising temperatures decrease FDI flows in developing countries but increase them in developed countries. These conflicting findings underscore the need for a closer examination of the interplay between climate risk and capital flows.

The present study addresses these gaps in the existing literature by investigating whether and how international capital flows and their components react to climate risk and climate-related policies, using the unique context of the Southern African Development Community (SADC) countries. Our decision to focus on SADC countries is underpinned by three key considerations. First, Southern Africa is warming nearly twice as fast as the global average, making it a climate change hotspot with limited adaptation options (Bauer and Scholz 2010). The associated extreme climatic events

have been more pronounced in the region in recent years (Kapuka and Hlásny 2021). Even under a 1.5°C rise, the region faces increasing aridity, extreme temperatures and declining rainfall, threatening water security, agriculture and biodiversity (Engelbrecht and Monteiro 2021; Zinyengere, Crespo and Hachigonta 2013; Girvetz et al. 2019; Masson-Delmotte et al. 2019). Rising wildfire risks and ecosystem degradation further endanger communities reliant on climate-sensitive resources (Pricope et al. 2015; Kuyah et al. 2014).

Second, cross-border capital flows are crucial for investment, growth and economic development in Southern Africa (Mkombe et al. 2021). However, these flows have become increasingly volatile, with substantial inflows during periods of economic stability and sharp outflows during times of uncertainty as investor sentiment shifts (Goel and Miyajima 2021). Existing research from other regions indicates that extreme weather and climatic events disrupt economic activities, hindering development (Kim et al. 2022). We know little about the role of climate risk in shaping capital flows in the SADC region. Thus, by examining the relationship between climate risk and global capital flows, this study enhances our understanding of how extreme weather and climatic events contribute to capital flow volatility in Southern Africa, identifying a previously overlooked determinant of international capital movements in the region.

Third, while emerging and developing countries often fear the potential capital withdrawal effects of climate-related regulatory policies (Brewer 2008; Contractor et al. 2020; Chen et al. 2022), Southern African nations – particularly South Africa – are increasingly adopting such policies (Climate Action Tracker n.d.). Given that global capital flows respond to a country's climate-related policies and regulations (Gu and Hale 2023; Ni et al. 2022; Fourné and Li 2024), these policy developments are likely to have significant implications for capital flows in the region. However, the interplay between climate policies and international capital flows in Southern Africa remains underexplored. This study addresses the research gap by examining whether and how the adoption of climate-related policies influences capital flows in Southern African economies. The findings of this study have enormous policy implications for other developing and emerging economy countries.

Using data from 10 SADC countries from 2000 to 2022, we find that climate risk – proxied by extreme weather and climatic events – negatively affects both aggregate international capital flows and each of the flow components: direct investment, portfolio investment and other investments. SADC countries with higher climate risk are associated with lower net foreign purchases of domestic assets. These findings support the argument that climate risk disrupts infrastructure and supply chains, decreases the profitability of investments and increases financial risk for foreign investors, which may discourage FDI inflows (Soussane et al. 2023; Chen et al. 2022; Gopalan, Gupta and Rajan 2023; Batten 2018; Pachauri et al. 2014). Our results align with Chen and Fang (2024) and Gopalan, Gupta and Rajan (2023), who document an inverse relationship between climate risk and FDI inflows. However, they contrast with Opoku et al. (2022), who suggest that environmental degradation can stimulate FDI inflows, particularly in low- and lower-middle-income countries.

To assess whether extreme weather and climatic events prompt domestic investors to divest and reallocate funds abroad (Cooper 2020), we regressed gross capital outflows – both aggregate and disaggregate – on climate risk and relevant control variables. Our results indicate a negative association between climate risk and international capital outflows in SADC countries, suggesting that domestic investors in high climate risk areas are less likely to increase net purchases of foreign assets. This finding contradicts the expectation that climate risk would drive capital relocation abroad but aligns with Broner et al.'s (2013) argument that crises, such as those induced by climate risk, can lead to the simultaneous retrenchment of both foreign inflows and domestic outflows.

The existing literature suggests that climate-related regulatory policies can weaken a country's ability to attract foreign capital inflow and reduce domestic capital outflow (Chen et al. 2022; Contractor et al. 2020). As a result, developing and emerging economies remain wary of potential capital withdrawal effects (Brewer 2008; Contractor et al. 2020; Chen et al. 2022). However, effective climate policies may reduce financial risks for both domestic and foreign investors by mitigating exposure to extreme weather events, potentially increasing foreign inflows and decreasing domestic outflows. Yet, as Broner et al. (2013) argue, the transition risks associated with such regulations could lead to a contraction in both. Consistent with this

perspective, our findings reveal that the extensiveness of a country's climate policies is linked to a decline in all three components of capital flows, regardless of whether inflows or outflows are considered.

Our study contributes to the literature in several ways. First, while prior research on the relationship between climate risk and international capital flows has primarily focused on FDI, it has largely overlooked portfolio and other investments (Cole, Elliott and Zhang 2017; Fourné and Li 2024). This study addresses the research gap by examining the impact of climate risk on not only FDI but also portfolio and other investments, using data from SADC countries. Second, existing studies on climate risk, related policies and capital flows have predominantly analysed international capital inflows (such as Chen and Fang 2024; Gopalan, Gupta and Rajan 2023; Gu and Hale 2023; Ni et al. 2022), offering limited insights into domestic investors' responses. By incorporating both inflows and outflows, this study provides a more comprehensive understanding of how investors react to climate risk and regulatory policies. Third, this study contributes to the policy debate on the capital withdrawal effects of climate-related policies in emerging and developing economies (Brewer 2008; Contractor et al. 2020), particularly in the highly climate-vulnerable SADC region. The findings offer valuable policy implications for other developing economies facing similar climate risks.

The remainder of the paper is organised as follows: section 2 presents a brief literature review followed by an outline of the empirical framework employed for the study. Section 3 presents the findings and our interpretations. Section 4 concludes the study.

2. Data and methods

2.1 Data

The annual dataset used in this study is drawn from multiple sources. Capital flows are drawn from International Financial Statistics compiled by the International Monetary Fund (IMF). Data on country-level climate risk are drawn from two sources: Climate Watch and the International Disaster Database. Data on climate-related policy actions are drawn from several sources, including the Climate Policy Database, the Organisation for Economic Co-operation and Development's Data for Climate Action and the IMF Climate Change Dashboard. Country-level factors relating to gross domestic product (GDP) growth, inflation rates, tax revenues, economic rents of

natural resources and institutional quality are drawn from the World Bank's Governance Indicators database. Data on capital account openness are based on the Chinn-Ito index (Chinn and Ito 2008) and data on legal origins are drawn from Djankov et al. (2008).

2.2 Model specification and estimation procedures

We first examine the effect of climate risk on international capital flows by estimating the following empirical model:

$$y_{it} = \beta_0 + \beta_1 CLIMATE_{it-1} + \theta X_{it-1} + \delta_t + \varepsilon_{it} \quad (1)$$

where i indexes for country and t indexes for time. y measures international capital flows to GDP (CFI – total capital inflows to GDP, CFO – capital outflows to GDP). β_0 is a constant. β_1 and θ are parameters to be estimated. $CLIMATE$ captures the level of climate risk of a country in a year and is proxied by a dummy variable set to 1 if a major climatic event has occurred in a country in a given year and 0 otherwise.¹ X_{it-1} is a vector of control variables documented in the existing literature that influence international capital flows. These control variables include capital account openness ($OPENNESS$), real GDP growth ($GDPGROWTH$), inflation ($INFLATION$), tax revenues (TAX), institutional quality ($INSTQUAL$), natural rent ($NATURE_RENT$) and civil law ($CIVIL$). δ_t and ε_{it} are time-fixed effects and error terms, respectively.

We consider capital inflows (CFI) and outflows (CFO) separately, rather than only net capital flows, due to the distinct insights that our approach provides into the interaction between investor behaviour and a country's macroeconomic environment. First, analysing gross or total flows allows us to distinguish between actions by domestic and foreign investors, which is not possible when looking solely at net capital flows (Schmidt and Zwick 2015). We also consider the disaggregate components of capital flows, namely, direct investments, portfolio investments and other investments. This approach is important because domestic and foreign investment behaviours often

¹ To ensure the robustness of our results, we also use alternative indicators for each type of major climatic event, namely, climate ($EVENT1_Climate$), hydrological ($EVENT1_Hydro$) and meteorological ($EVENT1_Meteo$). We also use the number of climate events ($NEVENT1$ and $NEVENT2$) in a year.

respond differently to economic shocks, exchange rate volatility or policy changes, which can have varied implications for financial stability (Forbes and Warnock 2012; Broner et al. 2013). Gross flows also offer a clearer picture of financial interconnectedness and vulnerability to capital flight, as net flows can obscure the scale of simultaneous large inflows and outflows that could cancel each other out in aggregate figures but still signal underlying volatility (Lane and Milesi-Ferretti 2007). Thus, focusing on gross capital flows offers a more nuanced understanding of global capital mobility, investor responses to economic policy and potential financial risks across different countries. All the other variables are defined in Annex A.

We first use a panel data framework to investigate the relationship between the research variables. This approach is deemed more appropriate considering the longitudinal structure of the dataset, which contains information on capital flows, climate risk and climate policy across multiple countries and periods. Panel data techniques enhance the statistical efficiency of our analysis by increasing degrees of freedom and helping to address reporting inconsistencies or missing observations inherent in data on capital flows (Hsiao 2022; Wooldridge 2010). Furthermore, panel methods provide a systematic means of addressing issues related to omitted variables – a common concern in cross-sectional analyses. By incorporating fixed or random effects, panel models control time-invariant factors that may confound the relationship between climate-related policy actions and capital flows (Baltagi 2008; Wooldridge 2010). Considering country-specific effects and time trends allows for a more nuanced understanding of the dynamic interplay between policy interventions and capital flows across countries.

3. Results and discussion

3.1 Summary statistics and correlations

Table 1 presents the summary statistics for the variables used in our analysis. We observe that capital inflows (*CFI*) have a mean value of 0.0499, which is relatively low compared to other regions. Similarly, other forms of capital inflows, including foreign direct investment inflows (*FDIL*), portfolio investment inflows (*PFIL*) and other investment inflows (*LOIL*), exhibit low average values, reinforcing the region's constrained access to international capital.

Capital outflows, represented by total outflows (*CFO*), foreign direct investment outflows (*FDIA*), portfolio investment outflows (*PFIA*) and other investment outflows (*LOIA*), are also relatively low, with mean values ranging between 0.0058 and 0.0388. These figures suggest that Southern Africa experiences not only limited capital inflows but also minimal capital outflows, which could be indicative of both structural financial constraints and investment frictions in the region.

In contrast, we find that the frequency of major climate events is substantially high. The proxies *CLIMATE* and *CLIMATE_2* have average values of 0.4847 and 0.5153, respectively, highlighting the region's pronounced vulnerability to climate-related shocks. This aligns with existing literature indicating that Southern Africa is particularly prone to extreme weather events, including droughts, cyclones and floods, which have far-reaching economic and social implications. The summary statistics for the remaining variables are broadly consistent with expectations and align with findings from prior studies.

Table 1: Summary statistics

#	Variables	N	Mean	Std. dev	Min	p25	p50	p75	Max
[1]	CFI	157	0.0499	0.1104	0.0041	0.0082	0.0110	0.0211	0.5322
[2]	FDIL	163	0.0269	0.0675	0.0004	0.0029	0.0042	0.0077	0.3188
[3]	LOIL	163	0.0172	0.0311	0.0014	0.0034	0.0057	0.0135	0.1362
[4]	PFIL	157	0.0045	0.0123	0.0000	0.0000	0.0005	0.0018	0.0793
[5]	CFO	156	0.0388	0.1049	0.0003	0.0023	0.0050	0.0085	0.4917
[6]	FDIA	160	0.0201	0.0611	0.0000	0.0001	0.0006	0.0016	0.2830
[7]	LOIA	163	0.0058	0.0115	0.0003	0.0010	0.0014	0.0036	0.0515
[8]	PFIA	159	0.0119	0.0324	0.0000	0.0000	0.0021	0.0050	0.1769
[9]	CLIMATE	163	0.4847	0.5013	0.0000	0.0000	0.0000	1.0000	1.0000
[10]	CLIMATE_2	163	0.5153	0.5013	0.0000	0.0000	1.0000	1.0000	1.0000
[11]	CLIMATE_N	163	0.6933	0.8413	0.0000	0.0000	0.0000	1.0000	4.0000
[12]	CLIMATE_1N	163	0.9571	1.4114	0.0000	0.0000	1.0000	2.0000	12.0000
[13]	POLICY	66	1.0719	0.4575	0.6931	0.6931	1.0986	1.3863	2.3979
[14]	CLIMATE_C	163	0.0123	0.1104	0.0000	0.0000	0.0000	0.0000	1.0000
[15]	CLIMATE_H	163	0.3067	0.4626	0.0000	0.0000	0.0000	1.0000	1.0000
[16]	CLIMATE_M	163	0.2209	0.4161	0.0000	0.0000	0.0000	0.0000	1.0000
[17]	GDPGROWTH	163	0.0390	0.0450	-0.1455	0.0240	0.0408	0.0616	0.1503
[18]	INFLATION	163	0.0893	0.1431	-0.1676	0.0373	0.0652	0.1007	1.4248
[19]	TAX	163	0.1975	0.0713	0.0834	0.1354	0.2071	0.2565	0.3463
[20]	OPENNESS	163	55.3961	8.6951	38.7910	49.2313	54.6871	61.1875	72.0465
[21]	NATURAL_RENT	163	0.0022	0.0066	0.0000	0.0000	0.0000	0.0006	0.0357
[22]	INSTQUAL	161	-0.1884	1.5006	-3.1551	-1.4005	0.1043	0.9841	2.1616
[23]	CIVIL	163	0.4356	0.4974	0.0000	0.0000	0.0000	1.0000	1.0000

Note: The table presents the summary statistics for the variable used. All variables are defined in Annex A.

Table 2 presents the pairwise correlations among the key variables used in our analysis. As expected, there is a significant positive correlation between capital inflows and capital outflows, along with their disaggregated components – direct investments, portfolio investments and other investment. This result aligns with Broner et al. (2013), who argue that capital inflows and outflows tend to move together due to global liquidity conditions, financial market integration and investor risk appetite.² The positive correlation suggests that regions experiencing higher capital inflows also tend to have higher capital outflows, reflecting the interconnected nature of financial markets.

Next, we observe that capital flows and their disaggregated components are significantly negatively correlated with climate risk and policy variables, providing prima facie evidence that higher climate risks are associated with reduced cross-border capital movements. This finding is consistent with existing literature, which suggests that heightened climate vulnerability increases economic uncertainty, exacerbates infrastructure damage risks and undermines long-term growth prospects, which in turn deter foreign investment. The negative correlation with policy variables further indicates that regulatory responses to climate risks, such as adaptation measures or stringent environmental policies, may also influence capital mobility.

The other pairwise correlations are generally low, mitigating concerns about multicollinearity in our regression analysis. Overall, these preliminary correlation patterns reinforce the hypothesis that climate risk plays a critical role in shaping capital flows in Southern Africa, warranting further econometric investigation.

² In Annex C1, we first find robust evidence suggesting that *CFI* is positively correlated with *CFO* even after controlling for country-year trends and country-fixed effects. This is consistent with the literature (Broner et al. 2013). The finding implies that climate change is likely to affect capital inflows and outflows in a similar way, indicating a parallel response to climate risk and policy across investment types.

Table 2: Correlations

#	Variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
[1]	CFI	1.000								
[2]	FDIL	0.996***	1.000							
[3]	LOIL	0.974***	0.956***	1.000						
[4]	PFIL	0.919***	0.908***	0.851***	1.000					
[5]	CFO	0.988***	0.986***	0.943***	0.945***	1.000				
[6]	FDIA	0.988***	0.991***	0.939***	0.934***	0.997***	1.000			
[7]	LOIA	0.977***	0.969***	0.974***	0.865***	0.959***	0.955***	1.000		
[8]	PFIA	0.955***	0.948***	0.906***	0.958***	0.984***	0.968***	0.917***	1.000	
[9]	CLIMATE	-0.291***	-0.298***	-0.270***	-0.256***	-0.307***	-0.300***	-0.325***	-0.303***	1.000
[10]	CLIMATE_2	-0.309***	-0.317***	-0.289***	-0.272***	-0.327***	-0.320***	-0.341***	-0.324***	0.940***
[11]	CLIMATE_N	-0.244**	-0.251**	-0.226**	-0.208**	-0.262***	-0.255**	-0.277***	-0.260***	0.852***
[12]	CLIMATE_1N	-0.201*	-0.208**	-0.180*	-0.185*	-0.216**	-0.212**	-0.224**	-0.215**	0.623***
[13]	POLICY	-0.118	-0.128	-0.143	0.001	-0.109	-0.105	-0.151	-0.097	0.090
[14]	CLIMATE_C	-0.040	-0.039	-0.053	-0.013	-0.035	-0.034	-0.048	-0.031	0.115
[15]	CLIMATE_H	-0.199*	-0.205**	-0.177*	-0.180*	-0.210**	-0.207**	-0.217**	-0.204**	0.686***
[16]	CLIMATE_M	-0.156*	-0.162*	-0.155*	-0.116	-0.167*	-0.160*	-0.186*	-0.168*	0.549***
[17]	GDPGROWTH	-0.143	-0.127	-0.131	-0.199*	-0.132	-0.127	-0.119	-0.140	-0.129
[18]	INFLATION	-0.173*	-0.155*	-0.158*	-0.147	-0.159*	-0.154	-0.169*	-0.158*	0.036
[19]	TAX	-0.058	-0.058	-0.073	-0.021	-0.045	-0.063	-0.023	-0.017	-0.280***
[20]	OPENNESS	0.552***	0.548***	0.500***	0.567***	0.563***	0.556***	0.554***	0.557***	-0.271***
[21]	NATURAL_RENT	-0.016	-0.037	0.063	-0.105	-0.105	-0.107	-0.047	-0.119	0.231**
[22]	INSTQUAL	0.422***	0.429***	0.358***	0.426***	0.462***	0.451***	0.440***	0.473***	-0.439***
[23]	CIVIL	-0.260***	-0.259***	-0.222**	-0.292***	-0.281***	-0.283***	-0.285***	-0.268***	0.312***

Note: The table presents the pairwise correlations for the variables used. ***, ** and * indicate significance at the 1%, 2% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

#	Variables	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]
[10]	CLIMATE_2	1.000								
[11]	CLIMATE_N	0.802***	1.000							
[12]	CLIMATE_1N	0.660***	0.623***	1.000						
[13]	POLICY	0.115	0.107	0.103	1.000					
[14]	CLIMATE_C	0.108	0.041	0.003	0.142	1.000				
[15]	CLIMATE_H	0.645***	0.687***	0.436***	0.025	-0.074	1.000			
[16]	CLIMATE_M	0.516***	0.530***	0.405***	0.191*	-0.059	-0.066	1.000		
[17]	GDPGROWTH	-0.111	-0.145	-0.067	-0.072	-0.005	-0.108	-0.109	1.000	
[18]	INFLATION	0.028	0.089	0.028	-0.097	-0.003	0.071	-0.060	0.176*	1.000
[19]	TAX	-0.274***	-0.215**	-0.225**	0.024	0.045	-0.081	-0.235**	-0.064	-0.154
[20]	OPENNESS	-0.259***	-0.203**	-0.186*	0.350***	0.104	-0.194*	-0.045	-0.231**	-0.365***
[21]	NATURAL_RENT	0.258***	0.191*	0.126	-0.035	-0.031	0.154*	0.141	0.042	-0.041
[22]	INSTQUAL	-0.434***	-0.398***	-0.323***	0.003	0.037	-0.315***	-0.198*	-0.166*	-0.365***
[23]	CIVIL	0.283***	0.233**	0.141	-0.305***	-0.098	0.194*	0.129	0.026	0.199*
#	Variables	[19]	[20]	[21]	[22]	[23]				
[19]	TAX	1.000								
[20]	OPENNESS	0.415***	1.000							
[21]	NATURAL_RENT	0.001	-0.175*	1.000						
[22]	INSTQUAL	0.588***	0.740***	-0.334***	1.000					
[23]	CIVIL	-0.060	-0.656***	0.332***	-0.530***	1.000				

3.2 The effects of climate risk on international capital flows

Table 3 presents the estimated results from equation (1), examining the relationship between climate risk (*CLIMATE*) and international capital flows. The models are well specified, with statistically significant *F-statistics* and adjusted R-squared values ranging from 0.339 to 0.429.

Column 1 of Table 3 shows that climate risk has a negative (*coefficient* = -0.0673) and statistically significant effect (at the 1% level) on gross capital inflows, indicating that SADC countries with higher climate risk attract lower net foreign purchases of domestic assets. This supports the argument that climate risk – by disrupting infrastructure and supply chains – heightens financial risk for foreign investors, thereby deterring FDI inflows (Soussane et al. 2023; Chen et al. 2022; Gopalan, Gupta and Rajan 2023; Batten 2018; Pachauri et al. 2014). It aligns with Chen and Fang (2024), who find that temperature anomalies in Chinese prefecture-level cities reduce FDI inflows, and Gopalan, Gupta and Rajan (2023), who document a similar inverse relationship across 68 emerging and developing economies. However, it contrasts with Opoku et al. (2022), who demonstrate that environmental degradation stimulates FDI inflows, particularly in low- and lower-middle-income countries.

Column 4 of Table 3 indicates that climate risk also negatively affects international capital outflows (*coefficient* = -0.0718; significant at the 1% level), suggesting that higher climate risk reduces net purchases of foreign assets by domestic investors. Given the adverse impact on foreign capital inflows and domestic capital outflows, we examined the relationship between the latter. This finding of similar effects aligns with the regression results in Annex C2 showing a positive and statistically significant correlation (at the 1% level) between *CFI* and *CFO*. While the negative association between climate risk and international capital outflows contradicts the conjecture that climate risk increases capital flight (Cooper 2020), it aligns with Broner et al. (2013), who argue that crises, including those driven by climate risks, can trigger simultaneous collapse and retrenchment in both foreign inflows and domestic outflows.

Table 3: The effects of climate on capital inflows and outflows

Dependent variables	CFI	CFI	CFI	CFI	CFO	CFO	CFO	CFO
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
CLIMATE	-0.0673*** (0.0168)				-0.0718*** (0.0171)			
CLIMATE_C		-0.1553*** (0.0281)				-0.1467*** (0.0314)		
CLIMATE_H			-0.0343** (0.0156)				-0.0354** (0.0150)	
CLIMATE_M				-0.0772*** (0.0181)				-0.0790*** (0.0176)
GDPGROWTH	-0.3218 (0.2284)	-0.2116 (0.2358)	-0.1580 (0.2303)	-0.4265* (0.2511)	-0.0126 (0.2076)	0.1401 (0.2134)	0.1607 (0.2072)	-0.0580 (0.2187)
INFLATION	-0.2419* (0.1250)	-0.2745** (0.1180)	-0.2316* (0.1209)	-0.3201*** (0.1156)	0.0419 (0.0331)	0.0598 (0.0402)	0.0654 (0.0407)	0.0274 (0.0285)
TAX	-0.7288*** (0.1213)	-0.6309*** (0.1064)	-0.6086*** (0.1064)	-0.7627*** (0.1238)	-0.6815*** (0.1171)	-0.5537*** (0.0984)	-0.5386*** (0.0978)	-0.7046*** (0.1187)
OPENNESS	0.0086*** (0.0013)	0.0095*** (0.0016)	0.0089*** (0.0015)	0.0094*** (0.0014)	0.0084*** (0.0013)	0.0093*** (0.0016)	0.0087*** (0.0015)	0.0093*** (0.0014)
NATURAL_RENT	3.0920*** (0.6456)	1.9672*** (0.4851)	2.1717*** (0.5938)	2.7448*** (0.6100)	1.7012*** (0.6000)	0.5335 (0.3737)	0.7353 (0.5006)	1.3250** (0.5447)
Constant	-0.2345*** (0.0575)	-0.3317*** (0.0644)	-0.3020*** (0.0627)	-0.2733*** (0.0540)	-0.2611*** (0.0540)	-0.3778*** (0.0678)	-0.3389*** (0.0639)	-0.3226*** (0.0547)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	157	157	157	157	156	156	156	156
F-statistics	9.421	8.930	7.776	9.336	8.137	6.469	6.410	7.938
F-statistics – p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Adj.R-squared	0.429	0.367	0.365	0.428	0.420	0.339	0.341	0.411

Note: The table presents results of regressing international capital inflows (columns 1 to 4) and outflows (columns 5 to 8) on climate risk. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

Having established the significant negative association between climate risk and capital flows, we examine whether such associations vary across different types of climate risks. This part of our analysis is important considering the complexity of measuring climate risks, which makes it crucial to assess the sensitivity of our findings to alternative proxies. Anecdotal evidence suggests that the impact of climate risks varies significantly depending on the type and severity of the risks. To accomplish our objective of assessing the differential effects, we analyse the distinct effects of climatological (*CLIMATE_C*), hydrological (*CLIMATE_H*) and meteorological (*CLIMATE_M*) events on international capital inflows and outflows.

Columns 2 to 4 of Table 3 report the regression results for gross capital inflows using alternative climate risk proxies (climatological, hydrological and meteorological) and controls, while columns 6 to 8 present the results for gross capital outflows. Overall, the results reinforce our findings in the main analysis that countries with higher climate risk are associated with lower foreign capital inflows and domestic capital outflows. The results also show that climatological, hydrological and meteorological events each have consistent and statistically significant effects on both foreign capital inflows and domestic capital outflows.

We also find in columns 2 to 4 of Table 3 that, when compared to other disaster risks, climatological risks (such as droughts or wildfires) exhibit a more pronounced effect on capital inflows and outflows. This may be due to their long-lasting economic disruptions directly affecting agricultural productivity, water availability and long-term investment confidence. Unlike meteorological risks (such as storms or extreme temperatures), which are often short-lived but intense, and hydrological risks (such as floods, landslides or wave surges), which primarily affect localised infrastructure and short-term economic activity, climatological risks can lead to prolonged uncertainty, discouraging both short-term and long-term capital commitments.

However, columns 6 to 8 of Table 3 show that the relative effects of meteorological and hydrological risks depend on the type of capital flow. Specifically, hydrological risks have a more pronounced impact on capital inflows, likely because they cause extensive infrastructure damage, making investment in affected regions riskier and reducing FDI and other external capital inflows. Conversely, meteorological risks have

a stronger effect on capital outflows, as extreme weather events can increase investor uncertainty and financial volatility, leading to capital flight as investors reallocate funds to safer markets. These differentiated impacts highlight the importance of risk-specific policy interventions to mitigate the financial consequences of climate-related disasters.

3.3 Robustness

Having established significant associations between climate risk and international capital flows, we then applied a battery of additional analyses and robustness tests to allay concerns that our results might be sensitive to lagged effects, alternative variable measurements, subsamples, estimation techniques and model specifications.

3.3.1 Alternative proxies for climate risk

Thus far, we have defined climate risk (*CLIMATE*) as a binary variable set to 1 if a country experiences a climatological, hydrological or meteorological event and 0 otherwise. To ensure robustness, we re-examined the data using an expanded definition (*CLIMATE_2*) that also includes biological and geophysical events. Beyond the binary indicators, we considered the frequency of incidents under both the original (*CLIMATE_N*) and expanded (*CLIMATE_1N*) definitions. Columns 1 to 3 and 5 to 7 of Table 4 present the results of re-estimating equation (1) using these alternative measures.

Columns 1 to 3 of Table 4 report the regression results for gross capital inflows using alternative climate risk proxies and controls, while columns 5 to 7 present the results for gross capital outflows. Overall, the results reinforce our findings in the main analysis that countries with higher climate risk are associated with lower foreign capital inflows and domestic capital outflows. The results also show that climatological, hydrological and meteorological events each have consistent and statistically significant effects on both foreign capital inflows and domestic capital outflows.

Table 4: Additional analyses based on climate policy and other variable definitions

Dependent variables	CFI	CFI	CFI	CFI	CFO	CFO	CFO	CFO
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
CLIMATE_2	-0.0753***				-0.0806***			
	(0.0167)				(0.0173)			
CLIMATE_N		-0.0355***				-0.0390***		
		(0.0106)				(0.0104)		
CLIMATE_1N			-0.0135**				-0.0154**	
			(0.0057)				(0.0061)	
POLICY				-0.1319***				-0.1156***
				(0.0381)				(0.0357)
Constant	-0.2284***	-0.2778***	-0.2899***	-0.2790**	-0.2524***	-0.2966***	-0.3224***	-0.2571**
	(0.0563)	(0.0575)	(0.0615)	(0.1034)	(0.0523)	(0.0552)	(0.0616)	(0.1003)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	157	157	157	59	156	156	156	54
Adj.R-squared	0.450	0.409	0.378	0.423	0.446	0.404	0.363	0.455

Note: The table presents the results of regressing international capital flows on climate policy and alternative proxies of climate risks and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

3.3.2 The effects of climate policies on international capital flows

Column 4 of Table 4 reveals that climate policy – measured as the natural logarithm of the number of climate policies implemented in a country – negatively affects gross capital inflows (*coefficient* = -0.1319; significant at the 1% level). This suggests that SADC countries with more extensive climate policies attract lower net foreign purchases of domestic assets. This finding supports the proposition that climate-related regulatory policies can weaken a country's ability to attract foreign capital (Chen et al. 2022; Contractor et al. 2020) and aligns with Fourné and Li (2024) and Ni et al. (2022), who document a similar inverse relationship between aspects of climate policy and FDI inflows. However, it contradicts the argument that effective climate policies can mitigate financial risks that foreign investors face by reducing greenhouse gas emissions and exposure to extreme weather events, potentially enhancing foreign capital inflows (Fourné and Li 2024).

Column 8 of Table 4 indicates that climate policy also negatively affects gross capital outflows (*coefficient* = -0.1156; significant at the 1% level), implying that countries with more extensive climate policies see lower net purchases of foreign assets by domestic investors. This contradicts the argument that climate policies reduce financial risks for domestic investors by curbing greenhouse gas emissions and exposure to extreme weather events, thereby discouraging capital reallocation abroad. However, it does support Broner et al. (2013), who contend that transition risks associated with climate-related regulatory policies can lead to contractions in both capital inflows and outflows. Their finding suggests that crises, including those linked to climate policies, can simultaneously reduce foreign capital inflows and domestic capital outflows.

3.3.3 Lagged effects of climate risks and climate policy

To account for lagged effects, we lag all independent variables in our baseline model by one-, two- and three-year periods. This approach aligns with the empirical literature (Uddin et al. 2019; Gu and Hale 2023; Gopalakrishnan, Jacob and Mohapatra 2021; Barassi and Zhou 2012; Chen et al. 2020), which highlights that the effects of climate and financial policies unfold over time. These steps help mitigate endogeneity concerns and better reflect the real-world impact of climate risk and related policy interventions. Table 5 presents the results based on lagged climate risk and climate policy.

Table 5: Additional analyses based on lagged climate policy and climate risks

Dependent variables	CFI	CFI	CFO	CFO
Independent variables	[1]	[2]	[3]	[4]
CLIMATE t-2	-0.1464*** (0.0410)		-0.1323*** (0.0372)	
CLIMATE t-3		-0.1374*** (0.0388)		-0.1229*** (0.0341)
Constant	-0.1919** (0.0914)	-0.1891* (0.1001)	-0.1819** (0.0809)	-0.1977** (0.0903)
Time-fixed effects	Yes	Yes	Yes	Yes
# of observations	54	51	51	49
Adj.R-squared	0.490	0.471	0.530	0.526

Note: The table presents the results of regressing international capital flows on lagged climate policy and climate risks and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

Consistent with the findings from our main analysis, we find in columns 1 to 4 of Table 5 that climate risk and climate policy variables exert a negative and statistically significant influence (at the 1% level) on both foreign capital inflows and domestic capital outflows. This result suggests that heightened climate risks and corresponding policy interventions dampen cross-border capital movements, reinforcing the view that investors perceive climate uncertainty as a significant financial risk. The persistence of these effects across different lag structures further supports the robustness of our findings, highlighting the long-term implications of climate-related shocks and regulatory responses to capital mobility.³

3.3.4 Types of international capital flows

In the main analysis, we examined the impact of climate risk and related policies on aggregate international capital flows. To gain deeper insights, we disaggregate capital inflows and outflows into their key components: FDI, portfolio investment and other investments. This distinction is important because different forms of capital respond differently to climate risk and policy measures. For instance, portfolio investments are typically more volatile and sensitive to short-term climate shocks, while FDI, given its

³ In Annex C3, we also find that the negative effects of climate policies remain statistically significant for the disaggregated capital flows (direct investments, portfolio investments and other investments) and for the second and third lags of the climate policy variables. This suggests that the impact of climate policies on capital flows persists over time, rather than dissipating in the short run.

long-term horizon, is influenced more by structural climate policies than by short-term fluctuations (Busse and Hefeker 2007; Bansal, Ochoa and Kiku 2016). Table 6 presents the results of these disaggregated analyses.

Columns 1 to 12 in panel A of Table 6 report the effects of climate risk and policies on different types of capital inflows, while columns 1 to 12 in panel B of Table 6 examine their effects on capital outflows. The results indicate that higher climate risk is consistently associated with reduced foreign capital inflows and domestic capital outflows across all flow types and climate risk indicators.⁴ This suggests that heightened climate risks increase economic uncertainty, deter foreign investors and trigger capital flight as both domestic and international investors seek safer assets.

Moreover, we find that the effects of climate risk on capital flows vary by event type, with climatological events exerting the strongest negative impact, followed by hydrological events and meteorological events. This likely reflects that climatological events tend to have longer-lasting economic repercussions due to their impact on agriculture, water resources and long-term infrastructure sustainability. In contrast, while still disruptive, hydrological and meteorological events may be more localised and episodic, allowing for faster recovery in some cases. For capital outflows, we observe a similar pattern, but the impact ordering differs slightly, with meteorological events having a stronger effect than hydrological events. This reversal may be explained by extreme storms and temperature variations, which can have more immediate and widespread financial market consequences, leading to short-term capital reallocations.

⁴ In Annex C4, we examine whether the effects of climate events vary across subsamples of high- and low-vulnerability economies. Interestingly, we find that the effects of climate risk are more pronounced in economies classified as less vulnerable to climate change. This result is not surprising, as less vulnerable economies often have higher capital market integration, greater financial openness and stronger institutional frameworks, making them more sensitive to shifts in investor sentiment triggered by climate risks. Additionally, firms and investors in these economies may have greater exposure to global financial markets, where climate-related risks are increasingly factored into investment decisions. Conversely, more vulnerable economies, which tend to have lower financial integration and limited capital mobility, may experience more muted immediate effects as structural challenges already constrain capital flows. This disaggregated analysis reassures us that our main findings remain qualitatively similar across subsamples, reinforcing the robustness of our results.

Table 6: Disaggregated capital flows and climate risks

Panel A: Capital inflows												
Dependent variables	FDIL	LOIL	PFIL	FDIL	LOIL	PFIL	FDIL	LOIL	PFIL	FDIL	LOIL	PFIL
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
CLIMATE	-0.0427*** (0.0105)	-0.0191*** (0.0049)	-0.0062*** (0.0021)									
CLIMATE_C				-0.0931*** (0.0182)	-0.0356*** (0.0076)	-0.0163*** (0.0044)						
CLIMATE_H							-0.0224** (0.0093)	-0.0110** (0.0046)	-0.0032 (0.0019)			
CLIMATE_M										-0.0478*** (0.0114)	-0.0213*** (0.0054)	-0.0071*** (0.0021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	163	163	157	163	163	157	163	163	157	163	163	157
Adj.R-squared	0.382	0.350	0.422	0.314	0.280	0.383	0.316	0.291	0.377	0.375	0.342	0.420

Panel B: Capital outflows												
Dependent variables	FDIA	LOIA	PFIA	FDIA	LOIA	PFIA	FDIA	LOIA	PFIA	FDIA	LOIA	PFIA
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
CLIMATE	-0.0401***	-0.0075***	-0.0202***									
	(0.0098)	(0.0018)	(0.0054)									
CLIMATE_C				-0.0834***	-0.0147***	-0.0480***						
				(0.0167)	(0.0026)	(0.0136)						
CLIMATE_H							-0.0203**	-0.0045***	-0.0102**			
							(0.0087)	(0.0017)	(0.0049)			
CLIMATE_M										-0.0435***	-0.0080***	-0.0228***
										(0.0101)	(0.0020)	(0.0054)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	160	163	159	160	163	159	160	163	159	160	163	159
Adj.R-squared	0.407	0.372	0.382	0.332	0.296	0.318	0.335	0.309	0.315	0.395	0.357	0.376

Note: The table presents the results of regressing the disaggregated international capital flows on climate risks and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

Overall, these findings underscore the importance of distinguishing between different types of capital flows and climate risks and considering the duration and severity of climate events when analysing their financial implications. The results provide robust evidence that climate risk and related policies play a crucial role in shaping capital mobility in Southern Africa, with significant variations depending on the nature of both the climate event and the type of capital involved.

3.3.5 Alternative model specifications

To assess the robustness of our findings to model specification, we explore alternative configurations. In columns 1 and 7 of Table 7, we re-estimate an augmented version of equation (1) that includes additional covariates – institutional quality (*INSTQUAL*), legal origin (*CIVIL*) and country income group dummies – to mitigate potential omitted variable bias. This expanded model tests whether the significant negative impact of climate risk on capital flows persists under more stringent specifications. The results in columns 1 and 7 align with our main analysis, reinforcing the robustness of our findings and underscoring climate risk as a key determinant of capital allocation patterns.

3.3.6 Weighted regressions

An uneven distribution of observations across countries may introduce bias, as some countries contribute disproportionately more data points than others. This imbalance could distort results, particularly if countries with larger samples exhibit distinct economic or policy characteristics affecting international capital flows. To address this, we re-estimate the models using weighted least squares (*WLS*). We apply two weighting strategies: *WLS_1*, which weights observations by the inverse of each country's sample size, and *WLS_2*, which uses the inverse of the square root of each country's sample size. These adjustments reduce the influence of countries with larger samples, ensuring a more balanced representation. The results, presented in columns 2 to 3 and 8 to 9 of Table 7, remain consistent with our main findings, confirming the negative impact of climate risk and climate policies on both foreign capital inflows and domestic capital outflows.

Table 7: Additional tests

	Controls	WLS1	WLS2	PSM1	PSM2	Entropy	Controls	WLS1	WLS2	PSM1	PSM2	Entropy
Dependent variables	CFI	CFI	CFI	CFI	CFI	CFI	CFO	CFO	CFO	CFO	CFO	CFO
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
CLIMATE	-0.0391*** (0.0131)	-0.0613*** (0.0167)	-0.0650*** (0.0167)	-0.0685*** (0.0251)	-0.0678*** (0.0170)	-0.0673*** (0.0168)	-0.0473*** (0.0137)	-0.0691*** (0.0168)	-0.0711*** (0.0170)	-0.0659*** (0.0247)	-0.0728*** (0.0174)	-0.0718*** (0.0171)
INSTQUAL	0.0748*** (0.0134)						0.0545*** (0.0122)					
CIVIL	0.1418*** (0.0164)						0.1315*** (0.0175)					
Low-income	0.0496*** (0.0162)						0.0539*** (0.0176)					
Lower-middle-income	-0.0612 (0.0445)						-0.0177 (0.0470)					
Upper-middle-income	-0.0147 (0.0502)						0.0136 (0.0524)					
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	155	157	157	101	147	157	154	156	156	103	146	156
Adj.R-squared	0.738	0.599	0.566	0.464	0.540	0.532	0.695	0.595	0.561	0.441	0.526	0.525

Note: This table reports regressing international capital flows on climate risk and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A. The *CLIMATE* dummy is set to 1 for countries with above average climate risk (*CLIMATE*) and 0 otherwise.

3.3.7 Propensity score matching and entropy balancing

To address potential selection bias and unobserved heterogeneity in the relationship between climate risk and international capital flows, we employ propensity score matching (PSM) and entropy balancing. These methods enhance the robustness of our comparisons between countries with high and low climate risk, approximating a quasi-experimental design.

For PSM, we estimate a propensity score model in which *CLIMATE* is the dependent variable, and all the covariates from equation (1) serve as independent variables. Each treated observation (*CLIMATE*=1) is matched with a similar control observation (*CLIMATE*=0) based on propensity scores, reducing selection bias by ensuring that both groups share comparable observable characteristics (Rosenbaum and Rubin 1983).

Entropy balancing further refines the analysis by reweighting the control group (*CLIMATE*=0) so that its covariate moments (e.g. mean and variance) match those of the treatment group (*CLIMATE*=1). Unlike PSM, which discards unmatched observations, entropy balancing adjusts weights to achieve covariate balance while preserving the full sample. This approach, introduced by Hainmueller (2012), enhances comparability and minimises selection bias, improving the validity of causal inferences.⁵

The results, presented in columns 4 to 6 and 10 to 12 of Table 7, indicate that *CLIMATE* remains negatively significant (at the 1% level across all models) for both foreign capital inflows and domestic capital outflows. These findings align with our main results and mitigate concerns that selection bias or unobserved confounders drive the findings. This robustness check further reinforces the negative association between climate risk and capital flows.⁶

⁵ Annex B shows that the covariates exhibit balance in terms of mean, variance and skewness following the application of reweighting through entropy balancing. This suggests that the reweighted samples achieve a comparable distribution across these statistical moments, ensuring the robustness of the subsequent analyses.

⁶ In Annex C2, we employ an instrumental variable (IV) estimation technique, specifically the two-stage least squares method, using the peer average country-year climate risk (excluding the focal country) as an instrument for the potentially endogenous climate risk variable. We conduct

3.3.8 Falsification tests

To address the possibility that our findings may arise by random chance, we implement a falsification test by randomly assigning countries to hypothetical high and low climate risk subgroups. Specifically, we create a placebo variable that takes a value of 1 for countries randomly allocated to the high climate risk group and 0 otherwise. We then estimate equation (1) on this placebo sample and record the coefficients and p-values for the climate risk variable across 2 000 iterations. This simulation approach is commonly used to test robustness by creating artificial scenarios, ensuring any observed patterns are not the result of random variation (see Abadie, Diamond and Hainmueller 2010; Bertrand, Duflo and Mullainathan 2004). Figure 1 shows that most p-values exceed 10%, suggesting non-significance, while the simulated coefficients largely diverge from those derived from actual data. This confirms that our original results are unlikely due to random chance. This falsification method, widely recognised in causal inference literature (e.g. Abadie, Diamond and Hainmueller 2010; Bertrand, Duflo and Mullainathan 2004), helps reinforce the robustness of our findings by accounting for potential spurious relationships.

standard diagnostic tests to assess the validity and strength of our IV approach. The Cragg-Donald Wald F-statistics exceed the conventional threshold of 10 and are greater than the critical values from the Stock-Yogo weak identification test, indicating that our instrument is sufficiently strong. Furthermore, the endogeneity test for climate risk does not yield statistically significant results, suggesting that climate risk is exogenous, aligning with our initial theoretical expectations. This finding implies that the ordinary least squares estimates used in our analysis remain consistent and reliable.

Figure 1: Falsification test

Figure 1(a): Capital inflows

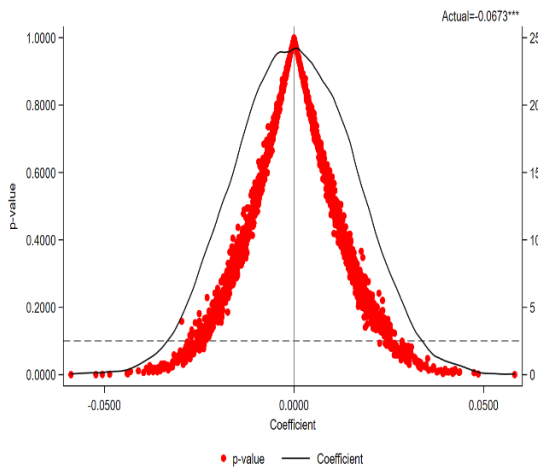
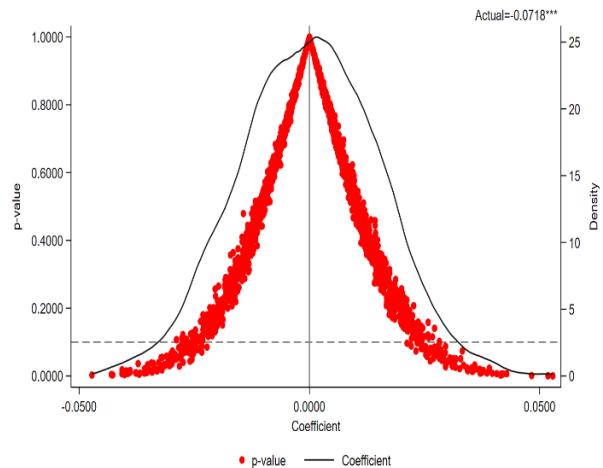


Figure 1(b): Capital outflows



Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors.

3.3.9 Omitted variables tests

Despite controlling for multiple covariates based on prior literature, omitted variable bias could still affect our results. To address this, we apply Oster's (2019) approach, which evaluates the robustness of treatment effects by considering potential unobserved confounders. The Oster test compares the stability of treatment coefficients across different specifications by analysing how changes in the R-squared and coefficient estimates respond to additional controls. Specifically, it estimates the degree to which omitted variables would need to influence the outcome to alter the observed relationships meaningfully. Table 8 presents the results for the omitted variables.

Table 8: Oster tests for omitted variable bias

Dependent variables	CFI	FDIL	LOIL	PFIL	CFO	FDIA	LOIA	PFIA
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Panel A: Estimates without controls								
CLIMATE	-0.0716***	-0.0445***	-0.0183***	-0.0075***	-0.0756***	-0.0426***	-0.0082***	-0.0228***
	(0.0196)	(0.0118)	(0.0054)	(0.0024)	(0.0193)	(0.0112)	(0.0019)	(0.0060)
Adj.R-squared	0.1359	0.1349	0.1475	0.1328	0.1560	0.1439	0.1651	0.1529
Panel B: Estimates with controls								
CLIMATE	-0.0673***	-0.0427***	-0.0191***	-0.0062***	-0.0718***	-0.0401***	-0.0075***	-0.0202***
	(0.0168)	(0.0105)	(0.0049)	(0.0021)	(0.0171)	(0.0098)	(0.0018)	(0.0054)
Adj.R-squared	0.5319	0.4891	0.4623	0.5254	0.5249	0.5110	0.4802	0.4912
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rmax	0.6914	0.6358	0.6010	0.6830	0.6823	0.6643	0.6243	0.6385
Delta	8.8109	10.3621	19.1405	7.7081	8.7805	10.1836	7.1344	7.2930
Bootstrap	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
# of observations	157	163	163	157	156	160	163	159

Note: This table presents the results of omitted variable bias tests following the methodology proposed by Oster (2019). Panel A displays the baseline estimates from equation (1) without control variables, while panel B shows results with the inclusion of control variables. The bias-adjusted coefficients in panel B are derived using Rmax, calculated as 1.3 times the R-squared from the fully specified model. Rmax represents the hypothetical maximum R-squared if all relevant covariates were included in the model. Additionally, the table reports the values of delta, which represents the ratio of selection on unobservable to observables. The delta statistics reflect the extent to which unobserved variables would need to influence the model to nullify the effect of climate risks.

The test uses three key inputs: the coefficient and R-squared from both a baseline (uncontrolled) model and a fully controlled model, along with an assumed upper bound for R-squared. By adjusting for this maximum R-squared, the test provides a bias-adjusted estimate of the treatment effect, assessing if omitted variables could undermine our findings. Our results reveal that the coefficient of interest remains robust across specifications, suggesting omitted variables would need substantial explanatory power to affect the outcome significantly. Thus, the Oster test findings affirm the robustness of our analysis, aligning with empirical studies that use this approach to strengthen causal inferences (see, for instance, Oster 2019; Altonji, Elder and Taber 2005).

4. Conclusion

The study sought to examine the impact of climate risk and related policies on capital flows in the SADC region, where countries are highly vulnerable to climate change. The study provides robust evidence that climate risk negatively affects international capital flows, both in aggregate and in its components: direct investment, portfolio investment and other investments. Similarly, it demonstrates that countries with more extensive climate policies tend to see a decline in capital flows across all three categories. These inverse relationships persist whether international capital inflows or outflows are used as the dependent variable.

Policymakers can leverage the findings to design and implement climate policies that align with economic objectives, optimise financial instruments for sustainable growth and foster inclusive development. The research contributes to evidence-based policymaking, offering a valuable framework for crafting resilient and adaptive policies that address the challenges of climate change in emerging market economies. Ultimately, the study aims to empower policymakers with knowledge to make informed decisions that balance environmental sustainability and economic advancement in the context of emerging market economies' unique challenges and opportunities.

Annexures

Annex A: Variable definitions

Variables	Definitions
CFI	The sum of inflows from direct investments, other investments and portfolio investments scaled by GDP (IMF Balance of Payments).
FDIL	The inflows from direct investments scaled by GDP (IMF Balance of Payments).
LOIL	The inflows from other investments scaled by GDP (IMF Balance of Payments).
PFIL	The inflows from portfolio investments scaled by GDP (IMF Balance of Payments).
CFO	The sum of outflows from direct investments, other investments and portfolio investments scaled by GDP (IMF Balance of Payments).
FDIA	The outflows from direct investments scaled by GDP (IMF Balance of Payments).
LOIA	The outflows from other investments scaled by GDP (IMF Balance of Payments).
PFIA	The outflows from portfolio investments scaled by GDP (IMF Balance of Payments).
CLIMATE	A dummy variable equal to 1 if a climate event occurs and 0 otherwise. A climate event is defined as any climatological, hydrological or meteorological incident that meets one or more of the following criteria: a formal appeal for assistance or declaration is issued, total damages exceed 10 incidents, over 100 people are injured or more than 100 people are rendered homeless. Data for this variable are sourced from EM-DAT, the international disaster database.
CLIMATE_2	A dummy variable equal to 1 if a climate event occurs and 0 otherwise. A climate event is defined as any climatological, hydrological, meteorological, biological or geophysical incident that meets one or more of the following criteria: a formal appeal for assistance or declaration is issued, total damages exceed 10 incidents, over 100 people are injured or more than 100 people are rendered homeless. Data for this variable are sourced from EM-DAT, the international disaster database.
CLIMATE_N	The number of climate events based on EVENT1 in a year.
CLIMATE_1N	The number of climate events based on EVENT2 in a year.
POLICY	The logarithm of the number of climate policies implemented (Climate Policy Database).
CLIMATE_C	A dummy variable equal to 1 if a climate event occurs and 0 otherwise. A climate event is defined as any climatological incident that meets one or more of the following criteria: a formal appeal for assistance or declaration is issued, total damages exceed 10 incidents, over 100 people are injured or more than 100 people are rendered homeless. Data for this variable are sourced from EM-DAT, the international disaster database.
CLIMATE_H	A dummy variable equal to 1 if a climate event occurs and 0 otherwise. A climate event is defined as any hydrological incident that meets one or more of the following criteria: a formal appeal for assistance or declaration is issued, total damages exceed 10 incidents, over 100 people are injured or more than 100 people are rendered homeless. Data for this variable are sourced from EM-DAT, the international disaster database.
CLIMATE_M	A dummy variable equal to 1 if a climate event occurs and 0 otherwise. A climate event is defined as any meteorological incident that meets one or more of the following criteria: a formal appeal for assistance or declaration is issued, total damages exceed 10 incidents, over 100 people are injured or more than 100 people are rendered homeless. Data for this variable are sourced from EM-DAT, the international disaster database.
GDPGROWTH	The rate of GDP growth (World Bank).

INFLATION	The annual inflation rate (World Bank).
TAX	Tax revenue to GDP (World Bank).
OPENNESS	The KOF Globalisation Index measures the economic, social and political dimensions of globalisation across countries over time.
NATURAL_RENT	The percentage of a country's GDP that is derived from the economic rents of natural resources.
INSTQUAL	The first principal component of the six World Bank Governance Indicators (WGI).
CIVIL	A dummy variable set to 1 for countries with legal origins rooted in civil law and 0 otherwise (Djankov et al. 2008).

Annex B: Entropy covariate balance

		Before entropy balancing						After entropy balancing					
	Samples	Treated			Control			Treated			Control		
#	Variables	Mean	Variance	Skewness	Mean	Variance	Skewness	Mean	Variance	Skewness	Mean	Variance	Skewness
[1]	GDPGROWTH	0.0331	0.0014	-0.4545	0.0447	0.0026	-1.5210	0.0331	0.0014	-0.4545	0.0331	0.0043	-1.5856
[2]	INFLATION	0.0946	0.0149	4.4368	0.0843	0.0259	7.1027	0.0946	0.0149	4.4368	0.0946	0.0292	6.9466
[3]	TAX	0.1770	0.0052	0.2330	0.2168	0.0043	-0.1401	0.1770	0.0052	0.2330	0.1770	0.0040	0.3046
[4]	OPENNESS	52.9773	73.1716	0.6656	57.6709	67.9965	0.1374	52.9773	73.1716	0.6656	52.9789	48.8936	0.9291
[5]	NATURAL_RENT	0.0037	0.0001	2.3386	0.0007	0.0000	6.1918	0.0037	0.0001	2.3386	0.0037	0.0001	1.9929

Note: The table presents the results of the covariate balance based on entropy balancing.

Annex C1: The relationship between capital inflows and outflows

Dependent variables	CFI	CFO
Independent variables	[1]	[2]
CFO	0.2469*** (0.0733)	
CFI		0.3676*** (0.1044)
Time-fixed effects	Yes	Yes
Country-year trend	Yes	Yes
# of observations	150	150
Adj.R-squared	0.474	0.246

Note: Column 1 reports the results of regressing capital inflows on capital outflows and country-year trend. Column 2 reports the results of regressing capital outflows on capital inflows and country-year trend. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

Annex C2: Two-stage least squares estimation of the effects of climate risks on capital inflows and outflows

Dependent variables	CFI	FDIL	LOIL	PFIL	CFO	FDIA	LOIA	PFIA
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
CLIMATE	-0.0789*** (0.0171)	-0.0479*** (0.0108)	-0.0210*** (0.0050)	-0.0075*** (0.0021)	-0.0790*** (0.0173)	-0.0443*** (0.0100)	-0.0079*** (0.0018)	-0.0229*** (0.0056)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	157	163	163	157	156	160	163	159
Adj.R-squared	0.400	0.354	0.297	0.387	0.393	0.381	0.334	0.350
Cragg-Donald Wald F-statistic	108.600	118.100	118.100	108.600	108.200	113.800	118.100	112.500
Endogeneity test	2.021	1.164	0.760	2.650	0.967	0.943	0.245	1.477
Endogeneity test (p-value)	0.155	0.281	0.383	0.104	0.325	0.332	0.620	0.224

Note: This table reports the results of regressing international capital flows on climate risk and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A. The peer average country-year climate risk (excluding the focal country) is used as an instrument for the potentially endogenous climate risk variable. The results are estimated based on the two-stage least squares method.

Annex C3: Disaggregated capital flows and climate policy

The table presents the results of regressing the disaggregated international capital flows on climate policy and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A.

Panel A: First lags of climate policy

Dependent variables	FDIL	LOIL	PFIL	FDIA	LOIA	PFIA
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]
POLICY t-1	-0.0792***	-0.0403***	-0.0124**	-0.0668***	-0.0149***	-0.0367***
	(0.0233)	(0.0108)	(0.0050)	(0.0210)	(0.0040)	(0.0110)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	59	59	59	57	59	56
Adj.R-squared	0.413	0.439	0.375	0.446	0.433	0.393

Panel B: Second lags of climate policy

Dependent variables	CFI	FDIL	LOIL	PFIL	CFO	FDIA	LOIA	PFIA
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
POLICY t-2	-0.1464***	-0.0928***	-0.0407***	-0.0129**	-0.1323***	-0.0793***	-0.0162***	-0.0380***
	(0.0410)	(0.0255)	(0.0114)	(0.0055)	(0.0372)	(0.0222)	(0.0043)	(0.0115)
Constant	0.0996	0.0626	0.0270	0.0118	0.0957	0.0567	0.0104	0.0280
	0.465	0.465	0.465	0.465	0.475	0.471	0.465	0.469
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	54	54	54	54	51	52	54	53
Adj.R-squared	0.490	0.490	0.464	0.475	0.530	0.526	0.472	0.506

Panel C: Third lags of climate policy

Dependent variables	CFI	FDIL	LOIL	PFIL	CFO	FDIA	LOIA	PFIA
Independent variables	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
POLICY t-3	-0.1374***	-0.0863***	-0.0402***	-0.0109**	-0.1229***	-0.0744***	-0.0154***	-0.0341***
	(0.0388)	(0.0243)	(0.0111)	(0.0048)	(0.0341)	(0.0212)	(0.0039)	(0.0102)
Constant	0.0966	0.0607	0.0271	0.0106	0.0916	0.0554	0.0101	0.0259
	0.466	0.466	0.466	0.466	0.473	0.468	0.466	0.471
Time-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	51	51	51	51	49	50	51	50
Adj.R-squared	0.471	0.472	0.445	0.444	0.526	0.519	0.456	0.489

Annex C4: The cross-sectional variations of the effects of climate risks on capital flows

Vulnerability	LOW	HIGH	LOW	HIGH
Dependent variables	CFI	CFI	CFO	CFO
Independent variables	[1]	[2]	[3]	[4]
CLIMATE	-0.1672***	-0.0016*	-0.1530***	-0.0007
	(0.0332)	(0.0009)	(0.0298)	(0.0006)
Constant	-0.1202	0.0036	-0.0813	-0.0060*
	(0.2233)	(0.0070)	(0.1973)	(0.0034)
Controls	Yes	Yes	Yes	Yes
Time-fixed effects	Yes	Yes	Yes	Yes
# of observations	68	77	68	78
Adj.R-squared	0.696	0.469	0.730	0.614

Note: This table reports the results of regressing international capital flows on climate risk and control variables. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively, based on robust standard errors. All variables are defined in Annex A. The sample is split into LOW and HIGH based on whether the country is below or above the median of the climate vulnerability index drawn from the ND-GAIN database.

References

- Abadie, A, Diamond, A and Hainmueller, J. 2010. 'Synthetic control methods for comparative case studies: estimating the effect of California's tobacco control program'. *Journal of the American Statistical Association* 105: 493–505.
- Altonji, J G, Elder, T E and Taber, C R. 2005. 'Selection on observed and unobserved variables: assessing the effectiveness of Catholic schools'. *Journal of Political Economy* 113: 151–184.
- Baltagi, B H. 2008. *Econometric analysis of panel data*. Springer.
- Bansal, R, Ochoa, M and Kiku, D. 2016. 'Climate change and growth risks'. National Bureau of Economic Research Working Paper 23009.
- Barassi, M R and Zhou, Y. 2012. 'The effect of corruption on FDI: a parametric and non-parametric analysis'. *European Journal of Political Economy* 28: 302–312.
- Barua, S, Colombage, S and Valenzuela, E. 2020. 'Climate change impact on foreign direct investment inflows: a dynamic assessment at the global, regional and economic level'. SSRN. <http://dx.doi.org/10.2139/ssrn.3674777>
- Batten, S. 2018. 'Climate change and the macro-economy: a critical review'. Bank of England Working Paper No. 706. SSRN. <http://dx.doi.org/10.2139/ssrn.3104554>
- Bauer, S and Scholz, I. 2010. 'Adaptation to climate change in Southern Africa: new boundaries for sustainable development?' *Climate and Development* 2(2010): 83–93.
- Bertrand, M, Duflo, E and Mullainathan, S. 2004. 'How much should we trust differences-in-differences estimates?' *The Quarterly Journal of Economics* 119: 249–275.
- Brewer, T L. 2008. 'Climate change technology transfer: a new paradigm and policy agenda'. *Climate Policy* 8: 516–526.

Broner, F, Didier, T, Erce, A and Schmukler, S L. 2013. 'Gross capital flows: dynamics and crises'. *Journal of Monetary Economics* 60: 113–133.

Busse, M and Hefeker, C. 2007. 'Political risk, institutions and foreign direct investment'. *European Journal of Political Economy* 23: 397–415.

Chen, J, Zhan, W, Tong, Z and Kumar, V. 2020. 'The effect of inward FDI on outward FDI over time in China: a contingent and dynamic perspective'. *International Business Review* 29: 101734.

Chen, X and Fang, T. 2024. 'Temperature anomalies and foreign direct investment: city-level evidence from China'. *International Review of Financial Analysis* 91: 102983.

Chen, Y, Zhang, D, Wu, F and Ji, Q. 2022. 'Climate risks and foreign direct investment in developing countries: the role of national governance'. *Sustainability Science* 17: 1723–1740.

Chinn, M D and Ito, H. 2008. 'A new measure of financial openness'. *Journal of Comparative Policy Analysis* 10: 309–322.

Climate Action Tracker. n.d. 'Country summary: South Africa'. https://climateactiontracker.org/countries/south-africa/?utm_source=chatgpt.com

Cole, M A, Elliott, R J and Zhang, L. 2017. 'Foreign direct investment and the environment'. *Annual Review of Environment and Resources* 42: 465–487.

Contractor, F J, Dangol, R, Nuruzzaman, N and Raghunath, S. 2020. 'How do country regulations and business environment impact foreign direct investment (FDI) inflows?' *International Business Review* 29: 101640.

Cooper, R. 2020. 'Risk of capital flight due to a better understanding of climate change'. *K4D Helpdesk Report* 727. Brighton, UK: Institute of Development Studies. https://opendocs.ids.ac.uk/articles/report/Risk_of_Capital_Flight_Due_to_a_Better_Understanding_of_Climate_Change/26427472?file=48076429

Djankov, S, La Porta, R, Lopez-De-Silanes, F and Shleifer, A. 2008. 'The law and economics of self-dealing'. *Journal of Financial Economics* 88: 430–465.

Engelbrecht, F A and Monteiro, P. 2021. 'The IPCC Assessment Report Six Working Group 1 report and Southern Africa: reasons to take action'. *South African Journal of Science* 117: 1–7.

Forbes, K J and Warnock, F E. 2012. 'Capital flow waves: surges, stops, flight, and retrenchment'. *Journal of International Economics* 88: 235–251.

Fourné, M and Li, X. 2024. 'Climate policy and international capital reallocation'. *IWH Discussion Papers*.

Girvetz, E, Ramirez-Villegas, J, Claessens, L, Lamanna, C, Navarro-Racines, C, Nowak, A, Thornton, P and Rosenstock, T S. 2019. 'Future climate projections in Africa: where are we headed?' In *The climate-smart agriculture papers: investigating the business of a productive, resilient and low emission future*, edited by T S Rosenstock, A Nowak and E Girvetz. Springer Cham: 15–27.

Goel, R and Miyajima, M K. 2021. 'Analyzing capital flow drivers using the 'at-risk' framework: South Africa's case'. IMF Working Papers No. 2021/253.

Gopalakrishnan, B, Jacob, J and Mohapatra, S. 2021. 'Risk-sensitive Basel regulations and firms' access to credit: direct and indirect effects'. *Journal of Banking & Finance* 126: 106101.

Gopalan, S, Gupta, B and Rajan, R S. 2023. 'Do climate risks influence foreign direct investment inflows to emerging and developing economies?' *Climate Policy* 23: 722–734.

Gu, G W and Hale, G. 2023. 'Climate risks and FDI'. *Journal of International Economics* 146: 103731.

Hainmueller, J. 2012. 'Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies'. *Political Analysis* 20: 25–46.

Hsiao, C. 2022. *Analysis of panel data*. Cambridge University Press.

Jorgenson, A, Clark, R, Kentor, J and Rieger, A. 2022. 'Networks, stocks, and climate change: a new approach to the study of foreign investment and the environment'. *Energy Research & Social Science* 87: 102461.

Kapuka, A and Hlásny, T. 2021. 'Climate change impacts on ecosystems and adaptation options in nine countries in Southern Africa: what do we know?' *Ecosphere* 12: e03860.

Kim, H S, Chaverri, C, Corugedo, E W F and Juarros, P. 2022. 'On the macro impact of extreme climate events in Central America: a higher frequency investigation'. IMF Working Papers No. 2022/237.

Koepke, R. 2019. 'What drives capital flows to emerging markets? A survey of the empirical literature'. *Journal of Economic Surveys* 33: 516–540.

Kuyah, S, Sileshi, G W, Njoloma, J, Mng'omba, S and Neufeldt, H. 2014. 'Estimating aboveground tree biomass in three different miombo woodlands and associated land use systems in Malawi'. *Biomass and Bioenergy* 66: 214–222.

Lane, P R and Milesi-Ferretti, G M. 2007. 'The external wealth of nations mark II: revised and extended estimates of foreign assets and liabilities, 1970–2004'. *Journal of International Economics* 73: 223–250.

Lemma, T T, Tavakolifar, M, Mihret, D and Samkin, G. 2023. 'Board gender diversity and corporate carbon commitment: does industry matter?' *Business Strategy and the Environment* 32: 3550–3568.

Li, X, Lu, X and Xie, W. 2024. 'Climate change in Europe and international portfolio allocation: micro-level evidence from global funds'. *Journal of Economic Surveys* 38(5): 1928–1955.

Masson-Delmotte, V, Pörtner, H, Skea, J, Buendía, E, Zhai, P and Roberts, D. 2019. *IPCC special report on climate change and land*.

Mkombe, D, Tufa, A H, Alene, A D, Manda, J, Feleke, S, Abdoulaye, T and Manyong, V. 2021. 'The effects of foreign direct investment on youth unemployment in the Southern African Development Community'. *Development Southern Africa* 38: 863–878.

Ni, L, Li, L, Zhang, X and Wen, H. 2022. 'Climate policy and foreign direct investment: evidence from a quasi-experiment in Chinese cities'. *Sustainability* 14: 16469.

Opoku, E E O, Acheampong, A O, Dzator, J and Kufuor, N K. 2022. 'Does environmental sustainability attract foreign investment? Evidence from developing countries'. *Business Strategy and the Environment* 31: 3542–3573.

Oster, E. 2019. 'Unobservable selection and coefficient stability: theory and evidence'. *Journal of Business & Economic Statistics* 37: 187–204.

Pachauri, R K, Allen, M R, Barros, V R, Broome, J, Cramer, W, Christ, R, Church, J A, Clarke, L, Dahe, Q and Dasgupta, P. 2014. 'Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change'. IPCC.

Prasad, E S, Rajan, R and Subramanian, A. 2007. *Foreign capital and economic growth*. National Bureau of Economic Research Working Paper 13619.

Pricope, N G, Gaughan, A E, All, J D, Binford, M W and Rutina, L P. 2015. 'Spatio-temporal analysis of vegetation dynamics in relation to shifting inundation and fire regimes: disentangling environmental variability from land management decisions in a Southern African transboundary watershed'. *Land* 4: 627–655.

Rosenbaum, P R and Rubin, D B. 1983. 'The central role of the propensity score in observational studies for causal effects'. *Biometrika* 70: 41–55.

Schmidt, N M and Fleig, A. 2018. 'Global patterns of national climate policies: analysing 171 country portfolios on climate policy integration'. *Environmental Science & Policy* 84: 177–185.

Schmidt, T and Zwick, L. 2015. 'Uncertainty and episodes of extreme capital flows in the euro area'. *Economic Modelling* 48: 343–356.

Shear, F, Ashraf, B N and Butt, S. 2023. 'Sensing the heat: climate change vulnerability and foreign direct investment inflows'. *Research in International Business and Finance* 66: 102005.

Soussane, J A, Mansouri, D, Fakhouri, M Y and Mansouri, Z. 2023. 'Does climate change constitute a financial risk to foreign direct investment? An empirical analysis on 200 countries from 1970 to 2020'. *Weather, Climate, and Society* 15: 31–43.

Uddin, M, Chowdhury, A, Zafar, S, Shafique, S and Liu, J. 2019. 'Institutional determinants of inward FDI: evidence from Pakistan'. *International Business Review* 28: 344–358.

Wooldridge, J M. 2010. *Econometric analysis of cross section and panel data*. MIT Press.

Xing, Z and Wang, Y. 2023. 'Climate risk, climate risk distance and foreign direct investment'. *International Journal of Climate Change Strategies and Management* 15: 41–57.

Zinyengere, N, Crespo, O and Hachigonta, S. 2013. 'Crop response to climate change in Southern Africa: a comprehensive review'. *Global and Planetary Change* 111: 118–126.