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Effect of Causality Between Financial Development and Climate Change in Sub-Saharan Africa

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Abstract: The aim objective of this article is to analyze the causal link between financial development and climate change in SSA. To this end, the Toda and Yammamoto (1995), Dumitrescu and Hurlin (2012) and the GMM test were carried out over the period 2008 to 2019 on dynamic panel data. The results show a unidirectional causality from credit to the economy to climate change in the countries in the sample. In terms of economic policy implications, credit is an instrument for combating climate change, since monetary policy is inseparable from credit policy. This means redirecting savings towards projects that do not harm the environment and promote the development of a circular, efficient, inclusive and clean economy, and penalizing credit institutions when they make loans to polluting activities.

Keywords: climate change, credit to the economy, climate finance, green growth, green finance

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1. Introduction

Analysis of the causality and/or relationship between climate change and macroeconomic variables is a compelling necessity (Card, 2021; Angrist and Imben, 2021 and Jeanneney, 2023). Indeed, the impact of a disaster on financial development is linked to physical risk factors such as wind speed, cyclone diameter, temperatures, rainfall, (Keucheyan, 2017). O'Connor (1973) was one of the pioneers to highlight the link between public finance crisis, financial development

and climate change back in the 1980s. NGFS (2019) considers climate change as a source of financial risk.

The environment is complex, and the effects of climate change are unpredictable (Von Bertalanffy, 1956; 2012; Le Moigne, 1994; 1999). According to these authors, climate change is heterogeneous and interactions are non-linear. In this sense, climate change is a complex phenomenon. Moreover, these authors emphasize that climate change is a tangle of interactions interrelated with the economy. The complexity of climate change is due to its unpredictability.

Dafermos et al (2018) have attempted to establish the relationship between climate and finance, showing that climate change leads to financial instability. The fundamental idea of these authors is that if climate change affects production, it is obvious that its effects will spill over into financial development. Indeed, climate indices impact the financial sector either directly by affecting companies, households and countries, or indirectly through their effects on the economy as a whole. According to Grippa *et al.* (2019), extreme climatic events (floods and drought...) increase the risk of mortgage loan portfolio losses in California. Because these events lower property values, this decreases asset values and increases the risk of default on loan portfolios. The result is credit or liquidity rationing in the event of unhedged risks (Dercon and Christiaensen, 2011). From this point of view, monetary and fiscal policy and the financing of the economy will be affected by the slowdown in economic activity.

Financial development affects climate change through investment. The socio-political, economic and environmental situation calls for responsible awareness. In this sense, socially responsible investment (SRI) is a way of investing differently (Capelle-Blancard *et al.*, 2021). Corporate social responsibility (CSR) guides SRI and is rooted in ESG (environmental, social and governance) criteria. However, an investment is socially responsible if it incorporates extra-financial criteria based on ESG criteria in addition to the return criterion. Extra-financial criteria: ISO standards and labels assess not only economic performance, but also the ESG practices of an organization, company, bank or government. For example, sustainable bonds enable the financing of projects/assets with environmental, climatic and social benefits. This has led to the development of sustainable finance (green finance). First issued in 2007 by the European Investment Bank (EIB) and in 2008 by the World Bank, sustainable bonds have been growing rapidly over the past 15 years (EIB, 2021; Dia, 2022 and ORSE, 2022). As a result, climate change has accelerated the pace of financial innovation.

Statistics from the Climate bonds initiative (2019) and ORSE (2022) show that in 2014, global green bond issuance was $9.1 billion, compared with $168.5 billion in 2018, $266 billion in 2019 and over $1,000 billion in 2020. This shows that the green bond market is expanding rapidly, but unevenly across regions. Sub-Saharan Africa accounts for the smallest proportion of any region in the world. In 2021, the amount of green bonds issued worldwide was $623 billion, of which Africa accounted for 0.26% (Bloomberg New Energy Finance, 2022). In 2020, Europe accounted for 43% of green bonds, North America 24%, Asia 22% and 11% for the rest of the world. With cats bonds or catastrophe bonds, the World Bank issued $10 billion in 2018 to cover the financial consequences of natural disasters such as earthquakes, cyclones, earthquakes and typhoons. In 2020, however, the cats bond market exploded to $16.4 billion.

Like greens bonds and cats bonds, transitions bonds are climate-related bonds that support the transformation of highly carbon-intensive sectors (carbon neutrality). In 2019, transitions bonds amounted to 100 million euros, enabling the refinancing of commercial loans. In addition, although Sustainable Development Goals (SDG) bonds are bonds linked to sustainability (SDGs), they are underdeveloped. SDG bonds amounted to 1.5 billion euros in 2019 and 2 billion euros in 2020 (ORSE, 2022). Unlike SDG bonds, sustainability-linked bonds enable environmental, social and good governance objectives to be met. Sustainability-linked bonds are in full development, with a total value of 650 million euros in 2020.

The volume of global green finance issuance in 2013 was $14.8 billion, compared with $40.5 billion in 2014. In 2015, the volume was $56.8 billion, compared with $109.2 billion in 2016 and $204.0 billion in 2017. However, in 2018, the volume was $261.4 billion, compared with $465.0 billion in 2019 (ecological Reveil, 2022). Sustainable finance (green finance) in 2019 was made up of $271 billion for green bonds, $46 billion for sustainability bonds, $19 billion for social bonds, $7 billion for green loans and $122 billion for sustainability-linked loans. According to Bloomberg NEF (2022) statistics, between 2017-2021, Sub-Saharan Africa accounted for less than 1% of issuance of green bonds, sustainable bonds, sustainability-linked bonds and loans. Only green loans reached 1.9% of global issuance by value in 2021. On the continent, South Africa accounted for 73.8% of all cumulative bond issuance between 2010 and 2021. Green and sustainable finance has contributed to extra-financial performance (Frimousse and Peretti, 2021).

On the other hand, climate change affects financial development through economic growth. For over twenty years, the global economy has been subject to the feedback of climate change, with recurrent economic and financial crises. In recent years, economic and financial instability has been caused by the disruptive shocks of climate change. In addition, the adverse effects of climate change and their impacts on the economy (Aguiton, 2018; Dafermos *et al.*, 2018; Chenet, 2019; Grippa *et al.*, 2019, NGFS, 2019; Allen *et al.*, 2020; Debels-Lamblin and Jacolin, 2020; Debels-Lamblin *et al.*,2020 GCF, 2020; Kpodar, 2021; NDC, 2021; Pereira Da Silva, 2021; Pestel and Oswald, 2021 and Jeanneney, 2023) have revealed the vulnerabilities of the financial sector, in particular its financial development dimension. As a result, urgent intervention is a necessity (Sterne, 2015; Nordhaus, 2019 and Oswald and Sterne, 2019). Climate change due to global warming is the lasting modification of the climate system and yet has a global dimension. This phenomenon affects agriculture, livestock farming, tourism and fisheries in heterogeneous ways, leading to fluctuations in GDP and a reduction in countries' economic growth rates. This reduction in economic growth could generate credit and market risk, leading to financial instability or even a financial crisis (lower credit, lower returns on financial assets, higher financial debt). However, the consequences are irreversible and irretrievable for the well-being of sub-Saharan African populations in particular (Noblet *et al.*, 2018). For example, in the Sahel and North Africa, rainfall is falling until the Sahel is hit by drought episodes. Yet projection models show a rise in rainfall in Eastern and Southern Africa (Ferdi, 2019 and Debels-Lamblin and Jacolin, 2020). Research in climatology, metrology and biophysical sciences shows a close link between rainfall, temperature and extreme events, which in turn illustrate the seriousness of the climate crisis.

According to statistics from Aguiton (2018) and Debels-Lamblin and Jacolin (2020), annual rainfall is falling by an average of 2.8 mm worldwide, compared with 7.1 mm in SSA. The value of this average drop is 8.5 mm and 4.0 mm respectively for the CEMAC and UEMOA zones. In addition, climatic events have caused 90% of natural disasters worldwide, including 15% in SSA. For example, during the period 1995-2015, 6457 natural disasters worldwide caused the death of nearly six hundred and six thousand people, and left 4.1 billion injured, homeless and in need of emergency aid. The financial cost of disasters over the last twenty years is estimated at six trillion dollars (Aguiton, 2018 and GCF, 2020). In SSA, an average of 26% of the population was affected by the worst droughts, compared with 23%

in East Asia and the Pacific over the period 2000-2018. In 2018, economic losses worldwide were estimated at $1.5 billion. While in SSA this amount is low due to the low level of development, there has been a 56% decline in GDP in these countries (Croitoru *et al.*, 2019 and Debels-Lamblin and Jacolin, 2020).

Climate change is an issue for credit policy. The depth of the financial system is one of the dimensions of financial development most affected. Depth refers to the importance of the financial sector within an economy and its ability to mobilize savings to finance investment opportunities (Sodokin *et al.*, 2021). As a sub-dimension of the depth of the financial system, financing refers to the mobilization and allocation of resources by the financial sector to the economy as a whole. Indeed, credit to the economy is credit granted to both private and public companies. Climate change not only has a direct impact on the economy, but also influences the conditions under which the economy is financed. In this context, we speak of the indirect effects of climate change. Indeed, the effects of climate indices on the agricultural, industrial and service sectors could be more favorable in some regions, and detrimental in others. Climate change brings both opportunities and risks to the financial sector. *"For the financial sector, climate change represents as much a source of business as a source of risk*" (Grippa *et al.*, 2019: p 4). Hence the need to analyze the causal link between financial development and climate change. Indeed, the two conferences held in New York in 2008 and 2009 on biodiversity and ecosystem finance testify to a growing relationship between biodiversity, ecosystems and finance (Dempsey, 2017). Similarly, current events testify to a growing relationship between the financial sector and environmental issues (Posca and Tabaichount, 2020). The debate in recent years has not led to any definitive conclusions, with the link between climate change and finance sometimes described as positive, sometimes negative or even non-existent. Given the complex effects of climate change on economic activities, and taking into account the financing of the economy, what causal link can be established?

The economies of sub-Saharan African (SSA) countries are among those that would be much more affected by climate change in its current state (Niang 2018). This is because the economies of these countries are highly dependent on the environment. If the economy struggles to add value in terms of sales due to climate change, this can have a very negative impact on the economy through lower agricultural value added and industrial value added, and can spill over into credit. Moreover, given the recurrent economic crises, financial development is highly

vulnerable, particularly in Sub-Saharan Africa. This is why SSA is the geospatial framework for this research, and is justified by the vulnerability of SSA economies to climate.

The relationship between climate change and financial development could be bidirectional, yet most empirical work deals with the effect of climate change on credit. As a result, empirical findings are mixed when it comes to the issue of climate change and financial development, in a context where finance is being brought to the fore to combat climate change. Studies on the causal effect between climate change and financial development5 are rare, and there are fewer published scientific papers on the causal effect to our knowledge. Yet it is well documented in the literature that climate change impacts the economy and hence on financial development (GCF, 2019 and Grippa *et al.*, 2019). Furthermore, Angrist and Imbens (2021) note the compelling need to analyze the causal relationship between climate change and macroeconomic variables. The empirical contribution of these authors on the methodology of causality analysis has given renewed interest to causality analysis, especially in the case of climate change.

The overall objective of this essay is to analyze the causal link between climate change and financial development. To achieve the objective, this essay defends the hypothesis that there is a causal relationship between climate change and financial development.

2. Climate change and finance

The literature on climate change and the financial sector is recent (Laret and Lorenzo, 2015) and developed after the 2012 post-Kyoto Protocol. In recent years, green finance has been gaining ground. However, the implementation of green finance (green bonds, sustainability bonds, social bonds, green loans, sustainability-linked loans) requires an extra-financial rating. This rating measures the climate risk explosion of financial assets in order to arbitrate between financing options. According to Weeren (2021), extra-financial ratings assess companies on other criteria than economic ones, notably ESG criteria. In this sense, there may be a link between financial development and climate change, such as climate derivatives, green credits, green bonds, green funds or environmentally responsible funds and ESG rating criteria.

These financial innovations take environmental and social considerations into account when making investment decisions. There are two imperatives that

must be met by sustainable finance. These are: i) to enhance the financial system's contribution to sustainable and inclusive growth by financing society's long-term needs, and ii) to strengthen financial stability in investment by integrating ESG factors into decision-making (ORSE, 2022). Financial development can therefore influence climate change through investment. For example, green credits incorporate a sustainable development benefit that directly affects the cost of credit. In this sense (environmental bonds, social bonds, sustainability-linked bonds and Sukuk bonds), sustainability-linked loans and green loans are transmission channels from financial development to climate change. These bonds can help reduce climate risks. This could be explained by the close link between economics and finance. According to Financial Sector Deepening Africa (FSD Africa) (2022), the increasing frequency and costs of climate change impacts in Africa will cause extreme losses to agricultural production, livestock and human health. To meet these challenges, the continent will need to seize the opportunity offered by a wide range of green financial instruments and funding sources, whose purpose is to produce positive environmental effects. However, like green bonds, green credit is dedicated to sustainable financing. But, unlike green bonds, green credit is used for the general financing of a company's activity. In view of this, credit is the relevant indicator for measuring financial development in the case of a climate change study.

Climate change indicators (physical risk and transition risk) are already significant. Sustainability risks have a negative impact on financial stability and the financing of the real economy, causing credit risks (ORSE, 2022). Indeed, the physical impacts (extreme weather variations) of climate change create asset risks and lower asset values. In addition, stranded assets show transition risks leading to depreciation of corporate assets and prices on the capital market. There are therefore two main avenues for financing the ecological transition: i) reducing the carbon footprint of investments, ii) reallocating funds in favor of climate transition or migration to low-carbon economies (carbon neutrality).

In this sense, green loans finance investment projects in favor of energy and ecological transition, which affects the climate. These climate risks have an impact on the insurance market and create a contagion phenomenon in the financial system. This is because they affect the real economy: agriculture, livestock farming, fishing, tourism and real estate (Grippa *et al.*, 2019). For example, 2.36% of net loans to the agricultural sector are exposed to climate change risks, and 1.98% for the energy sector (Scotiabank, 2020). From this point of view, the economy, in

particular the various real activities, is the major channel for transmitting climate change to financial development.

According to FSD Africa (2022), climate change is causing extreme production losses which, if not contained, will then become major social, economic and national security problems. In this case, it is clear that these losses will have knock-on effects on financial development, due to lower returns on credit-financed investment projects. In this sense, climate change is a source of financial instability and even financial crisis, hence the need to integrate sustainability factors into the assessment and management of ESG risks in credit ratings within the financial sector. ESG ratings are used to assess country credit risk. According to Laviale et al (2022), the systematic and transparent inclusion of ESG risks in credit ratings is a necessity.

Recent analyses of climate and economics have led to a new climate-related financial architecture. But climate change adaptation and sustainable mitigation financing are still poorly understood within African economies, and particularly in sub-Saharan Africa.

2.2. Empirical work on the relationship between climate change and financial development

The issue of the effects of climate change on the economy has been widely debated, but the results obtained are inconclusive. On the one hand, numerous empirical works have attempted to elucidate the relationship between financial development and climate change (Batten *et al.*, 2016 and Dafermos *et al.*, 2018; Chenet, 2019). Some authors find a negative effect of physical and transitional risks on credit through loss on investors, banks and the economy (Batten *et al.*, 2016; Dafermos *et al.*, 2018; Grippa *et al.*, 2019; Network for Greening the Financial System (NGFS), 2019; Kpodar, 2021). These authors find the same result that climate change negatively affects credit despite using different variables. Batten *et al.* (2016) measure climate change by physical risks, notably natural disasters, while Chenet (2019) and Grippa *et al.* (2019) use physical risks (temperature and precipitation) as well as transition risks (transition to a low-carbon economy, greenhouse gas emissions, etc, CO2).

These authors (Batten *et al.*, 2016; Dafermos *et al.*, 2018) use exchange rate, inflation, credit and price while Nasir *et al.* (2019) use bank credit, number of financial companies, and external debt to GDP to capture financial development. Physical risks are a source of natural disasters that slow down economic activity and

even lead to economic recession. This is followed by a reduction in credit due to the financial instability caused by economic recession. The negative effect of physical risks on growth leads to a reduction in credit in both affected and unaffected areas. In this case, climate change causes a decline in credit to the economy. As a result, the granting of credit to economic agents depends on climate change. According to Kpodar (2021), climate change causes credit to the economy. He points out that climate change generates externalities that require government intervention. Indeed, in order to finance adaptation and mitigation, governments are increasing climate loans, which has an impact on budgets and public debt. Debt repayment can be problematic, and non-repayment could lead to financial instability. In this way, climate change generates economic losses, leading to the inability to repay debt, which in turn can provoke a financial crisis and subsequently reduce credit.

On the other hand, some authors find a bidirectional causality between climate change and finance (Allen *et al.*, 2020; Spain *et al.*, 2021 and Pereira Da Silva, 2021). For these authors, climate affects the economy and financial shocks lead to macroeconomic impacts, including financial system instability. The total impact on banks has a feedback effect on liquidity risk and credit risk. The macroeconomic effect is associated with a feedback effect on climate. Spain *et al.* (2021) argue that the effect can be negative or positive. Allen *et al.* (2020) note that the transition to a low-carbon economy would occur sooner than expected if asset prices change in response to the transition path or changing expectations. For these authors, the effect depends on investor choice.

The financial sector has not been immune to the effects of climate change. The climate risks to which the financial sector is exposed are manifold. However, it is clear that credit risk is the most frequent of all these risks, despite innovations in the banking sector. For example, the Allianz group and World Wide Fund for nature (WWF) reports on climate change and the financial sector have advanced the debate in the financial community (Laret and Lorenzo, 2015). Indeed, the recurrence of various international climate conferences has marked the need to combat climate change.

As a result, empirical results are mixed as regards the issue of climate change and financial development in a context where finance is being brought to the fore to combat climate change.

This empirical work is inconclusive, as climate change presents both risks and opportunities to the financial sector. For Debels-Lamblin and Jacolin (2020), the

mobilization of domestic savings to combat climate change remains limited by the low level of financial development in SSA, both in terms of depth and financial inclusion. In this study, credit to the economy is a stock observed at the end of the period in relation to GDP. It is granted to both public and private enterprises. Credit to the economy allows us to delve more deeply into our research, as we believe that this indicator best approaches financial development. We could use components of credit to the economy or types of credit such as investment credit or consumer credit.

Based on these findings, this essay examines the causality between climate change and credit to the economy in the case of Sub-Saharan African countries.

3. Methodological Framework

3.1. Analysis of causality results financial development versus climate change

The result of the Toda and Yamamoto causality test highlights the causal links between the different variables. Thus, according to the result in the table below, in Sub-Saharan Africa, climate change as measured by the climate index does not cause credit to the economy. According to this result, the degree of reaction of credit to the economy following variations in climate change in SSA is low. This could be explained by the low impact of climate risks on all economic activities and investment. In this sense climate change has no effect on credit to the economy. This result differs from those of Dafermos *et al.* (2018) and Grippa *et al.* (2019).

Credit to the economy causes the climate index. This result implies that any variation in credit to the economy has an effect on climate change. The causality is indirect. In effect, credit to the economy causes climate change through the channel of economic growth, in particular the channel of trade openness and investment. From an economic point of view, the result can be explained by the fact that credit serves as an investment. Indeed, it is credit that enables economic agents to finance economic activities, which in turn contribute to the emissions that cause climate change. CO2 emissions causing climate change. This implies that all the changes in credit to the economy are the causes of the changes observed in climate change. This corroborates the analysis of Spain *et al.* (2021), which highlights the effect of financial development on climate change. From these results, it emerges that any desire to combat climate change, i.e. reduce temperatures, must first involve redirecting investments towards cleaner technologies, while discouraging polluting investments. To this end, previous

studies have established that innovation (the development of green finance) and the expansion of finance (the financialization of the economy) are factors10 that can reduce the climate phenomenon (Posca and Tabaichount, 2020).

From a theoretical point of view, this result is explained by the fact that credit serves economic activity. Considering the credit channel, Gurley and Shaw (1960) show that credit finances real activity. Yet climate change is directly or indirectly linked to real activity. From this point of view, human influence on climate is the cause of global warming, and according to Thiombiano (2004, p23) *"environmental problems can worsen or improve with income growth; some worsen and then improve"*. According to Thiombiano (2004), credit to the economy can worsen or improve the climate depending on whether it is granted to the most polluting or the least polluting economic activities. Debels-Lamblin and Jacolin (2020) show that climate change is a growing issue not only for fiscal and monetary policy, but also for financing the economy. On the other hand, this result invalidates the findings of NGFS (2019), who consider climate change as a source of financial risk. This result implies that directing credit towards less polluting sectors of activity could combat global warming. From this point of view, financial development is a relevant instrument in the fight against climate change. For example, the climate index affects agricultural yields. The impact of the climate index on agricultural yields is reflected in gross domestic product per capita. According to Grippa *et al.* (2019), a drop in economic activity due to climate leads to a tightening of credit to the economy. However, the results of our analyses show that the climate index does not cause credit.

This result confirms our research hypothesis that financial development causes climate change. This corroborates economic theory, which states that the expansion of finance promotes technological innovation. This in turn has a positive impact on the climate. Credit drives investment and economic growth, and is therefore the cause of climate change. However, our results also diverge from those of Batten *et al.* (2016), who find a unidirectional causality from natural disasters to credit. The role of finance in climate change resistance policies is now well established (Chiapello, 2020) and our results show that in Sub-Saharan Africa, finance can play an important role in the fight against global warming. For Chiappelo (2017), credit serves as investment, yet the effects of investment and economic growth on the environment pass through energy consumption and pollution. Investments can have both positive and negative effects. To this end, innovation and the expansion of finance are a sine qua non for redirecting polluting investments towards new green investments that improve the capacity to absorb technological progress.

The results also show bidirectional causality: foreign direct investment has an impact on trade openness, and trade openness has an impact on foreign direct investment. This result can be explained by the fact that trade openness creates more wealth. However, strong economic diversification and the presence of manufacturing industry can cause foreign direct investment. Yet direct investment can increase production and stimulate economic growth. This is the reason for trade openness.

In the same way, the index of financial institutions is the cause of foreign direct investment. Similarly, foreign direct investment influences the structure of the financial system. This causal relationship can be explained by the fact that financial institutions play an important role in the accumulation of savings. However, savings can reduce investment when their volume for investment purposes falls. Also, increased investment can stimulate economic growth, which affects ongoing financial institutions. The result is in line with the analysis of Gurley and Shaw (1960) and Stiglitz and Weiss (1981).

The results also reveal a unidirectional causality: credit to the economy is caused by credit to the economy. Credit causes trade openness, while investment causes climate change and agricultural value added. The climate index causes gross domestic product, while GDP influences trade openness. Agricultural value added is shown to cause gross domestic product per capita. However, agricultural yields are the cause of the interest rate, and the latter is the cause of GDP and agricultural value added. These findings are in line with Godard's (1995; 1997) analysis of the interconnection between economic sectors and their response to climate change.

We use the causality test of Dumitrescu and Hurlin (2012). Dumitrescu and Hurlin (2012) propose a causality test in a heterogeneous panel to test the robustesse. The advantage of this test is that it allows us to see direct causality between variables. In addition, the particularity of this test compared to the Granger and Toda and Yamamoto tests is that it allows us to see whether there is heterogeneity of slopes for the countries in the sample. In other words, homogeneity for some countries and heterogeneity for others.

3.2. Analysis effect of causality results financial development versus climate change

The results in Table 1 below have the expected signs. The coefficients obtained are elasticities and semi-elasticities, as some variables are taken in logarithm (DF, OUV, GDP).

The estimation shows that all variables have expected signs. However, most of the variables are not significant, except for the financial development variable and the structure of financial institutions. From an econometric point of view, the results show that variation in financial development, in particular credit to the economy, positively and significantly affects the climate index. A 1% increase in credit to the economy leads to an increase in climate change of 4.14 percentage points in the 21 countries in our sample. Economically, this can be explained by the fact that credit is the lifeblood of economic activity (Gurley and Shaw, 1960). Indeed, an increase in investment in polluting activities due to a rise in credit supply degrades the environment and negatively affects climate change. However, a better orientation of investment towards productive, non-polluting activities preserves the environment and reduces climate change. This result corroborates those of Lemmet and Ducret (2017); Allen *et al.* (2020), Pereira Da Silva (2021) and Spain *et al.* (2021). However, the result diverges from those of work highlighting the effect of climate change in relation to the financial sector (Dercon and Christiaensen, 2011; Xénogianni *et al.*, 2012; Batten *et al.*, 2016; Dafermos *et al.*, 2018; Grippa *et al.*, 2019 and Mouleye *et al.*, 2019).

The financial institutions index has a positive and statistically significant effect on climate change for all 21 SSA countries. Econometrically, the result shows that for every 1 percentage point increase in the financial institutions index, climate change increases by 1.035 percentage points. This can be explained economically by the fact that, as the size of financial institutions increases, so does economic growth. This result is in line with economic theory, and according to Thiombiano *et al.* (2010), the globalization of changes in the financial system has the effect of undermining the domestic financial system through the destabilization of trust.

Table 1: Estimation results

Variables	*Climate index*
L.climate index	-0,045
	(0,06)
Financial development	4,14**
	(2,18)
Economic growth	0,023
	(0,02)

Variables	*Climate index*
Agricultural yield	-0,0218
	(0,211)
Agricultural added value	0,0221
	(0,03)
Commercial opening	0,133
	(0,04)
Foreign direct investment	0,018
	(0,03)
Interest rates	-0,016
	(0,18)
Financial Institutions Index	1,035**
	(0,53)
Constant	0,871
	(0,67)
Observations	231
Sargan Test	66,6
	(0,15)
Hansen Test	3,36
	(0,99)
AR (1)	-3,78
	(0,00)
AR (2)	-0,48
	(0,62)
Number of contries	21

Standard deviations in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Source: Author based on Stata 16, WDI (2020) and FDI (2019)

Conclusion and Policy Implications

The present essay seeks to assess the causal effect between financial development and climate change for 21 SSA countries over the period 2008-2019. To test causality, we first estimated the VAR model and subsequently applied the causality test of Toda and Yammamoto (1995) and Dumitrescu and Hurlin (2012). In addition, a dynamic model with system GMM estimator was used to analyze the dynamic effect.

Empirical results show that financial development, in particular economic credit, has a positive and significant impact on the climate index. Hence the need to take climate change into account in finance. It also emerges that the relationship between climate change and financial development is indirect. However, the direction of causality is unidirectional, from financial development to climate change.

In terms of economic policy implications, authorities in Sub-Saharan African countries need to focus on financial development to combat climate change through innovation. Indeed, the fight against climate change is limited by weak financial development in SSA, with funding for climate projects at just 3%. Credit is a source of money creation and serves as an investment. As a result, the authorities have monetary policy at their disposal to combat climate change, since monetary policy is inseparable from credit policy. This means redirecting savings towards projects that do not harm the environment and promote the development of a circular, efficient and inclusive clean economy (Ruche, 2018), and penalizing credit institutions when they make loans to polluting activities. In addition, we need to develop financial markets and financial instruments such as the issuance of "Green *Bonds*" to finance green recovery activities. It will also be necessary to increase credit for innovative firms, particularly those developing carbon capture technologies. Sub-Saharan African countries need to develop climate finance in order to implement green climate projects. To combat climate change and promote sustainable development, financial players, financial markets, banks and financial institutions have a key role to play in issuing green bonds. In the case of SSA, credit to the economy is an instrument that could help combat climate change. To do so, credit needs to be redirected towards green projects aimed at accelerating growth and reducing temperatures.

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