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Effect of CO_2 emissions on the financialization of the economy in Sub-Saharan Africa

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CO_2 CO2 emissions, climate change, financialization, green finance, carbon finance.

ABSTRACT
Global warming has a global dimension. In recent years, the issue of finance and climate change is problematic. This is evidenced by the ecological, diplomatic and economic debates about reducing CO_2 emissions into the atmosphere. Thus, even if a country has not contributed to global warming, that country in turn suffers the effects of CO_2 emissions. Therefore, efforts to reduce or not reduce CO_2 emissions will be beneficial or harmful to all countries. Thus, the objective of this paper is to analyze the effect of CO_2 emissions on the financialization of the economy in Sub-Saharan Africa over the period 2000-2019 for a sample of 21 countries. Tests of cross-sectional dependence, stationarity, identification associated with specification tests, order and rank conditions have been performed. We used the double least squares (DLS) estimation technique. The estimation results of the equation of the financialization of the economy show that the CO_2 emissions positively affect the financialization of the economy in Sub-Saharan Africa. This result implies that the development of the financialization of the economy could be beneficial to the reduction of CO_2 emissions and thus fight against global warming. Thus, the authorities of Sub-Saharan African countries should focus on the development of financial markets and financial instruments.

1. INTRODUCTION

Greenhouse gas (GHG) emissions have been rising steadily since the 1970s. Pollution is global, and the consequences of GHG emissions affect all living beings and associated material elements. These GHG emissions, consisting mainly of carbon dioxide (CO_2), methane (CH_4), SF_6, PFCs, HFCs, and nitrous oxide (N_2O) (IPCC, 2021), are due to anthropogenic forcing, in particular human activity, including commercial economic activity. However, finance is the lifeblood of economic activity, hence the importance of the role of financialization in global warming. Air pollution due to the greenhouse effect is a global problem. However, CO2 equivalent is the most polluting GHG, accounting for more than 56% (IPCC, 2021) of total GHG emissions, but has been declining in recent years, from 147,740 tons of CO2 equivalent in 2018 to 134,782 tons of CO2 equivalent in 2019, and 118,258 tons of CO2 equivalent in 2020 worldwide (Scotiabank, 2020). According to Hasselmann (1988), winner of the 2021 Nobel Prize in Physics, CO2 controls the Earth's climate because CO2 levels correspond to rising global temperatures. Today, global warming due to atmospheric CO2 concentrations is a worldwide threat. As a result, the Intergovernmental Panel on Climate Change (IPCC) notes that efforts to reduce or not reduce CO2 emissions will be beneficial or harmful to all countries. The effects of CO2 emissions are complex and interact with the economy, as they lead to socioeconomic, health, and environmental changes.

"When it comes to financing the economy, the roles played by households, governments, and financial institutions vary greatly from country to country. These roles change over time" (Bodie et al., 2011: 27). The financialization of the economy means that banking and financial activities have taken on an increasingly important role (Karwowski and Stockhammer, 2017, and Posca and Tabaichount, 2020), for example, the development of financial markets and financial instruments.

The important role of finance in economic development has led to the emergence of financialization. Thus, while all

financial development is financialization of the economy, not all financialization of the economy is financial development. Financial development is a long-term, multidimensional process of which the financialization of the economy is one sub-dimension. However, the financialization of the economy, as a sub-dimension of financial development, particularly the depth of the financial system, is a short-term process that favors the option of financing productive investment. Admittedly, financialization and financing are two complementary sub-dimensions of the depth of the financial system, but they are fundamentally different. For Sodokin et al. (2021), the financialization of the economy is the share of the financial sector relative to the rest of the economy.

According to statistics, total gross global CO_2 equivalent emissions worldwide rose from 15 billion to over 37 billion tons between 1970 and 2018, with CO_2 emissions in 2019 accounting for 50% in Asia, 18% in North America, 15% in Europe, 8% in the Middle East, 3% in South America, 1% in Oceania and Latin America, and 4% in Africa (Goudlard, 2021). Emission rates vary according to the level of economic development. In Africa, Arezki, (2021) and Goudlard (2021) note that in 2019, CO_2 emissions reached 33% in South Africa, 17% in Egypt, 12% in Algeria, 10% in Nigeria, 5% in Morocco, 3% in Libya, and 20% in other countries. The World Bank forecasts a 70% increase in total global greenhouse gas emissions by 2040, with emission rates by 2030 reaching 34% for China, 21% for the G20, 14% for the US, 9% for India, 7% for the EU, and 15% for the rest of the world (Black, 2021). Similarly, the International Energy Agency (IEA) (2019) notes that in SSA, CO_2 emissions relative to global levels would reach and exceed 3%. However, changes in CO_2 levels affect all environments and compromise economic growth and human development, hence the importance of financializing the economy in sub-Saharan Africa (SSA) in the context of global warming.

Since the Paris Climate Conference (COP 21), financing the environment has become a necessity. Finance is the solution for reducing GHG emissions, particularly CO_2. For example, COP 26 notes that reducing CO_2 emissions requires $100 billion per year to finance the energy transition, and in terms of climate and energy, the European Commission estimates an annual investment of €200 billion from 2021 onwards to achieve the targets set for 2030. To do this, "countries must make financial flows compatible with a profile of transition to low greenhouse gas emissions" (Chiapello, 2020: 39). This financing involves developing green activities on the one hand and reducing brown activities on the other. In this sense, investment in green projects, mainly renewable energy and public transport financing projects, is increasing. For example, at the end of 2020, 77 projects had been implemented worldwide to reduce deforestation and forest degradation (REDD) for a total of $185 million, and the volume of renewable energy investments amounted to $350 million between 2017 and 2019 (Azerki, 2021). In addition, financial instruments are developing, particularly green bonds, blended finance, and the insurance market. The volume of green bonds amounts to $250 million worldwide (Azerki, 2021).

In Africa, the Great Wall reforestation project has been implemented (Goudlard, 2021). However, the cost of financing non-sovereign loans in the African context favors the development of financial markets. In addition, demand for climate finance for African countries is increasing. In Sub-Saharan Africa, investment in climate finance is emerging, particularly for the deployment of renewable energy and energy efficiency (Mungai et al., 2022). Since the end of 2015, green projects aimed at reducing CO_2 emissions have been multiplying in SSA in order to develop green activities. For example, in Sub-Saharan Africa (SSA), there have been 510 requests for climate finance, particularly in the agriculture, water, energy, and renewable energy sectors (NDC, 2021), of which 20.78% were for mitigation, 23.33% for adaptation and 55.88% for cross-cutting adaptation. Although climate finance requests in SSA are increasing, it is clear that not all of these requests are being supported. Falconer (2020) notes that climate project financing in SSA stands at 3%. According to NDC statistics (2021), in 2021, 61 out of 87 applications for agriculture were supported, compared to 49 out of 77 for water. However, 85 out of 126 applications for energy were supported, compared to 58 out of 74 for renewable energy, and 77 out of 93 applications for capacity-building activities were also supported. As a result, the consideration of CO_2 emissions by finance, particularly climate finance, is a reality in SSA.

Bankable green projects aimed at reducing CO_2 emissions are on the rise in SSA, but not all projects are able to secure financing (NDC, 2021). To address this, SSA countries are developing financial markets and financial instruments as strategies for mobilizing resources and climate finance, hence the importance of financialization of the economy. SSA countries are experiencing strong demand for climate finance and growth in investment in green projects. For the African Development Bank, the development of finance promotes green investments to mitigate CO_2 emissions (Azerki, 2021). In addition, investment in green projects catalyzes the development of the bond market, which promotes innovation and subsequently reduces CO_2 emissions. The consequences of CO_2 emissions are borne by all living beings and material elements. In light of this, a lack of climate policies would cause real, profound ecological disasters and even the disappearance of humankind. In this sense, the absence of policies aimed at reducing CO_2 emissions would lead to changes in the global economic system. However, for any policy adopted, the impacts of CO_2 emissions are likely to have a retroactive effect on the economy and society. Indeed, in the context of climate change, acting on CO_2 emissions would affect all economic sectors. This is what Faucheux and Joumni (2005) argued when they stated that "preventive policies that tackle the causes of global warming by acting on CO_2 emissions would affect all economic sectors."

However, according to Pestre (2020): "green finance in the 2015s is a fourth phase in environmental policy after i) the invention of environmental policy in 1960, ii) the promotion of market-based instruments for pollution rights in 1980, and iii) the takeover of environmental issues by multinational corporations in the name of sustainable development in 1988 and 1992." The effects of global pollution linked to CO_2 emissions are likely to have a knock-on effect on the economy and finance. This is what Schubert (2017) argued: short-term economic decisions have an impact on the environment and, in turn, environmental degradation weighs on economic activity, hence the need to understand the interactions. However, the debate over the last ten years has not led to any definitive conclusions, with the link between these dimensions sometimes described as positive, sometimes negative, and sometimes even non-existent. Therefore, given that the financing of the energy transition is the junction point (Schubert, 2017) between macroeconomics and the environment, how are CO_2 emissions reshaping the financialization of the economy? What is the effect of CO_2 emissions on the financialization of the economy in Sub-Saharan Africa?

It must be noted that the results of the link between financial development and CO_2 emissions are not unanimous, given that several econometric approaches are used. In view of these controversies and econometric shortcomings, the empirical results are mixed. Admittedly, SSA contributes only 4% of total CO_2 emissions, but if the continent develops through industrialization, emissions could become problematic. Although the continent is underdeveloped and poorly industrialized, Africa tends to emphasize nature conservation and defer the fight against pollution (Zang, 1998). Given this situation, it is important to look at the financialization of the economy in Sub-Saharan Africa in the context of climate change, particularly the effect of CO_2 emissions. on the financialization of the economy in SSA. This work is based on growth theory, in particular Schumpeter's innovation theory (1911, 1939).

In order to contribute to the understanding of CO_2 emissions, we take into account, as Sadorsky (2010) and Chang (2015) do, the heterogeneity of SSA countries to correct for bias. Unlike these authors, however, we analyze the effect of CO_2 emissions on the financialization of the economy in sub-Saharan Africa. The objective of this essay is to analyze the effect of CO_2 emissions on the financialization of the economy.

We assume that in SSA: the effect of CO_2 emissions on the financialization of the economy is positive.
The contribution of this article is empirical. The article contributes to the literature by highlighting the effect of CO_2 emissions on the financialization of the economy in SSA.

The rest of the paper is structured as follows: the first section reviews the literature on the subject. The second section presents the methodology of the analysis. The third section discusses the estimation results, and the fourth section concludes the article by providing economic policy implications.

2. CO_2 emissions and financialization of the economy : Literature Review

Several studies have sought to establish a relationship between financial development and CO_2 emissions. Schumpeter (1911) argues that financial development promotes technological innovation. Financial development makes it possible to finance the acquisition of human capital. Improvements in human capital enable the development of new technologies and the capacity for creation. The use of new technologies in human activities is likely to reduce CO_2 emissions. Indeed, financial development makes it possible to finance innovative projects, and the spread of technological innovation is a mechanism for containing pollution. Therefore, financial development reduces CO_2 emissions. According to the author, innovation (equipment, new products, new financial resources, and new markets, etc.) is the driving force behind long-term economic growth. However, economic activities are nourished by finance.

The Kuznets environmental curve (Kuznets, 1955) describes the relationship between CO_2 emissions and economic growth, which is sometimes negative and sometimes positive. CO_2 emissions interact with economic growth (Kuznets, 1955) and subsequently affect the financialization of the economy.

The endogenous growth theory states that structural and stabilization policies such as financial depth, trade openness, investment, budget deficit, debt, exchange rate, and innovation, etc., are the determinants that impact economic growth. Therefore, the relationship between CO_2 emissions and the financial sector is based on three economic sectors (Furuoka, 2015): the energy sector, the financial sector, and consumers and producers. According to Furuoka (2015), consumers and producers, in their decision-making for human activities, influence energy demand and consumption and credit to the economy. Energy production affects consumers, producers, and credit to the economy granted by banking and financial institutions. Credit from banking and financial institutions affects the conditions of consumers and producers for economic activities and, subsequently, the demand for energy consumption and production, which is fueled by economic activity. Indeed, the fundamental idea is that the decision to energy consumption in production processes, CO_2 emissions, and economic growth are simultaneous. However, the choice of banking and financial activities is a risky one. When carbon-intensive industries depend on external financing, an increase in global demand for the products manufactured by these industries leads to an increase in external financing. In this case, CO_2 emissions and financial development increase simultaneously without there being a causal link.

A review of the literature shows that the analysis of the relationship between the financialization of the economy and CO_2 emissions is based on innovation theory. Financial development promotes energy consumption through three main channels: the direct effect, the business effect, and the wealth effect (Zhang, 2011; Aslan et al., 2014, and Chang, 2015). However, the effect of CO_2 emissions on financial development has not led to any definitive conclusions, with the link between these two dimensions sometimes described as positive, sometimes negative, and sometimes non-existent. Understanding the link between financial development and CO_2 emissions therefore remains a fundamental limitation. From this perspective, the question of the effects of CO_2 emissions arises, and it is interesting to analyze these effects on the financialization of the economy.

Finance is one of the most effective means of reducing CO_2 emissions at the international level. Indeed, finance makes it possible to align capital flows with green activities, which promotes low-carbon development and combats global warming (Chiapello, 2020). Theoretical analysis of the relationship between energy and growth, as well as that between financial development and economic growth, has shown its limitations. Analysis of these relationships has revealed their inability to explain the causal relationship and variables of growth, financial development, and CO_2 emissions. To overcome these limitations, Tamazian et al. (2009); Sadorsky (2010), and Zhang (2011) have integrated financial development into the relationship between the environment and economic growth. Several studies have sought to establish a relationship between CO_2 emissions and the financialization of the economy for a country or group of countries such as the BRICS, China, and Eastern and Central Europe (Tamazian et al., 2009; Jalil and Feridun, 2011, and Ozturk and Acaravic, 2013).

According to Kuznets' environmental curve, one of the main channels through which CO_2 emissions affect the financialization of the economy is economic growth. The increase in CO_2 emissions in the atmosphere is directly linked to the use of fossil fuels by humans in the process of economic growth. Thus, since the 1990s, economic growth has been considered one of the main sources of CO_2 emissions (Grossman and Kruger, 1991 and Grossman and Kruger, 1995). However, the feedback effects of global warming due to CO_2 emissions have environmental impacts and their consequences lead to socioeconomic changes. These effects of CO_2 emissions affect the entire biosphere and reduce economic growth, hence the negative effect of CO_2 emissions. Therefore, there is a reciprocal relationship between economic growth and CO_2 emissions (Kuznets, 1955), which implies that a reduction in economic growth leads to a decrease in CO_2 emissions. However, not all authors agree with this conclusion. For example, Ren (2008) tests similar hypotheses and finds that economic growth can be increased while reducing CO_2 emissions.

From this point on, the question of increasing economic growth in a way that is compatible with low CO_2 emissions arises. The debate between economic growth and CO_2 emissions is long-standing and widely discussed (Kuznets, 1955; Kraft and Kraft, 1978; Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992 and Panayotou, 1993; Al-mulali et al., 2012 and Omri et al., 2015). However, the results are inconclusive and the controversy is far from being resolved. Recently, numerous empirical studies have attempted to verify Kuznets' (1955) hypothesis that the relationship between CO_2 emissions and economic growth is inverted U-shaped (Esso and Keho, 2016, and Cai et al., 2018). The main conclusion is that there is a unidirectional and/or bidirectional causality between economic growth and CO_2 emissions. The results are divergent, and the relationship between CO_2 emissions and economic growth raises questions and reflections on the models used. Thus, considering the augmented Cobb-Douglas production function, Shahbaz et al. (2013) find that the causality between economic growth and CO_2 emissions is bidirectional, and that the channels through which CO_2 emissions can reduce economic growth are per capita capital stock and human capital. Shahbaz et al. (2019) considered financial development in the relationship between energy consumption and economic growth in the case of India. However, for Mukhtarov et al. (2020), CO_2 emissions follow the evolution of energy consumption, hence the relationship between financial development and CO_2 emissions.

The link between CO_2 emissions and the financialization of the economy is established through economic growth. According to Schumpeter (1911), financial development leads to technological innovation. For example, the change and adoption of new technologies that are likely to contribute significantly to reducing CO_2 emissions (King and Levine, 1993, and Sadorsky et al., 2013). Recent empirical work has focused on the cause-and-effect relationship between financial development and CO_2 emissions (Tamazian et al., 2009; Tamazian and Rao, 2010; Aslan et al., 2014). Tamazian et al. (2009) analyze the relationship between financial development and CO_2 emissions. The results of their study show that financial development reduces CO_2 emissions, and Jalil and Feridun (2011) arrive at the same conclusion.

Referring to the finance-energy relationship, Aslan et al. (2014) examine the relationship between financial development and energy consumption in the Middle East. The results of their study indicate that, in the long term, financial development has a positive effect on energy demand, but in the short term, there is a bidirectional relationship between

energy consumption and financial development. Similarly, Sadorsky (2010) analyzed the relationship between financial development and economic growth in 22 emerging countries, focusing on energy consumption. His analysis shows that financial development has a positive effect on economic growth, energy demand, and CO_2 emissions. However, using an error correction vector model, Mukhtarov et al. (2020) found a direct relationship between energy consumption and CO_2 emissions between 1993 and 2014 in Kazakhstan. There appears to be a paradox in the effect of financial development on CO_2 emissions. The empirical relationship between financial development and CO_2 emissions is poorly understood. Considering the results of Aslan et al. (2014), financial development promotes CO_2 emissions in the long term, but in the short term, CO_2 emissions could impact financial development, thus creating a bidirectional causality. The contradiction in the results could be, on the one hand, methodological and geographical in nature, as the authors do not use the same methodology and geographical approach in their analysis. On the other hand, the effect of financial development on CO_2 emissions also depends on the measurement of financial development and the level of economic development.

The literature on the relationship between finance and energy is relatively recent. While analysis of the link between financial development and CO_2 emissions is still in its infancy, it is clear that the debate is controversial. Indeed, analysis of the relationship between financial development, particularly the financialization of the economy, and CO_2 emissions is based on three main effects: (i) direct effect, (ii) business effect, and (iii) wealth effect (Sadorsky, 2010).

2. METHODOLOGY

Analysis methodology and estimation technique

In the literature, numerous methods have been used to examine the relationship between energy, economic growth, and financial development, or between energy, the environment, and growth. However, most of these studies use the Cobb-Douglas production function.

The Cobb-Douglas production function links capital and labor, and can include other variables such as energy, human capital, financial development, and the environment to analyze their effects on production.

Econometric modeling: writing the theoretical analysis model

Thus, to study the effect of CO_2 emissions on the financialization of the economy, this study draws on the theoretical model developed by Kahouli (2017) based on Ehrlich and Holdren's (1972) model, which uses a Cobb-Douglas production function.

The model is based on Bekhet et al. (2017) and Kahouli (2017), excluding certain equations and adding certain variables that are more relevant in the context of SSA countries.

Econometric modeling empirical formulation of the analytical model and data source

In view of the objective of our study and to test our hypotheses, we use variables such as: financialization (IFE), economic growth (GDPpc); CO_2 emissions; energy consumption (EC), renewable energy consumption (REC), domestic investment (GFCF), urbanization (URB), and labor (L); trade openness (OUV).

The explanatory variables are: CO_2; K; URB; OUV; L; EC; CER.

The dependent variables are Y and IFE.

The simultaneous equation structural model is as follows:

$$\begin{cases} \mathrm{Y} = f(\mathrm{CO}_2, CE, K, URB, OUV, L, CER) & (1) \\ IFE = f(Y, \mathrm{CO}_2, CE, CER\ K, URB, OUV) & (2) \end{cases}$$

The empirical model takes the following form:

$$\begin{cases} \ln \mathrm{Y}_{it} = \mu_i + \gamma_t + \beta'_0 \ln \mathrm{EC}_{it} + \beta'_1 \ln \mathrm{OUV}_{it} + \beta'_2 \ln \mathrm{L}_{it} + \beta'_3 \ln \mathrm{CER}_{it} + \beta'_4 \ln \mathrm{URB}_{it} + \beta'_5 \ln \mathrm{K}_{it} \\ \qquad + \beta'_6 \ln \mathrm{CO}_{2it} + + \varepsilon_{it} \quad (3) \\ \ln \mathrm{IFE}_{it} = \mu_i + \gamma_t + \delta'_0 \ln \mathrm{CO}_{2it} + \delta'_1 \ln \mathrm{OUV}_{it} + \delta'_3 \ln \mathrm{Y}_{it} + \delta'_4 \ln \mathrm{CER}_{it} + \delta'_5 \ln \mathrm{URB}_{it} + \delta'_6 \ln \mathrm{CE}_{it} + \pi_{it} \quad (4) \end{cases}$$

All of these variables come from the World Development Indicators (WDI, 2020) database and the World Federation of Exchanges (2019) database, International Financial Statistics (IFS) (2019), and International Monetary Fund (IMF) (2019) databases, covering the period 2000-2019 for a sample of 21 SSA countries (Angola, Benin, Botswana, Cameroon, Democratic Republic of Congo, Congo, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania). Sub-Saharan Africa is the region facing the challenge of climate finance aimed at reviving green activities and financing bankable green projects, hence the choice of this area. Recent years have seen the development of financial markets, particularly in Sub-Saharan Africa, which justifies the choice of this study period.

Result

Endogeneity test

This test is conducted in three stages: first, the economic growth variable, which is assumed to be endogenous, is estimated using OLS. Second, the residuals recovered from the estimation are included as an explanatory variable and, finally, the significance of the coefficients is tested. The result of the test shows that economic growth and CO2 emissions are endogenous.

Specification test.

The study of homogeneity or heterogeneity is necessary in the case of panel data. We perform the Hausman test, which does not reject the presence of random effects for the equations, so we specify a random effects model.

Stationarity test

Stationarity is essential in the study of panel data. Indeed, when data are not stationary, standard tests are not valid. To this end, we perform a first-generation MW (1999) and second-generation CIPS Pesaran (2007) stationarity test. The results show that most variables are stationary in first differences except FE, CER, and URB, which are stationary in level.

In view of the endogeneity and stationarity results associated with the specification tests, the order and rank conditions are satisfied. In this case, the appropriate estimation method is double least squares, which applies to all well-identified or over-identified models.

Descriptive statistics

The financialization of the average economy (figure 1) is 0.07% for the entire sample, with a minimum financialization of zero and a maximum financialization of 0.88%. The intra-individual variance is equal to 0.02, representing a deviation of 0.144. However, the inter-individual deviation is 0.02, representing an inter-individual variance equal to 0.0004 out of a total deviation of 0.143, or a total variance of 0.0225. The average CO_2 emissions rate for the entire sample is 3.23%, with a maximum rate of 50.31% and a minimum rate of 0.057%. The intra-individual (between) variance is equal to 96.63 and a deviation of 9.83, while the inter-individual (within) variance is equal to 1, representing a deviation of 1 out of a total variance of 93.31. However, the average energy consumption (EC) rate for the 21 countries is 698.87%, with a minimum EC rate of 113% and a maximum rate of 3129.07%. However, there is a high intra-individual variance in EC of 410,881 for a deviation of 641.72 and a high inter-individual variance of 17,145.28 for a deviation of 130.94 out of a total variance of 410,278.68 with a total deviation of 640.53. This significant variation can be explained by the level of economic and industrial development of the countries. In terms of renewable energy consumption, the average rate for all 21 countries considered is 65.82%. However, the maximum renewable energy consumption is 98.34% and the minimum is 10.63%. The intra-individual variance is 663.57, representing an intra-individual difference of 25.76, while the inter-individual difference is 4.21, representing an inter-individual variance of 17.72. However, the average growth for the 21 countries is 0.26%, with a maximum rate of 1.09% and a minimum rate of 0.019%. At this level, growth variability is low, as evidenced by the total variance of 0.072, representing a total standard deviation of 0.27, with an intra-individual variance of 0.078 and a between-individual variance of 0.28, representing a within-individual variance of 0.05. The average investment rate for the entire sample is 23.61%, with a minimum investment rate of zero and a maximum rate of 53.98%. However, the intra-individual variance is 31.69, representing a difference of 5.83, while the inter-individual variance is 45.56, representing a difference of 6.65 out of a total variance of 75.86, representing a total difference of 8.71.

In the 21 countries considered, there is significant variability in investment between countries, and this result could be explained by the weight of the wage bill within countries. As for the labor factor, there is an average rate of 1.16e+07% for all 21 countries, with a maximum rate of 5.99e+07 and a minimum rate of 340,723. The intra-individual variance is very high at 1.77e+07 for a standard deviation of 1.33e+07, while the inter-individual variance is equal to 6.51e+12, a difference of 2,550,511 out of a total variance of 1.74e+07 with a total difference of 1.32e+07. This could be explained by the weakness of the individual dimension compared to the temporal dimension. The average urbanization for the entire sample is 2.55%, with a minimum of 0.32% and a maximum of 3.90%. The total variance is 0.55, with a total deviation of 0.74, and the inter-individual variance is equal to 0.04 and the intra-individual variance is equal to 0.53, with standard deviations of 0.19 and 0.73, respectively. The average trade openness is 71.99% for the 21 countries in the sample, with a minimum of 20.72% and a maximum of 165.64%. The intra-individual trade openness gap is 26.78, with an associated intra-individual variance of 717.17, while the inter-individual gap is 12.93, representing an inter-individual variance of 167.18 out of a total variance of 851.47, or a total gap of 29.18.

In light of these statistics, we can conclude that there is heterogeneity within the panel in terms of energy consumption, CO_2 emissions, investment in economic growth, and financialization of the economy. However, the gap in terms of growth and financialization of the economy is relatively small, while there is a wide disparity in terms of CO_2 emissions, energy consumption, investment, urbanization, trade openness, and labor intensity.

Table 1: Results of descriptive statistics for panel data.

	CE	CER	CO2	FBCF	GDP__P__C	L	OUV	URB	FD_FM_IX
Mean	698,87	65,82	32357,36	23,63	2663,73	1,2E+07	72	2,55	0,07
Median	476,626	74,90	5003,62	22,77	1283,11	7190076	65,85	2,68	0,02
Maximum	3129,08	98,34	503112,4	53,98	10949,24	6E+07	165,6	3,90	0,82
Minimum	113,09	10,63	575,71	0	194,87	340723	20,72	0,03	0
Std, Dev,	640,53	25,52	96660,98	8,71	2796,40	1,3E+07	29,19	0,74	0,14
Skewness	2,32	-0,705	3,97	0,09	1,31	1,77	0,72	-1,16	3,52
Kurtosis	7,54	2,23	17,62	3,98	3,41	5,71	3,06	4,92	15,55
Jarque-Bera	739,67	45,10	4845,75	17,57	124,12	348,72	36,93	158,5	3624,49
Probability	0	0	0	0	0	0	0	0	0
Sum	293526	27648,3	13590090	9925,3	1118769	4,89E+09	30238	1074	30,84
Sum Sq, Dev,	1,72E+08	273070	3,91E+12	31801	3,28E+09	7,31E+16	4E+05	234,6	8,61
Observations	420	420	420	420	420	420	420	420	420

Source: Author's construction based on Eviews

Estimation result

The results of the estimates (table 2) have the expected signs and the coefficients are elasticities, given that all our variables are logarithmic. The results of the estimates indicate that CO_2 emissions have a positive and significant effect on the financialization of the economy in sub-Saharan African countries. Thus, in sub-Saharan Africa, a 1% increase in CO_2 emissions leads to a 1.48e-06% increase in the growth of banking and financial activities, i.e., a growing role for financial motives, financial markets, and financial institutions in the activity of national and international economies. Indeed, an increase in CO_2 emissions leads to the development of innovative green financing policies and new financing mechanisms to limit global warming and ensure the transition to a sustainable economy. This results in the growing importance of banking and financial activities in the economy. This finding corroborates the results of studies highlighting the relationship between CO_2 emissions and financial development (Gallego-Alvarez, 2014 and Destek; Sarkodie, 2019 and Posca and Tabaichount, 2020).

Furthermore, the result is consistent with Aguiton's (2018) analysis, according to which environmental financing requires new financial products (climate derivatives) that enable companies to insure themselves against weather variations on the financial markets, which would lead to the development of green bonds. This implies that the increase in CO_2 emissions in SSA countries leads to a growing role for financial markets relative to banks in financing economic activities. Indeed, the increase in CO_2 emissions and its corollary of global warming leads to the development of short-term productive investment financing options. In Sub-Saharan African economies, countries are developing resource mobilization and climate finance strategies (NDC, 2021) to finance green project financing requests in order to reduce CO_2 emissions. The development of green investment financing is multiplying. For example, the development of green bonds and the proliferation of green projects such as renewable energy consumption and climate finance for CO_2 emissions mitigation in SSA. In ASS, NDC (2021) estimates that in 2021, the number of applications for climate finance will be 510, with 23.33% of financing directed towards mitigation. This result confirms our second research hypothesis, which states that CO_2 emissions have a positive effect on the financialization of the economy.

Paradoxically, urbanization measured by the urban population as a percentage of the total population has a negative and significant impact on the financialization of the economy in SSA. A 1% increase in the urban population as a percentage of the total population leads to a 1.33% decrease in the financialization of the economy. However, trade liberalization has a positive effect on the financialization of the economy. A 1% increase in trade liberalization results in a 3% increase in

the financialization of the economy. Indeed, the more a country opens up to international trade, the more trade with other countries leads to capital inflows or outflows. These capital flows, under the effect of globalization and financial globalization, lead to the development of financial markets and thus to the development of the financialization of the economy.

In order to ensure accurate results, we used the triple least squares method to take into account the interdependence between growth and financialization of the economy. TMCs consider the correlation between equations and a possible correlation between the error terms of the equations. The results obtained from the TMC estimates are consistent with those of the DMC in terms of sign and significance; only the coefficients vary very slightly.

Table 2 : Result of estimating the financialization of the economy.

Dependante Variable : financialization index (IF)	**Coefficients**
CO2	10,92**(0,05)
GDP	18,59(0,09)
OUV	0,08***(0,03)
Energy consumption (CE)	0,01***(0,0013)
renewable energy consumption (CER)	-0,26**(0,04)
L	-6,49(6,93)
Urbanization (URB)	-0,61(0,90)

Source: Author using Stata. * Significance at 10% ; ** Significance at 5%. ; *** Significance at 1%.

Robustness test

In order to test the validity of the results obtained from the estimates, we changed the variable used to measure the financialization of the economy. To do this, we used the financial market health index. The results obtained from the estimates are shown in (Table 3).

The results show that CO_2 emissions have a positive and significant influence on the financial market health index of the economy, including the financialization of the economy. The effect of CO_2 emissions on the health of financial markets is not very similar to the effect of CO_2 emissions on the financialization of the economy, as the signs of the different variables remain unchanged and statistically significant. When changing the method of estimating DMCs by TMCs, the results remain consistent.

In conclusion, although we changed the variable used to measure the financialization of the economy, the results obtained are not very similar to those obtained using the financial market health index. This validates our estimation results. In conclusion, the estimation results obtained are robust and valid.

Table 3: Robustness test result

Dependante variable : financial market health index IFM	Coefficients
CO2	2.37 (0,32)
GDP	-7,88**(0,09)
OUV	0,05***(0,01)
Energy	0,008***(0,009)
Renouvelate energy	-0,16***(0,02)
L	-5,42 (7,16)
Urbanisation (UBR)	-7,34(0,69)

Source: Author using Stata. * Significance at 10% ; ** Significance at 5%. ; *** Significance at 1%.

3. CONCLUSIONS

Since the 2015 Conference of the Parties in Paris, reducing temperatures to 2°C by 2050 has become a pressing goal and an urgent necessity for achieving sustainable development objectives. This research examines the issue of global warming in order to determine the effect that emissions may have on the financialization of the economy in sub-Saharan

African countries. The objective is therefore to examine the effect of CO_2 emissions on the financialization of the economy in sub-Saharan Africa between 2000 and 2019. To answer the research question, the DMC estimation technique was used. This choice is justified for two reasons: economically, by the dynamic relationship between CO_2 emissions and the financialization of the economy, but also between CO_2 emissions and economic growth. From an econometric perspective, it was justified by the endogeneity, simultaneity, and double causality between financialization and growth. The results of the estimates show that CO_2 emissions have a positive effect on the financialization index. In fact, given that the degree of financial penetration in the economy varies from one country to another, the effect of CO_2 emissions on the financialization of the economy varies according to the level of economic and financial development of a region or nation.

The various findings have implications for economic policy, such as the development of innovative green financing policies and new financing mechanisms, including the development of financial markets and financial instruments such as green bonds to finance green projects with a view to accelerating economic growth and reducing CO_2 emissions. Given that CO_2 emissions drive the development of financial markets, financial engineering needs to be developed. In SSA, climate finance is a means of financing bankable green projects and other green recovery activities aimed at accelerating economic growth and reducing CO_2 emissions (NDC, 2021). This raises the question of the role of finance in the relationship between sustainable development and CO_2 emissions

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