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Revisiting the Nexus between Climate Change and Unemployment in South Africa

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Abstract: Emancipating policy coherence and achieve a sustainable future, it is essential to identify the linkages between the 17 Sustainable Development Goals (SDGs) put out by the UN. Sequel to this, the study revisits the nexus between climate change and unemployment in South Africa. The study employed time series data span through 1986-2021. The ARDL econometric techniques is used to evaluates the nexus amid the variables. Given that the long-term coefficient of climate change (Tpr) is positive and statistically significant at the 5% level, the long-run result support the expected sign that climate change has a positive impact on unemployment in South Africa. The government of South Africa need thus concentrate more on lowering the country's inflation rate and strengthening the local currency relative to the US dollar. In the meantime, the shortage of jobs in South Africa will worsen due to the rise in unemployment brought on by the rising temperatures. Here, the government should increase funding at the federal level for a number of industries, including forestry, tourism, agriculture, and fisheries, that are heavily reliant on climate change.

1. Introduction

Emancipating policy coherence and achieve a sustainable future, it is essential to identify the linkages between the 17 Sustainable Development Goals (SDGs) put out by the UN (Li et al., 2023; Griggs et al., 2013; Wang et al., 2022; Zhao et al., 2017; Zhang et al., 2024). Urgent climate action is necessary to achieve a zero-carbon future as the effects of climate change become more apparent on a global scale.

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Nonetheless, there may be trade-offs and synergies between aggressive climate action and other goals including public health, the food system, and energy availability (Martinich et al., 2019). As a result, SDG 13 (Climate action) and its SDG interconnections receive particular attention (Liu et al., 2018; Soergel et al., 2021). One of the most important correlations among them is that developing nations that must simultaneously pursue economic growth and climate change mitigation must balance the trade-offs between SDG 13 (Climate action) and SDG 8 (Decent work and economic growth).

Many often, people think of unemployment as a temporary issue that can be resolved right away by implementing broad measures that increase aggregate demand (Martín-Román et al., 2023). However, the length of the monetary authority's disinflation strategy, which is one of the short-term reasons for the economic slump, will also have a significant impact on the existence of cyclical unemployment. Long-term disinflation means that those experiencing cyclical unemployment must also wait longer to find jobs.

Too much unemployment will cause a person to lose their skills and capacity to find new employment (Darity et al., 1996; Elsby et al., 2009). Because of this, unemployment—which was once thought to be a short-term, temporary scarcan turn into a long-term, permanent scar and contribute to future increases in unemployment rates. (Cerra et al., 2023; Handa, 2008; Kula et al., 2014; O'Shaughnessy, 2011). This phenomenon is known as hysteresis. Meanwhile, it is worried that climate change, which is known to be systemic and has long-term impacts, will increase the possibility of hysteresis (Babiker et al., 2007; ILO, 2018; Kahn et al., 2021). Climate change, such as warming temperatures, can make workers less productive due to limited working hours and health problems (physical risks) (Batten et al., 2020). As a result, workers become increasingly vulnerable to being laid off, especially in economic downturns, and have difficulty finding work immediately in economic upturns.

Increased temperatures will also cause disruptions to the economy in a number of industries that heavily rely on the natural environment, including forestry, agriculture, fisheries, and tourism (Dell et al., 2012; ILO, 2018; Olivier et al., 2007; Taher, 2019). Policies aimed at mitigating climate change will also restrict the activity of the industrial sector (Babiker & Eckaus, 2007; Batten et al., 2020). Both times, cyclical unemployment will rise during economic downturns due to disruptions in economic activity, which will also slow down the recovery process and lengthen the time it takes for cyclical unemployment to find new employment. As a result, climate change will have an impact on cyclical unemployment through its effects on labor productivity as well as on economic activity. Furthermore, it has the potential to leave a lasting legacy of cyclical unemployment. Essentially, it seems that policymakers in South Africa are also facing similar challenges.

Finally, estimates of cyclical unemployment and an analysis of the impact of climate change on it would be helpful for Indonesian policymakers, particularly the monetary authority. These estimates can be used as a gauge to assess the principal goal of monetary policy, which is to keep inflation low and steady. As for stakeholders supporting a green economy, examining how climate change affects cyclical unemployment can be used as an assessment tool (Fried, 2018; Jadoon et al., 2021; Khobai et al., 2020; Shah et al., 2023). It is important to note that prior research of this kind has not taken unemployment into account when examining the connection between price stability policies and climate change (Batten et al., 2020). Aside from that, other research on the South African scenario solely focuses on how aggregate supply and demand strategies affect excess unemployment (Yunus et al., 2017). As a result, this study is another one that is still quite uncommon.

In essence, this paper's innovations mostly pertain to the following three areas: First, it enriches the research on the economic effects of climate change. The influence of climate change on economic policy has received less attention than research on agriculture, economic growth, and the labor market (Jadoon et al., 2021; Ma et al., 2023; Zhang et al., 2005). It is difficult for policymakers to respond to climate shocks because of their significant effects on economic activity, which could exacerbate the uncertainty surrounding economic policy. Consequently, researching how climate change affects the uncertainty of economic policy is extremely important. Second, this work creatively includes climate change as a factor in the analysis of economic policy uncertainty to close the gap in the literature, although most research concentrate on the impact of such uncertainty. Determining the elements influencing economic policy uncertainty is essential since it affects investment, consumption, and production in a variety of ways. Third, we elucidate the mechanisms underlying inflation, income inequality, economic growth, and unemployment that contribute to economic policy uncertainty brought on by climate change. We also broaden the framework for addressing the formation of economic policy uncertainty and offer theoretical underpinnings for the development of a framework.

2. Literature Review

Climate change is now a genuine issue rather than a threat for the future. Economic activities, including labor markets, agriculture, unemployment, and economic growth, have all been shown to be impacted by climate change (Liu et al., 2023; Ma et al., 2017; Zhao et al., 2017; Bandara et al., 2014; Chen et al., 2016; Albert et al., 2021; Neog, 2022; Burke et al., 2016; Kotz et al., 2021; Deryugina et al., 2014; Colacito et al., 2019; Lanzafame, 2014; Wang et al., 2023; Zhang et al., 2022b). All of these effects have been demonstrated. Uncertainty arises from the need for countries to adopt a variety of policies in response to changing economic situations. Policy uncertainty is exacerbated by the public's and businesses' inability to fully understand changes in present economic policy, which makes it difficult to establish stable and consistent expectations for macroeconomic policy.

The causes of economic policy uncertainty, particularly as they relate to unemployment and climate change, have been covered in the literature from two angles. According to public choice theory, there are three temporal lags that are inescapable for any policy: the lags for policy recognition, formulation, and implementation (Tajaddini et al., 2021; Zhang et al., 2024). First, a phenomenon known as the policy recognition lag occurs when decision-makers require time to fully comprehend economic difficulties. Second, the process of drafting specific policy measures involves compromise, negotiation, and discussion, which causes a delay in the creation of policy. The last component of the policy implementation lag is the period of planning and transition preceding the actual execution of the policy. The policy-making process is made comparatively slow by these three lag stages, which creates vagueness and doubtful economic policies. This vagueness causes unpredictable focus and implementation in government plan directions to investors and aggregate business segments as a whole.

The following are the three ways that climate change affects the unpredictability of economic policies, including unemployment: First, natural resources, fixed assets, and human capital are directly harmed by climate change, which has a negative impact on financing and investment activities, consumption patterns, and production activities. El Nino and La Nina occurrences that alternate raise climate uncertainty, endangering food security, weakening supply chain industries' resilience, and raising risks in the energy and financial systems (Fisher et al., 2012; Burke & Emerick, 2016; Huang et al., 2020; Zhang et al., 2018). This has a compounding effect on the whole economy, resulting in increased rates of inflation, joblessness, bankruptcies, and significant limitations on the economic expansion of different nations. To combat the detrimental effects of climate change, governments must implement new economic policies, which increases the uncertainty surrounding short-term economic policies.

Second, objectives for reducing carbon emissions, like peaking emissions and becoming carbon neutral, create new difficulties for economic growth and call for long-term changes to economic strategies (Chen et al., 2023). With over 130 nations passing laws or implementing national climate change plans, including powerful economies like China, the European Union, the United States, Japan, and the United Kingdom, carbon neutrality has emerged as a worldwide necessity (Zhang et al., 2022a). In order to promote industrial and energy transformation, encourage the use of clean technologies, reduce carbon footprints, improve resource utilization, and stimulate green innovation, climate policies are being implemented, which includes carbon pricing, auditing, and environmental assessments (Wang et al., 2023). Climate policies have far-reaching implications that create derivative effects and intensify repercussions across multiple economic sectors. Future trade dynamics are expected to favor nations or areas that have a comparative advantage in low-carbon products and technologies (Zhang et al., 2021). This calls for the development of a clean, low-carbon energy system, a strong economic framework for circular development that is both green and low-carbon, the promotion of green and low-carbon lifestyles, and the encouragement of changes to the structures of consumption, industry, energy, transportation, and the economy. The global economic community and policymakers face a new challenge as a result of the green growth model, which calls for coordinated efforts in the areas of industrial policies, subsidies, tax and fiscal measures, and green financial policies (Ma et al., 2023). Continuous trial-and-error is a part of this dynamic process, which raises the uncertainty around changes to economic policy over the long run. Furthermore, the industrial chain's integrity may be jeopardized by quick industrial transformation and early separation from vital, highly polluting, and energy-intensive industries. This might lead to stranded assets and possibly lower levels of energy security, which would have an effect on the economy. The corporate market environment will undergo major changes as a result of the thorough implementation of climate policies, which will also result in higher amenability and climate costs (Qian et al., 2020). Small changes in the power distribution may have a big impact on the economy as a whole, upsetting current business processes. Carbon-escalated areas including energy, mining, and assembling might encounter more noteworthy creation costs, coming about to cost climbs in customer merchandise, expansion, and a fall in expectations for everyday comforts (Mukherjee et al., 2021). Short-term structural unemployment could arise from conventional power-intensive firms, which are frequently non-technology intensive. Moreover, the tight association between nearby financial income and modern advancement proposes that change could impact neighborhood monetary pay (Liu et al., 2021). Financial improvement directions, depending on asset and work concentrated industry structures, are hard to move quickly (Zhang et al., 2022a).

It takes time to cultivate new economic drivers, and in the short term, it is challenging to achieve a rapid uncoupling of CO_2 from GDP due to the substantial pressures of employment and growth. A careful balance is needed to resolve the inherent conflict between low-carbon upgrading and economic expansion. The task of carefully weighing the benefits and drawbacks while considering all relevant interests falls on policy makers, which will undoubtedly result in a rise in policy uncertainty.

3. Method

This study uses an ARDL approach, the variables used in the model are climate change measured as the average temperature in t year measured in degree Celsius, inflation measured as, unemployment measured as, FDI measured as and exchange rate measured as. Also testing the relationship among the variables above could be considered as an assessment for the physical policy in SA, where all economic plans targeted to reduce unemployment within the economy and reduce level of inflation gradually.

After confirming the integration order, the study employed Pesaran et al. (2001)'s Autoregressive Distributed Lag (ARDL) bounds testing approach to determine the long-term relationship between the variables under consideration. Compared to other cointegration techniques, this approach offers a number of benefits. For example, it may be used to small sample sizes and mixed orders of integration. Additionally, by utilizing an optimal lag in the model design, it can address endogeneity issues. To estimate the ARDL bounds testing approach, an unrestricted error correction model was used.

$$Unemp = Tpr, Exr, fdi, Infl \qquad 1$$

$$Unemp = \emptyset_1 + \emptyset_2 Tpr + \emptyset_3 Exr + \emptyset_4 fdi + \emptyset_2 Infl + \mu \qquad 2$$

$$\Delta Unemp = \emptyset_0 + \sum_{m=1}^{J} . \emptyset_{1m} \Delta Unemp._{t-n} + \sum_{m=1}^{J} . \emptyset_{2m} \Delta Tpr._{t-n} + \sum_{m=0}^{J} . \emptyset_{3m} \Delta Exr._{t-n} + \sum_{m=0}^{J} . \emptyset_{4m} \Delta Fdi._{t-n} + \sum_{m=0}^{J} . \emptyset_{5m} \Delta Inf._{t-n} + \partial_1 Unemp_{t-1} + \partial_2 Tpr_{t-1} + \partial_3 Exr_{t-1} + \partial_4 Fdi_{t-1} + \partial_5 Infl_{t-1} + \mu \qquad 3$$

Equation (4) makes use of the first difference operator, represented by Δ, in which the error term is μ, the constant term is ∅_1, and the coefficients in the short and long terms are represented by θ and ∂. The Wald test or F test is used in the ARDL limits testing method to determine the long-run relationship. By comparing the F-statistics to the crucial value, one can ascertain the existence or absence of a long-term link. We can determine the existence of a long-term link if the estimated F-statistics value is greater than the crucial value, and vice versa. In the event that the projected value is within the critical value range, no conclusions on cointegration may be drawn. A framework for estimating the long-term elasticities is given by equation (3). On the other hand, the following equation represents the error correction model:

$$\Delta Unemp = \emptyset_0 + \sum_{m=1}^{J} . \emptyset_{1m} \Delta Unemp._{t-n} + \sum_{m=1}^{J} . \emptyset_{2m} \Delta Tpr._{t-n} + \sum_{m=0}^{J} . \emptyset_{3m} \Delta Exr._{t-n} + \sum_{m=0}^{J} . \emptyset_{4m} \Delta Fdi._{t-n} + \sum_{m=0}^{J} . \emptyset_{5m} \Delta Inf._{t-n} + \partial_1 Unemp_{t-1} + \partial_2 Tpr_{t-1} + \partial_3 Exr_{t-1} + \partial_4 Fdi_{t-1} + \partial_5 Infl_{t-1} + + \in ECT_{t-1} + \in_t \quad 4$$

According to the ECM, the error correction term accurately represents the dynamics of the process of adjustment leading to the long-term equilibrium in the short term. The ECM coefficient, represented by ξ, quantifies the rate of adaptation towards the long-term equilibrium. It is anticipated to be negative and less than one, with a bigger magnitude indicating a quicker process of adjustment. In addition, we employed the time-varying exogeneity causality test, which enables us to track alterations in causal linkages across time. There are two reasons why this strategy is better than other approaches. It does this by first removing the requirement to run a unit root test in order to verify variable stationarity. Secondly, there is no need to conduct cointegration tests between the variables.

4. Findings and Discussion

Prior to the ARDL and causality model, the unit root test is performed as a necessary test, especially the DF and ADF test to guarantee that the data utilized is steady and prevent erroneous regression. Nonetheless, the outcomes demonstrate that the model can be regressed and has economic significance. At the 5% level, we discovered that the likelihood of every test in Table 1 is stationary. The outcomes demonstrated that the data are stable.

Table 1. Testing for Stationarity

		ADF (H_0)				DF (H_0)			
			DF_α				ERS_α		
	$z._t$	$\tau._\mu$	1%	5%	Prob.	τ_τ	1%	5%	Prob.
Intercept without Time Trend	$Unemp$	2.40	4.50	-3.62	0.31	0.82	3.41	2.64	0.62
	Tpr	0.25	4.75	3.74	0.68	0.57	3.75	2.78	0.83
	Exr	2.67	4.58	3.76	0.79	2.76	3.85	2.84	0.86
	Fdi	2.45	4.76	3.73	0.96	0.75	3.75	2.78	0.57
	Inf	0.85	4.85	3.76	0.97	2.74	4.89	3.78	0.63
	$Unemp$	5.84	5.64	4.76	0.00	3.92	4.93	4.36	0.02
	ΔTpr	6.36	4.84	3.76	0.00	3.58	4.96	4.45	0.03
	ΔExr	4.79	4.85	3.78	0.00	3.95	4.96	4.46	0.00
	ΔFdi	4.36	5.67	4.76	0.20	4.02	4.96	4.47	0.00
	ΔInf	4.38	5.47	4.74	0.20	7.06	4.86	3.75	0.00
Intercept with Time Trend	$Unemp$	6.85	4.85	3.76	0.00	4.97	3.84	2.76	0.00
	Tpr	3.56	5.45	4.65	0.63	5.75	3.85	2.76	0.00
	Exr	4.78	4.84	3.73	0.00	4.37	3.84	2.77	0.00
	Fdi	6.85	4.86	3.89	0.00	4.92	3.84	2.76	0.00
	Inf	3.72	4.84	3.76	0.24	0.83	5.42	4.77	0.08
	$\Delta Unemp$	5.68	5.49	4.75	0.00	5.78	4.96	4.32	0.00
	ΔTpr	6.46	5.56	4.87	0.00	6.08	4.96	4.32	0.00
	ΔExr	4.78	5.57	4.78	0.00	4.58	4.95	4.37	0.00
	ΔFdi	6.67	5.47	4.68	0.00	6.05	4.98	4.23	0.00
	ΔInf	6.70	5.57	4.78	0.00	8.38	5.40	4.78	0.00

Source: Author's compilation, H_0 = non-stationarity

4.1. Bound Testing

Since the computed F-statistics value (8.12) is larger than the upper critical values (4.01) when the variables are integrated of order I(0) and I (1), Table 2's F-statistics value indicates that there is a long-run relationship between unemployment and other employed factors. Rejecting the null hypothesis that there is no cointegration between the variables suggests that unemployment and its exogenous variables have a long-term relationship.

Using the ARDL cointegration framework, the study evaluated their long-run coefficients and the short-run dynamic relationship after the unemployment model demonstrated the existence of cointegration. Selecting the right lag length is just as important as deciding which variables to include in any equation form. The maximum lag period needed for the ARDL Bounds Test method is one (1).

Table 2. ARDL Bound Testing

Test Statistic	Value	K		
F-statistic	8.121437	4		
Significance	I0 Bound	I1 Bound		
10%	2.45	3.52		
5%	2.86	4.01		
2.5%	3.25	4.49		
1%	3.74	5.06		

Source: Author's Computation, 2024

4.2. ARDL Long-run Estimation

The long-run link between the variables was estimated using the ARDL approach, and the result is shown in Table 3. The cointegration result in Table 2 demonstrated that there is a connection among the variables. Given that the long-term coefficient of climate change (Tpr) is positive and statistically significant at the 5% level of significance, the long-run data support the expected sign that climate change has a positive impact on unemployment in South Africa. According to the coefficient (8.40), there would be an 8.4% increase in the unemployment rate in South Africa for every percentage increase in the level of climate change. This is in line with previous research (Liu et al., 2023; Yunus et al., 2024; Zhang et al., 2024; Zhang et al., 2022).

Contrary to expectations, foreign direct investment has a positive relationship with unemployment that is significant over the long term. Table 3 confirms the earlier hypothesis that the exchange rate and unemployment have a negative connection. In the unemployment model, the exchange rate coefficient is negative and has a statistically significant value of 1%. This outcome is in line with Yunus et al. (2024)'s finding that there is a negative correlation between the exchange rate and cyclical unemployment in the Indonesian economy. This conclusion is further supported by studies by Zhang et al. (2024) and Liu et al. (2003).

The inflation rate coefficient is substantial at 1% and positively signed with unemployment, as expected. A statistically significant coefficient of -0.15% for exchange rate suggests that a 1% increase in exchange rate will result in about a 0.15% drop in unemployment. Using quarterly data, Yunus et al. (2024) evaluated the empirical evidence of the association between unemployment and climate change for the Indonesian economy and found a positive correlation for the variables over the long term.

Table 3. Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TPR	8.462598	3.879775	2.181208	0.0388
FDI	1.046505	0.524658	1.994641	0.0521
INFL	1.205117	0.473380	2.545769	0.0174
EXR	-0.153635	0.058629	-2.620469	0.0147
C	21.964900	6.906708	3.180227	0.0039

Source: Author's Computation, 2024

4.3. ARDL Short-run Output

Tpr, Exr, Gdp, and Infl are cointegrated, according to Table 4's results, where the coefficient of the error correction term lag one period (CointEq-1) is negative and significant at the 1% significance level. In absolute terms, the coefficient of error correction term ECM (-1) is 24.9. This indicates that the annual correction from the short-run to the long-run accounts for roughly 24.9% of the long-term unemployment rate's variance. This implies that about 24.9% of the unemployment disequilibrium from the prior year is resolved in the current year. When there is a shock, the variable equilibrates more quickly in the long run when the coefficient of the error correction form in its absolute term is greater.

In light of the findings, there has been a rapid rate of correction. The short-run outcome demonstrates that inflation is considerable at 1% but negatively signed. Adekunle et al.'s study from 2024 supports the idea that unemployment and inflation are inversely correlated. Though not statistically significant, there is a positive correlation between the second lag of Tpr and a coefficient of 0.88, which defies the initial hypothesis. The findings indicate that a 1% increase (reduction) in Tpr from the prior year increased (decreased) unemployment by roughly 0.88%. In the medium term, there is a positive but non-significant correlation between the exchange rate and unemployment. Previous research has also shown that the exchange rate has a favorable impact on unemployment (Yunus et al., 2024). In researching Turkey's unemployment hysteresis, Kula (2014) discovered a positive correlation between the factors. Both in the short and long terms, there is a positive correlation between FDI and unemployment, but the short-term association is more substantial.

Table 4. Short-run Estimation

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(UNEMP(-1))	-0.640443	0.146573	-4.369463	0.0002
D(TPR)	0.460336	0.447960	1.027628	0.3140
D(TPR(-1))	-0.037249	0.512612	-0.072664	0.9427
D(TPR(-2))	-0.889934	0.535520	-1.661813	0.1090
D(FDI)	0.261055	0.107260	2.433844	0.0224
D(INFL)	0.113853	0.083327	1.366345	0.1840
D(INFL(-1))	-0.218106	0.080020	-2.725635	0.0116
D(EXR)	0.032999	0.024216	1.362679	0.1851
CointEq(-1)	-0.249454	0.070823	-3.522204	0.0017

Source: Author's Computation, 2024

4.4. Stability Test

Statistical features of the model were assessed with a variety of statistic to authenticate the outcomes to confirm that the regression result is desirable that is not serially-correlated, and also not homoscedastic. The model is normally distributed based on the normality test conducted. With a score of 0.38, the skewness lies between -0.3 and 0.5. Additionally, the data is somewhat above positive two (+2) according to the kurtosis value of 2.37. The Jarque-Bera test demonstrates that the information is ordinarily conveyed (coefficient of 0.52, $P > 0.05$). The outcome is shown in Figure 1. Given the p-value of sequential relationship and heteroscedasticity as 0.689 and 0.546 from Table 5, the outcome shows the shortfall of sequential connection and heteroscedastic.

As a result, at the 5% level of significance, we are unable to reject the null hypothesis that there is no serial correlation, accurate functional form, normally distributed residuals, and homoscedasticity. Lastly, the stability of the long-run and short-run coefficients was assessed using the Cumulative Sum of Squares (CUSUM SQ) by Brown et al. (1975) methods. The model's stability tests, which employed the CUSUM and CUSUM SQ tests, generally indicated the lack of structural break.

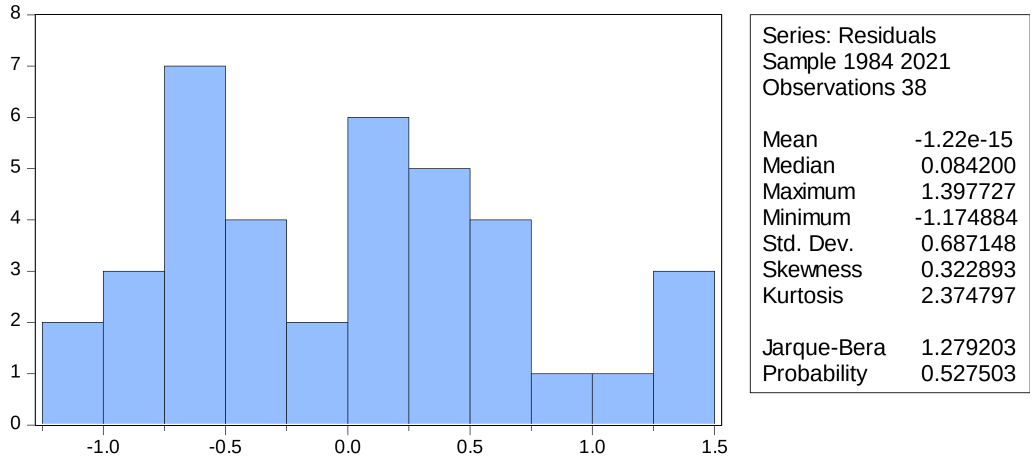

Figure 1. Normality Test

Source: Author's Computation, 2024

Table 5. Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.378097	Prob. F(2,23)	0.6893
Obs*R-squared	1.209594	Prob. Chi-Square(2)	0.5462

Source: Author's Computation, 2024

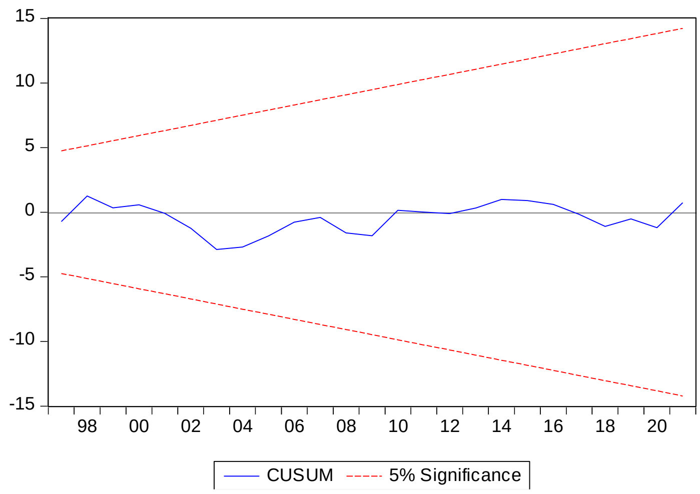

Figure 2. Cusum Sum

Source: Author's Computation, 2024

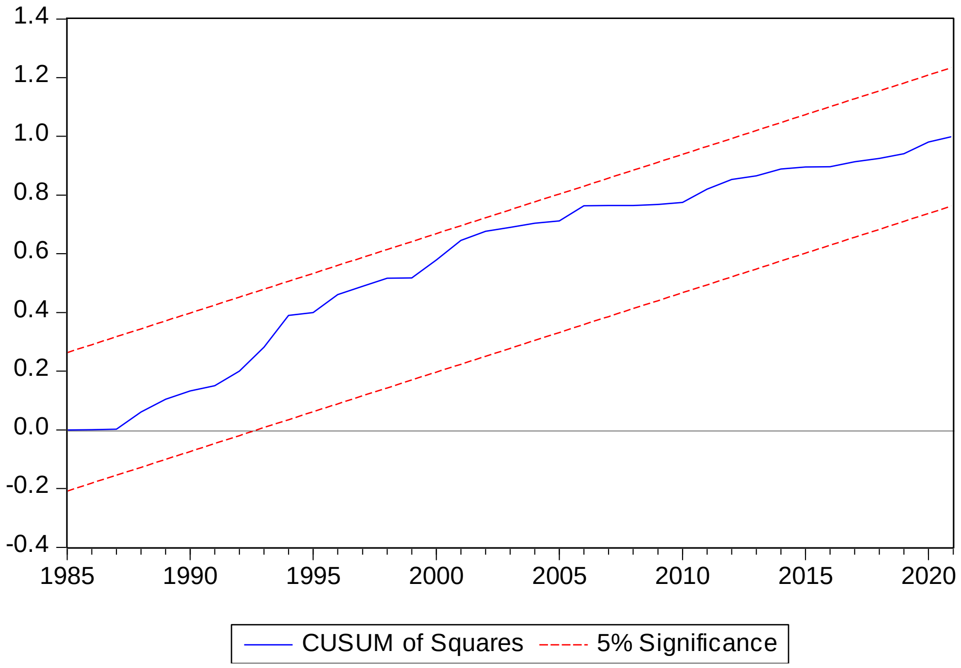

Figure 3. Cusum of Squares

Source: Author's Computation, 2024

5. Conclusion

Based on many numerous economic disruptions that the country is experiencing; climate change does have a direct impact on unemployment. The consequences are also a result of the labor force's inability to successfully adapt to any changes in the climate. The government of South Africa must thus concentrate more on lowering the country's inflation rate and strengthening the local currency relative to the US dollar. In the meantime, the shortage of jobs in South Africa will worsen due to the rise in unemployment brought on by the rising temperatures. Here, the government should increase funding at the federal level for a number of industries, including forestry, tourism, agriculture, and fisheries, that are heavily reliant on climate change.

The industrial sector can use a similar funding strategy. Nonetheless, the government must green the borrowers who operate in the industrial sector in order to finance it. Lastly, hysteresis cannot be avoided even though monetary authorities have projected the short-term impacts of control on inflation.

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