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Time-Varying Connectedness Between Global Uncertainties and Economic Activity in a Developing Economy Using a Dynamic Conditional Correlation — GARCH Model

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ABSTRACT
As economies become increasingly interconnected, individual economies are at risk of shocks from external uncertainties ranging from fluctuations in climate regulations to geopolitical conflicts and international economic policies. **The purpose** of the study is to investigate the time-varying correlation between global uncertainties (e.g., global economic policy uncertainty, climate policy uncertainty and geopolitical risk) and economic activity in a developing economy using a dynamic conditional correlation generalized autoregressive conditional heteroskedasticity (GARCH) model. **The relevance** of the research lies in the increasing interconnectedness of global economies and the subsequent exposure of individual economies to external shocks. The scientific **novelty** is hinged on the study being among the first to study the relationship in Ghana. Using monthly data for the 2002–2022 period for Ghana, we estimate a multivariate GARCH model. **The results** of the study indicate that climate policy uncertainty and global economic policy uncertainty are mean reverting, implying that the volatility of the variables decay slowly and persists for a longer time such that the conditional variance will eventually return to its long-term average level after being disturbed by shocks. Global uncertainties over time are strongly negatively correlated with economic activity and produce significant spikes, especially during periods of major world events. **The study recommends** that policymakers need to consider the prolonged impact of global uncertainties on economic performance when designing economic policies and interventions. The significant spikes during major global events highlight the importance of crisis management and preparedness in maintaining economic stability during periods of heightened uncertainty.
Keywords: global uncertainties; economic activity; GARCH; dynamic correlations; vector autoregressive models; Ghana; Africa

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Исследование изменяющейся во времени связи между глобальной неопределенностью и экономической активностью в развивающейся экономике с использованием модели динамической условной корреляции — GARCH

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АННОТАЦИЯ

По мере того как глобальная экономика становится все более взаимосвязанной, отдельные страны подвергаются риску потрясений, связанных с внешней неопределенностью, обусловленной различными факторами, начиная от изменений климатических регламентов и заканчивая геополитическими конфликтами и международной экономической политикой. **Целью исследования** является изучение изменяющейся во времени корреляции между глобальными неопределенностями (например, неопределенностью глобальной экономической политики, неопределенностью климатической политики и геополитическим риском) и экономической активностью в развивающейся экономике с использованием динамической корреляционной модели с обобщенной авторегрессионной условной гетероскедастичностью (GARCH). **Актуальность** исследования обусловлена растущей взаимосвязанностью мировой экономики и, как следствие, подверженностью отдельных экономик внешним шокам. **Научная новизна** заключается в том, что данное исследование является одним из первых, изучающих указанную взаимосвязь на примере Ганы. Используя ежемесячные данные за период 2002–2022 гг. для Ганы, мы применили многомерную GARCH-модель. **Результаты** исследования показывают, что неопределенность в области климатической политики и неопределенность глобальной экономической политики являются среднереверсивными, что означает, что волатильность переменных медленно снижается и сохраняется в течение длительного времени, так что условная дисперсия в конечном итоге возвращается к своему долгосрочному среднему уровню после того, как будет нарушена потрясениями. Глобальная неопределенность с течением времени имеет сильную отрицательную корреляцию с экономической активностью и вызывает значительные всплески, особенно в периоды крупных мировых событий. Исследование **рекомендует** политикам учитывать длительное влияние глобальной неопределенности на экономические показатели при разработке экономической политики. Значительные всплески во время крупных мировых событий подчеркивают важность управления кризисами и готовности к поддержанию экономической стабильности в периоды повышенной неопределенности.

Ключевые слова: глобальная неопределенность; экономическая активность; GARCH; динамическая корреляция; векторные авторегрессионные модели; Гана; Африка

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Introduction

The world is becoming increasingly interconnected. As economies become more linked globally, individual countries face various external uncertainties. These uncertainties, such as fluctuations in international economic policies, changing climate regulations, and geopolitical conflicts, can significantly impact domestic economic activity over time. Following the work of Bloom [1], the effect of uncertainty on macroeconomic conditions has been extensively studied. Researchers have primarily used vector autoregressive models to study the effect of uncertainty at the macroeconomic level [2–5]. Since the end of the financial crisis of 2008, several geopolitical occurrences have emphasized in policy debates the potential threats that increased economic unpredictability could present to worldwide economic outlooks. These occurrences encompass the unforeseen United Kingdom (UK) referendum, known as BREXIT; the political landscape in Italy following the Constitutional referendum of 2016; the uncertainties surrounding recent trade protectionist policies and developments; the conflict in Ukraine; the Israel-Palestine conflict; and the impact of COVID-19.

It has been highlighted in both the theoretical and empirical literature that economic activity could be affected by heightened uncertainty in global economic policy [2, 6, 7]. This phenomenon could manifest across diverse channels, especially impacting household consumption and saving behaviors (precautionary savings), as well as firms' investment and employment choices. Geopolitical uncertainties and instabilities have been identified as significant factors influencing economic decision-making processes, as indicated by Lo Duca et al [8]. Consequently, it is plausible that geopolitical uncertainties and unfavorable geopolitical occurrences will exert a substantial impact on the economic growth rates of nations.

At both the corporate and individual levels, uncertainty slows down and negatively impacts most financial decisions, as indicated by Bloom [9]. The presence of uncertainty compels both individuals and corporations to adopt a more cautious approach, potentially resulting in reduced overall economic consumption and growth, a decrease in debt issuances, and a rise in unemployment [3, 10]. In addition, heightened uncertainty has implications for inflation rates [11] and currency exchange markets [12], with the housing market also being negatively impacted [13]. Furthermore, the consequences of governmental instability stretch to commodity markets, with studies indicating its adverse effects on oil [14], gasoline [15], and futures markets. Additionally, elevated economic policy uncertainty (EPU) can potentially have detrimental effects on the cryptocurrency market [16]. The author of [17] highlights the sensitivity of African economies to external shocks, emphasizing the need for robust policy frameworks to manage uncertainty.

Against the backdrop of empirical evidence of the impact of global uncertainties on output growth, predominantly presented at the collective level of individual countries or a group of nations, our objective is to contribute further to the literature in the following ways. For the first time, we analyse the time-varying effect of global uncertainties on economic activities using a unique index of economic activities for Ghana. The theoretical rationale for this study is grounded in subsequent lines of logic: Initially, it was well established that heightened levels of uncertainty can detrimentally impact the overall demand within the economy via the conventional mechanism linked to exchange rates. The study [1] posits that uncertainty influences decision-making by elevating the value associated with waiting. Moreover, uncertainty is also anticipated to adversely influence the productive aspect of the economy through efficiency, stemming from the improper allocation of resources among different enterprises [6]. According to [6], unproductive businesses contract, while productive businesses expand under normal circumstances, thereby contributing to elevated levels of overall productivity. However, in times of heightened uncertainty, firms curtail both expansion and contraction, thus impeding much of the productivity-enhancing reallocation, leading to a decline in the quantifiable aggregate total factor productivity.

The literature on how global uncertainties affect economic activity in developing economies in the global south is rare and still expanding. Our study is among the earliest to examine the relationship in Ghana. We use the dynamic conditional correlation Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model, which is well suited for analysing the volatility of economic variables over time and captures the episodic nature of global uncertainties. Second, it allows for the modelling of asymmetric effects, where positive and negative shocks to uncertainty can have different impacts on economic activity.

The remainder of the paper is organized as follows: an empirical literature section, a data and methodology section, and results, discussion and conclusions sections.

Literature review

Economic activity has been found in the literature to be influenced by global uncertainties (including global economic policy uncertainty, climate policy uncertainty and geopolitical risk). This review of the literature looks at empirical studies that investigate these correlations, stressing methods, conclusions, and areas of unmet research need. The influence of economic policy uncertainty (EPU) on a range of economic activities has been extensively researched. Using an EPU index, a study [2] discovered that higher levels of uncertainty result in lower levels of hiring, output, and investment. Using vector autoregressions (VARs), their study demonstrated that policy uncertainty shocks significantly impair economic performance. Research [1] used a model that takes adjustment costs and real options into account to investigate how uncertainty shocks affect the economy. According to his research, businesses may postpone hiring and investment due to uncertainty, which would reduce overall economic activity. The processes through which EPU influences macroeconomic variables were further established in this study. This topic has been further explored in other research by examining various nations and situations. Research [7], for example, used a time-varying parameter VAR model to demonstrate that macroeconomic variables in the UK are significantly impacted by EPU shocks in the US. Similarly, a study [18] demonstrated how EPU has a detrimental effect on investment and consumption in emerging nations using a structural VAR method.

Vaswani and Padmaja [19] conducted an analysis of the derivatives market, indicating that economic policy uncertainty (EPU) exerts a positive influence on the aggregate turnover of derivatives by shaping financial decision-making through innovative practices and market trends. Khurana et al. [20] investigated the impact of EPU on entrepreneurship in 26 countries spanning a period of 19 years and discovered that higher levels of EPU lead to an increase in necessity-driven entrepreneurship but do not significantly affect opportunity-driven entrepreneurship. This study underscores the significance of economic safety nets in advanced economies. Ashena and Shahpari [21] utilized a nonlinear autoregressive distributed lag methodology to explore the relationship between EPU and carbon emissions in Iran, revealing that EPU contributes to an increase in CO_2 emissions, with notable asymmetric effects of economic production on emissions. Study [22] delves into the correlation between EPU and corporate financialization in China, revealing that EPU has a dampening effect on financialization, especially within state-owned enterprises, and that this effect is moderated by CSR. Research [23] scrutinizes the impact of firm-level EPU on corporate innovation, demonstrating that heightened EPU has a negative effect on innovation activities, particularly in nonstate-owned enterprises and those facing financial constraints.

A relatively recent field of study, climate policy uncertainty (CPU), reflects growing concerns about climate change and policy responses. By building a CPU index, Fried [24] discovered that uncertainty around climate policy has a detrimental impact on firm-level investment decisions, especially in sectors of the economy that are heavily subject to climate regulation. Andersson [25] conducted an empirical analysis using panel data from OECD countries to show that CPU decreases investments in renewable energy. The analysis demonstrated strong negative implications of CPU for green investment, underscoring the importance of a stable climate policy in promoting economic activity. Fixed-effects models were employed to account for variation among nations. Bolton and Kacperczyk [26] investigated how financial markets were affected by the uncertainty surrounding climate policy. They discovered that CPU increases the cost of capital for businesses in carbon-intensive industries, which discourages investment and slows growth in these areas. They arrived at this conclusion using a panel regression technique. Uncertainty resulting from geopolitical events, such as conflicts, terrorism, and diplomatic difficulties, is referred to as geopolitical risk (GPR). Using a GPR index, study [27] discovered that decreases in trade, employment, and industrial production follow increases in geopolitical risk.

Recent research has started to investigate how various uncertainties work together to affect economic activity. For instance, Phan [28] used a dynamic connectivity technique to analyse the interaction between EPU, CPU, and GPR. The interdependence between these uncertainties was measured using a spillover index, and it was discovered that the sum of these uncertainties had a greater impact on economic activity than the sum of their individual uncertainties. Another study by Antonakakis [29] examined the relationships among oil prices, EPU, and GPR using a time-varying parameter VAR model. They discovered that changes in geopolitical risk have a major impact on oil prices, which in turn have an impact on economic activity, illustrating the intricate relationship between these concerns. Financial market factors were added to this research by Wang and Li [30]. They investigated the dynamic connections between stock market returns in major economies and global uncertainties using a DCC-GARCH model. According to their research, EPU, CPU, and GPR all work together to lower investor confidence and increase market volatility, which has an impact on economic growth.

Methodology

Data sources and analysis

We use monthly data on the index of economic activity from the Bank of Ghana for our study. Our data span the period from January 2002 to December 2022. The beginning of the data are motivated by the availability of data for the index of economic activity for Ghana. To capture global uncertainties, we use the global economic policy uncertainty index, climate policy uncertainty index and geopolitical risk index. In our study, we use the real exchange rate, which is used to control for spillovers to the economy.

To aid in the estimation of the data, we use OxMetrics, an econometric software suite that is particularly well-suited for time-series analysis and volatility modeling, including GARCH-based models like DCC-GARCH. OxMetrics provides a comprehensive set of tools for estimating, testing, and forecasting models in a user-friendly environment, which allowed us to efficiently implement the DCC-GARCH model with a multivariate t-distribution, as discussed in our study. The OxMetrics platform uses the Ox programming language for high-performance econometric computations.

Variable definitions

Economic activity index: The study uses a composite index of economic activity by the Bank of Ghana that is derived from a combination of 10 different components of economic time series data that contain the outputs and activities of key sectors of the economy, including all kinds of electricity consumption, imports, exports, patterns of employment growth, sale of key national assets, port/harbour activities, tourism, sale of companies involved in manufacturing, VAT collection domestically, and domestic credit to the private sector [31]. Further details about the index of economic activity can be found in [31].

Economic policy uncertainty: We use the global economic policy uncertainty index developed by [2].[1] A composite mean of three unique elements is utilized to construct the index. The principal and predominant aspect is ascertained by tallying print media publications containing pivotal phrases linked to policy uncertainty. The second element examines uncertainty relating to forthcoming changes in tax regulations by assessing the financial repercussions of expiring tax provisions. The ultimate element utilizes the dispersion of economic predictions of the Consumer Price Index and government spending as an alternative gauge to evaluate the degree of uncertainty regarding fiscal and monetary policies.

Climate policy uncertainty: To measure climate policy uncertainty, we use the index developed by [32] following the study of Baker et al. [2]. Further information on the computation of the index is found in [32].

Geopolitical risk: We use the index of geopolitical risk developed by Caldara and Iacoviello [33]. They constructed an index for geopolitical risk by counting the number of times words related to geopolitical tensions appear in leading international newspapers. The Caldara and Iacoviello Geopolitical Risk (GPR) index is based on automated text searches of 10 major newspapers, tracking articles related to adverse geopolitical events. The index is calculated monthly by counting the share of articles on topics such as war threats, military buildups, nuclear threats, and terror threats. It is divided into eight categories, with two subindexes: the Geopolitical Threats (GPRT) index, covering categories 1 to 5, and the Geopolitical Acts (GPRA) index, covering categories 6 to 8.

Model specification

To measure the time-varying volatilities and connectedness of global uncertainties and economic activities, we use the dynamic conditional correlation (DCC) GARCH model developed by Engle [34]. The key advantage of the DCC-GARCH model lies in its ability to capture time-varying correlations between multiple variables, which is essential when analyzing the dynamic and evolving relationships between uncertainties and economic activities over time. Unlike static models, which assume constant correlations, DCC-GARCH allows the correlations to change as new information becomes available, reflecting the reality of global uncertainties that are influenced by external shocks and policy changes.

Although the standard DCC-GARCH model assumes a Gaussian distribution, which may not be appropriate for heavy-tailed distributions (as seen in extreme events like geopolitical shocks or economic crises), we address this limitation by adopting a multivariate t-distribution, as recommended by Pesaran and Pesaran [35]. The t-distribution is well-

[1] The data is hosted at https://www.policyuncertainty.com/

suited for capturing the heavier tails often observed in real-world financial and economic data, thereby making the model more robust to extreme events and sudden spikes in volatility, which are frequently discussed in the literature on global uncertainties. This modification allows us to retain the strengths of DCC-GARCH — its capacity to model time-varying correlations and conditional volatilities — while also ensuring that the model accounts for the fat tails and extreme events that are characteristic of the uncertainties being studied. By doing so, the model provides more accurate estimates of both volatility and correlation dynamics, enabling a better understanding of the interconnectedness of global uncertainties. Moreover, the model offers enhanced precision in estimating conditional variances [34]. Thus, we specify the general DCC-GARCH model as follows:

$$H_t = D_t R_t D_t. \quad (1)$$

The definitions of the variables in equation (1) are as follows. The matrix conditional variance is denoted as H_t. D_t is denoted as a diagonal matrix of dimensions kxk with a conditional variance, which is denoted as $\sqrt{h_{it}}$ on the principal diagonals, while the matrix of time-varying correlations (values off the diagonal elements) is denoted by R_t. Thus, the conditional variance for the variables could be estimated using a univariate GARCH model as indicated;

$$h_t = \omega_i + \sum_{x=1}^{X_i} \alpha_{ix} r_{t-x}^2 + \sum_{y=1}^{Y_i} \beta_{iy} h_{t-y}^2. \quad (2)$$

From equation 2, ω_i, α_{ix} and β_{iy} are expected to be nonnegative values and must meet the conditions that $\sum_{x=1}^{X_i} \alpha_{ix} + \sum_{y=1}^{Y_i} \beta_{iy} < 1$ at which we indicate the model

to be mean reverting and where

$\sum_{x=1}^{X_i} \alpha_{ix} + \sum_{y=1}^{Y_i} \beta_{iy} = 1$, the model is said to be integrated.

α_{ix} measures the short-term persistence of shocks to economic activity variable to long-term persistence (denoted as GARCH effects). Furthermore, from the equation, we are able to estimate and obtain the conditional standard deviations and the residuals. The conditional standard deviation is expressed by a diagonal matrix D_t with $\sqrt{h_{it}}$ on the principal diagonal. This is shown in equation 3.

$$D_t = \begin{bmatrix} \sqrt{h_{11,}t} & 0 & \cdots & 0 \\ 0 & \sqrt{h_{22,}t} & \cdots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & \cdots & \sqrt{h_{kk},t} \end{bmatrix}. \quad (3)$$

In equation 4, the standardized residuals de noted as $\left(\sigma_t = \frac{\varepsilon_t}{\sqrt{h_t}}\right)$ are used for estimating the dynamic or time varying correlation matrix R_t (Lim and Masih, 2017).

$$R_t = Q_t^{*-1} Q_t^* Q_t^{*-1}. \quad (4)$$

$$Q_t^* = \begin{bmatrix} \sqrt{q_{11,}t} & 0 & \cdots & 0 \\ 0 & \sqrt{q_{22,}t} & \cdots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & \cdots & \sqrt{q_{kk},t} \end{bmatrix}. \quad (5)$$

In equation 5, Q_t^* shows the diagonal matrix of its diagonal elements. Q_t is a positive definitive conditional covariance matrix and is symmetrical such that $Q_t = \left(q_{ij,t}\right)$ and $\bar{Q}$ are the unconditional covariances of the standardized residuals of the univariate model.

$$Q_t = (1-a-b)\bar{Q} + \alpha\varepsilon_{t-1} - 1\varepsilon_{t-1}^{'} + bQ_{t-1.} \quad (6)$$

In a typical correlation form, $\rho_{ij,t} = \frac{q_{ij,t}}{\sqrt{q_{ij,t} q_{ij,t}}}$ (the conditional correlation) can be expressed by setting $Q_t = \left(q_{ij,t}\right)$ from equation (6), as indicated in equation (7).

$$\rho_{ij,t} = \frac{(1-a-b)\bar{Q} + \alpha\varepsilon_{t-1} - 1\varepsilon_{t-1}^{'} + bQ_{t-1}}{\sqrt{(1-a-b)\bar{Q} + \alpha\varepsilon_{t-1} - 1\varepsilon_{t-1}^{'} + bQ_{t-1}} \sqrt{(1-a-b)\bar{Q} + \alpha\varepsilon_{t-1} - 1\varepsilon_{t-1}^{'} + bQ_{t-1}}}. \quad (7)$$

Additionally, as suggested by [34], the DCC-GARCH model based on t-distribution uses devolatised values $r_{i,t-1} = \frac{r_{it}}{\sigma_{i,t-1}^{realised}}$ and, as such, estimates the correlation model against the DCC-GARCH model that utilizes standardized values $r_{i,t-1} = \frac{r_{it}}{\sigma_{i,t-1}}$

and uses two steps in the model estimation. The parameters of the conditional covariance model can be estimated. Using GARCH(1,1) for conditional volatility $\sigma^2_{i,t-1}$ is presented in equation (8), which can then be used as a matrix to determine conditional correlation.

$$V\left(r_{it} \mid \Omega_{t-1}\right) = \sigma^2_{i,t-1} =$$
$$= \overline{\overline{\sigma}}^2_t \left(1 - \lambda_{1i} - \lambda_{2i}\right) + \lambda_{1i}\sigma^2_{i,t-2} + \lambda_{2i} r^2_{i,t-1}. \quad (8)$$

In equation (8), $\overline{\sigma}^2_t$ denotes the unconditional variance of the economic activity index. λ_{1i} *and* λ_{2i} are volatility parameters for the global uncertainty variables. $\left(1 - \lambda_{1i} - \lambda_{2i}\right)$ represents the restriction to test whether the volatility is mean reverting. If the term $\left(1 - \lambda_{1i} - \lambda_{2i}\right)$ is equal to zero in this case, the model shows an integrated GARCH (IGARCH) process.

Results and discussion

Table 1 shows the summarized descriptive statistics of the variables used in the study. The return series are also presented in *Table 1*. The average value of the economic activity index for the study period is approximately 17.09, with minimum and maximum values of –1.71 and 44.07, respectively, per month. The mean values of global economic policy uncertainty (147.5062), climate policy uncertainty (120.2249), geopolitical risk (103.9464) and the exchange rate (82.9173) per month. For all the variables, the wide differences between the minimum and maximum values indicate significant fluctuations in the various series over the period of the data used for the study. Similarly, large values of the level series indicate high volatility in the variables. With the exception of the level series of the economics activity index, all other variables show the presence of nonnormality in the distribution of the data.

In *Fig. 1 and 2*, we show the graphical evolution of the variables on global uncertainties, the index of economic activity and the exchange rate. We also show the graphical evolution of their return series. The level series indicates the presence of a trend in the series and fluctuates over time. In particular, the trend of the level series of the economic activity index reflects major events in the Ghanaian economic landscape. We observe significant upwards spikes in 2004, 2008, and 2012, which reflect election periods. This could be explained by the fact that during election periods, government expenditures increase and introduce inflationary pressures to the economy.

Unit root test results

Time series frequently exhibit nonstationarity and trends. In light of this, regression estimates of one nonstationary variable on one or more additional nonstationary variables are erroneous and lead to a false conclusion. As a result, before estimating the regression models, it is essential to look at the variables' stationarity property. Furthermore, a fundamental tenet of GARCH models is the stationarity of the variables. Therefore, we ran the Phillips-Perron (PP) and enhanced Dickey-Fuller (ADF) unit root tests. The results of the unit root tests are presented in *Table 2*. The results of the augmented Dickey fuller test indicate that at levels, only the index of economic policy uncertainty and exchange rate are non-static. However, at the first difference for both methods, all the variables are stationary. Thus, to estimate our models, the return series are used for all the variables.

Univariate GARCH results

To estimate the DCC-GARCH model, we first estimate a symmetric GARCH (1, 1) model to determine the volatility characteristics of variables and subsequently identify the most efficient technique to employ in the estimation of the multivariate GARCH model. The GARCH (1, 1) model is a very efficient model for the estimation of series that exhibit volatile characteristics, as indicated by Engel [34]. The results of the univariate models, as shown in *Table 3*, indicate that the ARCH terms for all the models are significant, indicating the presence of both ARCH and effects in the variables used. The GARCH terms for all variables except geopolitical risk and exchange rate are significant, indicating the presence of a GARCH effect for all variables except geopolitical risk and exchange rate. Furthermore, we find that the indices of economic activity, climate policy uncertainty and geopolitical risk are all mean reverting since the sum of the alpha and beta terms are less than one; as such, their effects are persistent. The implication of the results is that volatility for the variables decays slowly and persists for a longer time such that the conditional variance will eventually return to its long-term average level after being disturbed by shocks. However, the sums for economic policy uncertainty and exchange rate are greater than one signifying

Table 1
Descriptive statistics

	ECONINDEX	EPU	CPU	GPR	EXCHANGE	DECONINDEX	DEPU	DCPU	DGPR
Mean	17.59	147.5062	120.2249	103.9464	82.9173	−0.0462	0.6124	0.5321	−0.244
Median	17.03	126.8340	102.6259	92.5978	82.8911	0.03000	−0.7445	−0.0097	−0.744
Maximum	44.07	428.1531	411.2888	358.7111	105.5654	12	137.155	231.084	119.100
Minimum	−1.71	48.95131	28.1619	58.4207	51.2927	−20.1	−101.66	−149.267	−127.811
Std. Dev.	7.82	75.40141	64.4506	36.8125	12.4070	4.8752	30.62	47.54	24.763
Skewness	0.32	1.06542	1.42547	3.00529	0.14063	−0.27817	0.692	0.5017	0.029
Kurtosis	3.11	3.6033	5.1988	17.04030	1.9700	4.12779	6.843	6.4912	10.413
Jarque–Bera	4.57	51.49720	136.1093	2449.2027	11.9692	16.539	174.520	138.005	574.818
Probability	0.10	0.0000	0.0000	0.0000	0.0025	0.0003	0.0000	0.0000	0.0000
Observations	252	252	252	252	252	251	251	251	251

Note: ECONINDEX represents Index of Economic Activity, EPU represent Economic Policy Uncertainty, CPU represents Climate Policy Uncertainty, GPR represents Geopolitical Risk.

Source: Developed by the authors.

Table 2
Unit root test

Variable	ADF		PP	
	Level	First Difference	Level	First Difference
Index	−3.065**		−4.406***	
Epu	−2.261	−12.665***	−2.755*	
Cpu	−4.034***		−6.097***	
Gpr	−5.817***		−5.656***	
Exchange	−1.355	−12.492***	−1.393	−11.777***

Note: ***, ** and* indicate that they are significant at the levels of 1%, 5% and 10%, respectively.

Source: Developed by the authors.

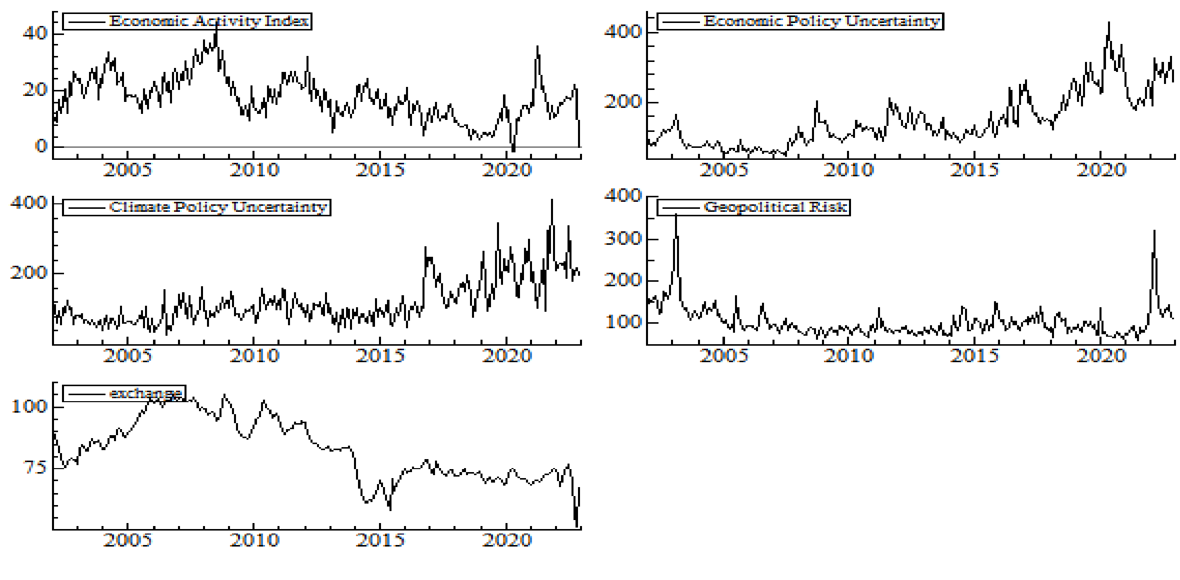

Fig. 1. **Dynamics of the economic activity index, global uncertainties and exchange rate at various levels**
Source: Developed by the authors.

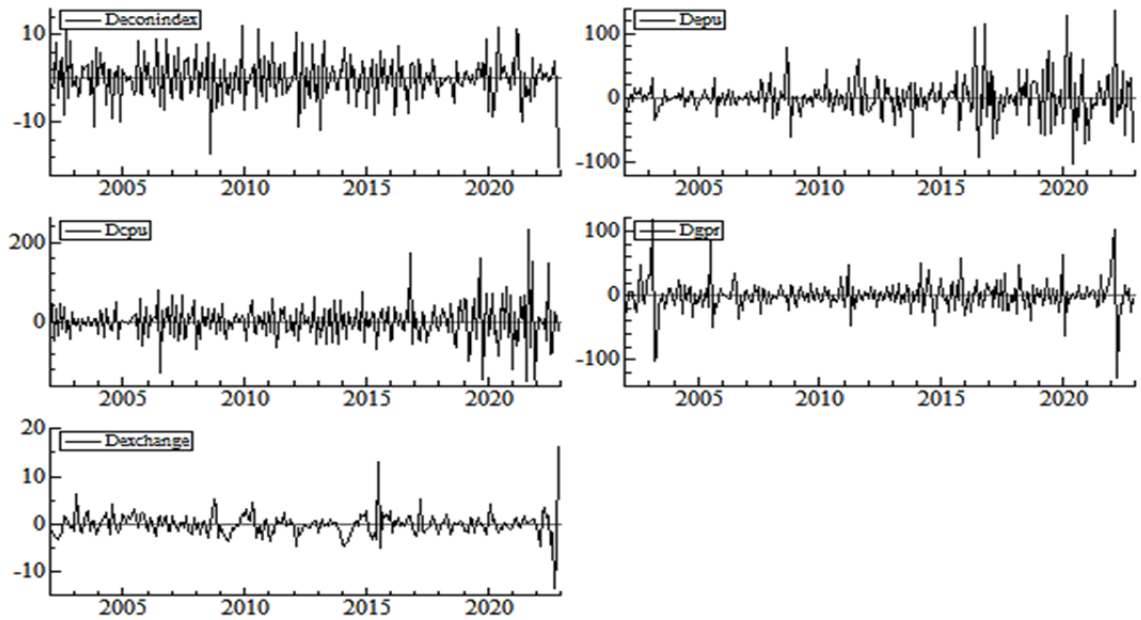

Fig. 2. **Dynamics of the economic activity index, global uncertainties and exchange rate at first difference**

Source: Developed by the authors.

a nonpersistence in their effects. This implies that the volatility of the model could increase without bounds over time. Importantly, for the index of economic growth, we find that since volatilities are mean reverting, shocks to the economy will eventually return the economy slowly to its long-term average level. However, the exchange rate is not mean reverting, suggesting that shocks could increase the conditional variance over time without bounds.

Multivariate model

Table 4 presents the results of the DCC-GARCH model. The results indicate the existence of a dynamic conditional correlation between the indices of economic activity, global economic policy uncertainty, climate policy uncertainty, geopolitical risk and exchange rate (for purposes of spillover) since the values of the alpha and beta are statistically significant. The constant conditional correlation hypothesis is rejected, suggesting that assuming independence or neutrality between the variables may be misleading. Additionally, we find that the sum of the alpha and beta parameters is less than 1, indicating that the conditional variance will eventually return to its long-term average level after being disturbed by shocks or that the conditional correlations between the variables are mean reverting. As a result, it can be argued that the DCC-GARCH model captures the time-varying conditional correlations between variables.

Fig. 3 presents the dynamic conditional correlation between the economic activity index, global economic policy uncertainty, climate policy uncertainty, geopolitical risk and exchange rate. We already find a time-varying correlation in the relationships between the variables, as shown in *Table 4.* This variability results in occasional sharp declines and increases in the conditional correlation, with oscillations observed between high and low values. The top-left graph shows the dynamic conditional correlation between the economic activity index and climate policy uncertainty (cpu). The correlation varies significantly over time, oscillating between positive and negative values. From approximately 2002 to 2010, the correlation fluctuates but remains mostly negative, indicating an inverse relationship. Post-2010, there are periods where the correlation turns positive, suggesting a direct relationship at times. Notably, significant negative correlations are observed approximately 2008 (coinciding with the global financial crisis) and 2015. In approximately 2020, the correlation became positive, potentially indicating a change in the impact of climate policy uncertainty on economic activity. This corresponds to the results of [17].

The top-right graph displays the dynamic conditional correlation between the economic activity index and global economic policy uncertainty (epu).

Table 3
Univariate GARCH estimates

Variable	Econindex	Cpu	Epu	Gpr	Exchange
Cst (Mean)	15.9938*** (0.7663)	93.4907*** (4.4301)	111.7467*** (3.7738)	91.4877*** (2.5101)	74.2019*** (0.3915)
Cst (Variance)	12.1378*** (3.5087)	158.5632 (130.20)	114.2265*** (42.412)	225.413*** (75.041)	1.7371** (0.6952)
ARCH (1)	0.6275*** (0.0937)	0.2005** (0.0911)	0.6506*** (0.1183)	0.8194*** (0.1474)	1.1025*** (0.1338)
GARCH (1)	0.1929** (0.0855)	0.7591*** (0.1205)	0.4160*** (0.0959)	−0.0405 (0.0639)	0.0241 (0.0534)
$\alpha+\beta$	0.82052	0.9596	1.0667	0.7789	1.12666
Log L	−833.092	−1337.346	−1339.090	−1140.850	−892.604
	Persistent	Persistent	Not Persistent	Persistent	Not Persistent

Source: Developed by the authors.

Note: *** and ** indicate that they are significant at the levels of 1% and 5%, respectively.

Table 4
Estimates of the DCC-GARCH model

Variable	DCC estimates	Standard Errors
Econindex vs cpu	−0.0822***	0.0134
Econindex vs epu	−0.1369***	0.0137
Econindex vs gpr	0.01504***	0.0013
Econindex vs exchange	0.2135***	0.0144
Alpha (α)	0.2198***	0.0318
Beta (β)	0.7108***	0.0452
$\alpha+\beta$	0.9306	
Log L	−5285.96	

Source: Developed by the authors.

Note: *** indicate that they are significant at the levels of 1%.

This correlation also oscillates but with more pronounced peaks and troughs. There was a notable negative correlation around the 2008 financial crisis, which indicates that global economic policy uncertainty had a significant adverse impact on Ghana's economic activity. The correlation becomes positive during 2010–2012 and again approximately 2020, suggesting that during these periods, global eco-

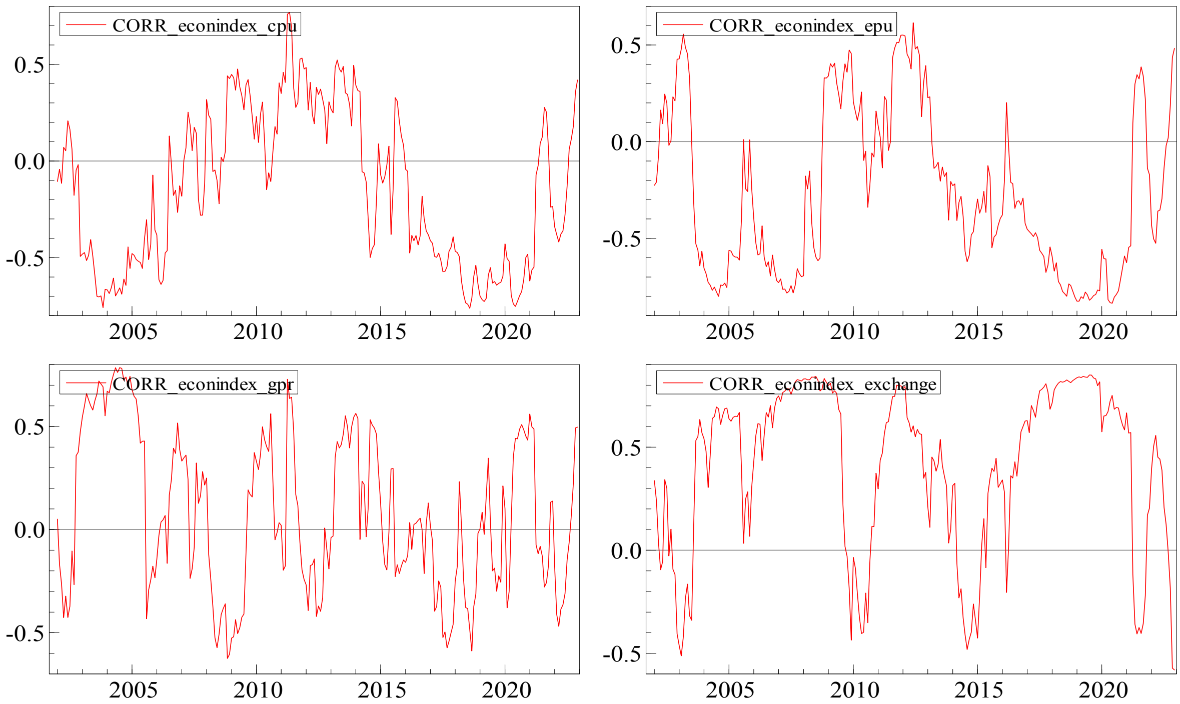

Fig. 3. **Dynamic conditional correlations between the economic activity index, global uncertainties and exchange rate**

Source: Developed by the authors.

nomic policy uncertainty may have had a different, possibly stabilizing, impact on economic activity. Antonakakis [29], on the relationship between global economic policy uncertainty and stock market returns in various countries, show similar fluctuating correlations, emphasizing the importance of policy uncertainty in economic dynamics. Similarly, [1] highlights how economic policy uncertainty can affect firm-level investment and economic activity, which aligns with the observed correlation patterns in the graphs.

In the bottom-left graph, the dynamic conditional correlation between the economic activity index and geopolitical risk (gpr) is depicted. The correlation here also fluctuates, with a more volatile pattern than in the previous two graphs. The early period (2003–2007) shows a strong positive correlation, suggesting that geopolitical risk is positively correlated with economic activity. However, after 2007, the correlation fluctuated more widely. At approximately 2008–2015, the correlation decreases significantly, showing negative values, which implies that geopolitical risk had a negative impact during these periods. Caldara and Iacoviello [27] indicated that geopolitical events can have substantial impacts on financial markets and economic conditions, which is consistent with the volatile correlations observed between economic activity and geopolitical risk in Ghana. This suggests that geopolitical tensions and conflicts could significantly disrupt economic stability. The bottom-right graph shows the dynamic conditional correlation between the economic activity index and exchange rates. The correlation is highly volatile with sharp oscillations. From 2003 to 2007, there was a predominantly positive correlation. After 2007, the correlation became more volatile, with periods of strong positive and negative correlations. The correlation is notably negative approximately between 2008 and 2015, suggesting that exchange rate fluctuations adversely impacted economic activity during these times.

Fig. 4 shows the time-varying covariance between the economic activity index, climate policy uncertainty, global economic policy uncertainty and geopolitical risk in Ghana. The covariance between economic activity and climate policy uncertainty fluctuates significantly over time, with notable negative spikes in approximately 2008 and again in 2020. These periods correspond to the global financial crisis and the COVID-19 pandemic, respectively, suggesting that climate policy uncertainty had a substantial negative impact on economic activity during these crises. Prior to 2008, the covariance hovered around zero, indicating minimal impact. Post-2008, there

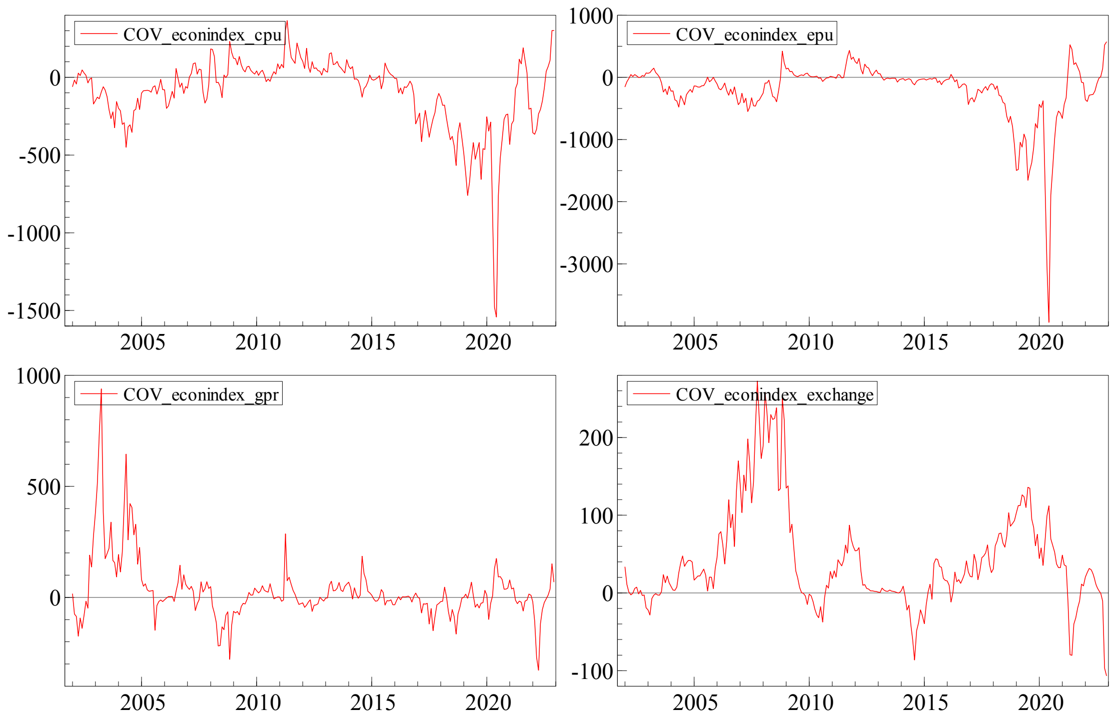

Fig. 4. **Dynamic conditional covariance between the economic activity index, global uncertainties and exchange rate**

Source: Developed by the authors.

are periods of both positive and negative covariance, reflecting changing dynamics and possibly varying policy responses and economic conditions.

The conditional covariance between the economic activity index and global economic policy uncertainty (epu) also fluctuates, with a marked negative spike approximately in 2020. The period from 2003 to 2010 shows relatively stable, slightly negative covariance, suggesting a mild inverse relationship. After 2010, the covariance fluctuates more, with significant decreases, particularly around global economic events. The strong negative covariance approximately 2020 aligns with the onset of the COVID-19 pandemic, indicating that global economic policy uncertainty significantly adversely impacted Ghana's economic activity. The covariance between the economic activity index and geopolitical risk is more volatile in the early period (2003–2005), with high positive spikes, suggesting that geopolitical risk had a positive impact on economic activity during these times. However, after 2005, the covariance became relatively stable at approximately zero, indicating a neutral impact of geopolitical risk on economic activity. In approximately 2020, there was a significant negative spike, again reflecting the adverse impact of the global pandemic and heightened geopolitical tensions.

Conclusions and recommendations

This study investigates the time-varying correlation between global uncertainties (e.g., global economic policy uncertainty, climate policy uncertainty and geopolitical risk). The dynamic conditional correlation GARCH model is used in the estimation using monthly data from January 2002 to December 2022. The DCC-GARCH model is adept at capturing time-varying correlations between variables, which is crucial for understanding the dynamic relationships in economic and financial time series. The univariate GARCH models for each of the variables indicate that the series were mean reverting. For the economic activity index, climate policy uncertainty and global economic policy uncertainty, the implication of the results is that the volatility of the variables decays slowly and persists for a longer time, such that the conditional variance will eventually return to its long-term average level after being disturbed by shocks. From the multivariate GARCH model, we find that over time, the correlation between economic activity and variables measuring global uncertainties oscillated and were predominantly negative for climate policy uncertainty and global economic policy uncertainty. We also find major spikes in the correlation, especially during periods of major world events, notably the 2008 global financial crisis and the COVID-19. These periods witnessed significant negative spikes. The results demonstrate the significant impact of global uncertainties.

The findings have significant implications for policymakers, investors, and economic analysts. The persistent and mean-reverting nature of volatility in economic activity, climate policy uncertainty, and global economic policy uncertainty suggests that shocks to these variables can have long-lasting effects. Policymakers need to consider the prolonged impact of global uncertainties on economic performance when designing economic policies and interventions. The predominantly negative correlations indicate that heightened global uncertainties can dampen economic activity, emphasizing the need for robust policy measures to mitigate these adverse effects. The significant spikes during major global events highlight the importance of crisis management and preparedness in maintaining economic stability during periods of heightened uncertainty.

Therefore, from the findings of the study, several policy recommendations can be drawn. It is crucial that policymakers develop strategies to manage and minimize the impacts of climate policy uncertainty and global economic policy uncertainties on economic activity. This can be done through the creation of more stable and predictable policy environments that streamline and improve transparency in communication around policy changes and, finally, through the implementation of measures that reduce related volatility to both of these uncertainties. Second, from the policy-making perspective, it is important to apply crisis management, especially for large global events, and to be better prepared to minimize negative impacts on economic activity. To strengthen monetary-fiscal coordination and the proactiveness of public communication during the crisis, more targeted support should be offered to affected sectors, financial safety networks that bind major economies should be reconstructed, and an international response to global crises should be coordinated as they emerge. The time-varying relationships of economic activity with global uncertainties can also be exploited for better-informed risk management and investment strategies for investors. Therefore, investor portfolios should be considered for potential impacts of global uncertainties, thus diversifying investors' investments. Finally, this research further recommends determining the channel-specific impacts of global uncertainties on economic activity and other factors that may alter these relationships.

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Ishaque Mahama — methodology, writing original draft, review and editing.

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