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Analyzing Climate Vulnerability and Financial Development Through the Lens of Global Uncertainty

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ABSTRACT

Climate change has intensified environmental risks, disproportionately affecting developing countries due to limited resources and weaker infrastructure. This study examines the impact of global uncertainty on climate vulnerability and financial development in Asian developing and developed economies, controlling for GDP, inflation, population, and labor force participation. Using panel data from 1995 to 2023 and applying an ARDL model, the study analyzes both short- and long-run relationships. The findings indicate that global uncertainty has a significant long-run effect on climate vulnerability and financial development in developing countries, which exhibit lower resilience to shocks compared to developed nations. The study provides policy insights to support sustainable development, particularly in achieving SDG 3 (Good Health and Well-Being) and SDG 8 (Decent Work and Economic Growth).

INTRODUCTION

Climate threats such as floods, storms, droughts, earthquakes etc. always have a greater effect on economies, especially developing countries. Asian developing countries are greatly influence by these dreadful events. These threats always challenged the international aid agencies and civilian governments. For the past few decades, due to climate change the possibility and frequency of these climate threats has

increased and the situation has become worse day by day. These climate threats have an exert influence on economic progress making it difficult for these countries to improve their financial systems as well as infrastructure and overall growth. So, Sustainable development is not possible because of huge effects of climate vulnerability.

Numerous studies shed light on the fact that investors are affected by changes in climate policies because it is difficult for them to predict the market trends that lead to less investments toward green and sustainable projects. Nicholas Bloom (2014) defines uncertainty as a vague concept. Uncertainty is thought of as a possible future in the minds of consumers, policy makers and managers. Uncertainty is an extensive concept, which covers all the perspectives from micro (like firm's growth rates) to macro (like GDP, inflation rate) level. Uncertainty also differs from country to country. The ratio of macro uncertainty in developing countries is one third more than the developed countries. Uncertainty also rises due to abrupt changes in the economy like fluctuation in oil prices, financial panics, wars etc. During the recession period, economies are facing a more uncertain situation due to the lower level of growth in their economy that lower growth causes higher level of uncertainty at micro and macro level. When economies are facing higher uncertainty their investment capabilities are reduced, and the purchasing power of customer are also decreased. But in some cases, the uncertainty prevails in research and development sectors.

Bloom (2009) elaborated the negative effect of uncertainty on economic conditions. This is because of the reluctance and inability of consumers and firms regarding investment due to an unpredictable future. Moreover, for costly and irreversible investment plans firms expect more information, while because of the lower income of consumers they are less attracted towards investment and market opportunities (Foote et al., 2000). Rise in domestic vulnerability is examined due to instability in global uncertainty (Engle, 2004). However, change in volatility may not always be directly in relation to change in level of uncertainty. Whereas Brooks & Persand (2003) analyze that volatility measures the up or down (strength of fluctuation) in the index, while change only measures the direction in which fluctuation occurs. Thus, any factor of uncertainty is affected by change in volatility (Barrot Araya et al., 2016; Gnangnon Sena, 2016). On this basis, the vulnerability of developing nations is directly influenced by the volatilities of diverse indicators of global uncertainties.

Worldwide economies are facing severe environmental problems and fluctuations in climate are considered the most critical issue. Due to industrialization activities, i.e. deforestation and fossil fuel burning, the large number of gases exist in the atmosphere and these greenhouse gas emissions are absorbing heat from the earth surface that leads to an increase in global temperature and
severely affecting the conditions of climate due to lasting atmospheric retention (Xiao and Fei, 2024).

Studies regarding climate change mostly discussed the changes in mean climate, as these are more vigorous in climate models as compared to climate variability changes. On the other hand, these studies may substantially undervalue the consequences of climate change on human and biological systems due to only focused on climate mean changes (Thornton et al., 2014). Economies' vulnerability to climate change is mostly dependent on their political and socioeconomic conditions. The main factors like income levels, location, jobs and governess play an essential role that how basically these climate changes impacted different economies (O'Brien et al., 2011).

The term "vulnerability" refers the ability to be harmed, means that how much the system is able to suffer damage when it's exposed to hazard. The research in vulnerability has started in only geography and natural hazards studies but now it's widely used in other research settings like sustainability, ecology, poverty, climate change and public health studies (Turner II et al., 2003). The study conducted by Omar and Bardsley (2024) explored that worldwide economies are experiencing climate crisis that are escalating economic, social and political challenges. Agrarian systems and other factors like regional climate patterns, labor and agricultural markets, liberalization and agricultural policies and economic development are affected due to severe climate changes. The connections between these processes can affect rural

communities in an unexpected way and make them more vulnerable to climate risks (Leichenko et al., 2010; Turner II et al., 2003).

When systems are incapable of managing the severe impacts of uncertainties or climate change determined by their sensitivity, adaptiveness and sensitivity then this thing will lead them to be more vulnerable towards climate change (Adger, 2006; Portner et al., 2022). Assessing climate change vulnerability helps economies to better identify those regions that are most vulnerable to climate change after those vulnerability assessments it will be helpful to create effective strategies or adaptive measures that can lower their vulnerability and make them more resilient (Nyashilu et al., 2024). Notre Dame Global Adaptation Initiative (ND-GAIN) climate vulnerability Index shows that South Asian and sub-Saharan African economies are more vulnerable towards climate change as compared to others (ND-Gain, 2022). So, that's why this study chose the Asian countries for better show this impact of climate change.

For measuring vulnerability numerous ways or techniques have been determined. These techniques include the livelihood vulnerability Index, asset approach, resource access, multidimensional livelihood index, climate vulnerability Index and household vulnerability (Sorre et al., 2017; Simotwo et al., 2018; Recha et al., 2017; Asmamaw et al., 2019; Zurovec et al., 2017; Okafor et al., 2017).

Hussain et al. (2023) discussed that there is extensive research on economic uncertainty but few of them discussed the direct effect of uncertainty on financial development. On the other hand, some of them indirectly explore the connection between these two by looking that how economic uncertainty affects the financial systems through economic growth processes. Prior studies explore that financial development is affected by global uncertainties in different regions. Economies need to update their outdated machinery with new capital goods. Investors are attracted to these goods due to higher consumer prices. For boosting nation's capital development economies need to quickly increase overall economic performance and revenue generation. High income economies have that option because they can easily afford them, which significantly boosts their financial development.

The decisions made by different financial institutions, governments and also an individual are extremely affected by global uncertainty, it also includes economic decisions. Economic activities are curtailed during the time of uncertainty which have a detrimental effect on the operations of financial institutions (Hussain et al., 2023). In most countries local and regional uncertainties have a significant impact on economic decision making. So, it would be an intriguing study to assess

the impact of global uncertainties on financial development in high-income economies (Gozgor et al., 2019). By keeping that perspective in mind, this study asserted to observe the impact of uncertainties on financial development in Asian developed and developing countries and look into that in which economy this will affect more.

Financial development increases economic growth by reducing transaction and information cost. Through innovative processes financial development boost resource allocation this will lead to enhance productivity and economic growth and promote investment as well. Developed nations attain capital and economic growth by using global innovation nets which includes think tanks, universities, trade networks, financial systems and policymakers. Thus, FD expected to have a positive impact on innovation. On the other hand, in developing nations the effects of financial development on innovation are lower compared to developed ones because they have less interaction with different institutions and also have limited connections to global innovation networks and financial sector as well (Ramirez et al., 2017). Higher financial development boost transparency, fosters asset diversification, reduces credit, sovereign and exchange risks and also promotes long-term investments. Greater financial development enhances labor productivity and overall output and makes trade easier (Botev et al., 2019).

Through financial development environmental damage is less because FD supports research and development, funding eco-friendly initiatives and also attracts foreign direct investment (Horvey et al., 2024). Environmental problems are resolved through strong financial systems, and it also helps to promote

environmental performance as well. On the other hand, weaker financial development has a detrimental effect on quality of environment (Tamazian and Rao's, 2010).

For measuring financial development, this study used Global Financial Development Index (GFDI) computed by IMF that measures financial efficiency and access of financial markets and institutions at country level (Svirydzenka, 2016). This study used this index to provide a more holistic representation of a complex multidimensional financial system. To align with exiting literature and ensure reliable and unbiased estimates, this study included control variables in the model. We use GDP, Inflation, Population and Labor force participation to account for other factors that might influence our dependent variables. These variables will play a crucial role in influencing the relationship between our main IV and DV's and enhance the accuracy and validity of this study.

Numerous studies examine these variables, i.e. financial development, global uncertainty and climate vulnerability in different perspectives. The study conducted by Muzzammil Hussain et al. (2023) investigated the linkage between financial development, world uncertainty, consumer prices and natural resources in developed nations. This study basically examines the impact of global uncertainties on financial development in developed countries and reveals that there is a negative effect of world uncertainty on countries' financial systems. The other study conducted by Helena Glebocki et al. (2024) examined the impact of uncertainty shocks in advanced economies and emerging markets. However, the impact for Asian developing and developed countries mostly Pakistan and its neighboring countries are not examined together in previous literature. This study is basically conducted to fill the gap of prior studies.

Canh Phuc Nguyen et al. (2022) investigated the impact of global uncertainty on socioeconomic and environmental vulnerability in developing nations. Despite the research done on global uncertainty, financial development and climate vulnerability but there is a significant research gap in comparative studies that mainly focusing on Asian countries. Prior studies do not examine an

Interconnectedness between global uncertainty, financial development and climate vulnerability in one study. So, this research investigates the relationship between climate vulnerability, financial development and global uncertainties and highlights the connection between these factors along with control variables i.e. GDP, Inflation, Population and Labor Force Participation. This study gives a valuable insight into formulating those strategies that help to minimize climate vulnerability and boost the financial system of those nations that are facing challenging conditions due to global uncertainty.

DATA AND METHODOLOGY

According to World Bank segregation, this study selected 10 countries including lower income and lower middle income as a developing nation and 12 countries including high income and upper middle income as a developed nation (WDI, 2024). The detailed information about the sample is presented in Table below. The World Uncertainty, Financial Development and ND-Gain Index is used to compute global uncertainty, financial development and climate vulnerability and for measuring our macroeconomic indicators we have collected data from WDI.

Table 1: *List of Countries*

S. No	Country Name	Category	Grouping
1	Bangladesh	Lower middle income	**Developing**
2	India	Lower middle income	**Developing**
3	Jordan	Lower middle income	**Developing**
4	Cambodia	Lower middle income	**Developing**
5	Lao PDR	Lower middle income	**Developing**
6	Sri Lanka	Lower middle income	**Developing**
7	Nepal	Lower middle income	**Developing**
8	Pakistan	Lower middle income	**Developing**

9	Philippines	Lower middle income	**Developing**
10	Myanmar	Lower middle income	**Developing**
11	China	Upper middle income	**Developed**
12	Japan	High income	**Developed**
13	Korea	High income	**Developed**
14	Kuwait	High income	**Developed**
15	Kazakhstan	Upper middle income	**Developed**
16	Mongolia	Upper middle income	**Developed**
17	Indonesia	Upper middle income	**Developed**
18	Thailand	Upper middle income	**Developed**
19	Malaysia	Upper middle income	**Developed**
20	Singapore	High income	**Developed**
21	Qatar	High income	**Developed**
22	**Saudi Arabia**	**High income**	**Developed**

Table 2: Variables

Variable	Explanation	Data Sources
Global Uncertainty	The World Uncertainty Index is used to measure global uncertainty, this index included 143 countries. All the indicators are measured by computing the frequency of the world uncertainty in Economic Intelligence Unit (EIU) country reports.	**Economic Policy Uncertainty > World Uncertainty Index**
Climate Vulnerability	Notre Dame Global adaptation Initiative (ND-Gain) Index is used to measure climate vulnerability. This Index provides data on readiness and climate vulnerability and estimating the nation's climate related risk i.e. sensitivity, adaptive capacity and exposure. This index included all sectors i.e. health, water, food, infrastructure and services related to ecosystem. It helps to investigate the country's robustness and keep an eye on the country's progress.	**ND-Gain Country Index**
Financial Development	The Financial Development Index is used to measure this variable. This index basically provides data regarding a country's financial development which covers efficiency, access and depth of financial institutions and markets. It provides insights into the country's development and growth by looking into their financial systems.	**International Monetary fund (IMF)**
GDP	GDP growth	**World Bank**
Inflation	Inflation consumer prices	**World Bank**
Population	Population growth	**World Bank**
Labor Force Participation	**Labor force participation rate total (% of total population ages 15+, modeled ILO estimate)**	**World Bank**

According to prior literature and theories, this study used empirical regression model to examine the impact of global uncertainty on climate vulnerability and financial development.

Model:

$CVit = \alpha\circ + \beta 1\ GUit + \beta 2\ GDPit + \beta 3\ INFit + \beta 4\ POPit + \beta 5\ LFPit +$ s,

$FDit = \alpha\circ + \beta 1\ GUit + \beta 2\ GDPit + \beta 3\ INFit + \beta 4\ POPit + \beta 5\ LFPit +$ s, where: $\alpha\circ$ = Regression intercept/constant term, β = Coefficient of independent variables CV= Climate Vulnerability
FD= Financial Development GU= Global Uncertainty GDP= Gross Domestic Product INF= Inflation
POP= Population
LFP= Labor Force Participation

RESULTS AND DISCUSSION

In the regression model when the residuals are correlated across time, it means the future errors are influenced by past errors showed that data is autocorrelated. This study applied the Wooldridge test to check the auto/serial correlation in data. The results for both models in developing and developed countries are shown in Table below. On the other hand, heteroskedasticity indicates that the error terms are not constant across observations and variance of residuals are not equally distributed about its mean value. This study applied the Modified Wald test to check the heteroskedasticity in data. The p-value of less than 0.05 indicates the presence of both autocorrelation and heteroskedasticity. The results for both models in developing and developed countries are shown in Table below.

Table 3: *Serial Correlation*

Developing Countries (10)		Developed Countries (12)
Model 1 (Prob > F)	0.0001	**0.0000**
Model 2 (Prob > F)	**0.0165**	**0.0002**

The above Table showed that the p-value is less than 0.05 in both cases so, according to the p-value in model 1 (GU with CV) and model 2 (GU with FD), autocorrelation exists.

Table 4: *Heteroskedasticity*

Developing Countries (10)		Developed Countries (12)
Model 1 (Prob > chi2)	0.0000	**0.0000**
Model 2 (Prob > chi2)	**0.0000**	**0.0000**

The above Table showed that the p-value is less than 0.05 in both cases so, according to the p-value in model 1 and model 2, heteroskedasticity exists. So, with the presence of both serial correlation and heteroskedasticity neither random (Re) nor fixed effect (Fe) will be appropriate model for analysis. So, this study estimated further test for selection of model and better analysis.

As in both models we are having the problem of autocorrelation and heteroskedasticity so, as a remedial measure this study applied the Driscoll Kraay robust standard error method. This method adjusts the problem of both issues and helps to validate the robustness of results.

Cross-Sectional Dependence:

CSD represents that residuals across different units are correlated. If CSD exists, which means that errors between entities are correlated. After this, we should go for a panel cointegration test to better check whether there is any long-term relationship between the variables or not. This study applied the Pesaran test to check the cross-sectional dependency in full and sub-sample. This test is appropriate for this study because a dataset of N=22 cross sections for T=29 years. The p-value of less than 0.05 indicates the existence of CSD in data. The results for CSD in full and sub-sample are reported in Table below

Table 5: *Cross-Sectional Dependence*

Variable	Full Sample		Developing		Developed	
	CD-test	**P-value**	**CD-test**	**P-value**	**CD-test**	**P-value**
CV	52.840	0.000	27.050	0.000	24.180	**0.000**
FD	24.880	0.000	5.130	0.000	20.500	**0.000**
GU	3.810	0.000	0.450	0.656	4.190	**0.000**
GDP	25.130	0.000	13.550	0.000	12.550	**0.000**
INF	18.550	0.000	10.160	0.000	7.120	**0.000**

POP	16.230	0.000	17.800	0.000	3.700	**0.000**
LFP	**0.850**	**0.398**	**8.350**	**0.000**	**0.870**	**0.386**

The above Table represents P < 0.05 in all variables except LFP in developed and full sample and GU in developing sample. So, the majority of the results show significance level at 1% which means that there is a presence of cross-sectional dependency in data. So, on the basis of these results we have selected ARDL because this is the appropriate approach to handle CSD effectively in panel data analysis.

Panel Co-integration:

Co-integration test are used to measure whether there is any long-term influencing effect between variables or not. It assures us that despite short-term variations, there is also an inducing effect on the variables in the long-run. By checking the relationship further, we will be able to select a model like ARDL for better long-run analysis. This study applied Pedroni, Kao and Westerlund test to better check the existence of co-integration among variables.

Table 6: *Kao (1999) results for full and sub-sample (Global Uncertainty with Climate Vulnerability)*

	Kao (Full Sample)		Kao (Developing)		Kao (Developed)	
	Statistics	**P-value**	**Statistics**	**P-value**	**Statistics**	**P-value**
Modified Dickey-Fuller t	3.2762	0.0005	-8.0239	0.0000	2.9054	**0.0018**
Dickey-Fuller t	3.7496	0.0001	-11.1341	0.0000	3.8674	**0.0001**
Augmented Dickey-Fuller t	4.5990	0.0000	-6.0853	0.0000	3.9256	**0.0000**
Unadjusted modified Dickey-Fuller t	0.2869	0.3871	-26.8698	0.0000	1.5049	**0.0662**
Unadjusted Dickey-Fuller t	**0.1675**	**0.4335**	**-16.0952**	**0.0000**	**1.5538**	**0.0601**

Table 7: *Pedroni (2004) results for full and sub-sample (Global Uncertainty with Climate Vulnerability)*

	Pedroni (Full Sample)		Pedroni (Developing)		Pedroni (Developed)	
	Statistics	**P-value**	**Statistics**	**P-value**	**Statistics**	**P-value**
Modified Phillips-Perron t	-1.3219	0.0931	-1.5281	0.0632	-0.4209	**0.3369**
Phillips-Perron t	-13.1905	0.0000	-11.8396	0.0000	-7.0456	**0.0000**
Augmented Dickey-Fuller t	**-12.9024**	**0.0000**	**-11.7170**	**0.0000**	**-6.7738**	**0.0000**

Table 8: *Westerlund (2005) results for full and sub-sample (Global Uncertainty with Climate Vulnerability)*

Westerlund (Full Sample)			Westerlund (Developing)		Westerlund (Developed)	
	Statistics	**P-value**	**Statistics**	**P-value**	**Statistics**	**P-value**
Variance ratio	**-1.8963**	**0.0290**	**-2.2789**	**0.0113**	**-1.3322**	**0.0914**

The above results for global uncertainty with climate vulnerability in all test are clearly show that cointegration exists and for further check the short and long-run estimation this study will use ARDL approach. For the purpose of robustness this study applied Kao test which represents the
notion that there is an existence of cointegration between variables, but this study mainly focuses on Pedroni and Westerlund test results due to the characteristics of data. The Pedroni and Westerlund test are considered the best approach when there is a presence of cross-sectional dependence and heteroskedasticity.

The above Table represents the results of Pedroni test for global uncertainty with climate vulnerability in full and sub-sample, which clearly shows the existence of cointegration between variables and in developing countries variables have a significant impact with the p-values of 0.0632, 0.000 and 0.000. On the other hand, the whole Asia region reported a weak significance level as compared to developing nations with the p-values of 0.0931, 0.000 & 0.000. Further, developed countries also represent significant

values in two tests except one and the p-values for developed nations are 0.3369, 0.000 & 0.000. The above Table represents the Westerlund results for global uncertainty with climate vulnerability in full and sub-sample, which also supports this notion that cointegration exists and in developing nations there is a significant relationship among variables as compared to others with the p-value of 0.0113.

Table 9: *Kao (1999) results for full and sub-sample (Global Uncertainty with Financial Development)*

	Kao (Full Sample)		Kao (Developing)		Kao (Developed)	
	Statistics	P-value	Statistics	P-value	Statistics	P-value
Modified Dickey-Fuller t	1.8367	0.0331	1.6030	0.0545	0.7947	**0.2134**
Dickey-Fuller t	0.8380	0.2010	1.7540	0.0397	-0.9555	**0.1697**
Augmented Dickey-Fuller t	2.6867	0.0036	2.7801	0.0027	0.9894	**0.1612**
Unadjusted modified Dickey-Fuller t	-1.9422	0.0261	-1.3362	0.0907	-2.2726	**0.0115**
Unadjusted Dickey-Fuller t	**-2.3565**	**0.0092**	**-0.8452**	**0.1990**	**-3.2318**	**0.0006**

Table 10: *Pedroni (2004) results for full and sub-sample (Global Uncertainty with Financial Development)*

	Pedroni (Full Sample)		Pedroni (Developing)		Pedroni (Developed)	
	Statistics	P-value	Statistics	P-value	Statistics	P-value
Modified Phillips-Perron t	4.1140	0.0000	-1.1645	0.1221	**3.0425**	**0.0012**
Phillips-Perron t	-0.6836	0.2471	-10.8893	0.0000	**-1.2208**	**0.1111**
Augmented Dickey-Fuller t	**-0.2302**	**0.4089**	**-10.6690**	**0.0000**	**-1.2208**	**0.1111**

Table 11: *Westerlund (2005) results for full and sub-sample (Global Uncertainty with Financial Development)*

	Westerlund (Full Sample)		Westerlund (Developing)		Westerlund (Developed)	
	Statistics	P-value	Statistics	P-value	Statistics	P-value
Variance ratio	**6.0070**	**0.0000**	**2.6545**	**0.0040**	**-1.3958**	**0.0814**

The above results for global uncertainty with financial development in full and sub-sample clearly show that cointegration exists across variables. For the purpose of robustness this study applied Kao test which also represents the notion that there is an existence of cointegration between variables, but this study mainly focuses on Pedroni and Westerlund test results due to the presence of cross-sectional dependence and heteroskedasticity.

The above Table represents the results of Pedroni test which clearly shows the existence of cointegration between variables and in developing countries variables have a significant impact with the p-values of 0.1221, 0.000 and 0.000. On the other hand, the whole Asia region reported a weak significance level as compared to developing nations with the p-values of 0.000, 0.2471 & 0.4089. Further, developed countries also represent significant values in one test except the other two tests and the p-values for developed nations are 0.0012, 0.111 & 0.111. The above Table 4.16 represents the Westerlund results which also support this notion that cointegration exists and in developing nations there is a significant relationship among variables with the p-value of 0.0040 and the p-values for developed and full sample are 0.000 & 0.0814 respectively.

Panel Autoregressive Distributed Lag (ARDL) Model:

ARDL is used to analyze the long-term impact among variables especially when we are dealing with panel data. It implies lagged values of both independent and dependent variables to better depict the past impacts and observe long and short run changing aspects and this model is more flexible while treating those variables that are stationary at level 1(0) and 1st difference 1(1). This study applied panel ARDL with PMG and MG and stated the most efficient results. The results for global uncertainties with climate vulnerability in developing, developed and whole sample are reported in Tables below

Table 12: *Pooled Mean Group (PMG) results for full and sub-sample (Global uncertainties with climate vulnerability)*

Long-run impact	Full Sample		Developing Countries		Developed Countries	
CV	**Coef.**	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**
GU	-0.112	0.087	0.036	0.052	0.005	**0.390**
GDP	-0.115	0.040	0.049	0.000	-0.004	**0.093**
INF	-0.129	0.019	0.001	0.908	0.002	**0.296**
POP	-0.265	0.014	0.013	0.258	0.009	**0.001**
LFP	-5.544	0.000	-0.550	0.006	-0.457	**0.000**
Short-run impact						
Error Correction	0.002	0.345	-0.044	0.235	-0.126	**0.012**
ΔGU	-0.001	0.284	-0.001	0.402	-0.002	**0.027**
ΔGDP	0.002	0.127	0.003	0.295	0.001	**0.166**
ΔINF	0.000	0.349	0.001	0.352	-0.000	**0.476**
ΔPOP	0.000	0.984	-0.010	0.167	0.009	**0.299**
ΔLFP	-0.144	0.000	-0.119	0.245	-0.213	**0.000**
_cons	-0.052	0.347	0.057	0.295	0.122	**0.016**
No of Observations	616		280		**336**	
No of Countries	**22**		**10**		**12**	

The above Table clearly shows the results for GU with CV which represents that in developing countries there is a long-run impact of global uncertainty on climate vulnerability with the significant p-value of 0.052 which means in developing nations, global uncertainty increases climate vulnerability also increases. The control variables GDP and labor force participation also
have an influencing impact on climate vulnerability in the long-run with the significant p-values of 0.000 and 0.006. On the other hand, in the short-run the error term is negative and insignificant ($P > 0.05$, $P = 0.235$) which indicates that after external shocks, the system is not efficiently adjust back to equilibrium. So, in this case short run dynamics are considered inconsistent and weak in driving immediate corrections. These results also indicate that changes in these variables are immediately affecting the economy, so systems take a longer time to adjust and are not too advanced to quickly respond to the abrupt variations. In short run impact, the above table shows the p-values of 0.402, 0.295, 0.352, 0.167 and 0.245, which clearly show that in developing countries there is a long-run impact instead of short-run.

In developed countries, the p-value of 0.390 clearly justifying that there is no long-run impact of global uncertainty on climate vulnerability as well as the control variables except population and labor force participation are also not showing significant impact with the p-values of 0.093 and
0.296. On the other hand, in the short-run the error term is significant but negative ($P < 0.05$, $P = 0.012$) which indicates that after external shocks, the system is efficiently adjusted back to equilibrium. So, in this case short run dynamics are considered consistent in driving immediate corrections also indicate that systems do not take a longer time to adjust, they efficiently respond to this variation in a shorter time period and quickly adapt to abrupt variations as compared to developing nations.

In the full sample certain variables are showing stronger effect in the long run and some are showing influencing impact in short-run. So, it's a blend of both developing and developed nations. GU shows marginally significant value (P = 0.087) in long-run and insignificant value in short-run and the same case with other variables like GDP, inflation, population and labor force participation and the error term representing positive and significant value which indicates the divergence from its equilibrium and show that there is a weak unstable long-run impact which shows marginally significant values. Overall, in Asia region the impact of global uncertainty on climate vulnerability is marginally significant in long-run so it means that due to developed nations the full sample is not showing strongly impact in long-run because developed nations have a strong short-run impact and developing have a strong long-run impact so, full sample results are showing marginally significant values in both cases according to the results in these two sub-samples.

Table 13: *Pooled Mean Group (PMG) results for full and sub-sample (Global uncertainties with financial development)*

Long-run impact	**Full Sample**		**Developing Countries**		**Developed Countries**	
FD	**Coef.**	**P-value**	**Coef.**	**P-value**	**Coef.**	**P-value**
GU	-0.011	0.655	-0.082	0.031	0.016	**0.595**
GDP	0.024	0.019	-0.068	0.026	0.040	**0.001**
INF	-0.020	0.067	-0.032	0.167	-0.024	**0.049**
POP	-0.029	0.026	-0.034	0.524	-0.015	**0.290**
LFP	-1.275	0.000	-0.806	0.045	-0.679	**0.025**
Short-run impact						
Error Correction	-0.260	0.000	-0.254	0.000	-0.276	**0.002**
ΔGU	-0.010	0.267	-0.002	0.897	-0.013	**0.280**
ΔGDP	-0.009	0.117	0.008	0.459	-0.014	**0.002**
ΔINF	0.009	0.323	0.003	0.840	0.015	**0.238**
ΔPOP	0.062	0.334	0.194	0.112	-0.049	**0.376**
ΔLFP	0.942	0.047	1.101	0.195	0.494	**0.446**
_cons	1.105	0.000	0.456	0.000	0.613	**0.003**
No of Observations	616		280		**336**	
No of Countries	**22**		**10**		**12**	

The above Table clearly shows the results for GU with FD which indicate that in developing countries there is a long-run impact of global uncertainty on financial development with the p-value of 0.031and coefficient value of -0.082 which means in developing nations, when global uncertainty increases the financial development decreases. The control variables GDP and labor force participation also have an influencing impact on financial development in the long-run with the p-values of 0.026 and 0.045. On the other hand, in the short-run the error term is significant and negative and other variables show an insignificant result which indicates that after external shocks, the system is not efficiently adjusted back to equilibrium. So, in this case short run dynamics are considered inconsistent and weak in driving immediate corrections and also represent means that systems take a longer time to adjust and not as much advanced to quickly respond to the abrupt variations. In short run impact, the above table shows the p-values of 0.897, 0.459, 0.840, 0.112 and 0.195, which clearly show that in developing countries there is a long-run impact instead of short-run.

For developed countries, the p-value of 0.595 clearly justifying that there is no long-run impact of global uncertainty on financial development as well as the control variables except GDP and inflation are also not showing significant impact with the p-values of 0.290. On the other hand, in the short-run the error term is significant and negative. Additionally, the majority of the variables show insignificant results in

both short and long-run except GDP. So, according to the majority of insignificant results, it means that changes in these variables are not affecting the economy in the short run as well as long-run because the financial systems in developed countries are as advanced that they are not affected by any uncertainties or other influencing variables except GDP. These systems are as efficient that there is no need to take any precautionary measures to respond to any kind of uncertainties that are affecting their financial systems as compared to developing countries.

In the full sample certain variables are showing stronger effect in the long run and some are showing influencing impact in short-run. So, it's a blend of both developing and developed nations. GU is showing insignificant results (P = 0.655) in long-run as well as short-run and the same case with other variables like GDP, inflation, population and labor force participation. Overall, in Asia the impact of global uncertainty on financial development is not too much influencing in the long-run as well as short-run so it means that due to developed nations the full sample is not showing strong impact because developed nations are not affected by any sort of abrupt variations as compared to developing ones. By keeping in view, the results of developed nation, whole Asia region are showing results where there is an influencing impact but not strong impact on financial system. So, full sample representing results in both models according to the influencing effect by these two sub-samples.

Driscoll-Kraay Robust Standard Errors:

This method is useful to check the validity of the results and ensure the accurate relationship among variables by correcting implicit biases in the standard errors. Additionally, assure the influencing effect of variables while encountering the issues of CSD, serial correlation and heteroskedasticity. This method is a fundamental step to check the relationship strength among variables under robust conditions.

Table 14: *The results of Driscoll in Full Sample (Global uncertainties with climate vulnerability and FD)*

Driscoll/Kraay					Driscoll/Kraay				
CV	**Coef.**	**Std.Err.**	**t**	**P>t**	**FD**	**Coef.**	**Std.Err.**	**t**	**P>t**
GU	0.029	0.022	1.290	0.206		-0.144	0.050	-2.870	**0.008**
GDP	0.038	0.008	4.900	0.000		-0.133	0.026	-5.180	**0.000**
INF	0.038	0.004	9.350	0.000		-0.229	0.021	-10.91	**0.000**
POP	0.010	0.013	0.760	0.451		-0.045	0.037	-1.200	**0.239**
LFP	-0.294	0.012	-25.29	0.000		0.369	0.101	3.650	**0.001**
_cons	0.315	0.073	4.330	0.000		-2.396	0.373	-6.420	**0.000**
***Model 1:* Prob > F = 0.0000 R-squared = 0.2758**					***Model 2:* Prob > F = 0.0000 R-squared = 0.2510**				

The above results confirm the results of ARDL by showing that there is no strong influence or significant impact of global uncertainty on climate vulnerability but on financial development there is a slight impact in full sample with the p-values of 0.206 and 0.008. On the other hand, certain control variables are showing influencing impact, but others are not. Additionally, the value of F-stats (F = 0.000) shows the overall fitness of model so, in this study for both models the strongly significant value shows that the model is good fitted. Further, the value of R-square (R-sq = 0.2758) in model 1 (GU with CV) represents how much the variation in dependent variable is explained by independent variables.

The value of R-square shows that 27% variation in dependent variable (CV) is explained by the independent variables (GU, GDP, INF, POP and LFP), which represent that the control variables are also contributing to the R-square value and reducing the impact of unknown variables in the model. On the other hand, the value of R-square (R-sq = 0.2510) for model 2 (GU with FD) shows that 25% variation in dependent variable (FD) is explained by the independent variables (GU, GDP, INF, POP and LFP). Overall, this test validates the results of the above applied approach under robust conditions.

Table 15: *The results of Driscoll in developing countries (Global uncertainties with climate vulnerability and FD)*

Driscoll/Kraay	Driscoll/Kraay

CV	Coef.	Std.Err.	t	P>t	FD Coef.	Std.Err.	t	P>t
GU	0.022	0.007	3.130	0.004	-0.257	0.050	-5.100	**0.000**
GDP	0.010	0.013	0.760	0.455	-0.006	0.043	-0.130	**0.896**
INF	0.028	0.009	3.100	0.004	-0.046	0.038	-1.210	**0.237**
POP	-0.012	0.015	-0.830	0.414	0.110	0.089	1.240	**0.226**
LFP	0.182	0.018	10.050	0.000	-1.326	0.118	-11.210	**0.000**
_cons	-1.449	0.069	-20.920	0.000	3.353	0.423	7.930	**0.000**
***Model 1:* Prob > F = 0.0000 R-squared = 0.3103**					***Model 2:* Prob > F = 0.0000 R-squared = 0.2948**			

The above results confirm the results of ARDL by showing that there is a significant impact of global uncertainty on climate vulnerability and financial development in developing countries with the p-values of 0.004 and 0.000. On the other hand, the control variables INF and LFP also have a strong significant impact on climate vulnerability with the p-values of 0.004 and 0.000 and for control variables in model 2 (GU with FD), LFP have a significant impact on financial development after global uncertainty with the p-value of 0.000.

The value of R-square shows that 31% variation in dependent variable (CV) is explained by the independent variables (GU, GDP, INF, POP and LFP), which represents that the control variables are also contributing to the R-square value and reducing the impact of unknown variables in the model. On the other hand, the value of R-square (R-sq = 0.2948) for model 2 (GU with FD) shows that 29% variation in dependent variable (FD) is explained by the independent variables (GU,

GDP, INF, POP and LFP). Overall, these results validate significant relationship among variables under the robust conditions.

Table 16: *The results of Driscoll in developed countries (Global uncertainties with climate vulnerability and FD)*

Driscoll/Kraay					Driscoll/Kraay			
CV	**Coef.**	**Std.Err.**	**t**	**P>t**	**FD Coef.**	**Std.Err.**	**t**	**P>t**
GU	0.006	0.017	0.350	0.729	0.065	0.042	1.550	**0.132**
GDP	0.010	0.004	2.270	0.031	-0.025	0.021	-1.230	**0.227**
INF	-0.002	0.005	-0.460	0.648	-0.177	0.016	-11.280	**0.000**
POP	0.018	0.007	2.530	0.017	-0.063	0.018	-3.580	**0.001**
LFP	-0.288	0.022	-12.900	0.000	0.436	0.199	2.190	**0.037**
_cons	0.250	0.121	2.070	0.048	-2.240	0.836	-2.680	**0.012**
***Model 1:* Prob > F = 0.0000 R-squared = 0.1414**					***Model 2:* Prob > F = 0.0000 R-squared = 0.2582**			

The above results confirm the results of ARDL by showing that there is an insignificant impact of global uncertainty on climate vulnerability and financial development in developed countries with the p-values of 0.729 and 0.132 which means that developed countries have too much advanced systems that are not affected by any sort of uncertainties as compared to developing nations. On the other hand, only the control variables GDP, POP and LFP have an influencing effect on climate vulnerability of developed nations and only INF and POP have an influencing effect on financial development of these countries, other variables are not affecting their systems. So, on the basis of the majority of the results developed nations are not severely affected by these variations as compared to developing nations.

The value of R-square shows that 14% variation in dependent variable (CV) is explained by the independent variables (GU, GDP, INF, POP and LFP), which represent that the control variables are also contributing to the R-square value and reducing the impact of unknown variables in the model. On the other hand, the value of R-square (R-sq = 0.2582) for model 2 (GU with FD) shows that 25% variation in dependent variable (FD) is explained by the independent variables (GU, GDP, INF, POP and LFP).

Overall, these results validate that in developing nations there is more influencing significant effect among variables as compared to developed nations.

Overall, by developing hypothesis this study focused on this notion that there is a relationship among those variables in developing and developed countries. So, by using the above approaches or model we proved that there is a relationship between variables in both significant and insignificant way due to deviation in their geographical locations, resource capabilities and economic development. For developing nations this situation is very challenging because of lack of resources and weak infrastructure that make than highly vulnerable to environmental damage and have an influencing effect on their financial systems as well. This effect is proved by using ARDL model and reported that there is a strong significant long-run impact of global uncertainties on climate vulnerability and financial development as compared to developed nations. So, this study gives valuable insight to policy makers into formulating those policies that lead to better outcomes to minimize climate vulnerability and boost the financial system of developing nations who are facing more challenging conditions due to global uncertainties as compared to developed countries.

CONCLUSION

This study investigated the impact of global uncertainty on climate vulnerability and financial development with the help of control variables GDP, inflation, population and labor force participation. By empirical testing and analysis, this study proved that the relationship among these variables exists. This study selected the ARDL model to better assess the influencing effect among these variables by considering short and long-run impact. This study analyzes this impact by using the sample of Asian countries including both developing and developed nations for the time period of 1995-2023. The results of this study are investigated with two models, the first one analyzes the impact of global uncertainty on climate vulnerability and in the second model this study analyzed the effect of global uncertainty on financial development in both developing and developed countries. The results for both models indicate that in developing countries when uncertainty in an economy increases then climate vulnerability increases and financial development decreases. On increase in GDP, inflation and labor force participation the climate vulnerability increases and FD decreases. On the other hand, the results for both models in developed countries show that there is an insignificant impact of global uncertainty on climate vulnerability and financial development which means that developed nations have too advanced systems that are not affected by any sort of uncertainties as compared to developing nations. So, on the basis of the majority of the results developed nations are not severely affected by these variations as compared to developing nations. Overall, in Asia the effect of global uncertainty on climate vulnerability as well as financial development is not showing a significant influencing impact which means that due to developed nations the full sample is not showing strong impact because developed nations are not affected by any sort of abrupt variations as compared to developing ones. By keeping in view, the results of developed nation whole Asia region are showing results where there is no strong significant influence on financial system as well as climate vulnerability. So, full sample representing results in both models according to the influencing effect by these two sub-samples. The developing nations are facing severe environmental and financial instabilities because of their weak institutional frameworks, restrained financial resilience and higher vulnerability to climate threats as compared to developed countries. These climate threats basically disturb the economy's agricultural productivity, their economic stability and infrastructures. To deal with these severe

issues systems should promote strategies regarding climate adaptation, modify their financial regulations and focus on sustainable projects that help them to deal with environmental and financial challenges.

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