Available Online
Journal of Social Sciences Advancement
www.scienceimpactpub.com/jssa
DOI: https://doi.org/10.52223/JSSA25-060408

Does Export Product Diversification Strategies Reshape the Country's Resilience against Climate Change? Evidence from CAREC Economies

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ARTICLE INFO

ARTICLE HISTORY
Received: September 23, 2025
Accepted: December 19, 2025
Published: December 30, 2025

KEYWORDS
Climate Change;
Economic Fitness;
CAREC Countries;
Notre Dame Index;
Environmental Kuznets Curve

ABSTRACT

Climate change and environmental degradation have emerged as major issues of the globe in the recent decades that required an immediate solution. To cope with this unavoidable problem, the SDGs-13 goal underscores the significance of the developing adaption measures that decrease its adverse influence and eventually safeguard both environment and society. The country's economic fitness (EF) displays its capability to produce complex goods as well as its ability to diversify its product line, is crucial in handling all types of susceptibilities. This study explores the influence of EF on country's resilience against climate change in CAREC (Central Asia Regional Economic Cooperation) economies. An inverted N-shaped relationship is found between EF and country's resilience against climate change in CAREC nations. Further, the study findings remain robust after additions of other covariates such as financial development (FD), economic growth (EG), and foreign direct investment (FDI). The government should stimulate EF through extensive margins in order to boost country's resilience.

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INTRODUCTION

In current decades, climate change and environmental degradation (ED) have arisen as the most difficult as well as controversial problems of the world, and growing global agreement that these severe concerns must be settled on priority basis (Khan et al., 2022). Now, with rising temperatures, environmental sustainability is enormously endangered. The major goal of the Kyoto Protocol in 1997 was to reduce greenhouse gas emissions (GHGE), which are the main cause of ED. The primary reason of this problem is nations' aspiration to build their economies (Younis et al., 2021). The damaging effect of global warming harms not only the ecology and environment but also the every facet of the world economy and society (Ikram et al., 2021).

Climate change's actual effects are already being practiced by many world economies (Kling et al., 2021). Natural disasters such as storms, landslides, floods, droughts, and heat waves are frequently occurring (Beck & Mahony, 2018; Kling et al., 2021). There are momentous economic insinuations linked with this massive escalation of climate change-related disasters (Botzen et al., 2019). Existing research has explored numerous factors that have crucial effect on ED, involving ICT (Usman et al., 2021), industry structure (Khan et al., 2019), innovation (Khan et al., 2020), globalization (Baloch et al., 2021), FD (Umar et al., 2020), urbanization, and FDI (Ahmad et al., 2021). The increasing ecological pollution caused to many developed and less developed economies have started to pay thoughtful focus on measures of environmental protection, and international organizations have taken noteworthy steps and implemented many vital measures of environmental protection to decrease pollution (Shahzad et al.,2020). Moreover, awareness about ED is increasing in modern societies due to world ecological degradation (Çınar et al., 2022).

Energy-related carbon emissions are mainly driven through the economic activities in Central Asia. The contribution of the energy sector to carbon emissions in CAREC fluctuates due to difference in energy mixes of nations (Qadir & Dosmagambet, 2020). Fossil fuels is mainly dominated in many economies. In addition, energy sector share, involving heating, electricity in local carbon emissions cross up to 60 in Kazakhstan and Mongolia. The low level per capita carbon emissions in Georgia, Tajikistan, and Kyrgyzstan is due to the higher hydropower share in whole energy generation. Undeniably, the People's Republic of China (PRC) is the biggest GHG in CAREC and the globe, given its fast-growing economy and population size. The carbon emission level of the PRC's touched to 11,255 million metric tons (MT) during 2018, which indicates that 29.7% contributed to world emissions (Tsevegjav, 2020). The CAREC emissions levels have been uneven such as Kazakhstan is the second greater emitter across the globe. Until 2000 its emission levels decreased but again rose and touched to 309Mt million in 2018. In Pakistan, it enhanced by more than three times from 64.31Mt-196.18Mt million during 1990- 2015. While in Tajikistan, Georgia, and Azerbaijan it gradually declined. The emission level in Georgia fell almost four times from 34 Mt-11Mt million during 1990-2018. Kyrgyzstan, Georgia, and Tajikistan have lower carbon emissions, 10.13 Mt, 11 Mt, and 5.93 Mt million, respectively[1].

Further, local and international organizations are promoting environmental friendly goods and services in an effort to decrease the harmful influence of industrialization. In addition, environmental laws or policies are gradually being accepted by the decision-makers to stimulate the production of sustainable as well as climate-neutral products and also to stop selling of the environmentally hazardous products. Concerning to this, environmental goods have been explained and categorized by the WTO, OECD, and APEC. The EU and OECD statistics office indicate some items utilized to gauge, prevent, or reduce air pollution as "environmental goods" (Eurostat). The extensive product range makes it feasible to make ecologically-friendly products (Can et al., 2021; Can et al., 2022).

EF is the more significant tool in reducing ED, by manufacturing the energy-efficient commodities that decrease the demand for energy (Iskenderoğlu & Akdağ, 2018; Ul-Haq et al., 2023). EF measures the nation' capability to develop a complex goods that are globally competitive and its diversification level. Economically proficient nations are more capable for the product basket diversification, enlarge into supplementary complex items, and have more expected growth for long term, as well as get a competitive edge over the rival countries (World Bank, 2021). Economies with low levels of EF, poorly fight with poverty, have less capabilities, less projected growth, lower value addition, and face the upgrading problems and slow diversification process as compared to other nations. Thus, in order to obtain SDGs in CAREC countries, it is important to stimulate the economic structure as well as produce less pollution-intensive goods (Peng et al., 2022).

The effects of EF on the environmental degradation are dependent on the nation's strategies for diversification of the export products. The diversification of products can be raised by expending the intensive margins by more traditional goods or extensive margins by bring together different and new items (Dou et al., 2023). If the respective country is continuously manufacturing new goods along with the prevailing commodities of polluting industries, this accumualtion boosts the diversification effects, thus making the EF rise as well as degrading the environment (Hu et al., 2020). Conversely, if the respective nation is producing new products along with ceasing or halting the production of the products in the polluting industries, this enhances the diversification effects, making EF to increase along with the degradation of the environment. However, this is particularly noted among those economies that manufacture the green products for the consumer as well as the exporting objective (Can et al., 2022). Therefore, such types of economic fitness contribute positively to the environment, and its effects are on the environment through the process of diversifications of products (Ul-Haq et al., 2023). Moreover, as the economies are still in the development stages, the increased population increases the energy consumption to meet the demand with respect to the energy demand of the respective populations along with enhancing economic development activities through the process of diversifications, thus accelerating the process of creating carbon foot-prints that are deadly to humanity as well as the planet (Ul-Haq et al., 2024). It is estimated that by the year 2040, the emerging economies are expected to consume around 90% more energy compared to that in the developed economies (EIA, 2013).

Numerous outcome-based indicators (i.e., $PM_{2.5}$, CH_4, SO_2, and CO_2) have been utilized as a proxy of ED in existing research. Many studies utilized these outcome measures as a proxy of ED in context of EKC hypothesis (Cetin et al., 2022; Destek & Sarkodie, 2019; Hye et al., 2023; Sarkodie & Ozturk, 2020; Shahzad et al., 2023; Ul-Haq et al., 2024; Xie et al., 2019). To the best of our knowledge, there is no study that has focused on the country's resilience against climate change in cases where EKC exists in CAREC countries. In this study, our analysis will utilize GAI, which is a more comprehensive and appropriate measure for the above-referenced reason, as it measures the risk exposure from climate change. This index shows the nation's vulnerability to climate change as well as world problems, as well as its ability to increase resilience. The annually updated GAI measures the nation's vulnerability to extreme climatic events such as droughts, super storms, natural catastrophes, as well as its ability to effectively apply adaptation strategies (Kling et al., 2021). GAI identifies two factors: readiness and vulnerability. In regard to the measurement of readiness, it is broken down into breakdowns of the three types: social, governance, and economic. In regard to breakdowns of measurement of vulnerability, there is breakdowns of three types: adaptive, sensitivity, and exposure capacity. GAI examines the factors common for effective climate change adaptation, such as an established economy, access for resources such as pure clean fresh water, as well as the ability for political stability and agricultural strength (Kling et al., 2021). Each economy faces challenges of adaptation, but vary from one economy to another. Most of the countries are also known as the most vulnerable ones for the negative effects of climate change, as a result of their socio economic conditions as well as geographic situations. In addition, these countries are prepared to adopt measures for adaptation by utilizing private as well as government resources, as well as having an ability for private

[1] International Energy Agency Statistics, https://www.iea.org/data-and-statistics.

sector's policy-making for effective climate change measures (Chen et al., 2015). Thus, it is necessary to enumerate a climate change risk in CAREC countries for the sustainable growth and development.

To achieve this objective, our research conduct a study to explore the CAREC nations' climate risk exposure in context of EKC framework. In case of CAREC economies, the study of Qadir and Dosmagambet (2020) explored the regional energy trade integration impact on carbon emissions during 2000-2019. Moreover, the empirical study of Ul-Haq et al. (2023) which explored how EF influences the CO_2 emissions in BRICS economies with relation to EKC is a only paper that studied EF as a whole. No research have used GAI, which assesses the complete risk exposure to the climate change. This study fill this pot, especially for CAREC countries.

This research makes various contributions to prevailing literature, First, investigate the impact of EF on country's resilience (measured by GAI) in the framework of EKC in CAREC economies. Second, this research use overall index of economic fitness with wide-ranging proxy to explore environmental concerns in CAREC nations. Third, our study used the country's resilience again climate change based measure of the environmental sustainability, in comparison to generally utilized outcome based measures (like $PM_{2.5}$, CH_4, SO_2, and CO_2) as environmental degradation proxy in existing research at least in case of CAREC countries. GAI calculates the nation's overall resilience against climate change. It motive to support business as well as public sector in properly ordering investment to more significantly address the future harsh global challenges.

LITERATURE REVIEW

Over the past decades, the production of industrial sector has hastened in CAREC economies, and are speedily growing economies across the globe. Moreover, these economies are devoted to solving the issues with world climate change, environmental management, and biodiversity (Pradhan et al., 2022). Many existing research have explored the influence of different ED factor linked to EKC (Adebayo et al., 2022). Qadir and Dosmagambet (2020) explored the regional energy trade integration impact on CO_2 in CAREC countries during 2000-2019. The paper found that the increase of energy imports in CAREC economies is linked with the CO_2 reduction. Mehrara and Rezaei (2013) explored, in BRICS during 1960-1996, liaison between EG, CO_2e, and trade liberalization. The study revealed the indication for EKC utilizing the panel co-integration tests. Bakirtas et al. (2014) illustrated the strong relation between income and CO_2 emissions for long run and short run in BRICS. Ahmed et al. (2016) probed the link of energy consumption, CO_2 emissions, and trade in BRICS during 1970-2013. Contrary to earlier research, the study revealed that liberalization of trade lead to the decrease of CO_2 emissions and EKC relationship exist.

Sinha and Sen (2016) showed the EKC applicability in BRICS economies for India and Brazil, but not for China and Russia, founded the EKC relation between air pollution and EG. Tedino (2017) explored the relationship between finance transportation, energy, and EG to analyze the EKC, and found that EKC exists for India, China, and South Africa, Nassani et al. (2017) exposed a U-shaped liaison. Tacchella et al. (2012) established the index of economic fitness to evaluate the relationship between economic complexity and production potential for the several economies. This index uses to explore the link between ED, eco-friendly production potential and low carbon for 122 economies. This paper showed that the countries with advanced Green Complexity Index (GCI) practiced fewer ecological degradation. In addition, Can and Gozgor (2017) demonstrate the inverse liaison between economic complexity and CO2e in developed economies, on the other hand, Doğan et al. (2019) and Yilanci and Pata (2020) showed the positive association between economic complexity and CO_2 emissions in emerging economies.

Çınar et al. (2022) examined, using state level (United States) panel data, the link between EF, and environmental complexity. They found that through the export of big green complex products has the infinitesimal effects on the global and local level, for example, CO2e. The effect of EF is negative to CO2e, increasing that complex production of the US has a considerable effect on the improvement of the environment, hence reducing the exposure of the countries to adverse climatic conditions. Similarly, Ul-Haq et al. (2023) examined the impact of EF to the CO2e of the BRICS nations during 1995 to 2015. The findings reveal the inverted-N shaped curve and EKC relation CO2e and EF apply the methods of FGLS and PCSE. Ul-Haq et al. (2024) investigation of the BRICS economy examined the comparative study of the effects of EF to CO2e of the fossil fuel and biofuel. The findings explore that the EKC is N-shaped for Biofuels; instead, the inverted-N-shaped curve is identified for Fossil fuel.

Moreover, in case of CAREC, Mukhtarov et al. (2021) study on the sample of Azerbaijan on the association of FDI and CO_2 emissions for the period of 1996-2013 utilizing the structural time series modeling. The research demonstrated the positive influence of FDI before 2006 and after that negative impact of FDI for CO_2 emissions. Fauzel (2017) explored the FDI impact on CO_2 emissions at the manufacturing and non-manufacturing sectors of Mauritius during 1980-2012. The ARDL estimates revealed that FDI in manufacturing sector is destructive for environment, while FDI in non-manufacturing does not influence the environment. In addition, Petrović and Lobanov (2022) consider the link between FDI and CO_2 in 24 selected economies over the sample period of 1970-2014. The long-run results show the direct and indirect influence of FD on environment Abid et al. (2022) explore the association of FDI, FD, technology innovation and CO_2 for the case of G8 countries during 1990-2019. The FMOLS results show the negative link between technological innovation, FDI, and FD with CO_2e in long run. In sum, no research until now have used the GAI, which measures country's resilience against climate change along with EF. One exception is the study of Ul-Haq et al. (2024) that explored the liaison between EF and GAI for the BRICS economies. They found an inverted N-shaped EKC. To achieve this objective, we conducted our study to explore the CAREC nation's resilience against climate change in context of EKC. Thus, it is essential to measure the country's resilience against climate change in CAREC countries for sustainable and development growth.

METHOD AND DATA

Carbon emissions targets and policies in CAREC economies

The Paris Climate Agreement set obligations, CAREC economies targets to decrease 10%-20% carbon emissions by 2030. All parties involved in agreement are compulsory to consistently update the status of emission and the implementation efforts. In PRC fuel combustion caused to increased approximately 340% total carbon emission during 1990-2014. The national policies adoption and the implementation such as Action Plan (2014-2015) for the conservation, energy, emission decreased and low carbon development and Climate Change National Plan (2014-2020), goal to decrease carbon emissions in stages. The PRC reduced its emissions GDP per unit by 45.8% during 2005-2018, meeting 40%-45% target. In 2014, PRC underway the carbon emission trading in major seven provinces and cities, undertaking almost more than 1,900 emission-control enterprises and units as well as assigning approximately 1.2 billion tons of CO_2 emissions quota. The PRC at the end of 2020, goal to establish the countrywide emission trading system (Sharma et al., 2019). The Table 1 illustrate the CAREC countries carbon emissions targets.

Table 1: CAREC countries carbon emissions targets

CAREC countries	Targets
Uzbekistan	The target of 2030 reducing 10% carbon emissions per-unit of GDP. Solar energy arrangement to decrease emissions from minimum 5.3Mt to maximum 14.4Mt CO_2-equivalent by 2030.
Turkmenistan	Unrestricted objective of stabilizing the carbon emissions per-unit of the growth GDP by 2030.
Tajikistan	Flexible objective not beyond 80% to 90% of its carbon emissions as of the 1990 levels by the 2030, which may be dropped to 65% to 75% of carbon emissions with reservations to the international support.
Kyrgyzstan	11.49% to 13.75% decrease in the per capita carbon emissions by the 2030 in comparison to 2010 BAU levels. Controlling per capita carbon emission to extreme of 1.23t carbon or 1.58t carbon in 2050 to get less than 2°C objective, along with 66%, and 55% probability respectively.
Kazakhstan	In comparison to 1990 Kazakhstan target to reduce 15% carbon emissions, which could touch 25% with the support of international investments, green climate funds, and access to technology.
Mongolia	Regarding Mongolia, reduce 7.3 Mt carbon emissions of energy sector by 2030, equivalent to 14% decreased in comparison to 2014 level.
Azerbaijan	The target of 2030 is to eliminate 13.6% carbon emissions compared to the 1990.
Afghanistan	The target of 2030 is the elimination of 13.6% carbon emissions compared to the 2005, and along with external support.
Georgia	Reduce the 15% carbon emissions till 2030 in comparison to 2013. Sustained by the technical cooperation involving technology transfer and financial resources, the objective would be elevated to 25% by the 2030.
China	In 2015 the target is to decrease 60% carbon emissions per-unit of GDP till 2030.
Pakistan	The baseline of 2015 is to reduce 20% carbon emissions till 2030, with financial support of international approximately estimated US$40 billion at the current prices.

Method

In this paper, panel data from 1995-2015 is utilized to investigate the impact of EF on GAI in CAREC countries. To empirically evaluate the relationship between EF and GAI, our study used the following econometric model:

$$GAI_{it} = a_0 + a_1 EF_{it} + a_2 (EF_{it})^2 + a_3 (EF_{it})^3 + e_{it} \quad (1)$$

In equation (1), GAI demonstrate the country's resilience against climate change, which denote GAI will firstly decrease with the increase of EF (a_1<0), then increase after touching to the minimum point (i.e., a_2>0), signifying the positive relationship between the EF and GAI, and then GAI once again show declining trends as the increase in EF further (a_3<0). In our case, FGLS technique is more suitable for empirical analysis, because it handle the issues of first-order autocorrelation as well as heteroscedasticity, that's why considered to be a better technique than previous ones (Davidson & MacKinnon, 1993; Hassan, Bukhari, & Arshed, 2020). Now, we demonstrate the core model including other covariates as follows:

$$GAI_{it} = a_0 + a_1 EF_{it} + a_2(EF_{it})^2 + a_3(EF_{it})^3 + a_4 FD_{it} + a_5 EG_{it} + a_6 \mathrm{FDI}_{it} + e_{it} \quad (2)$$

Whereas, i denotes nations (CAREC), t is a time, and e_{it} is a noise term. The description of all variables are given in Table 2. The EF parameter is associated with various signs, will have the effect on a curvature of a EKC (Çınar et al., 2022). We build the hypothesis about the parameter directions on the basis of existing literature. Concerning to the theory of cubic EKC, the hypothesis is that EF has the negative effect on GAI, EF demonstrating that emissions are reducing in initial stages; EF^2 revealing that emissions are growing, meaning that positive effect, whereas EF^3 has an inverse impact on GAI, displaying that emissions are yet again declining with the increase of EF. While, our study anticipated that the increase of economic activities cause to enhance GAI, meaning that EG would escalate the GAI, and it is also anticipated that it would reduce GAI, thus EG will play a dual role and can have mixed sign. Financial development would have the inconsistent influence on GAI. Finally, we anticipated that FDI would increase the GAI.

Estimation Procedure

The estimation procedure of current study is comprised of four estimation steps: firstly, this paper used cross sectional dependence (CD) test to confirm the issue of CSD in study data. It is essential before analyzes because in the presence of CSD problem results in spurious estimates (Zhao et al., 2020). Moreover, complete independence is not possible in the era of the economic globalization. The CSD panel model is as:

$$y_{it} = \alpha_i + \beta' X_{it} + \mu_{it,}\ i = 1, \dots, N \ and \ t = 1, \dots T$$

While, X_{it} is the $K \times 1$ vector of the regressors, and β is the $K \times 1$ vectors parameters to be assessed. α_i denote time invariant disturbance parameters at individual level. Moreover, null hypothesis consider that the μ_{it} is the independent as well as identically distributed across the periods and cross sectional units. The alternative hypothesis, μ_{it} it may be linked across cross sections, but assumption is that no serial correlation stands. The hypothesis:

$$H_0: \rho_{ij} = \rho_{ji} = cor(\mu_{it,}\mu_{jt}) = 0 for\ i \neq j\ against\ H_0: \rho_{ij} = \rho_{ji} = cor(\mu_{it,}\mu_{jt}) \neq 0\ for\ i \neq j\ is\ tested$$

Whereas,
$\rho_{ij} = \rho_{ji}$ is correlation coefficient of disturbances computed as:

$$\rho_{ij} = \rho_{ji} = \frac{\sum_{t=1}^{T} \mu_{it}\mu_{jt}}{\sqrt{\sum_{t=1}^{T} \mu^2{}_{it}\sqrt{\sum_{t=1}^{T} \mu^2{}_{jt}}}}$$

The BPLM test is taken to explore the occurrence of CD among residuals developed by Breusch and Pagan (1980). Utilizing OLS method, BPLM is implemented, which is reliable for the fixed N and the large T. The LM test specification is as:

$$LM_{BP} = T \sum_{i=1}^{N} \sum_{j=i+1}^{N} \hat{\rho}^2{}_{\mathrm{it}}$$

$\hat{\rho}_{\mathrm{it}}$ indicates a sample estimates of the residuals cross sectional pairwise correlation, T signify time, i specifies every entity, and N denotes cross-section number. $\hat{\rho}_{\mathrm{it}}$ is designed as:

$$\hat{\rho}_{\mathrm{ij}} = \frac{\sum_{t=1}^{T} \hat{\mu}_{it}\, \hat{\mu}_{jt}}{\sqrt{\sum_{t=1}^{T} \widehat{\mu_{it}^2}}\sqrt{\sum_{t=1}^{T} \widehat{\mu_{jt}^2}}}$$

$\hat{\mu}_{it}$ is u_{it} estimate in above mentioned equation. Practically, LM is the identically distributed as χ^2 with degrees of freedom N(N-1) under null-hypothesis. While, considerable distortions size are anticipated in scenario of N larger and T finite for this approach.

Next, Modified Wald test is applied to diagnose the problematic heteroscedasticity. It is important econometric problem that error term variance does not remain constant among the all independent variables values. Additional, heteroscedasticity is problematic due to the reason that OLS estimator in occurrences of heteroscedasticity violets the BLU properties (Bera & Jarque, 1981).

$$Var\ (\varepsilon|X) \neq \sigma^2{}_{\varepsilon} I$$

$\sigma^2{}_{\varepsilon}$ not constant for whole j (j= 1,2, … n)

Further, to confirm the serial correlation problem, Wooldridge test is utilized. The test illustrate the serial correlation problem as the number of observations is not independent to each other. The Wooldridge (2010) test is used and demonstrated as:

$$y_{it} = \alpha + X_{it}\beta_1 + Z_i\beta_2 + \mu_i + \epsilon_{it} i \in, t \in \{1,2, \dots, T_i\}$$

Although, y and x are the dependent and independent respectively. Z symbolize the controls. Time and country indicate with t and i respectively. The model parameters are the α, β and the error terms of the different variables and whole model is demonstrated as μ and ε. Besides, if μ_i is related to their corresponding variable it yield poor parametric results. Thus, to control this problem Wooldridge test is consider better in comparison to others. It hold first difference of the model to control this problem (Drukker, 2003). The model is as:

$$y_{it} - y_{it-1} = (X_{it} - X_{it-1})\beta_1 + \epsilon_{it} - \epsilon_{it-1}$$
$$\Delta y_{it} = \Delta X_{it}\beta_1 + \Delta\epsilon_{it}$$

Finally, panel diagnostics recommends the FGLS approach to empirically analyze the relationship of EF and GAI. In our study case N=11 and T=21, FGLS is more suitable where N is less than T, as supported by Parks-Kmenta method (Al-Malki et al., 2007). The FGLS model is as:

$$B_{GLS} = \left(\acute{X}\Omega^{-1}X\right)^{-1}\acute{X}\Omega^{-1}y$$

$$Var(B_{GLS}) = \left(\acute{X}\Omega^{-1}X\right)^{-1}$$

$$\Omega = \sum\nolimits_{n*n} \Theta I_{T_i * T_i}$$

$$\sum \hat{\imath}, \hat{\jmath} = \frac{\hat{\varepsilon}_i \hat{\varepsilon}_j}{T}$$

During the βs coefficients as well as its standard errors calculations, the Ω identity matrix is managed with the consideration of heteroscedasticity and autocorrelation. In addition to FGLS, this paper also PCSE and FE-DKSE techniques for robustness purpose.

Data and Variables Description

This paper covered the sample period from 1995-2015[2], to investigate the empirical liaison between EF and GAI in CAREC (Afghanistan, Azerbaijan, People's Republic of China, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan). GAI precises the country's resilience against climate change. Further, higher scores (i.e., GAI index greater value) were anticipated better. The data for the dependent variable of GAI is collected from ND-GAIN (2022). EF is the core independent, EG, FD, and FDI are the control variables of our study and data is taken from the WorldBank (2022), and FD from IMF (2022). Moreover, Table 2 demonstrate the variables definition, and Table 3 shows the descriptive statistics.

Table 2: Definition of Variables

Variable	Sign	Description	Source	literature
		Dependent variable		
Global Adaptation Initiative Index	GAI	GAI precises the country vulnerability to climate change as well as other world challenges in combination with its readiness to promote resilience.	ND-GAIN (2022)	(Chen et al., 2015; Kling et al., 2021; Ul-Haq et al., 2024)
		Independent variables		
Economic Fitness Index	EF	A country's ability to produce complex goods on a globally competitive basis is measured by its EF index.	World Bank (2021)	(Çınar et al., 2022)
		Other Control Variables		
Economic-Growth	EG	Natural-Log of GDP per capita (2015 constant USD)	World Bank (2022)	(Al-Malki et al., 2022; Ul-Haq et al., 2023)

2 We select this time period due to data availability.

Foreign direct investment	FDI	Foreign direct investment, net inflows (BOP, current US$) Foreign direct investment, net inflows (% of GDP)	World Bank (2022)	(Kim & Seok, 2023; Mukhtarov et al., 2021)
Financial development	FD	Financial development index	IMF (2022)	(Al-Malki et al., 2022; Ul-Haq et al., 2023)

RESULTS AND DISCUSSIONS

The present study explored impact of EF on GAI in CAREC economies. The average level of EF in CAREC is 0.888, along with minimum 3.89e-07, and maximum 10.68784, as present in Table 3. The average of climate change to risk exposure is 46.04, along with 37.58 minimum and 58.85 maximum.

Table 3: Summary Statistics

Variables	N	Mean	St. De	Mini	Maxi
GAI	189	46.0466	4.6161	37.5860	58.8554
EF	189	0.8888	1.9671	3.89e-07	10.6878
EG	189	0.1952	0.1278	0	0.6199
FD	189	24.3327	2.1812	21.5316	30.0345
FDI	189	6.5585	8.3558	0.1798	55.0729

The research panel diagnostics is given in Table 4 and 5, we test the heteroscedasticity through the use of modified Wald test. In addition, serial correlation is confirmed with the use of Wooldridge test and BPLM and VIF test are adopted to investigate the issue of CSD as shown below.

Table 4: Serial Correlation and Heteroscedasticity Panel Diagnostic Tests

Test	(1)
Modified Wald (χ2)	285.06 ***
Wooldridge Test	245.732***
BPLM	947.51***

Note: asterisk show the significance level at 1%***.

Table 5: VIF Test

	VIF	1/VIF
EG	4.86	0.2057
FD	4.35	0.2298
EF	2.99	0.3349
FDI	1.03	0.9677
Mean VIF	3.31	-

The impact of EF on GAI in CAREC economies is shown in Table 6. In this table, the GAI is the dependent variable in all models. Column (1) show the FGLS, column (2) indicate PCSE, column (3) represent FE-DKSE results.

Table 6: Impact of EF on GAI in CAREC

Variables	FGLS	PCSE	FE-DKSE
EF	-3.495***	-2.718***	-2.718***
	(0.773)	(1.009)	(0.850)
EF^2	1.250***	0.993***	0.993***
	(0.212)	(0.272)	(0.220)

EF^3	-0.0804***	-0.0627***	-0.0627***
	(0.0144)	(0.0180)	(0.0155)
Constant	45.38***	45.93***	45.93***
	(0.281)	(0.383)	(0.432)
Wald-stat.	222.46	154.76	96.41
P-Val.	0.000	0.000	0.000
N	189	189	189

Note: dependent variable is the GAI. ***p<0.01.

Considering Table 6, the EF coefficient in association to the GAI is negative, demonstrating that EF boosts the CAREC countries susceptibility to the climate change. Next, the square term of EF (EF^2) is positively associated to GAI, revealing that EF lead to decrease the vulnerability to the climate change. Finally, the cubic term of EF (EF^3) once again indicate that EF contribute to enhance susceptibility to the climate change. The EF including linear, square, and cubic term are associated to GAI and significance level is 1%. The 1% increase in EF lead to -3.495% increase, 1.250%, decrease & -0.0804% increase GAI in CAREC respectively. Thus, FGLS results show that the relationship between EF and GAI is inverted N-shaped and statistical significant in column (1). Moreover, the PCSE and FE-DKSE method also demonstrate the inverted N-shaped results and statistical significant as shown in column (2-3). Our study found the same findings with the use of FGLS, PCSE, and FE-DKSE, proved that our study empirical findings are reliable in all aspects. The P-value also shows that the overall model is significant. In addition, this paper also include various controls in core model to robustness checks. The controls are the FD, EG, and FDI, and results is shown in Table 7.

Table 7: Impact of EF on GAI in CAREC (robustness checks-FGLS)

Variables	(1)	(2)	(3)	(4)
EF	-3.495***	-3.615***	-2.181***	-1.821***
	(0.773)	(0.278)	(0.303)	(0.322)
EF^2	1.250***	1.000***	0.818***	0.746***
	(0.212)	(0.0712)	(0.0703)	(0.0785)
EF^3	-0.0804***	-0.0603***	-0.0542***	-0.0500***
	(0.0144)	(0.00487)	(0.00463)	(0.00537)
FD		15.03***	25.44***	24.44***
		(0.442)	(0.728)	(0.945)
EG			-1.088***	-1.064***
			(0.0561)	(0.0716)
FDI				0.0381***
				(0.00709)
Constant	45.38***	43.71***	67.52***	66.75***
	(0.281)	(0.122)	(1.143)	(1.496)
Wald-stat.	222.46	3248.96	3874.64	2159.20
P-Val.	0.000	0.000	0.000	0.000
Obs.	189	189	189	189

Note: dependent variable is the GAI. ***p<0.01**p<0.05,*p<0.10.

In Table 7, the FGLS results show that EF is negatively related to GAI, EF^2 coefficient show positive sign, and negative liaison of GAI and EF^3, illustrating the inverted N-shape link between EF and GAI. Considering the controls, the coefficient of FD is positive and significant at 1%. The FD cause to enhance GAI significantly. FD is playing positive role in increasing the resilence of the country. The association between EG and GAI is inverse, demonstrate that increase in EG reduce GAI in CAREC economies. Ahmed et al. (2019) indicated that as the growth of economy enhances, so does the risk of climate change exposure. While, FDI is positive linked to GAI and statistical significant.

The study revealed that 1% rise of FDI funded to 0.03% enhance the GAI. Demena and Afesorgbor (2020) show that increase in FDI reduce the environmental emissions.

Table 8: Impact of EF on GAI in CAREC (robustness checks).

Variables	PCSE			FE-DKSE		
	(1)	(2)	(3)	(4)	(5)	(6)
EF	-4.203***	-2.456**	-2.088*	-4.203***	-2.456**	-2.088*
	(1.153)	(1.243)	(1.229)	(1.006)	(1.037)	(1.063)
EF^2	1.159***	0.897***	0.809***	1.159***	0.897***	0.809***
	(0.300)	(0.300)	(0.295)	(0.198)	(0.208)	(0.210)
EF^3	-0.0717***	-0.0604***	-0.0549***	-0.0717***	-0.0604***	-0.0549***
	(0.0196)	(0.0193)	(0.0190)	(0.0130)	(0.0131)	(0.0138)
FD	15.53***	26.58***	26.31***	15.53**	26.58***	26.31***
	(4.104)	(4.573)	(4.584)	(6.517)	(5.514)	(5.200)
EG		-1.137***	-1.125***		-1.137***	-1.125***
		(0.287)	(0.289)		(0.183)	(0.212)
FDI			0.0536**			0.0536**
			(0.0214)			(0.0193)
Constant	43.75***	68.55***	67.85***	43.75***	68.55***	67.85***
	(0.652)	(6.320)	(6.373)	(0.885)	(4.049)	(4.714)
Wald-stat.	198.54	220.29	222.47	139.97	99.55	85.31
P-Val.	0.000	0.000	0.000	0.000	0.000	0.000
Obs.	189	189	189	189	189	189

Note: dependent variable is the GAI. ***p<0.01**p<0.05,*p<0.10.

In Table 8, the PCSE estimates demonstrate the liaison of EF with GAI is inverted N-shaped. The FE-DKSE method also show the same effect between concerned variables for the CAREC economies. As indicated by inverted N-shaped association, GAI declines, then increases, and then declines. In addition, FGLS, PCSE, and FE-DKSE generate empirical results according to hypotheses that are identical. Further, our core results held true even after consider the imperative factors involving FD, EG, and FDI. The CAREC economies are dedicated to endorsing regulations and laws that imperatively influence the environmental estimates and prevent global warming in emerging countries. The CAREC countries have also efforts together to establish policies that boost the green economic development.

The role of EF towards risk exposure to climate change depends on the country's strategy for diversification. CAREC economies should stress on diversification through the extensive margins, where an economy to produce newly products as well as decreases or ends the production of polluting industries products, as this will increase diversification and enhance economic fitness while promoting country's adaptation and resilence against climate change risk-exposure in CAREC regions.

CONCLUSIONS AND POLICY IMPLICATIONS

Now, economies are doing more struggles to challenge a global warming issues that the countries are facing today. In prevailing research, studies used various outcome-based measures (i.e., SO_2, $PM_{2.5}$, CH_4, and CO_2). The GAI was utilized in our study, as the more wide-ranging measure because it demonstrate the whole risk exposure to climate change. The GAI Index counts the nation's vulnerability to world problems like climate change and its adaptability-building capacity. Utilizing the CAREC 1995-2015 panel data; our study evaluated the impact of EF on risk exposure to the climate change in context of EKC. In addition, FGLS, PCSE, and FE-DKSE methods provides the evidence of an inverted N-shaped relationship between EF and GAI in CAREC regions. Further, the robustness check results indicates that our results are robust and significant after incorporating the major controls such as EG, FD, and FDI in our core model. The countries climate change is momentously affected by EG, FD, and FDI. Additionally, EG is found to be the boosting factor of CAREC countries risk exposure to climate change. FD and FDI have an positive impact on reduction of risk exposure to climate change.

CAREC nations are working thoroughly to endorse laws that protect environment, as they are now facing difficulties for the ED that have inverse influence for the citizens. CAREC countries should emphasis on diversification through the extensive margins, where an economy continuously to produce newly products as well as decreases or ends the production of polluting industries products, as this will increase diversification and enhance economic fitness while promoting environment. The policy for product diversification through extensive margins will help the CAREC countries mitigate vulnerability as well as enhance their resilience to climate change risk. This research findings support the policies that promote the environmental quality and can decrease the GAI and offers guidance for some of these significant policy outcomes. The study results will help the policymakers in preferring the EF, which expressively reduces a rate of GAI, which account the vulnerability of CAREC to world problems such as climate change and also capability for building adaptability. Additional, based on data availability, our study used the sample period from 1995-2015. Thus, this is considered as one of the limitation of our study, which may influence results and this could be cover in future research. Moreover, our study will also use GAI, which can be divided into sub-risks in future work.

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