DOI: https://doi.org/10.52131/pjhss.2022.1004.0293

Pakistan Journal of Humanities and Social Sciences

Volume 10, Number 4, 2022, Pages 1352–1363
Journal Homepage:
https://journals.internationalrasd.org/index.php/pjhss

PAKISTAN JOURNAL OF HUMANITIES AND SOCIAL SCIENCES (PJHSS)
INTERNATIONAL RESEARCH ASSOCIATION FOR SUSTAINABLE DEVELOPMENT

A Revisit of Energy Consumption Preferences and Economic Growth in Developing Economies

Muhammad Waqas Ashraf[1], Hafeez-ur- Rehman[2]

[1] Ph.D. Scholar of Economics, University of Management and Technology Lahore, Pakistan.
Email: mianwaqqasashraf@gmail.com
[2] Professor, Department of Economics, University of Management and Technology Lahore, Pakistan.
Email: hafeez.rehman@umt.edu.pk

ARTICLE INFO

Article History:
Received: August 21, 2022
Revised: December 23, 2022
Accepted: December 25, 2022
Available Online: December 31, 2022

Keywords:
PQR
FGLS
Sustainable Growth
GDP per Capita

JEL Classifications:
O13, O47, P18, Q43

Funding:
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Clean and green energy consumption has become a global challenge for all developing countries and international organizations. Not many studies have examined the impact of energy consumption preferences on economic growth particularly in developing counties. Due to the rapid increase in population and the desire for achieving high economic growth, the demand for energy is on the upswing in developing counties. The main objective of this study is to develop an empirical model that measures the impact of energy mix on economic growth in 82 developing countries. PQR and FGLS estimation techniques have been used for examining the impact of energy mix on economic growth for the period 1990-2020 in developing economies of the globe. The results of the study confirm the existence of an inverted U-shaped relationship between the energy mix and economic growth. The study concludes that developing countries should use more renewable energy than fossil fuel energy for achieving rapid economic growth without environmental degradation.

Corresponding Author's Email: hafeez.rehman@umt.edu.pk

1. Introduction

Ever since the evolution of production function by (Solow, 1957), labor and capital were considered as main inputs. Afterward some imperative new inputs for growth were added by various economists (Mankiw, Romer, & Weil, 1992). The role of energy as a contributing input to economic growth with labor and capital was suggested by (Nicholas Apergis & Danuletiu, 2014). Fossil fuels or non-renewable energy is mostly obtained from earth and its replacement rate is not compatible but the replacement rate of renewable energy is compatible with the existing usage (Brundtland, 1987). The advancement of renewable energy cradles along with conservative non-renewable energy cradles is very crucial for economic growth (UNIDO, 1984). It has been observed that rapid short-term economic growth has been achieved due to the excessive use of non-renewable energy along with environmental pollution, adverse health conditions, social hardness and cultural richness (Farrell & Lyons, 2015).

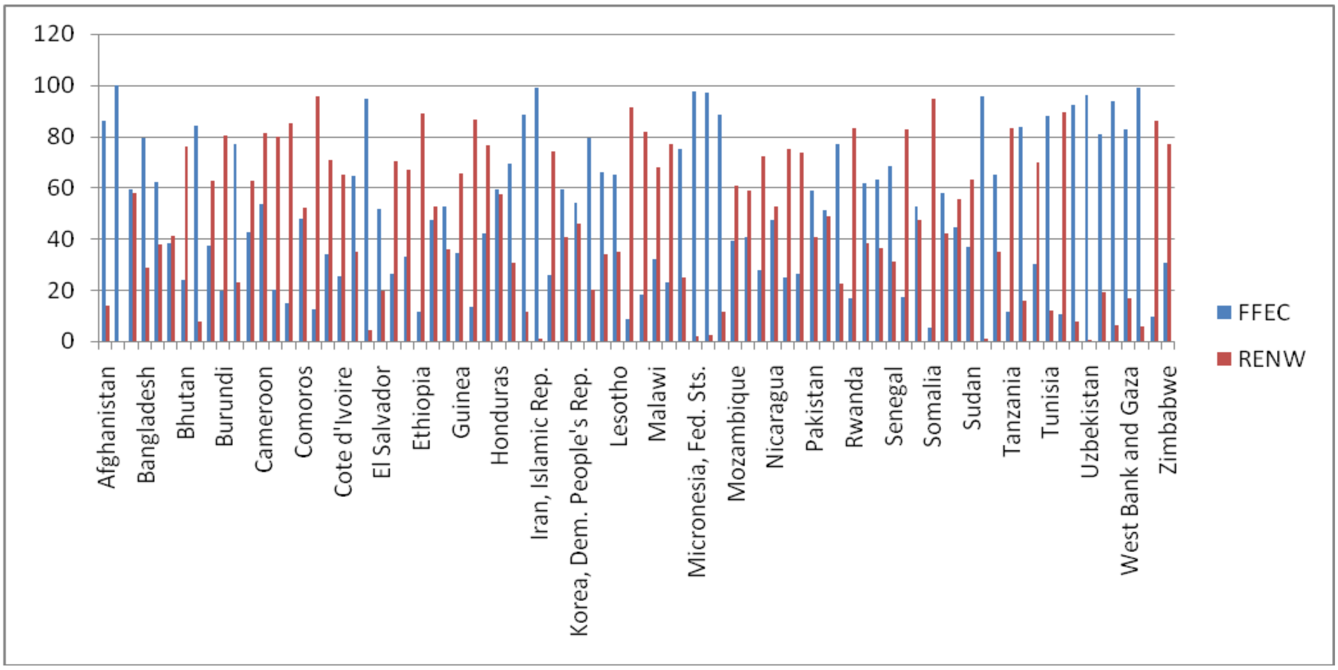
Besides these paybacks and hitches, the fact remains that fossil fuels will diminish over time because they are intensely used for energy production and their accessibility depends upon the extraction of new resources and hence, their prices are also projected to be unpredictable. Moreover, dependence on non-renewable energy is damaging the provisions of food (Ahmad et al., 2022; Zhongming, Linong, Xiaona, Wangqiang, & Wei, 2019). Due to inadequate legacy of fossil fuels in natural surroundings and above stated undesirable effects, the use of renewable energy sources to fulfill energy requirements has become indispensable. The excessive use of fossil fuels energy resources have been directly affecting the climate change for the last 10 years globally and the shortage of energy supply accompanying with high prices have badly effected economic growth in developing countries.

In developing economies, under exclusively possible climate situations, the temperature has been mounting and is anticipated to increase further in few decades (Edenhofer et al., 2014), which will deepen the energy demand. Though, unchecked supply of energy is among the major problems that developing economies are facing on the track of development (Ahmed, Rehman, & Ozturk, 2017). Developing economies rest on a sole source to make available more than 50% of entire production of electricity, including Nepal (Hydropower- 99.8%), Bangladesh (Natural gas- 92%), India (coal- 78.1%), Sri-Lanka (oil- 50%) and Pakistan (oil-35%) (Azam, Khan, Zaman, & Ahmad, 2015). Furthermore, it is also vital to observe that in several economies fewer than 4.9% of energy used up emanated from renewable cradles (Shukla, Sudhakar, & Baredar, 2017).

As far as the access to electricity is concerned about 418 million people have no access to electricity in Asian developing countries and 1.3 billion people are deprived of electricity in developing economies globally. This indicates that presently there is a need to promote alternative clean and green energy possessions and such strategies and policies should be included in future preferences. Several obstacles have been acknowledged to the usage of renewable energy technologies such as cost- usefulness, procedural obstacles and market barriers i.e. governing and unpredictable pricing structure, political obstacles, environmental concerns and social barriers. Some of these hurdles are regional, whereas others are technology specific. Nevertheless, the shifting price to clean and green energy is very high but running cost is cheaper than the non- renewable sources due to negligible maintenance cost. Approximately average charge for fixing a solar system in 2017 was about $2000 per kilowatt for large-scale and around $3700 for households and while about $1300 to $1800 per KW for setting up a wind field.

The present study evaluates the impact of energy mix on economic growth in 82 developing countries. Figure 1 shows fossil fuels energy consumption and renewable energy consumption in developing counties especially lower income countries which are using non-renewable energy resources more than the renewable energy resources.

Figure 1: Renewable and non-renewable energy consumption of developing countries in 2020



Most of the developing countries heavily depend on fossil fuels consumption to meet their growing demand of energy (Salem & Kinab, 2015). Presently energy demand has massively increased which have caused disequilibrium between energy demand and supply and the efforts to bridge the gap between energy demand and probable energy supply from non-renewable energy or fossil fuels to encounter the targeted objectives by 2025 have exerted adverse impact on environmental degradation. It brings up the need to shift from nonrenewable energy to renewable green energy for meeting energy demand which may help in reducing environmental vulnerabilities (Shukla et al., 2017). This study intends to bring up the contribution of the energy mix on economic growth in developing economies. Additionally, the present study tries to explore the prospects of the changes in energy consumption on economic growth for reducing environmental degradation in developing economies and to find out whether the revenues of chasing renewable energy are non-constant using the quadratic transformation. The current study determines the impact of energy mix on economic growth using panel data of eighty two developing economies for the period 1990 - 2020.

2. Literature Review

Several studies have analyzed the linkage between the use of energy mix for economic growth and environmental degradation. But the results are inconclusive regarding which type of energy to be used for promoting environmental condition. Enduring growth means the unification of conservative macroeconomic idea beside with the sustainability of environment and natural resources (Mikesell, 1994). The economic growth has various definitions and several approaches are available to measure the catalogs of sustainability (Neumayer, 2007). Stiglitz (2002) pointed out that economic growth and renewable energy are interconnected in several ways and this aspect has achieved considerable amount of attention of academicians and policy makers. Bugaje (2006) evaluated numerous features of sustainability i.e. economic, societal and environmental, which are critical for the suitability of renewable energy consumption for economic growth. Nicholas Apergis and Payne (2010) are of opinion that green and clean energy usage has optimistic impression on per capita income in OECD economies.

Tugcu, Ozturk, and Aslan (2012) examined the impact of non- renewable energy on economic growth and established an affirmative correlation between renewable energy and economic growth in G-7 countries. Tiwari, Apergis, and Olayeni (2015) evaluated 12 Sub-Saharan countries by using co-integration technique and stated that growth process might be affected badly by the policies of energy ingesting. Nicholas Apergis, Chang, Gupta, and Ziramba (2016) analyzed the relationship between renewable energy and economic growth for 10 leading energy producing countries. The study confirmed the existence of an affirmative connection between energy and economic growth. Nicholas Apergis and Payne (2012) examined the part of fossil fuels ingestion and economic growth. The results showed that economic growth is certainly exaggerated by energy demand from fossil fuels but the borderline effect is less than the renewable energy use. The study also found assorted results in case of the use of nuclear energy in developed and developing countries.

Recent studies have used time-varying method to check the effect of renewable and non-renewable energy on economic growth (N Apergis & Payne, 2014). Aslan, Apergis, and Yildirim (2014) revealed positive effect of energy on economic growth. Omay, Apergis, and Özçelebi (2015) confirmed the comparable consequences by using panel data analysis and concluded that renewable energy has much affluent discharged than the conservative non-renewable energy but price unpredictability of non- renewable energy resources overshadows this advantage in the long run. The previous research work revealed that sustainable environment conditions are approximately 30% healthier in extremely exposed economies than the moderate exposed economies and about 50% healthier as compare to closed economies. These outcomes might be according to the Porter hypothesis: productivity can be increased with healthier environment and it has an optimistic impact on trade and revenue. No doubt, trade openness affects economic growth and quality of environment as trade encourages technological innovations that can optimistically affect both economy and environment simultaneously. Multidimensional organizations bring clean technologies to the host nations and also provide healthy environmental conditions through public awareness which help in reducing environmental degradation (Hussain, Shah, & Ayub, 2021; Qadir & Majeed, 2018).

Hasan, Quibria, and Kim (2003) pointed out that there exists a correlation between economic growth and environment and it also helps in reducing poverty in developing economies. Antweiler, Copeland, and Taylor (2001) are of opinion that trade has an impact on quality of environment through technological effect, scale effect and composition effect. According to scale effect; quality of environment decreases due to high economic activities. Technological effect leads to improve quality of environment whereas; composition effect endorsed both increase or decrease the volume of emissions depending upon the use of technology in industries. The review of literature presented above leads to the need of analyzing the relationship between energy preferences, economic growth and environmental degradation using recent economic developments. The results of the study may provide a guideline to the policy makers to formulate policies which ensure healthy environmental condition particularly in developing countries.

3. Methodology

3.1 Variables and samples

Table 1 demonstrates the description of the variables and units used in this study. The study uses panel data of 82 low and middle income developing countries. The data has been collected from the WDI for the period 1990-2020. GDP per capita has been used as the proxy of economic growth. While the key independent variable is energy mix which is the ratio of non-renewable energy consumption and renewable energy consumption. Furthermore, education, exports of goods and services, labor and capital are used as the control variables in this study.

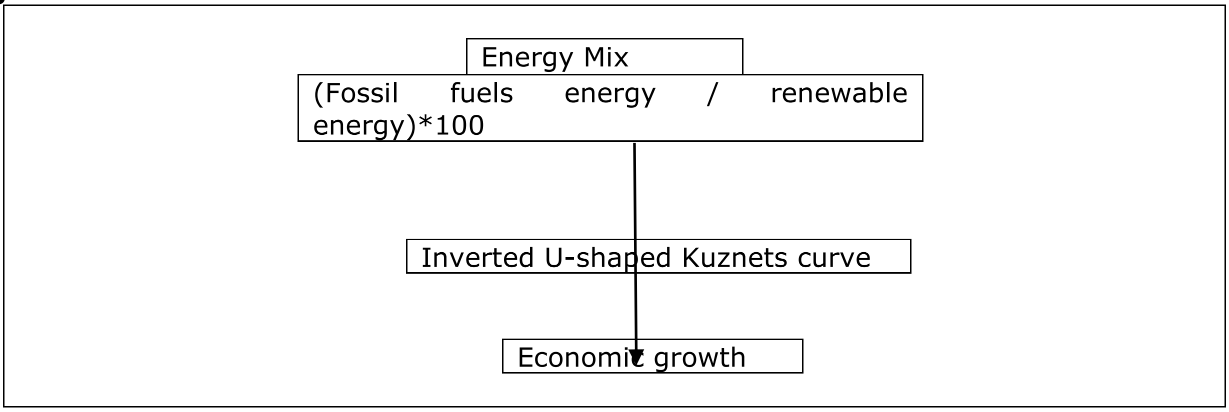
Table 1: Description of the variables

Symbol	Indicator	Units
GDPPC	GDP per capita	constant 2015 US$
ENMIX	(Fossil fuel energy consumption/ renewable energy consumption)*100	Ratio
EDU	School enrollment, primary	% gross
EXPO	Exports of goods and services	% of GDP
GFCF	Gross fixed capital formation	% of GDP
LFTOT	Labor force	Total

3.2 Theoretical Framework

This study emphasizes that initial increase in the renewable energy consumption will decline the fossil fuels energy consumption, so the value of the ratio of energy mix declines. Furthermore, due to increase in renewable energy consumption and backward infrastructure there may emerge higher cost and risks that cause economic growth to decline. Later on, as the infrastructure is improved and consumption of renewable energy increases the use of fossil fuels energy decreases. As a result the ratio of energy mix declines more which improves the environment with the increase in economic growth.

Figure 2: Theoretical Framework



The theoretical framework of this study is presented in Figure 2 which reveals that there emerge a lot of fluctuations in energy mix over time which indicates the presence of non-linear trend (see, figure 3). As a result this study uses energy mix as the quadratic variable. For analyzing the relationship between energy mix and economic growth the following model has been used in which all variables are converted into natural logarithm for the purposes of elasticity based comparison.

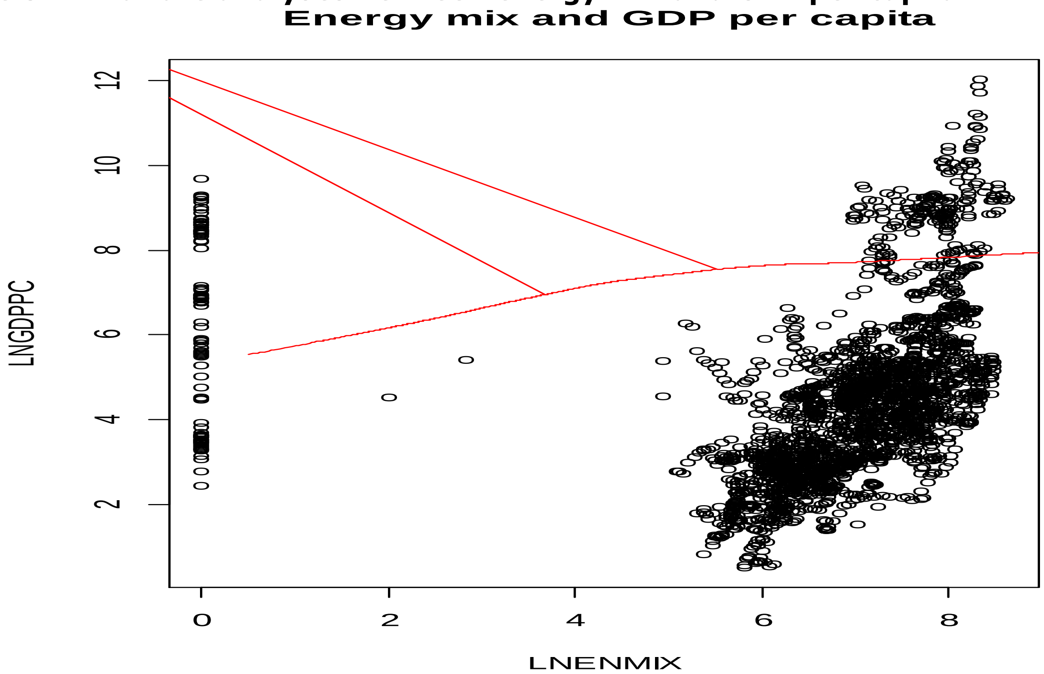
$$GDPPC = \beta_0 + \beta_1(ENMIX) + \beta_2(ENMIX)^2 + \beta_3(EDU) + \beta_4(EXPO) + \beta_5(LFTOT) + \beta_6(GFCF) + \epsilon_t \quad (1)$$

Where, GDPPC is Natural logarithm of GDP per capita, ENMIX is Natural logarithm of energy mix, $ENMIX^2$ is Natural logarithm of quadratic energy mix, EDU is Natural logarithm of school education, EXPO is Natural logarithm of export of goods and services, LFTOT is Natural logarithm of total labor force, GFCF is Natural logarithm of gross fixed capital formation. The quadratic form helps in individual country wise analysis and for finding the cut off values of the inverted U shaped Kuznets's Curve.

$$\frac{dGDPPC}{dENMIX} = \beta_1 + 2\beta_2(LNENMIX) = 0$$

$$ENMIX^* = -\frac{\beta_1}{2\beta_2}$$

Figure 3: Bi-variate analyses between energy mix and GDP per capita



3.3 Estimation Technique

For the estimation of the model, Panel Quantile Regression (PQR) and Feasible Generalized Least Squares (FGLS) methods are employed. The traditional regression cannot estimate the relevant coefficients as most of the series appeared non-stationary at level. The coefficients may be over or under estimated due to the existence of Heteroscedasticity, autocorrelation, non-normality and functional form problems.

4. Empirical Results

Table 2 presents the descriptive statistics of the variables used in this study. The mean of all variables are greater than the standard deviation, showing that variables are under dispersed. The probability value of Jarque-Bera (JB) test is statistically significant which shows that all variables are not normally distributed. While, the higher value of Kurtosis shows the presence of outliers.

Table 2: Descriptive Statistics

	LNGDPPC	LNENMIX	LNEDU	LNEXPO	LNGFCF	LNLFTOT
Mean	7.115	4.328	4.553	3.224	2.979	15.202
Median	7.130	4.140	4.618	3.253	3.021	15.268
Maximum	8.633	12.040	5.296	5.386	4.630	20.019
Minimum	2.008	0.511	3.151	-2.308	-1.228	10.958
Std. Dev.	0.725	1.869	0.272	0.722	0.520	1.695
Skewness	-0.239	1.069	-1.472	-1.257	-1.468	-0.109
Kurtosis	3.132	4.467	6.536	11.390	10.606	3.109
Jarque-Bera	21.604	591.720	1863.984	6753.412	5851.671	5.223
Probability	0.000	0.000	0.000	0.000	0.000	0.073
Observations	2113	2113	2113	2113	2113	2113

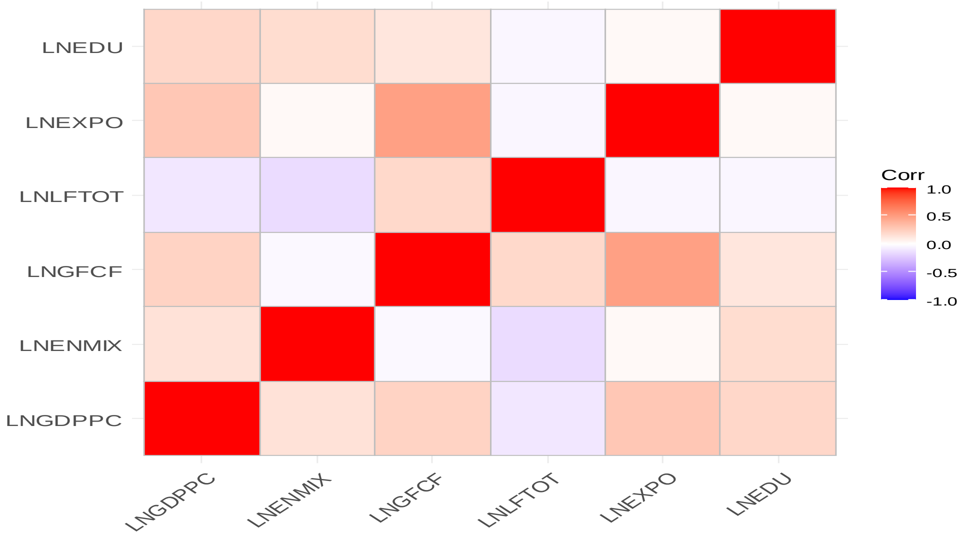
This study uses Levin, Lin & Chu (LLC) unit root test. The results of panel unit root test are presented in table 3 which shows that variables included in the model are of mixed order of integration i.e. either I(0) or I(1).

Table 3: Panel unit root test by Levin, Lin & Chu (LLC)

	I(0)	I(1)	Order of integration
GDPPC	-0.156	-39.023*	I(1)
ENMIX	2.010	-36.821*	I(1)
EDU	105.911	36.844*	I(1)
EXPO	-4.953*	-42.522*	I(0)
GFCF	-19.332*	-39.464*	I(0)
LFTOT	7.027	13.768*	I(1)

In Figure 4 the dark red color shows the perfect positive correlation and dark blue color shows perfect negative correlation. The light red color indicates the weak positive correlation and light blue color reveals weak negative correlation. The light red color between the independent variables indicates the absence of Multicollinearity in the model.

Figure 4: Correlation matrix



The Variance Inflation Factor (VIF) is presented in table 4. The value of VIF is less than 10 which indicates that the model is free from Multicollinearity problem.

Table 4: VIF value

Variable	VIF	1/VIF
ENMIX	1.18	0.845
GFCF	1.13	0.883
EDU	1.13	0.888
EXPO	1.12	0.891
LFTOT	1.05	0.953
Mean VIF	1.12	

For analysis purpose the study uses co-integration test developed by Kao (1999). The results are presented in Table 5. The statistically significant values of Kao test confirm the existence of long run relationship between dependent and independent variables in the model.

Table 5: Panel co-integration test

Test Method	Statistic	The Value of Statistic	Prob.
Kao test	ADF	-16.031	0.000

The long run coefficients are estimated by the Panel Quantile regression (PQR) at lower, middle and upper quartiles. The results are presented in Table 6. The Pseudo R^2 values are

0.374, 0.410 and 0.383 respectively at Q_1, Q_2 and Q_3 which show the goodness of fit of the model. It can be observed that at lower quartile (Q_1) the level coefficient of ENMIX is positive while the quadratic coefficient is negative at 1% level of significance. Table 7 shows that the cut off value of ENMIX at Q_1 is 13.245 that is not between the minimum and maximum values in table 2. This indicates that all the countries lie below the cutoff value which means that there is no evidence of inverted U-shaped Kuznets curve. When we trace this effect by using the mean, standard deviation and constant it proposes non-linear positive curve as shown in figure 5(a). At middle quantile (Q_2) and upper quantile (Q_3) the level coefficients of ENMIX are positive and quadratic coefficients are negative at 1 percent level of significance. The cut-off values of ENMIX is 10.082 at Q_2 and 10.688 at Q_3 (see table 7) which lie between the minimum and maximum values that support the inverted U-shaped Kuznets curve in figure 5(b) and 5(c).

The detailed results of FGLS are presented in column 4. The level coefficient of ENMIX is positive while quadratic coefficient is negative at 1 percent level of significance. The cut-off value 9.994 falls between minimum and maximum value of ENMIX. When these values are traced by using the mean, standard deviation and constant term the inverted U-shaped Kuznets curve is proposed in figure 5(d). The PQR and FGLS econometric techniques show that the ratio of fossil fuels to renewable energy follows an inverted U-shaped Kuznets curve. It means that fossil fuels energy consumption helps in increasing economic growth as these energy resources are cheaper and easily available in developing countries (Nicholas Apergis & Payne, 2012; Hanif, Nawaz, Hussain, & Bhatti, 2022). But in the long run consumption of fossil fuels consumption is non-sustainable as it deteriorates the environment and adversely affects health and is also responsible for causing climate change.

Table 6: Results of Panel Quantile Regression (PQR) and FGLS

Dependent variable: GDPPC				
Panel Quantile Regression Model				
	1	**2**	**3**	**4**
Variables	Q1	Q2	Q3	FGLS
ENMIX	0.409* (0.034)	0.500* (0.024)	0.447* (0.029)	0.491* (0.023)
ENMIX2	-0.015* (0.003)	-0.025* (0.002)	-0.021* (0.003)	-0.025* (0.002)
EXPO	0.246* (0.022)	0.292* (0.016)	0.271* (0.019)	0.225* (0.015)
EDUI	0.150 (0.107)	0.605* (0.076)	0.545* (0.090)	0.199* (0.040)
LFTOT	-0.026* (0.009)	-0.030* (0.007)	-0.033* (0.008)	-0.019* (0.006)
GFCF	0.124* (0.031)	0.051** (0.022)	0.047*** (0.026)	0.068* (0.021)
Constant	4.624* (0.201)	4.966* (0.143)	5.480* (0.171)	3.983* (0.203)
Number of Observations	2113	2113	2113	2113
Pseudo R^2	0.374	0.410	0.383	Wald chi2(6): 2896.150

In this study EXPO, EDU, LFTOT, and GFCF have been used as the control variables. The results of PQR and FGLS models show that EXPO significantly increases the GDPPC (Our results are in line with (Antweiler et al., 2001; Deyshappria, 2018; Iqbal & Bukhari, 2018; Urooj & Zafar, 2022). EDU is statistically insignificant at Q_1 while Q_2, and Q_3 positively affect the GDPPC (Similar studies are (Joesoef, 2021; Özdoğan Özbal, 2021)) and LFTOT negatively affect the GDPPC (Similar studies are Dao, 2012; Peterson, 2017). The GFCF positively affects the GDPPC (our results are in line with (Bhatti, ur Raheem, & Zafar, 2020; Boamah, Adongo, Essieku, & Lewis Jr, 2018; Kong, Nketia, Antwi, & Musah, 2020; Meyer & Sanusi, 2019).

Table 7: Table cut off value of ENMIX

	Q1	Q2	Q3	GLS
Level coefficients	0.409	0.500	0.447	0.491
Quadratic coefficients	-0.015	-0.025	-0.021	-0.025
Cut off value	13.245	10.082	10.688	9.994
Antilog of cut off	919635.451	34625.901	64930.905	31611.14

Figure 5: Quadratic effect of energy mix

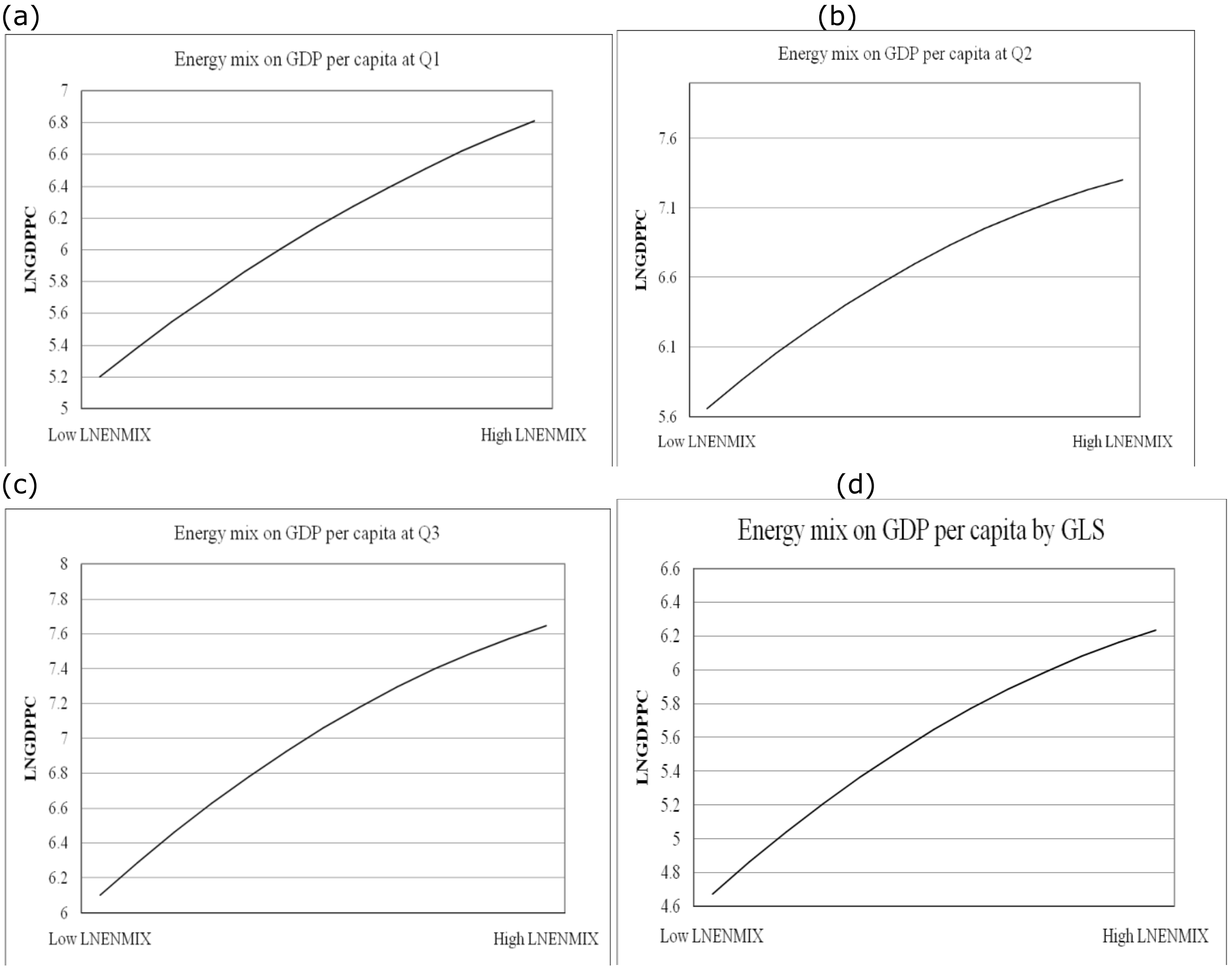


Table 8 shows linear effect of quadratic function and marginal effect of ENMIX on GDPPC using PQR and FGLS at Q_1, Q_2 and Q_3 for each country using the mean value of ENMIX. The marginal effects of 82 countries reveal that all countries have positive energy mix effect to economic growth which means all the developing countries prefer to use the fossil fuels energy consumption.

Table 8: Marginal effect of ENMIX by PQR and FGLS methods

Year	Country	Mean Value of ENMIX	Marginal effect			
			PQR at Q1	PQR at Q2	PQR at Q3	GLS
1	**Afghanistan**	3.637	0.300	0.318	0.294	0.309
2	**Algeria**	3.580	0.302	0.321	0.297	0.312
3	**Angola**	3.373	0.308	0.331	0.305	0.322
4	**Bangladesh**	3.548	0.303	0.323	0.298	0.314
5	**Belize**	3.515	0.304	0.324	0.299	0.315
6	**Benin**	3.593	0.301	0.320	0.296	0.311
7	**Bhutan**	3.771	0.296	0.311	0.289	0.302
8	**Bolivia**	3.952	0.290	0.302	0.281	0.293
9	**Burkina Faso**	3.868	0.293	0.307	0.285	0.298
10	**Burundi**	3.949	0.291	0.303	0.281	0.294

11	**Cabo Verde**	3.979	0.290	0.301	0.280	0.292
12	**Cambodia**	3.904	0.292	0.305	0.283	0.296
13	**Cameroon**	3.898	0.292	0.305	0.283	0.296
14	**Central African**	3.879	0.293	0.306	0.284	0.297
15	**Chad**	3.969	0.290	0.302	0.280	0.293
16	**Comoros**	4.237	0.282	0.288	0.269	0.279
17	**Congo, Dem. R.**	4.364	0.278	0.282	0.264	0.273
18	**Congo, Rep.**	4.480	0.275	0.276	0.259	0.267
19	**Cote d'Ivoire**	4.409	0.277	0.280	0.262	0.271
20	**Djibouti**	4.387	0.277	0.281	0.263	0.272
21	**Egypt, Arab Rep.**	4.259	0.281	0.287	0.268	0.278
22	**El Salvador**	4.154	0.284	0.292	0.273	0.283
23	**Eritrea**	4.132	0.285	0.293	0.273	0.284
24	**Eswatini**	4.155	0.284	0.292	0.273	0.283
25	**Ethiopia**	4.208	0.283	0.290	0.270	0.281
26	**Gambia, The**	4.285	0.280	0.286	0.267	0.277
27	**Ghana**	4.295	0.280	0.285	0.267	0.276
28	**Guinea**	4.298	0.280	0.285	0.266	0.276
29	**Guinea-Bissau**	4.371	0.278	0.281	0.263	0.272
30	**Haiti**	4.436	0.276	0.278	0.261	0.269
31	**Honduras**	4.473	0.275	0.276	0.259	0.267
32	**India**	4.425	0.276	0.279	0.261	0.270
33	**Indonesia**	4.416	0.277	0.279	0.262	0.270
34	**Iran, Islamic Rep.**	4.357	0.278	0.282	0.264	0.273
35	**Kenya**	4.192	0.283	0.290	0.271	0.281
36	**Kiribati**	4.202	0.283	0.290	0.271	0.281
37	**Korea, Dem. P.**	4.062	0.287	0.297	0.276	0.288
38	**Kyrgyz Republic**	4.100	0.286	0.295	0.275	0.286
39	**Lao PDR**	4.048	0.288	0.298	0.277	0.289
40	**Lesotho**	4.029	0.288	0.299	0.278	0.290
41	**Liberia**	4.028	0.288	0.299	0.278	0.290
42	**Madagascar**	4.042	0.288	0.298	0.277	0.289
43	**Malawi**	4.157	0.284	0.292	0.272	0.283
44	**Mali**	4.108	0.286	0.295	0.274	0.286
45	**Mauritania**	4.334	0.279	0.283	0.265	0.274
46	**Micronesia, Fed.**	4.469	0.275	0.277	0.259	0.268
47	**Mongolia**	4.366	0.278	0.282	0.264	0.273
48	**Morocco**	4.206	0.283	0.290	0.270	0.281
49	**Mozambique**	4.199	0.283	0.290	0.271	0.281
50	**Myanmar**	4.413	0.277	0.279	0.262	0.270
51	**Nepal**	4.418	0.276	0.279	0.261	0.270
52	**Nicaragua**	4.502	0.274	0.275	0.258	0.266
53	**Niger**	4.580	0.272	0.271	0.255	0.262
54	**Nigeria**	4.812	0.265	0.259	0.245	0.250
55	**Pakistan**	4.826	0.264	0.259	0.244	0.250
56	**Papua New G.**	4.813	0.265	0.259	0.245	0.250
57	**Philippines**	4.866	0.263	0.257	0.243	0.248
58	**Rwanda**	4.768	0.266	0.262	0.247	0.253
59	**Samoa**	4.711	0.268	0.264	0.249	0.255
60	**Sao Tome and P.**	4.724	0.267	0.264	0.249	0.255
61	**Senegal**	4.641	0.270	0.268	0.252	0.259
62	**Sierra Leone**	4.559	0.272	0.272	0.256	0.263
63	**Solomon Islands**	4.650	0.269	0.267	0.252	0.258
64	**Somalia**	4.614	0.271	0.269	0.253	0.260
65	**South Sudan**	4.625	0.270	0.269	0.253	0.260
66	**Sri Lanka**	4.561	0.272	0.272	0.255	0.263
67	**Sudan**	4.468	0.275	0.277	0.259	0.268
68	**Syrian Arab Rep.**	4.514	0.274	0.274	0.257	0.265
69	**Tajikistan**	4.317	0.279	0.284	0.266	0.275
70	**Tanzania**	4.269	0.281	0.287	0.268	0.278

71	**Timor-Leste**	4.316	0.280	0.284	0.266	0.275
72	**Togo**	4.352	0.278	0.282	0.264	0.273
73	**Tunisia**	4.481	0.275	0.276	0.259	0.267
74	**Uganda**	4.405	0.277	0.280	0.262	0.271
75	**Ukraine**	4.448	0.276	0.278	0.260	0.269
76	**Uzbekistan**	4.228	0.282	0.289	0.269	0.280
77	**Vanuatu**	3.981	0.290	0.301	0.280	0.292
78	**Vietnam**	3.929	0.291	0.304	0.282	0.295
79	**West Bank**	3.910	0.292	0.305	0.283	0.296
80	**Yemen, Rep.**	3.800	0.295	0.310	0.287	0.301
81	**Zambia**	3.611	0.301	0.319	0.295	0.310
82	**Zimbabwe**	3.618	0.300	0.319	0.295	0.310

5. Conclusion and Policy Recommendations

The present study explores the impact of energy mix on economic growth in 82 developing countries from 1990-2020. The study uses two econometric techniques namely PQR and FGLS. The energy mix is used as the ratio of fossil fuels and renewable energy consumption while economic growth is measured by GDP per capita. Energy mix has non-linear association with economic growth. As a result the quadratic function of this variable is used for analysis. The study uses trade, education, labor and capital as the control variables. The results of both of the econometric techniques reveal that energy mix has inverted U-shaped Kuznets curve with economic growth. While the marginal effect of all the selected countries have positive impact on economic growth. In developing countries fossil fuels energy consumption is excessively used in production process because it is cheaper and easily accessible. The extensive use of fossil fuels in long run deteriorates the environment and badly effects human health. It brings up the need to minimize the use of fossil fuels and gradually move towards the renewable energy resources.

For the sake of economic affluence sustainable economic growth, better environment and improved health conditions, transition of the energy from non-renewable to renewable are considered essential. This study endorses that developing countries should inspect their standing with respect to economic mix-energy growth. Furthermore, trade, education, labor and capital also accommodate the growth process which means that these developing countries ought to open themselves to import knowledge for energy transition, pay emphasis to primary education and focus on skilled labor force for achieving the rapid and sustainable economic growth. The present study can be extended to analyze the impact of ENMIX on economic growth in developed countries. Furthermore, due to Russia-Ukraine war has affected adversely the continuity of energy supply which caused sharp increase in the prices of energy in all the countries of the world. It has affected living standard of the people in developing countries adversely. Furthermore, the developing countries are forced to depend heavily on fossil fuels for meeting their energy demand which have changed the energy mix preferences. This calls for the need to analyze the role of energy mix in the development process of an economy minutely using latest economic development. It will help the policy makers to devise policies to tackle the problem of climate change and protect the global world from the adverse impact of climate change.

References

Ahmad, T. I., Nawaz, M. A., Kiran, K., Dagar, V., Bhatti, M. A., & Hussain, A. (2022). Dirty versus clean fuel for cooking in Pakistan: regional mapping and correlates. *Environmental Science and Pollution Research*, 1-14. doi:10.1007/s11356-022-23757-4

Ahmed, K., Rehman, M. U., & Ozturk, I. (2017). What Drives Carbon Dioxide Emissions in the Long-Run? Evidence from Selected South Asian Countries. *Renewable and Sustainable Energy Reviews, 70*, 1142-1153. doi:10.1016/j.rser.2016.12.018

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is Free Trade Good for the Environment? *American economic review, 91*(4), 877-908. doi:10.1257/aer.91.4.877

Apergis, N., Chang, T., Gupta, R., & Ziramba, E. (2016). Hydroelectricity Consumption and Economic Growth Nexus: Evidence from a Panel of Ten Largest Hydroelectricity Consumers. *Renewable and Sustainable Energy Reviews, 62*, 318-325. doi:10.1016/j.rser.2016.04.075

Apergis, N., & Danuletiu, D. C. (2014). Renewable Energy and Economic Growth: Evidence from the Sign of Panel Long-Run Causality. *International Journal of Energy Economics and Policy, 4*(4), 578-587.

Apergis, N., & Payne, J. (2014). A Time Varying Coefficient Approach to the Renewable and Non-Renewable Electricity Consumption-Growth Nexus: Evidence from a Panel of Emerging Market Economies. *Energy Sources, Part B: Economics, Planning, and Policy, 9*(1), 101-107. doi:10.1080/15567249.2013.792400

Apergis, N., & Payne, J. E. (2010). Energy Consumption and Growth in South America: Evidence from a Panel Error Correction Model. *Energy economics, 32*(6), 1421-1426. doi:10.1016/j.eneco.2010.04.006

Apergis, N., & Payne, J. E. (2012). Renewable and Non-Renewable Energy Consumption-Growth Nexus: Evidence from a Panel Error Correction Model. *Energy economics, 34*(3), 733-738. doi:10.1016/j.eneco.2011.04.007

Aslan, A., Apergis, N., & Yildirim, S. (2014). Causality Between Energy Consumption and GDP in the US: Evidence from Wavelet Analysis. *Frontiers in Energy, 8*(1), 1-8. doi:10.1007/s11708-013-0290-6

Azam, M., Khan, A. Q., Zaman, K., & Ahmad, M. (2015). Factors Determining Energy Consumption: Evidence from Indonesia, Malaysia and Thailand. *Renewable and Sustainable Energy Reviews, 42*, 1123-1131. doi:10.1016/j.rser.2014.10.061

Bhatti, M. A., ur Raheem, F., & Zafar, M. A. (2020). Environmental Kuznets Curve (EKC): Empirically Examined Long Run Association Between Globalization, Financial Development and CO2 Emission for ASEAN Countries. *iRASD Journal of Energy & Environment, 1*(1), 01-13. doi:10.52131/jee.2020.0101.0001

Boamah, J., Adongo, F. A., Essieku, R., & Lewis Jr, J. A. (2018). Financial Depth, Gross Fixed Capital Formation and Economic Growth: Empirical Analysis of 18 Asian Economies. *International Journal of Scientific and Education Research, 2*(04). doi:10.2139/ssrn.3424688

Brundtland, G. H. (1987). Our Common Future—Call for Action. *Environmental Conservation, 14*(4), 291-294. doi:10.1017/S0376892900016805

Bugaje, I. M. (2006). Renewable Energy for Sustainable Development in Africa: A Review. *Renewable and sustainable energy reviews, 10*(6), 603-612. doi:10.1016/j.rser.2004.11.002

Deyshappria, R. (2018). Globalization-Poverty Nexuses: Evidences from Cross-Country Analysis. *Empirical Economic Review, 1*(1), 24-48.

Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Agrawala, S., Bashmakov, I. A., Blanco, G., . . . Bustamante, M. (2014). Summary for Policymakers. 32.

Farrell, N., & Lyons, S. (2015). Who Should Pay for Renewable Energy? Comparing the Household Impacts of Different Policy Mechanisms in Ireland. *Energy Research & Social Science, 7*, 31-42. doi:10.1016/j.erss.2015.02.006

Hanif, S., Nawaz, A., Hussain, A., & Bhatti, M. A. (2022). Linking Non Renewable Energy, Renewable Energy, Globalization and CO2 Emission under EKC Hypothesis: Evidence from ASEAN-6 Countries through Advance Panel Estimation. *Pakistan Journal of Humanities and Social Sciences, 10*(1), 391–402-391–402. doi:10.52131/pjhss.2022.1001.0204

Hasan, R., Quibria, M. G., & Kim, Y. (2003). *Poverty and Economic Freedom: Evidence from Cross-Country Data*.

Hussain, A., Shah, S. Z. A., & Ayub, M. (2021). Analysis of Factors Affecting Renewable Energy Consumption Evidenced from Thailand. *iRASD Journal of Energy & Environment, 2*(2), 67-77. doi:10.52131/jee.2021.0202.0018

Iqbal, A., & Bukhari, N. (2018). Consequences of Capital Formation, Trade Liberalization on the Economic Growth: Pakistan's Experience. *Journal of Management Info, 2*(1), 1-4. doi:10.31580/jmi.v5i1.37

Joesoef, H. (2021). The Effect Of Children Education On Economic Growth In Aceh Province-Indonesia. *Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12*(11), 3881-3884.

Kong, Y., Nketia, E. B., Antwi, S. K., & Musah, M. (2020). Scrutinizing the Complex Relationship between Financial Development Gross Fixed Capital Formation and Economic Growth in Africa by Adopting CCEMG and AMG Estimation Techniques. *International Journal of Science and Business, 4*(11), 160-174.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A Contribution to the Empirics of Economic Growth. *The Quarterly Journal of Economics, 107*(2), 407-437. doi:10.2307/2118477

Meyer, D. F., & Sanusi, K. A. (2019). A Causality Analysis of the Relationships between Gross Fixed Capital Formation, Economic Growth and Employment in South Africa. *Studia Universitatis Babes-Bolyai Oeconomica, 64*(1), 33-44.

Mikesell, R. F. (1994). Sustainable Development and Mineral Resources. *Resources Policy, 20*(2), 83-86. doi:10.1016/0301-4207(94)90020-5

Neumayer, E. (2007). Sustainability and Well-Being Indicators. In *Human well-being* (pp. 193-213): Springer.

Omay, T., Apergis, N., & Özçelebi, H. (2015). Energy Consumption and Growth: New Evidence from a Non-Linear Panel and a Sample of Developing Countries. *The Singapore Economic Review, 60*(02), 1550018. doi:10.1142/S0217590815500186

Özdoğan Özbal, E. (2021). Dynamic Effects of Higher Education Expenditures on Human Capital and Economic Growth: An Evaluation of OECD Countries. *Policy Reviews in Higher Education, 5*(2), 174-196. doi:10.1080/23322969.2021.1893125

Qadir, N., & Majeed, M. T. (2018). The impact of Trade Liberalization on Health: Evidence from Pakistan. *Empirical Economic Review, 1*(1), 71-108.

Salem, T., & Kinab, E. (2015). Analysis of Building-Integrated Photovoltaic Systems: A Case Study of Commercial Buildings under Mediterranean Climate. *Procedia Engineering, 118*, 538-545. doi:10.1016/j.proeng.2015.08.473

Shukla, A. K., Sudhakar, K., & Baredar, P. (2017). Renewable Energy Resources in South Asian Countries: Challenges, Policy and Recommendations. *Resource-Efficient Technologies, 3*(3), 342-346. doi:10.1016/j.reffit.2016.12.003

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The review of Economics and Statistics, 39*(3), 312-320. doi:10.2307/1926047

Stiglitz, J. E. (2002). Participation and Development: Perspectives from the Comprehensive Development Paradigm. *Review of development economics, 6*(2), 163-182. doi:10.1111/1467-9361.00148

Tiwari, A. K., Apergis, N., & Olayeni, O. R. (2015). Renewable and Nonrenewable Energy Production and Economic Growth in Sub-Saharan Africa: A Hidden Cointegration Analysis. *Applied Economics, 47*(9), 861-882. doi:10.1080/00036846.2014.982855

Tugcu, C. T., Ozturk, I., & Aslan, A. (2012). Renewable and Non-Renewable Energy Consumption and Economic Growth Relationship Revisited: Evidence from G7 Countries. *Energy economics, 34*(6), 1942-1950. doi:10.1016/j.eneco.2012.08.021

UNIDO. (1984). *UNIDO Anual Report*. Retrieved from

Urooj, K., & Zafar, M. A. (2022). Sectoral Growth, Exports, and Energy Consumption: A Case of Pakistan. *iRASD Journal of Energy & Environment, 3*(1). doi:10.52131/jee.2022.0301.0025

Zhongming, Z., Linong, L., Xiaona, Y., Wangqiang, Z., & Wei, L. (2019). *Marine life, fisheries increasingly threatened as the ocean loses oxygen–IUCN report*. Retrieved from China: https://www.iucn.org/news/marine-and-polar/201912/marine-life-fisheries-increasingly-threatened-ocean-loses-oxygen-iucn-report