*Do export quality, urbanization and fertility rate affect the ecological footprint? (Case study: A panel of developing countries)*

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**Abstract**:

The purpose of this study is to investigate the effect of export quality and fertility rate on ecological footprint in a panel of developing countries. For this purpose, panel quantile regression in the period 1990-2014 has been used. Also in this study, the variables of trade openness, urbanization, and GDP per capita were considered as observer variables. Experimental results show that the quality of exports and Fertility rate at all levels of the quantile improve the quality of the environment. Open trade and urbanization help to improve the quality of the environment. GDP per capita further degrades the environment. Therefore, policymakers should take into account these factors affecting the ecological footprint and adopt appropriate policies.

**Keywords**: export quality, fertility rate, ecological footprint, panel quantile regression.

**Classification JEL:** Q56, Q57, F18.

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**1. Introduction**

In recent decades, economic growth and industrialization have led to an overuse of natural resources. So that the destruction of the environment and the emission of polluting gases has exceeded the biological capacity of the planet. Therefore, policymakers and researchers paid much attention to environmental factors. Many studies have examined the effect of various factors such as economic growth, energy consumption, globalization, urbanization, etc. on the environment (Gozgor and Can, 2017; Dogan and Turkekul, 2016; Albulescu et al., 2019).

So far, various indicators have been introduced to study environmental degradation and its sustainability. In most studies, greenhouse gas emissions and CO2 emissions have been considered as criteria for assessing environmental degradation, but carbon dioxide emissions are only a part of environmental damage and cannot be considered as a comprehensive measure of degradation environment (Shahbaz et al., 2016).

Today, the Ecological Footprint Index has been introduced to measure the set of pressures on the environment, which has been considered as the most successful criteria for evaluating sustainable development by researchers and politicians (Uddin et al., 2017; Neagu, 2020). The ecological footprint is a measure that shows the amount of human consumption of biological resources and wastes production in different areas. In other words, ecological footprints are the effects that societies have on nature according to their lifestyle and show which societies have put more pressure on the environment (Wilson and Anielski, 2005; Lin et al., 2020).

The expansion of global trade, on the one hand, leads to the transfer of new environmentally friendly technologies, and on the other hand, accelerates economic growth, which requires more consumption of resources. Therefore, the expansion of trade regardless of the quality of export products causes damage to the environment (Fang et al., 2019).The quality of exports is an indicator that is estimated based on the standard unit values of products (Hallak., 2006). This index is calculated based on the quality score of 90% of each country's export products. These products are selected based on 1. Standard International Trade Classification up to 4- digit level 2. Broad Economic Categories up to 3-digit level 3. Aggregate Sectors: Agricultures, Commodities and Manufactures (IMF, 2020). The higher values of export quality means a higher level of quality of export products (Henn et al, 2013). The quality of export products depends on the research and development activities of countries and their production efficiency. In addition, improving institutional quality and growing human capital leads to improved export quality (Henn et al., 2013: Shahbaz et al., 2019; Fang et al., 2019). To produce diverse and high quality export goods, advanced technologies are needed, and the development of technologies will improve the environment. Some factors, such as the growth of the share of high-skilled workers over total labor force and the increase R&D investments of countries, help to increase the quality of their products and exports. In developing countries, the educated workforce has grown over the period under study, for example (Bahrain's highly educated workforce was 72% in 2006, up from 79% in 2014), a high figure for Iran. (From 40% in 2000 to about 60% in 2014) (World Bank). R&D investment costs also increased in most of the countries studied, for example (R&D investment costs in Indonesia increased from 0.060 in 1996 to 0.1 in 2014). For Iran, this figure has risen from about 0.200 in 1996 to 0.300 in 2014 and about 0.830 in 2018. Israel has doubled to 2.59 percent in 1996. Reached 4.173 in 2014.) (World Bank) (Gozgor and Can, 2017; Murshed and Dao, 2020).

Despite the significant impact of the quality of export products on the environment, few studies have addressed this issue (Murshed and Dao, 2020). Therefore, this study analyzes the effect of export quality of developing countries on ecological footprint.

The effect of the fertility rate on the environment depends on various factors such as laws and regulations, ownership, consumption patterns, and so on. Today, despite the growth of the world's population, some issues, such as increasing education and women's employment, have reduced the fertility rate in societies. Until the 1980s, low fertility rates were seen only in developed countries (World Trade Organization (WTO), 2020). But recently, fertility decline has spread to other parts of the world and developing countries (Sobotka and Furnkranz- Prskawetz, 2020). The fertility rates of the countries selected in this study have also been decreasing during the study period so that the average fertility rate of all countries studied in 1990 is about 4.295%, which in 2014 reached about 2.434%, which is close to Decreased to 2% (World Bank Data (WBD), 2020). Some studies suggest that fertility rates lead to the overuse of natural resources and further environmental degradation (Liddle and Lung 2010). But as fertility decreases, the young and active population decreases, and the elderly population increases, leading to a reduction in the labor force (Alola et al., 2019). Some studies have also examined the two-way effect of fertility rate and the environment, stating that there is a complex and dynamic relationship between the environment and fertility rate (Jacobson, 1988). Given that the relationship between fertility rate and the environment is complex and ambiguous, this study examines the effect of fertility rate on ecological footprint.

As mentioned above, studies with indicators such as export quality and fertility rate have not been widely considered. Therefore, the purpose of this study is to enrich the literature related to these topics. This study is innovative in several ways. First, the use of the ecological footprint index as a measure of environmental degradation provides more realistic and comprehensive results. Second, in this study, the countries under study are classified into six groups based on characteristics related to ecological footprint, which helps policymakers to guide development policies. Thirdly, to our knowledge, this study analyzes for the first time the effect of export quality and fertility rate on the ecological footprint in developing Asian countries. Therefore, in this study, we seek to answer the following questions:

1. Does increasing the quality of export products reduce the ecological footprint and environmental degradation?

2. Does increasing the fertility rate destroy the environment or help improve the environment? To answer these questions, the main purpose of this study is to investigate the effect of export quality and fertility rate on the ecological footprint for a panel of 20 developing countries with quantum panel regression. The empirical findings of this study, in addition to contributing to the development of existing literature, have important implications for the policies of developing economies to protect the environment.

The rest of the structure of this paper is as follows: Section 2 shows a review of the literature, Section 3 presents data and models, Section 4 focuses on empirical results and discusses, and finally, conclusions and the policy implications are presented in Section 5.

**2. Literature review**

This section examines previous studies related to the variables of export quality and fertility rate on environmental performance.

*1. The relationship between export quality and ecological footprint*

Various studies have shown that in addition to the volume of exports, attention to the quality of export products is also very important (Hausmann et al., 2014). Increasing the quality of a country's export products gives that country a competitive advantage over other competitors in international trade. Competitive advantage increases the income and wealth of the country. With increase incomes, the possibility of investing in research and development activities increases (Guloglu & Tekin, 2012). On the other side, the increase in R&D expenditure leads to a more efficient production process and increased use of environmentally friendly technologies. Although the quality of exports has an important effect on the environment, it has not received much attention from researchers. Studies have also reported different results. Some studies have shown a positive relationship between export quality and environmental degradation. Fang et al (2019) examined the effect of export quality on CO2 emissions in 82 developing countries. Literature shows disagreement on the relationship between export quality and environmental degradation. Some studies have shown that increasing the quality of exports harms the environment and reducing the quality of exports helps to improve the quality of the environment (Fang et al, 2019). Nevertheless, other studies have also shown that increasing the quality of exports helps to improve the quality of the environment (Murshed & Dao, 2020). Dogan et al (2020) investigated the impact of export quality on CO2 emissions. For this purpose, they used data from 63 developing and developed countries during the period 1971-2014 using quantile panel regression. Their experimental results showed that increasing the quality of exports increases CO2 emissions and environmental degradation. Wang et al (2021) discussed the effect of export quality on CO2 emissions in a panel of the top 10 countries in the Economic Complexity Index and the top 10 renewable energy countries. They used DOLS (Dynamic Ordinary Least Squares) and FMOLS (Fully Modified Ordinary Least Squares) models for experimental analysis. Their results showed that the quality of exports, in the long run, increases CO2 emissions and environmental degradation.

A group of studies found a negative relationship between export quality and environmental degradation. Gozgor and Can (2017) analyzed the effect of export quality on CO2 emissions in China. They found that export quality reduced CO2 emissions and improved the environment. In addition, they showed that economic growth and energy consumption contribute to environmental degradation. Murshed and Dao (2020) analyzed the impact of export quality on the environment in selected Asian countries (such as Bangladesh, India, Pakistan, Sri Lanka, and Nepal) during the period 1972-2014. They used the FMOLS approach for experimental analysis. Their results showed that increasing the quality of exports reduces CO2 emissions and reduces environmental degradation. In addition, they found that the overall effects of economic growth on CO2 emissions and environmental degradation depend on the quality of exports. Therefore, they concluded that increasing the quality of export products guarantees environmental sustainability throughout Asia.

*2. The relationship between fertility rate and ecological footprint*

In reviewing and analyzing previous studies in the discussion of population, fertility rate, and environment, there is a great variety in the results and their interpretation. Undoubtedly, one reason for this diversity can be considered different time periods, groups of different countries studied and different methods used. Some theories suggest that increasing fertility rates and populations increase the use of natural resources due to increases aggregate consumption. Due to the limited resources and capacity of the planet, population growth causes environmental degradation (Malthus, 1803). Some theories also state that human beings are a valuable asset that is a potential source for various activities and the creation of new and advanced ideas. In addition, resource constraints are constantly changing due to advances in technology (Boserup, 1981).

The results of different studies about the effect of population and fertility rate on the environment too are different. Some studies have found a positive relationship between fertility rate and population with environmental degradation (Khan et al., 2021; Charfeddine and Mrabe, 2017). These studies claim that increasing fertility rates lead to an increase in population, which leads to consuming more resources and more waste, which contributes to the deterioration of the quality of the environment. Charfeddine and Mrabet (2017), In a study of 15 countries of MENA over the period 1975-2007, it was shown that increasing fertility rates further damage the environment. Khan et al. (2021) studied the effect of population growth on environmental degradation using the GMM approach from 1971 to 2016 and found that population growth causes environmental degradation.

Some studies have also found a negative relationship between fertility rates and environmental degradation. Toth and Szigeti (2016), Showed that population growth does not cause environmental degradation, but it is the population consumption pattern of communities that harms the environment. Alola et al (2019) analyzed the effect of fertility rate on the ecological footprint in a panel of 16 EU member states. Their experimental results showed that in the short run, increasing the fertility rate increases the ecological footprint, but in the long run, the fertility rate reduces the ecological footprint and reduces environmental degradation.

As noted above, most previous studies consider various indicators of trade, economic and social development to explain environmental degradation and ecological footprint. In addition, most previous studies have used CO2 as an indicator of environmental degradation (Fang et al., 2019). Few studies have analyzed the effect of new indicators such as export quality and fertility rate on ecological footprint. In addition, there is no consensus on the impact of export quality and fertility rates on CO2 emissions and ecological footprints. These different results can be considered as methods of analysis due to the use of different variables, groups of different countries or regions. So this study complements previous studies to examine the effect of export quality and fertility rates on the ecological footprint in a group of developing countries. In the next section, we will describe the data and econometric methods used to conduct this experimental study.

**3. Data and Method**

This section includes two subsections: 3.1. database / variables, 3.2. methodological approaches used in this experimental study.

*3.1. Data*

This section shows the variables used in this study. Given the availability of all available data for all countries studied, the period 1990-2014 has been selected. The variables used in this study and their sources are described in Table 1.

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| *Table 1. Variable acronyms, definitions, and sources* | | |
| *Abbreviation* | *Variables* | *Sources* |
| EFP | Ecological footprint (in global hectares - gha) | Global Footprint Network (GFN) (2020) |
| EQ | Export Quality Index | International Monetary Fund (IMF) (2020) |
| TO | Total economic openness = Import+Export (constant=2010 $) | WBD (2020) |
| UR | Urban population = % of total population | WBD (2020) |
| GDP | Gross domestic product per capita (GDP) (constant= 2010 $) | World Bank Data (WBD) (2020) |
| FR | Fertility rate, total (births per woman) | WBD (2020) |
| Notes: All data are annual over the period from 1990 to 2014; the authors created this table. | | |

After describing the variables and their sources, we describe the statistics of the variables used in this study. In this context, Table 2 below shows the descriptive statistics of the variables.

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| *Table 2. Descriptive statistics* | | | | | |
| *Variables* | *Descriptive statistics* | | | | |
| *Obs.* | *Mean* | *Std.-Dev.* | *Min.* | *Max.* |
| EFP | 500 | 1.27e+08 | 2.19e+08 | 4151729 | 1.48e+09 |
| EQ | 500 | 0.807948 | 0.141613 | 0.45 | 1.07 |
| TO | 500 | 96.892 | 74.65409 | 0.020999 | 437.3267 |
| UR | 500 | 63.55258 | 25.17984 | 15.546 | 100 |
| GDP | 500 | 14266.6 | 18137.03 | 321.2812 | 69679.09 |
| FR | 500 | 3.127032 | 1.131586 | 1.15 | 7.165 |
| Notes: Obs. is the number of observations in the model, Std.-Dev. is the standard deviation, Min and Max are the minimum and maximum, respectively. | | | | | |

*3.2. Method approach*

Although ordinary least squares regression is the most popular regression analysis, it sometimes performs poorly (for example, when the error distribution is abnormal, especially in distributions with long and asymmetric sequences).The quantile regression, which expresses an arbitrary quantile relation of the dependent variable distribution to the descriptive variables, is a technique that can overcome the limitations mentioned by the OLS estimator. This model, introduced by Koenker and Bassett in 1978, gradually became a comprehensive method for statistical analysis of linear and nonlinear models of response variables in different fields (Buhari et al., 2020; Gomes and Rodriguez, 2020).

The main motivation for using quantile regression is to provide a model with a detailed and comprehensive look at the evaluation of the dependent variable to allow the inclusion of independent variables in all parts of the distribution and not face the limitations of ordinary regression assumptions. The quantile regression is a statistical method with the ability to calculate and plot different regression curves and correspond to different percentiles, which, while expressing a more complete and comprehensive picture of the data, the possibility of measuring the relationship between independent variables and the desired dependent variables without the need provides data normality even in the presence of remote points, meaning that this regression is stronger than remote data (Koenker, 2004).

Therefore, this research applies the quantile panel regression method to evaluate the effect of export quality and fertility rate on the ecological footprint. The mathematical formula of the quantile regression model is as follows in Equation (1).

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| , | (1) |

where X is the vector of independent variables; Y is the vector of dependent variables; μ is a random error; is the quantile of the independent variable; the βθ estimate shows the quantile regression θth and solves the Equation (2):

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|  | (2) |

Given that, θ is equal to different values. Therefore, estimation of different parameters is obtained. The mean regression is a particular case of quantile regression under θ = 0.5 (Xu and Lin 2018).

The econometric theory states that logarithmic model variables must be used to eliminate possible heterogeneities. Therefore, it became logarithmic and our model follows Equation (3):

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|  | (3) |

Where EFP represents ecological footprint measured in global hectares; EQ is export quality; TO is trade openness; UR is urban population (in % of the total population); GDP is Gross Domestic Product; FR denotes fertility rate (births per woman).

Given in this study was used panel quantile regression to measure ecological footprint, Equation (4) is converted to the following form:

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|  | (4) |

In this regard, means the estimation of the quantile regression in the ecological footprint, and is the constant component. The coefficients are the quantile regression parameters and show the influencing factors.

**4. Empirical results and discussion**

This section consists of two parts. In the first part, we check the pre-estimation tests. In the second part, we examine the effect of independent variables on the ecological footprint using the panel quantile regression model.

*4.1. Pre-estimation tests*

Before estimating quantile panel regression, it is necessary to consider preliminary testing such as the normality test (Royston, 1992; Royston, 1983), the multicollinearity of the variables (Belsley et al., 2005), the existence of cross-sectional dependence (Pesaran, 2004), order of integration, i.e., unit roots (Pesaran, 2007) and cointegration test (Kao, 1999; Pedroni, 1999). Therefore, in this section, we examine the preliminary tests mentioned.

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| *Table 3. Normality test* | | | | | |
| *Variables* | *Shapiro-Wilk test* | | *Shapiro-France test* | | *Obs* |
| *Statistic* | | *Statistic* | |
| EFP | 0.51116 | \*\*\* | 0.50949 | \*\*\* | 500 |
| EQ | 0.95697 | \*\*\* | 0.95873 | \*\*\* | 500 |
| TO | 0.77188 | \*\*\* | 0.77150 | \*\*\* | 500 |
| UR | 0.94184 | \*\*\* | 0.93891 | \*\*\* | 500 |
| GDP | 0.73594 | \*\*\* | 0.73724 | \*\*\* | 500 |
| FR | 0.96084 | \*\*\* | 0.96162 | \*\*\* | 500 |
| Notes: \*\*\* denotes statistical significance at 1% level. | | | | | |

An abnormal distribution of data is a prerequisite for using quantile panel regression. If the data have an abnormal distribution, the results of the quantile regression estimate are slightly stronger than the OLS estimate (Koenker and Xiao, 2002). Therefore, before performing a regression analysis, the normality of all variables should be tested. In this research, the numerical method has been used to check the normality of the data. In the numerical method, Shapiro-Wilk (Royston, 1992) and Shapiro-France (Royston, 1983) tests were applied to measure the normality of the data. Table 3 shows that the probability values ​​of Shapiro-Wilk and Shapiro-France tests are significant for all variables at the level of less than 1%, so we conclude that the variables are non-normal.

After checking the normality of the variables, we examine the variance inflation factor (VIF) to check the multicollinearity of variables (Belsley et al., 2005). The results of the multicollinearity test show that the VIF values for all variables are less than the usually accepted standard of 10. In addition, the mean VIF of the variables is 1.65 and is less than the accepted value of 6. So the result indicated that there is no harmful multicollinearity problem (see Table 4, below).

In this study, the number of sections is equal to 20 and the number of years is equal to 25 (). So the LM test (Breusch- Pagan, 1980) is used to examine cross-sectional dependence (CSD) in the panel data. The null hypothesis in this test is the existence of cross-sectional independence. As shown in Table 4, the results of the LM test reject the null hypothesis, which indicates the existence of cross-sectional dependence in all model variables.

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| *Table 4. VIF test and Breusch- Pagan (LM test)* | | | | |
| *Variables* | *VIF-test* | | *Breusch- Pagan (LM test)* | |
| *VIF* | *Mean VIF* | *t-statistic* | *Prob.* |
| EFP | n.a. | 1.65 | 2047.908 | 0.0000 |
| EQ | 1.37 |  |  |
| TO | 1.60 |  |  |
| UR | 2.01 |  |  |
| GDP | 1.94 |  |  |
| FR | 1.33 |  |  |
| Notes: n.a. denotes not available. | | | | |

According to the results of the cross-sectional dependence test in the previous section, in this part, the panel unit root test (CIPS) prepared by Pesaran (2007) was used to check the stationary of variables. The null hypothesis in this test is that all series have a unit root. The results of CIPS tests (see Table 5, below) show that all of the variables except EQ and GDP at the level cannot reject the null hypothesis. However, EQ and URB with a delay of 1 and 2 and POP with a delay of 2 at the 5% significance level reject the null hypothesis. However, after the first-order difference, all variables became stationary in level 1%.

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| *Table 5. Panel unit root test (CIPS)* | | | | |
| *Variables* | *CIPS\** | *Variables* | *CIPS\** |
| EFP | -2.125\* | LEFP | -2.604\*\*\* |
| EQ | -2.820\*\*\* | LEQ | -2.997\*\*\* |
| TO | -1.747 | LTO | -2.415\*\*\* |
| UR | -1.487 | LUR | -2.39 \*\*\* |
| GDP | -0.906\*\*\* | LGDP | -2.475\*\*\* |
| FR | -1.345 | LFR | -2.454\*\*\* |
| Notes: Significant critical values without trends -2.11, -2.20, -2.38 respectively for levels 10%, 5%, 1%; Significant critical values with trends -2.63, -2.72, -2.88 respectively for levels 10%, 5%, 1%. | | | | |

The results of the panel unit root test in the previous section show that the variables are stationary in the first-order difference. Thus, the cointegration test can be used to check long-term relationships between variables (Al-Mulali and Ozturk, 2016). The Pedrony (1999) and Kao (1999) cointegration tests are used to examine long-term relationships in this study. The null hypothesis in both tests is the absence of cointegration. The results of the Pedrony and Kao tests (see Table 6) show that the null hypothesis is rejected. Therefore, there is a long-run equilibrium relationship between ecological footprint (EFP) and explanatory variables.

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| *Table 6. Kao and Pederoni cointegration test* | | | | | |
| *Kao cointegration test* | | | *Pedroni cointegration test* | | |
| *Estimators* | *t-Statistic* | *Prob.* | *Estimators* | *t-Statistic* | *Prob.* |
| ADF | -4.3062 | 0.0000 | Modified Phillips-Perron t | 6.0214 | 0.0000 |
| Residual variance | 0.00064 |  | Phillips-Perron t | -10.8530 | 0.0000 |
| HAC variance | 0.00035 |  | Augmented Dickey-Fuller t | -9.5734 | 0.0000 |

After reviewing the preliminary tests and confirming the not normal distribution of the data, the quantile panel regression model is suitable for investigating the experimental analysis of the effect of explanatory variables on the ecological footprint.

*4.1.1. Panel quantile regression result and discussion*

In this study, following most studies, quantile values of 10th, 25th, 50th, 75th, and 90th are used as representative values for experimental analysis. In this study, a fixed-effects panel is also used to evaluate the robustness of the results. In addition, the countries in Table 7 are classified into six groups based on the Ecological Footprint Scale.

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| *Table 7. Country distribution of ecological footprint (gha)* | |
| *Country* | *Quantile* |
| Bahrain, Jordan | The lower 10th quantile group |
| Cambodia, Lebanon, Singapore | The 10th - 25th quantile group |
| Oman, Israel, Iraq, Qatar, United Arab | The 25th - 50th quantile group |
| Bangladesh, Malaysia, Saudi Arab, Philippines,  Pakistan | The 50th - 75th quantile group |
| Thailand, Iran, Turkey | The 75th - 90th quantile group |
| Indonesia, India | The upper 90th quantile group |
| Notes: According to the level of ecological footprint, we divided the panel of 20 countries into six grades. | |

As shown in Table 8, the effect of export quality on ecological footprint is negative and significant in all quantiles. The results show that this effect is greater at lower quantile levels. In addition, the experimental results of this study show that a one percent increase in export quality in Quantile 10th reduces the ecological footprint by 3.81 percent. This is a significant amount. Hence, it can be said that the quality of the environment throughout the developing economies of Asia reacts strongly to changes in the quality of export products. Therefore, increasing the quality of export products helps to improve the quality of the environment in these countries. Increasing the quality of export products increases the international competition potential and the share of countries' trade. As the share of countries' international trade increases, the income of these countries increases. Therefore, increasing income leads to an improved production processes and more use of green technologies, which helps to improve the environment. Some studies support the findings of this study. Gozgor and Can (2017) also in a study for China found that CO2 emissions decrease as the quality of trade increases. Murshed and Dao (2020) also confirm these results in a study of selected South Asian economies (Bangladesh, India, Pakistan, Sri Lanka, and Nepal). They found that improving export quality reduced CO2 emissions and improved the environment. Some studies have found a positive relationship between export quality and environmental degradation (Fang et al., 2019: Wang et al., 2021).

The results of Fertility rate on ecological footprint indicate that in all quantiles Fertility rate has a negative and significant effect on ecological footprint. The results show that by increasing the fertility rate by 1%, in Quantile 10th, the ecological footprint decreases by about 2.27%. Therefore, policymakers in these countries to protect the environment should adopt policies to promote fertility rate. Toth and Szigeti (2016) found that the main cause of environmental degradation and increased ecological footprint was consumption patterns, not population growth. Therefore, the results of this study are somewhat consistent with their study results. Alola et al (2019) also discovered similar results from this study. As the fertility rate increases, so does the number of skilled and innovative people, which in turn helps to increase the production of environmentally friendly technologies.

The trade openness variable in all quantiles has a negative and statistically significant effect on the ecological footprint (see table 8). This means that as trade liberalization increases, the environment improves. In addition, the results show that this effect is greater at higher quantile levels. Increasing trade openness in developing countries will lead to the transfer of more advanced and environmentally friendly technologies from developed countries to these countries, which will improve the environment. Some studies support these results (Zhang et al, 2017: Ahmed et al, 2016: Sbia et al, 2014: Baek et al, 2009: Frankel & Rose, 2005). Aşıcı and Acar (2016) in a study of 116 countries concluded that trade openness reduces the ecological footprint. Some studies have reported different results (Ali et al, 2020: Al-Mulali et al, 2016).

As shown in Table 8, the urbanization at all levels of quantiles has a significant negative effect on the ecological footprint, and this effect is more significant at higher levels. So that 1% increase in urbanization causes a 3.319% decrease in ecological footprint at the level quantile 90th. Increased urbanization leads to greater use of public transportation, which greatly helps to reduce CO2 emissions. Many studies confirm these results (Lv & Xu, 2019: Saidi & Mbarek, 2017: Sharma, 2011). However, some studies have found conflicting results (Wang & Dogan, 2019: Wang et al, 2016).

As expected, the relationship between GDP per capita and ecological footprint is positive. This effect is greater in 90th quantile. So that 1% increase in GDP in the 90th quantile causes a 0.416% increase in ecological footprint. Economic growth requires more energy, which leads to more environmental degradation. Given that economic growth adversely affects the environment in developing Asian countries and contributes to higher levels of ecological footprint. Therefore, it is ideal for the governments and political authorities of these countries to consider strict regulations for economic growth in various sectors. In addition, the authorities of these countries can use tax and subsidy tools to punish and encourage environmentally polluting and environmentally friendly sectors. Some studies confirm these results. Hassan et al (2019) in a study for Pakistan found that as economic growth increases, so does the ecological footprint and environmental degradation. Saud et al (2019) obtained similar results.

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| *Table 8. Estimation results from panel quantile regression model and panel fixed effects* | | | | | | | | | | | | | |
| *Variables* | *Quantiles* | | | | | | | | | | | *OLS* | |
| *10th* | | *25th* | | | *50th* | | *75th* | | *90th* | | *Fixed Effects* | |
| LEQ | -3.8115 | \*\*\* | -2.4534 | \*\*\* | | -1.1145 | \*\*\* | -1.0171 | \*\*\* | -1.5414 | \*\*\* | -1.8050 | \*\*\* |
| LTO | -0.3777 | \*\*\* | -0.4672 | \*\*\* | | -0.7054 | \*\*\* | -0.7346 | \*\*\* | -0.4867 | \*\*\* | -0.5076 | \*\*\* |
| LUR | -0.6298 | \*\*\* | -0.6996 | \*\*\* | | -1.2684 | \*\*\* | -1.8501 | \*\*\* | -3.3194 | \*\*\* | -0.8816 | \*\*\* |
| LGDP | 0.0820 | \*\* | 0.0519 | \*\* | | 0.0204 | \* | 0.0440 | \*\* | 0.4165 | \*\*\* | -0.0136 | \*\*\* |
| LFR | -2.2740 | \*\*\* | -1.9064 | \*\*\* | | -1.5617 | \*\*\* | -1.6816 | \*\*\* | -2.137 | \*\*\* | -1.7677 | \* |
| Constant | 21.591 | \*\*\* | 23.115 | \*\*\* | | 27.498 | \*\*\* | 30.406 | \*\*\* | 32.872 | \*\*\* | 25.232 | \*\*\* |
| Pseudo R2 | 0.795 |  | 0.8831 |  | 0.8802 | |  | 0.9019 |  | 0.9089 |  | 0.8661 |  |
| Notes: \*\*\*, \*\*, \* denote statistically significant at the 1%, 5%, and 10% levels, respectively; “L” denotes variables in natural logarithms. | | | | | | | | | | | | | |

**5. Conclusion and policy implications**

The aim of this study is to investigate the impact of export quality and fertility rate on the ecological footprint in a panel of 20 developing Asian countries. For this purpose, a quantile panel regression is used to identify the explanatory power of export quality and fertility rate on the ecological footprint. The study period covers 1990 to 2014 with respect to access to all data. The quantile panel approach is used because the relationship between the described variable (ecological footprint) and the explanatory variables (export quality index, trade openness, GDP per capita, urban population as a percentage of total population, and fertility rate) are nonlinear.

The quality of export products plays an important role in reducing the ecological footprint. However, as the quantile increases, the effect decreases. The urbanization variable reduces the ecological footprint and reduces environmental degradation for all quantiles. In addition, as the quantile increases, the effect becomes larger. GDP per capita leads to a deterioration in the quality of the environment because they intensify the ecological footprint. However, economic growth does the most damage to the environment in the quantile 90th. Finally, the variable fertility rate improves the environment. In addition, it has the greatest effect in quantile 10th, so that a one percent increase in fertility rate reduces about 2.274 percent of ecological footprint.

Ecological footprint shows the amount of human consumption of biological resources and waste production in different areas. Various factors affect the ecological footprint. Consumption patterns and lifestyles of individuals in a society play an important role in ecological footprint. Therefore, the people of a society should follow a commensurate lifestyle with environmental sustainability. Therefore, governments should implement policy measures in line with improving the quality of the environment, for which the authorities of developing countries should pay special attention to increasing the quality of export products. In addition, policymakers in developing countries need to adopt policies to increase fertility rates to improve the environment. The results of this study show that increasing urban infrastructure also helps to improve the environment, so policies should be directed towards promoting urbanization.

In addition to paying attention to domestic laws and policies, officials should also pay special attention to foreign policy. Governments must move towards open trade, and in this way increase the quality of their export products to increase their share of trade. In addition, use environmentally friendly technologies and renewable energy. In the studied countries, attention to the fertility rate is also very important for environmental sustainability.

**Statements and Declarations**

**Competing interest:** The authors declare that they have no competing interests.

**References**

Ahmed K., Shahbaz M., Kyophilavong P. (2016). Revisiting the emissions-energy-trade nexus: evidence from the newly industrializing countries. *Environmental Science and Pollution Research*, 23(8): 7676-7691. DOI 7610.1007/s11356-11015-16018-x.

Albulescu C., Tiwari A.K., Yoon S.M., Kang S.H. (2019). FDI, income, and environmental pollution in Latin America: Replication and extension using panel quantiles regression analysis. *Energy Econ,* 84:104504. <https://doi.org/10.1016/j.eneco.2019.104504>.

Ali S., Yusop Z., Kaliappan SR., Chin L. (2020). Dynamic common correlated effects of trade openness, FDI, and institutional performance on environmental quality: evidence from OIC countries. *Environmental Science and Pollution Research*, 1-12. https://doi.org/10.1007/s11356-11020-07768-11357.

Al-Mulali U., Ozturk I. (2016). The investigation of environmental Kuznets curve hypothesis in the advanced economies: the role of energy prices. *Renewable and Sustainable Energy Reviews, 54*:1622-1631. <https://doi.org/1610.1016/j.rser.2015.1610.1131>.

Al-Mulali U., Solarin SA., Sheau-Ting L., Ozturk I. (2016). Does moving towards renewable energy cause water and land inefficiency? An empirical investigation. *Energy Policy,* 93:303-314. https://doi.org/310.1016/j.enpol.2016.1003.1023.

Alola AA., Bekun FV., Sarkodie SA. (2019). Dynamic impact of trade policy, economic growth, fertility rate, renewable and nonrenewable energy consumption on ecological footprint in Europe. *Sci. Total Environ,* 685:702–709. <https://doi.org/10.1016/j.scitotenv.2019.05.139>.

Aşıcı AA., Acar S. (2016). Does income growth relocate ecological footprint? *Ecological Indicators,* 61:707-714. https://doi.org/710.1016/j.ecolind.2015.1010.1022.

Baek J., Cho Y, Koo WW. (2009) The environmental consequences of globalization: A country-specific time-series analysis. *Ecological Economics,* 68(8-9):2255-2264. https://doi.org/2210.1016/j.ecolecon.2009.2202.2021.

Belsley DA., Kuh E., Welsch RE. (2005). Regression diagnostics: Identifying influential data and sources of collinearity. *John Wiley & Sons,* 571. http://dx.doi.org/10.1002/0471725153.

Boserup E. (1981). Population and Technological Change: A Study of long- Term Trends. Chicago: *University of Chicago Press*.

Breusch TS., Pagan AR. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. T*he review of economic studies,* 47(1): 239-253. <https://doi.org/210.2307/2297111>.

Buhari DO., Lorente DB., Ali-Nasir M. (2020). European commitment to COP21 and the role of energy consumption, FDI, trade and economic complexity in sustaining economic growth. *Journal of Environmental Management,* 273. DOI: [10.1016/j.jenvman.2020.111146](https://www.x-mol.com/paperRedirect/1294269621563170816).

Charfeddine L., Mrabet Z. (2017). The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries. *Renew. Sustain. Energy Rev,* 76:138-154. <https://doi.org/10.1016/j.rser.2017.03.031>.

Dogan E., Turkekul B. (2016). CO2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environ Sci Pollut Res,* 23: 1203–1213. DOI 10.1007/s11356-015-5323-8.

Dogan B., Madaleno M., Tiwari AK., Hammoudeh S. (2020). Impacts of export quality on environmental degradation: does income matter?. *Environmental Science and Pollution Research*, 1-38. https://doi.org/10.1007/s11356-11019-07371-11355.

Fang J., Gozgor G., Lu Z, Wu W. (2019). Effects of the export product quality on carbon dioxide emissions: evidence from developing economies. Environmental *Science and Pollution Research*, 26(12): 12181-12193. https://doi.org/12110.11007/s11356-12019-04513-12187.

Frankel JA., Rose AK. (2005). Is trade good or bad for the environment? Sorting out the causality. *Review of Economics and Statistics*, 87(1):85-91. https://doi.org/10.1162/0034653053327577.

Global Footprint Network (GFN). (2020). URL: https://www.footprintnetwork.org/resources/data/.

Gómez M., Rodríguez JC. (2020). The Ecological Footprint and Kuznets Environmental Curve in the USMCA Countries: A Method of Moments Quantile Regression Analysis. *Moments Quantile Regression Analysis Energies,* 13(24):6650. <https://doi.org/10.3390/en13246650>.

Gozgor G., Can M., (2017). Does export product quality matter for CO2 emissions? Evidence from China. *Environmental Science and Pollution Research*, 24(3):2866–2875. <https://doi.org/10.1007/s11356-016-8070-6>.

Guloglu, B., & Tekin, R. B. (2012). A panel causality analysis of the relationship among research and development, innovation, and economic growth in high-income OECD countries. Eurasian Economic Review, 2(1), 32-47.‏ <https://link.springer.com/article/10.14208/BF03353831>.

Hallak, J. C. (2006). Product quality and the direction of trade,” Journal of International Economics, 68, 238–65.

Hassan ST., Baloch MA., Mahmood N., Zhang J. (2019). Linking economic growth and ecological footprint through human capital and biocapacity. *Sustainable Cities and Society*, 47:101516. <https://doi.org/101510.101016/j.scs.102019.101516>.

Hausmann R., Hidalgo CA., Bustos S., Coscia M., Simoes A., Yildirim MA. (2014). The Atlas of Economic Complexity: Mapping Paths to Prosperity; *MIT Press: Cambridge*, MA, USA.

Henn, C., Papageorgiou, M. C., & Spatafora, M. N. (2013). Export quality in developing countries. International Monetary Fund. https://books.google.com/books?hl=en&lr=&id=slaYuinTyPIC&oi=fnd&pg=PP8&dq=Export+Quality+in+Developing+Countries+&ots=NusExXQxtS&sig=oeSUIolmnJjSaXsRaDsEJaR4Ww8#v=onepage&q=Export%20Quality%20in%20Developing%20Countries&f=false.

International Monetary Fund (IMF). (2020). URL: <https://data.imf.org/?sk=3567E911-4282-4427-98F9-2B8A6F83C3B6>.

Jacobson J. (1988). Environmental refugees: a yardstick of habitability. Washington DC: World Watch Institute.

Kao C. (1999). Spurious regression and residual-based tests for cointegration in panel data*. Journal of Econometrics,* 90(1):1-44. <https://doi.org/10.1016/S0304-4076(1098)00023-00022>.

Khan I., Hou F., Le HP. (2021). The impact of natural resources, energy consumption, and population growth on environmental quality: Fresh evidence from the United States of America. *Science of The Total Environment*, 754:142222. <https://doi.org/142210.141016/j.scitotenv.142020.142222>.

Koenker R. (2004). Quantile regression for longitudinal data. *J. Multivar. Anal,* 91:74–89. <https://doi.org/10.1016/j.jmva.2004.05.006>.

Koenker R., Bassett JG. (1978). Regression quantiles. Econometrica: *journal of the Econometric Society*, 33-50. <https://doi.org/10.2307/1913643>.

Koenker R., Xiao Z. (2002) Inference on the quantile regression process. *Econometrica,* 70(4):1583-1612. <https://doi.org/1510.1111/1468-0262.00342>.

Liddle B, Lung S, (2010) Age-structure, urbanization, and climate change in developed countries: revisiting STIRPAT for disaggregated population and consumptionrelated environmental impacts. Popul Environ 31:317– 43.

Lin D., Hanscom L., Martindill J., Borucke M., Cohen L., Galli A., Lazarus E., Zokai G., Iha K., Eaton D. (2020). Working Guidebook to the National Footprint and Biocapacity Accounts. *Global Footprint Network*, Oakland CA USA. <http://www.footprintnetwork.org/>.

Lv Z., Xu T. (2019). Trade openness, urbanization and CO2 emissions: Dynamic panel data analysis of middle-income countries. *The Journal of International Trade & Economic Development*, 28(3):317-330. <https://doi.org/310.1080/09638199.09632018.01534878>.

Malthus T. (1803). An Essay on the Principle of Population, as It Affects the Future Improvement of Society. (First Essay on Population,1796 ,and Second Essay on Population). New York: Modern Library and Random House.

Murshed M, Dao NTT. (2020). Revisiting the CO2 emission-induced EKC hypothesis in South Asia: the role of Export Quality Improvement. *GeoJournal*, 1-29. https://doi.org/10.1007/s10708-10020-10270-10709.

Neagu O. (2020). Economic Complexity and Ecological Footprint: Evidence from the Most Complex Economies in the World. *Sustainability,* 12(21):1-18. <https://doi.org/10.3390/su12219031>.

Pedroni P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics, 61*(S1): 653-670. <https://doi.org/610.1111/1468-0084.0610s1653>.

Pesaran H. (2004). General diagnostic tests for cross-sectional dependence in panels. University of Cambridge, *Cambridge Working Papers in Economics*, 435. https://www.econstor.eu/bitstream/10419/18868/1/cesifo1\_wp1229.pdf.

Pesaran MH. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics,* 22(2): 265-312. https://doi.org/210.1002/jae.1951.

Royston J. (1983). A Simple Method for Evaluating the Shapiro–Francia W′ Test of Nonnormality. *Journal of the Royal Statistical Society: Series D (The Statistician), 32*(3):297-300. <https://doi.org/210.2307/2987935>.

Royston, P. (1992). Approximating the Shapiro-Wilk W-test for non-normality. *Statistics and computing, 2*(3), 117-119. <https://doi.org/110.1007/BF01891203>.

Saidi K., Mbarek MB. (2017). The impact of income, trade, urbanization, and financial development on CO2 emissions in 19 emerging economies. *Environmental Science and Pollution Research*, 24(14):12748-12757. https://doi.org/12710.11007/s11356-12016-16303-12743.

Saud S., Chen S., Haseeb A. (2019). Impact of financial development and economic growth on environmental quality: an empirical analysis from Belt and Road Initiative (BRI) countries. *Environmental Science and Pollution Research,* 26(3):2253-2269. https://doi.org/2210.1007/s11356-11018-13688-11351.

Sbia R., Shahbaz M., Hamdi H. (2014). A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. *Economic Modelling*, 36:191-197. https://doi.org/110.1016/j.econmod.2013.1009.1047.

Shahbaz, M., Mahali, M.K., Shah, S.H., Sato, J.R. (2016). Time-varying analysis of CO2 emissions, energy consumption, and economic growth Nexus: statistical experience in next 11 countries. *Energy Policy*, 98: 33-48. <https://doi.org/10.1016/j.enpol.2016.08.011>.

Shahbaz M., Shafiullah M., Mahalik MK. (2019). The dynamics of financial development, globalisation, economic growth, and life expectancy in sub-Saharan Africa. Aust. *Econ,* 58 (4): 444–479. <https://doi.org/10.1111/1467-8454.12163>.

Sharma SS. (2011). Determinants of carbon dioxide emissions: empirical evidence from 69 countries. *Applied energy,* 88(1): 376-382. <https://doi.org/310.1016/j.apenergy.2010.1007.1022>.

Sobotka T., Fürnkranz-Prskawetz A. (2020). Demographic change in Central, Eastern and Southeastern Europe: trends, determinants and challenges. In 30 Years of Transition in Europe. Edward Elgar Publishing.

Toth G., Szigeti C. (2016). The historical ecological footprint: From over-population to over-consumption. *Ecological Indicators,* 60: 283-291. <https://doi.org/210.1016/j.ecolind.2015.1006.1040>.

Uddin GZ., Salahuddin M., Alam K., Gow J. (2017). Ecological footprint and real income: Panel data evidence from the 27 highest emitting countries. *Ecological Indicators*, 77: 166–175.

Wang Y., Chen L., Kubota J. (2016). The relationship between urbanization, energy use and carbon emissions: evidence from a panel of Association of Southeast Asian Nations (ASEAN) countries. *Journal of Cleaner Production*, 112: 1368-1374. <https://doi.org/1310.1016/j.jclepro.2015.1306.1041>.

Wang J., Dong K. (2019). What drives environmental degradation? Evidence from 14 Sub-Saharan African countries. *Science of The Total Environment,* 656: 165-173. https://doi.org/110.1016/j.scitotenv.2018.1011.1354.

Wang Z., Jebli MB., Madaleno M., Doğan B., Shahzad U. (2021). Does export product quality and renewable energy induce carbon dioxide emissions: Evidence from leading complex and renewable energy economies. *Renewable Energy,* 171: 360-370. <https://doi.org/310.1016/j.renene.2021.1002.1066>.

Wilson J., Anielski M. (2005). Ecological Footprints of Canadian Municipalities and Regions, the Canadian Federation of Canadian Municipalities. Anielski Management Inc from: [www.anielski.com](http://www.anielski.com).

World Bank Data (WBD). (2020). https://databank.worldbank.org/home.

Xu B., Lin B. (2018). What cause large regional differences in PM2. 5 pollutions in China? Evidence from quantile regression model. *Journal of Cleaner Production*, 174: 447-461. https://doi.org/410.1016/j.jclepro.2017.1011.1008.

Zhang S., Liu X., Bae J. (2017). Does trade openness affect CO2 emissions: evidence from ten newly industrialized countries? *Environmental Science and Pollution Research*, 24(21): 17616-17625. https://doi.org/17610.11007/s11356-17017-19392-17618.

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