Income distribution and environmental pollution: A panel data analysis for the provinces of Iran, 2005–2016

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In this paper, the effect of income inequality (Gini coefficient) on environmental quality (carbon dioxide [CO_2] emissions per capita) in the provinces of Iran (2005–2016) was studied. The generalized method of moments (GMM) was used for data analysis. The results indicated that the impact of income inequality on CO_2 emissions per capita is a function of the level of economic development (real gross domestic product [GDP] per capita). At low-income levels, rising inequality increases CO_2 emissions per capita. However, after the threshold, raising income inequality reduces CO_2 emissions per capita. The U-shaped relationship between real GDP per capita and CO_2 emissions per capita has also been confirmed. Per capita energy consumption and population density are the factors that increase CO_2 emissions per capita, while increasing urbanization is the factor that reduces CO_2 emissions per capita.

Introduction

Over the past 30 years, the economies of many countries have grown significantly. Meanwhile, some developing countries have experienced rapid economic growth (Dong et al. 2018, Wang et al. 2018). Nevertheless, serious social challenges have arisen through increasing inequality between the rich and the poor (Hao et al. 2016), resulting in the cessation of sustainable economic development (Galor–Moav 2004). If high inflation occurs at the same time as per capita national income grows, not all members of the community will benefit from such growth (Wu–Xie 2020). On the other hand, the expansion of economic and industrial activities in recent years has led to serious environmental degradation, and thus, serious concerns have been raised

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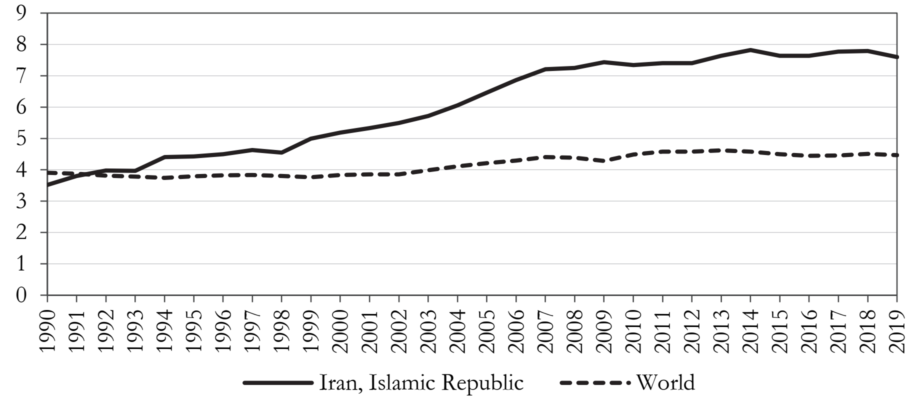
about the sustainability of development for developing countries (Baloch et al. 2020). Simultaneous reduction of poverty and improvement of the environment have always been two challenges facing human beings in the 21st century (Grunewald et al. 2017). All countries of the world are currently trying to save humanity from the clutches of poverty and create a healthy environment for future generations (Maji 2019). However, policies adopted based on economic growth lead to an increase in energy demand and consequently more CO_2 emissions, which lead to serious implications for human well-being and sustainable development (Danish 2020, Kiss–Balla 2022). Achieving a balance between economic growth, reducing inequality, and environmental sustainability is one of the biggest challenges a society faces (Mittmann–de Mattos 2020). Thus, these indicators were considered by the United Nations among the 17 most important sustainable development indicators in 2016 (UN 2017).

New studies show that factors other than income can play a role in determining environmental pollution. One of the economic variables considered in recent years is income distribution. Boyce (1994) was the first to suggest that income distribution significantly affects environmental quality. Theoretical debates about the relationship between income distribution and environmental degradation began in the mid-1990s in an attempt to determine whether there was a trade-off between income distribution and global warming. Theoretical frameworks and experimental studies have provided different answers to this question. On the one hand, some scholars (e.g., Baloch et al. 2020, Hao et al. 2016, Golley–Meng 2012, Vera–de la Vega Navarro 2019, Bert–Elie 2015) have emphasized the positive effect of inequality on emissions and environmental degradation. On the other hand, a group of researchers (e.g., Demir et al. 2019, Kasuga–Takaya 2017, Heerink et al. 2001, Ravallion et al. 2000) have highlighted the negative impact of income inequality on environmental pollution. However, some studies have suggested that the way income inequality relates to environmental pollution depends on the level of per capita income (e.g., Grunewald et al. 2017, Mittmann–de Mattos 2020, Rojas-Vallejos–Lastuka 2020, Mitsis 2021, Ghalehteimouri et al. 2021, Thakur–Das 2022).

Extreme environmental pollution, particularly air pollution, has threatened the life of many Iranians in the last few years, resulting in the temporary shutdown of some social activities. For example, nearly 33,000 people die in Iran every year due to air pollution, water pollution and other pollution (Velayatzadeh 2020). Between 1990 and 2019, the CO_2 per capita has had a rising trend, and the average increase in CO_2 per capita in Iran (2.8%) has been more than that of the world (0.048%).

Figure 1

The trend of CO_2 per capita for Iran and the world



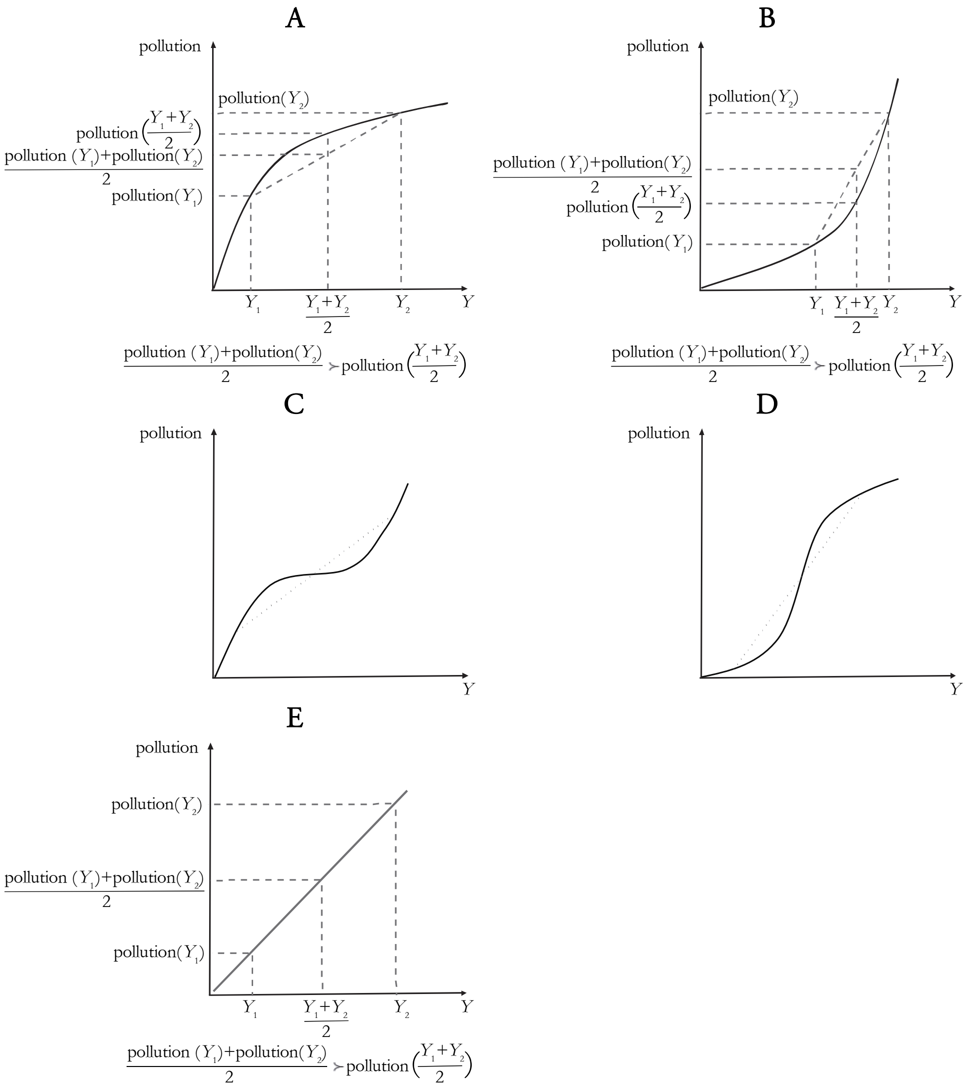
In 2019, Iran had a 1.8% share of CO_2 release worldwide, which is more than the total population of the country relative to the world population (1%) and the GDP relative to the fixed price in 2015 (0.5%). The marked release of CO_2 in Iran has inspired researchers, including the authors, to investigate some factors affecting it, such as income inequality, and to study the same variables from 2005 to 2016. Given the significance of the association between income inequality and environmental pollution and the lack of research in this field in Iran, this study aims to explore these two factors in the provinces of Iran using panel data from 2005 to 2016. In this research, for the first time, energy consumption and carbon dioxide emissions in the provinces of Iran are calculated. The rest of this paper is organized as follows: reviews previous studies in the literature on the impact of income distribution on CO_2 emissions, describes the procedure for data collection and model development, which is followed by model estimation and data analysis. Finally, conclusions and suggestions for future research.

Theoretical framework

The emission of pollutants, due to increasing economic activities, has created many challenges for human life on the planet (Jaber 2022). The environmental Kuznets curve (EKC) is the basic theoretical framework of many studies addressing the impact of economic activities on environmental quality (Wu–Xie 2020). This theory expresses an inverted U-shaped relationship between income and environmental pollution (Mitsis 2021). Recent studies have focused on economic and noneconomic determinants. Income inequality is also one of the variables that has been studied in recent years as a factor affecting environmental pollution. Boyce (1994) first examined the relationship between inequality and environmental degradation. Boyce (1994) suggested that by reducing inequality, environmental quality improves. However, subsequent studies have challenged this hypothesis. Following the theoretical analyses and experimental studies, four general scenarios can be considered for the relationship between income inequality and environmental degradation:

Figure 2

Income inequality and environmental degradation



Considering the first scenario, less income inequality causes less environmental degradation. According to Boyce (1994), increasing power and wealth inequality leads to more environmental degradation for three reasons: (a) The excess environmental degradation driven by powerful winners is not offset by the environmental degradation prevented by powerful losers; (b) inequality raises the valuation of benefits reaped by rich and powerful winners relative to costs imposed on poor and less powerful losers; and (c) inequality raises the rate of time preference applied to environmental resources by both the poor and the rich by increasing their poverty and political insecurity, respectively. Learning the effective consumption pattern and knowledge regarding the importance of not wasting energy also play a very important role in reducing the levels of pollutants (Li et al. 2019). Galor–Moav (2004) argued that reducing income inequality leads to improved human capital and reduced environmental degradation. The economic behavior of individuals also has a significant impact on the relationship between income inequality and emissions because the increase in consumerism and individualism in a society are considered serious obstacles to improving environmental conditions (Berthe–Elie 2015). As a result of the consumer competition approach, income inequality leads to the increased consumption of highly polluting goods and services (Schor 1998). On the other hand, more energy is used to produce goods and services for rich households than in the production of goods and services suited for poor households, and thus, more pollution is released (Golley–Meng 2012). The positive relationship between income inequality and CO_2 emissions can also be explained through political economy. Boyce (1994) first used this approach to describe the relationship. According to him, rich people have a high tendency to pollute the environment. These people tend to receive political rights through their high economic capacity, and thus, they can play a significant role in macroenvironmental decisions. Accordingly, due to the polluting preferences of the rich, as inequality increases, CO_2 emissions intensify as well (Guo et al. 2020). This can also be addressed in terms of working hours. As income inequality increases, the number of working hours also increases. As a result, longer working hours lead to more energy consumption and more CO_2 emissions (Knight et al. 2013, Fitzgerald et al. 2015).

According to the second scenario, an increase in inequality reduces environmental degradation (Figure 2/B). The marginal propensity to emit (MPE) of the poor to the rich is high because low carbon products require much higher technical requirements; therefore, they often have higher prices so that the poor cannot afford them. In addition, the poor use inefficient energy products compared to the rich, which leads to a higher MPE (Ravallion et al. 2000).

The third approach states that the positive or negative effects of income inequality on environmental quality depend on the income level of the community (Figures 2/C and 2/D). At lower income levels, less inequality causes less pollution, and at higher income levels, the environment becomes a luxury item, and higher inequality reduces environmental degradation (Scruggs 1998).

According to You et al. (2020), the poorest people usually have a higher MPE than the richest people. There are several possible reasons for this. Poor people use more inefficient energy products than rich people. This means that they have a higher MPE. In addition, the production of low-carbon goods requires higher technology that poor people do not have the financial means to use. Thus, it can be argued that in very poor societies, the MPE of the poor is high, but in relatively rich societies with higher per capita incomes, the MPE of the poor is lower than that of the rich in the same society. Finally, some studies have shown no significant relationship between income inequality and environmental pollution (Figure 2/E). Table 1 summarizes the empirical studies on these three scenarios discussed above:

Table 1

Summary of empirical findings

Denomination	Inequality index	Pollution index	Sample	Author(s)
Positive effect	GINI coefficient	Per capita CO_2 emissions	U.S (1967–2008)	Baek–Gw**eisah** (2013)
	Average income of income groups	Per capita CO_2 emissions	Mexico (1990–2014)	Vera–de la Vega Navarro (2019)
	Household income inequality (estimated by the author)	Per capita CO_2 and SO_2 emissions	90 developed and developing countries (1970–2000)	Drabo (2011)
	Gini index	Per capita CO_2 emissions	40 Sub-Saharan African countries (2010–2016)	Baloch et al. (2020)
	Wealth share of the top 10 per cent	Per capita CO_2 emissions	BRICS (2000–2014)	Aye (2020)
	Gini index	Per capita CO_2 emissions	23 Chinese provinces (1995–2012)	Hao et al. (2016)
	Gini index	Per capita CO_2 emissions	Turkey (1984–2014)	Uzar–Eyuboglu (2019)
	Percentage of total wealth owned by the top 10 percent of wealth holders (adults aged 20 and up)	Per capita CO_2 emissions	26 high-income countries (2000–2010)	Knight et al. (2017)
	Gini coefficient	Per capita emissions	36 countries over 20 years (1980, 1985, 1990, 1993, and 1996)	Qu–Zhang (2011)
	Gini coefficient	Per capita CO_2 emissions	Sub-Saharan Africa (1983, 1985, 1961–1986)	Heerink et al. (2001)

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Denomination	Inequality index	Pollution index	Sample	Author(s)
Negative effect	Gini index	Per capita CO_2 emissions	92 countries (1991–2015)	Huang–Duan (2020)
	Gini index	Per capita SO_2 emissions	29 countries (1979–1990)	Scruggs (1998)
	Gini index	Per capita CO_2 emissions	(1975–1992)	Ravallion et al. (2000)
	Gini index	Per capita CO_2 emissions	47 developing countries (1980–2016)	Yang et al. (2020)
	Income share of the top 10% and the Gini coefficient	Per capita CO_2 emissions	U.S. state-level data (1997–2012)	Jorgenson et al. (2017)
	Gini index	Per capita CO_2 emissions	Turkey (1963–2011)	Demir et al. (2019)
	Gini index	Per capita CO_2 emissions	Indonesia (1975–2017)	Kusumawardani–Dewi (2020)
	Gini Index	River water pollution, air pollution, and carbon emissions	City-level data in Japan (1992–2012)	Kasuga–Takaya (2017)
Nonlinear	Gini index	Per capita CO_2 emissions	158 countries (1980–2008)	Grunewald et al. (2017)
	Income share of top 10%	Per capita CO_2 emissions	78 countries (1990–2017)	Wu–Xie (2020)
	Gini index	Per capita CO_2 emissions	G20 countries (1988-2015)	Chen et al. (2020)
	Gini index	Per capita CO_2 emissions	G7 countries (1870–2014)	Uddin et al. (2020)
	Gini index	Per capita CO_2 emissions	68 countries (1961–2010)	Rojas-Vallejos–Lastuka (2020)
	Gini index	Per capita CO_2 emissions	67 countries (1991–2008)	Jorgenson et al. (2016)
	Gini index and decile dispersion ratio	Water and air pollution variables	58 countries for water pollution data and 19 of up to 42 countries for air pollution data (1977–1991)	Torras–Boyce (1998)
No relationship	Gini index	Per capita CO_2 emissions	China and India	Wolde-Rufael–Idowu (2017)

Data collection and analysis procedure

The following logarithmic equation was estimated for panel data from 28 provinces[2] of Iran for 2005–2006[3]:

$$lnpcc_{it} = \alpha_i + \lambda lnpcc_{it-1} + \beta_1 \ln rgdppc_{it} + \beta_2 (\ln rgdppc_{it})^2 + \beta_3 \ln pcec_{it} + \beta_4 ineq_{it}$$
$$+ \beta_5 (ineq_{it} * \ln rgdppc_{it}) + \beta_6 \ln pd_{it} + \beta_7 ur_{it} + \varepsilon_{it}$$

where pcc_{it} is the per capita CO_2 emissions (tons) in province i in year t (as an indicator of environmental quality). This is taken from Iran's energy balance sheet from 2005 to 2016.

- $rpcgdp_{it}$ is the real GDP per capita (as an indicator of economic development), which is taken from regional data in the statistical center of Iran, and they are realized through the consumer prices index and service consumption index.
- pcecit is energy consumption per capita in gigajoules, which is deduced by dividing the total energy (extracted from Iran's energy balance sheet) by the population (extracted from the statistical center of Iran).
- ineqit is the income inequality index (urban Gini coefficient, rural Gini coefficient and national Gini coefficient). This index is taken from the statistical center of Iran for the regional and rural areas.
- pdit is the population density of the province, which is extracted by dividing the population into the area of each province, the data of which are extracted from the statistical center of Iran.
- urit is the urbanization rate of the provinces, which is deduced by dividing the rural population by the total population, the data of which are extracted from the statistical center of Iran.
- α_i is individual effects, β_1, β_2, β_3, β_4, β_5, β_6, and β_7 are regression coefficients and εit is the regression error. The existence of the square power of real GDP per capita makes it possible to study the environmental Kuznets curve. Based on Hao et al. (2016), Ineqit *ln rgdppcit is used, which provides the possibility to examine the impact of income level on the effectiveness of carbon dioxide emissions from income inequality. The threshold level of real per capita income for the effectiveness of carbon dioxide emissions from income inequality can be determined as follows:

$$\frac{\partial lnpcc_{it}}{\partial ineq_{it}} = \beta_4 + \beta_5 \ln rgdppc_{it} = 0 \quad \rightarrow \ln rgdppc_{it} = -\frac{\beta_4}{\beta_5} \quad \rightarrow e^{-\frac{\beta_4}{\beta_5}} = rgdppc_{it}$$

If β_1 is negative and β_2 is positive, at values below the threshold level of the real GDP per capita, higher income inequality increases CO_2 emissions, and at values above the

[2] During the period in question, changes occurred in the provincial divisions in Iran. To collect data with a fixed number of sections over time, the data for Alborz and Tehran provinces were merged. Similarly, the data for North, South, and Razavi Khorasan provinces were merged.

[3] The data were extracted from the Statistical Center of Iran and the Energy Balance Sheet of Iran from 2005 to 2016.

threshold level of the real GDP per capita, higher income inequality decreases CO_2 emissions. If β_5 is positive and β_4 is negative, at values below the threshold level of real GDP per capita, higher income inequality reduces CO_2 emissions, and at values above the threshold level of real GDP per capita, higher inequality causes more CO_2 emissions. When β_4 and β_5 are positive, the destructive effect of increasing income inequality on the quality of the environment increases. When β_4 and β_5 are negative, as the level of development increases, the constructive effect of increasing income inequality on the quality of the environment also increases.

The most important benefits of panel data are controlling individual heterogeneity, more variability, less collinearity among variables, a greater degree of freedom, better study of adjustment dynamics, and the possibility of examining complex behavioral models (Baltagi 2008). Creating a rich environment for the development of techniques for estimating theoretical outcomes (Greene 2002) has led to the use of panel data to be considered by economic researchers. In contrast, due to the existence of two cross-sectional and time-series dimensions in panel data, the analysis of this type of data is more complex (Dougherty 2011). The existence of the dependent variable lag on the right side of Eq. (1) leads to a dynamic panel regression. Under these conditions, the OLS estimation method obtains biased estimates (Bond 2002). To estimate dynamic panel regression, Arellano–Bond (1991) proposed GMM, which is more efficient than Anderson and Hsiao's (1982) estimators (Baltagi 2008). The consistency of GMM estimators depends on the validity of the serial noncorrelation assumption of error terms and instruments. To validate the instruments, Arellano–Bond (1991) suggested the Sargan test. For the consistency of GMM estimators, there should be no second-order serial correlation in the error terms in the first-order differential equation.

Data analysis

A. Descriptive statistics

Descriptive statistics were used to provide a simple picture of the data:

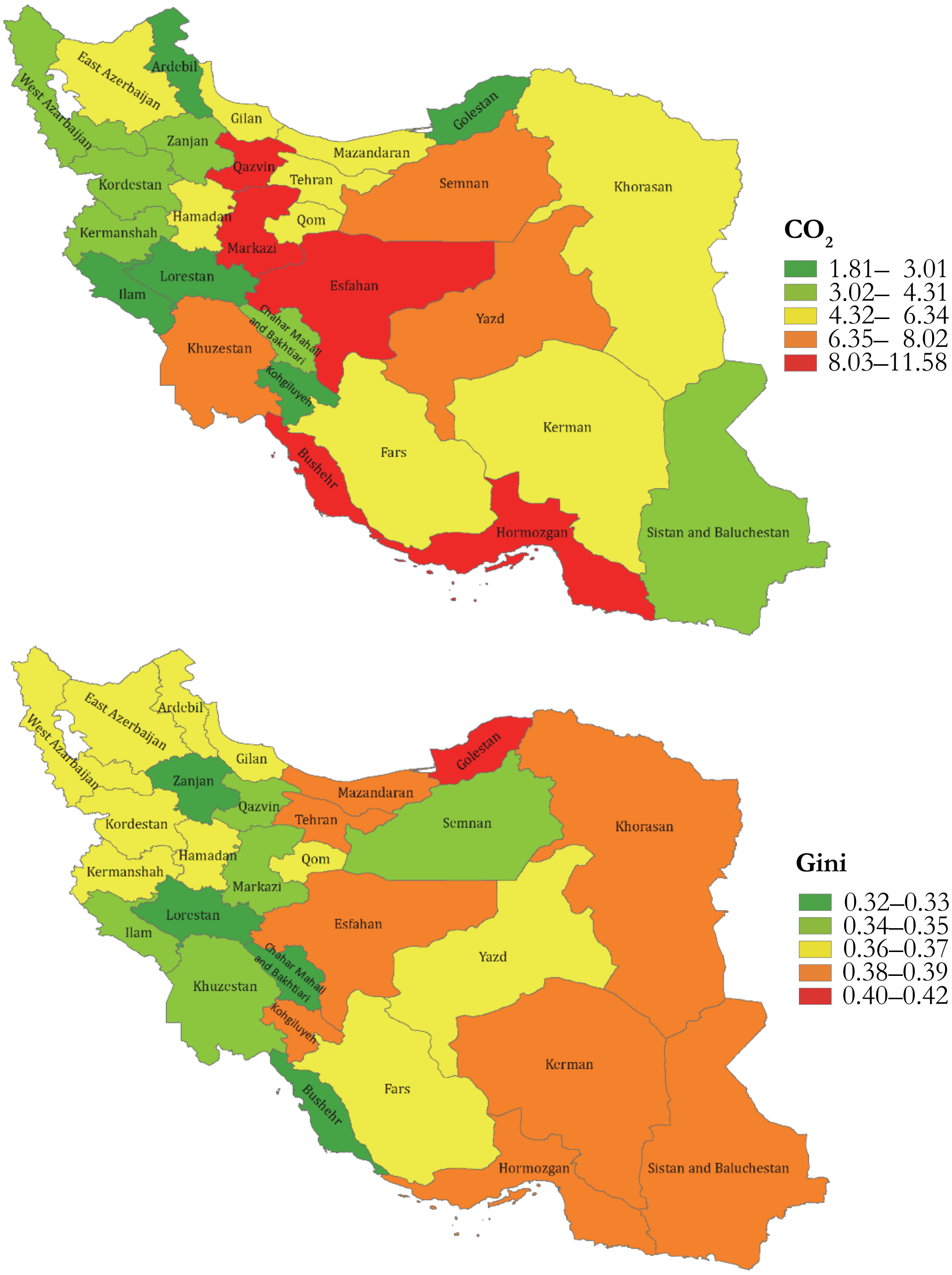
Table 2

Descriptive statistics of the provinces in Iran, 2005–2016

Variable	Mean	Maximum	Minimum	Std.dev
Ugini	0.344	0.469	0.233	0.043
Rgini	0.33	0.49	0.199	0.044
Gini	0.338	0.432	0.221	0.039
Pcec	114.596	683.8	33.138	77.356
Pcco2	6.553	38	1.81	4.463
Ur	65.92	96.743	46.035	11.907
Pd	82.557	821.24	5.954	128.491
Rgdppc	25.525	110.932	6.93	16.368

Figure 3

GIS maps of Iran's provinces
2005



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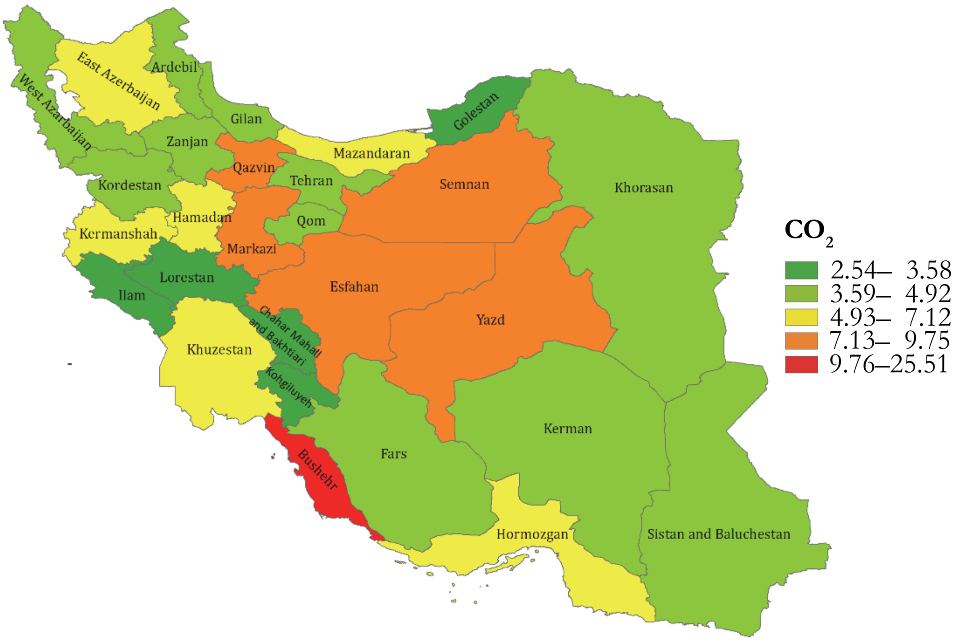
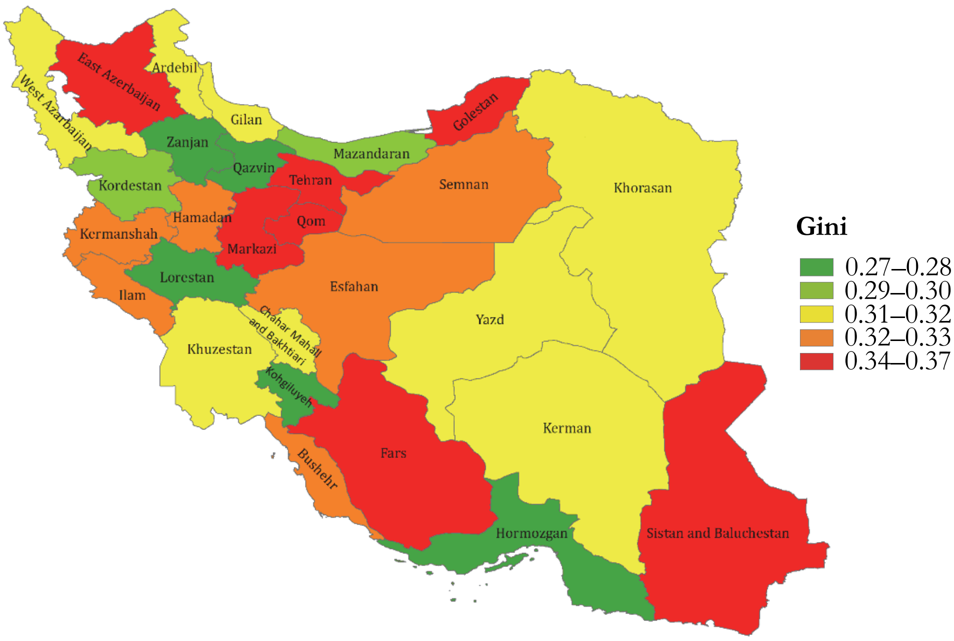
2011





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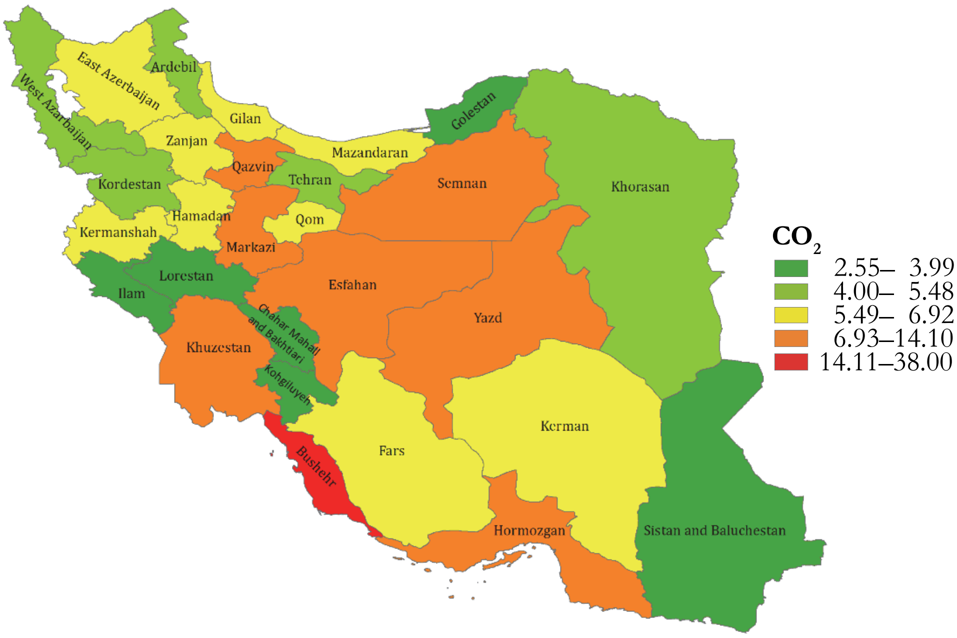
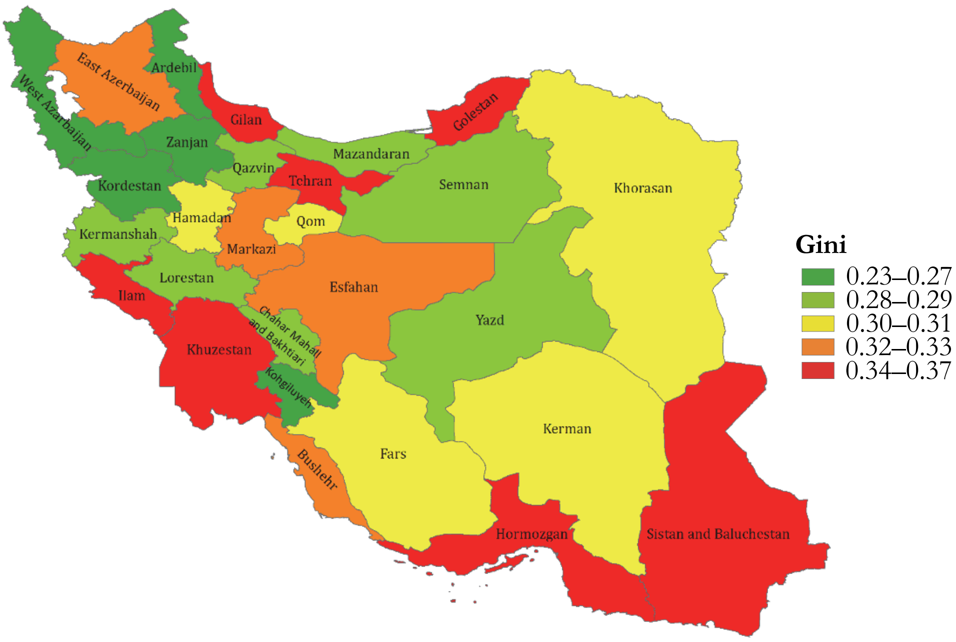
2016





The average Gini coefficient for the urban areas is higher than that for the rural areas, but in terms of dispersion (indicated by standard deviation), they are almost the same. The difference between the maximum and minimum values and changes in variables such as population, per capita energy consumption, and urbanization shows a high dispersion of these variables across the provinces of Iran. To better specify the position of each province in terms of the main variables used in this study (per capita CO_2 emissions and Gini coefficient), GIS maps of the provinces for the three periods of 2005, 2011, and 2016 are shown in Figures 3.

According to GIS maps in 2005, Bushehr, Qazvin, Hormozgan and Markazi provinces had the highest per capita CO_2 emissions in Iran. An important point to note is that the per capita CO_2 emissions in 2005 were higher in the central and southern regions. However, border areas in eastern and western Iran were in a better state. Furthermore, Golestan, Hormozgan, and Kerman provinces had the highest income inequality in 2005. In contrast, Bushehr, Chaharmahal and Bakhtiari, and Zanjan provinces had the lowest income inequality. As shown in the Figure 3, income inequality is mostly found in the central and eastern regions.

According to GIS maps in 2011, Bushehr, Qazvin, and Markazi provinces had the highest per capita CO_2 emissions. Kohgiluyeh and Boyer-Ahmad, Ilam, and Lorestan provinces have the lowest per capita CO_2 emissions. Compared to previous years, the level of income inequality in the whole country has decreased. Sistan and Baluchestan, Golestan, and Qom provinces had the highest income inequality, while Zanjan, Hormozgan, and Qazvin provinces had the lowest income inequality in Iran.

According to GIS maps in 2016, Bushehr, Yazd, and Hormozgan provinces had the highest per capita CO_2 emissions, while Kohgiluyeh and Boyer-Ahmad, Lorestan, and Chaharmahal and Bakhtiari provinces had the lowest per capita CO_2 emissions. Moreover, Tehran, Ilam, and Golestan provinces had the highest income inequality, and Kohgiluyeh and Boyer-Ahmad, Kurdistan and West Azerbaijan provinces had the lowest income inequality in the same year compared to the other provinces of Iran.

A review of the GIS maps plotted for income distribution in Iran indicates that during the years under study, income inequality has moved from the northwestern provinces to the southeastern provinces. In addition, in the early years, the regions located in the southwest of the country had a more equal income distribution than the other provinces, while during the same period, these provinces showed a trend toward unequal income distribution.

Although there are fluctuations in the Gini coefficient at the national level, this coefficient has seen a declining trend in the long run at the national level and in the provinces of Iran, and its value decreased below 0.35 in 2016.

B. Estimation results

Regression equations were estimated using the data for 28 provinces from 2005 to 2016. The results of estimating the equations for three modes (urban Gini coefficient as an inequality index, rural Gini coefficient as an inequality index, and total Gini coefficient as an inequality index) are presented in Table 3.

Table 3

The estimation results for the provinces of Iran, 2005–2016

Econometric model		1)	2)	3)	4)	5)	6)	7)
LPCEC		0.677*** (38.244)	0.657*** (31.02)	0.666*** (35.166)	0.693*** (25.187)	0.697*** (18.182)	0.688*** (19.666)	0.692*** (19.964)
LRGDPPC		0.017 (–1.314)	–0.00055 (–0.04)	–0.0096 (–0.959)	–0.353** (–2.116)	–0.148 (–0.8711)	–0.292* (–1.665)	–0.277* (–1.25)
(LRGDPPC)^2					0.081** (3.707)	0.056** (2.521)	0.079*** (3.668)	0.072* (1.855)
LPD		0.085 (0.255)	0.182*** (2.768)	0.122* (1.783)	0.15 (1.051)	0.242* (1.938)	0.18 (0.915)	0.65 (0.73)
UGINI		0.177* 1.743)			2.096*** (3.792)			
RGINI			0.297*** (4.006)			2.714*** (3.99)		
GINI				0.195** (2.35)			2.782*** (2.893)	2.431* (1.741)
UGINI* LRGDPPC					–0.629*** (–4.567)			
RGINI *LRGDPPC						–0.786*** (–4.179		
GINI *LRGDPPC							–0.842*** (–3.445)	–0.74*** (–1.855)
UR		0.006*** –8.54)	–0.007*** (–9.537)	–0.007*** (–9.565)	–0.007*** (–7.767)	–0.007*** (–8.699)	–0.0078*** (–8.328)	–0.0166 (–1.007)
UR^2								0.0000673 (0.563)
Sargan test (p value)		0.348	0.24	0.318	0.235	0.293	0.283	0.277
Arellano–Bond serial correlation test	AR(1)	0.000	0.000	0.000	0.001	0.005	0.002	0.000
	AR(2)	0.374	0.168	0.119	0.443	0.131	0.416	0.319
Obs./instrument		80/28	280/28	280/28	280/28	280/28	280/28	280/28

* Significance at a level of 10%. ** Significance at a level of 5%. *** Significance at a level of 1%.
Note: The values in brackets are t-statistics.

The p values of Sargan and Arellano–Bond tests for AR(2) of all models are higher than 10%, indicating the validity of the results. The real GDP per capita was used to measure the level of economic development. Given the significance level of the real GDP per capita coefficient and the real GDP per capita square and the sign of their coefficients, the U-shaped relationship between per capita income and per capita CO_2 emissions is confirmed. As real GDP per capita increases, per capita CO_2 emissions first decrease and then increase. Previous studies such as Hao et al. (2016) and Wang et al. (2011) for the provinces of China, Leitão (2010) for 94 countries, and Sanu (2019) for India have reported similar results. In contrast, studies by Shahbaz et al. (2018) in France, Apergis et al. (2017) in the United States, Alam–Adil (2019) in India, Shahbaz et al. (2017) in China, Wang et al. (2016) for sulfur emissions in China, Grunewald et al. (2017) for 158 countries, Awad–Abugamos (2017) for the Middle East and North Africa, and Kiliç–Balan (2018) for 151 countries have confirmed the inverted U-shaped relationship between the two variables. The N-shaped pattern between national income and carbon dioxide emissions was obtained by Mitsis (2021).

The negative impact of urbanization on carbon dioxide emissions indicates that environmental reconstruction dominates the impact of increasing economic activities (urban environmental transition theory). Studies by Awad–Abugamos (2017) in the Middle East and North Africa and Zhang et al. (2021) in the Chinese provinces reported similar results. Some studies have reported a positive relationship, such as Hao et al. (2016) for Chinese provinces and Martínez-Zarzoso–Maruotti (2011) for developing countries, inverted U by Zhu et al. (2012) for 20 emerging countries and Angulo et al. (2018) for 182 countries. However, some studies show a nonsignificant relationship, such as Rafiq et al. (2016) and Sadorsky (2014) for emerging countries and U-shaped by Shahbaz et al. (2016) for Malaysia.

The positive effect of population density on CO_2 emissions indicates that with increased population density due to a higher degree of industrialization and urbanization, CO_2 emissions increase as well. Studies by Uzair et al. (2020) in India, Pakistan, and Bangladesh, Rafiq et al. (2016) in emerging countries, Zhang et al. (2021), and Hao et al. (2016) in the provinces of China also found a positive relationship between population density and CO_2 emissions. In contrast, the negative effect of population density on CO_2 emissions has been concluded by Glaeser–Kahn (2010) and Timmons et al. (2016).

The positive coefficient of the Gini coefficient indicates that first, environmental pollution increases with the increasing income gap. However, higher incomes reduce the destructive effect of income inequality on CO_2 emissions. The threshold of real per capita income (million Rials) can be calculated according to the national Gini coefficient using the following equation:

$$\ln rgdppc = -\frac{\beta_4}{\beta_5} = 3.304 \quad \rightarrow rgdppc = 27.221 \tag{1}$$

At high-income levels, distributing income to the rich makes them more inclined to use cleaner technologies. In other words, at high-income levels, the use of clean technologies and improving environmental quality is a priority for rich people. Therefore, the luxury of environmentalism can be confirmed for the research sample. Thus, the impact of income inequality on CO_2 emissions in the provinces of Iran depends on the level of income.

Conclusion

In recent decades, more attention has been given to environmental quality in developing countries, as is the case in developed countries. Environmental pollutants have increased significantly in Iran in recent decades. Despite the declining trend of the global average per capita CO_2 emissions, this variable is still undergoing an upward trend in Iran, highlighting the significance of environmental research for Iran. Income inequality does not follow a similar pattern among the provinces of Iran. In recent decades, however, policies to reduce income inequality have been among the most important economic policies in Iran. Numerous studies have been conducted in different communities on the impact of income distribution on CO_2 emissions. However, given the lack of research in this field in Iran, the present study examined the impact of income inequality on per capita CO_2 emissions using data from Iranian provinces and employing GMM. Following some recent theories, the nonlinear and income-dependent relationship between income inequality and environmental quality was investigated. The controlled variables were urbanization, per capita income, per capita energy consumption, and population density. The results confirmed the U-shaped relationship between real GDP per capita and per capita CO_2 emissions. There was no nonlinear relationship between urbanization and per capita CO_2 emissions. Furthermore, urbanization was shown to negatively affect per capita CO_2 emissions. The data also indicated that per capita energy consumption and population density had a positive and significant effect on per capita CO_2 emissions. The results also confirmed the significant and nonlinear (income-dependent) effect of the rural and urban Gini coefficients on per capita CO_2 emissions. In the early per capita income levels, higher income inequality led to higher per capita CO_2 emissions, but after a threshold per capita income level, higher inequality served as a declining driver of per capita CO_2 emissions. In other words, at high-income levels, the redistribution of income from the poor to the rich reduces per capita CO_2 emissions. Accordingly, there is a need for income redistribution policy-making regarding fitting income levels in different regions of Iran to reduce per-capita CO_2 emissions. The negative effect of urbanization and the positive effect of population density indicate that the expansion of cities with low density can be presented to policy-makers. Considering the key role of energy consumption, improving technology and innovation to reduce energy consumption can reduce environmental pollution. These measures are significant for Iran, where there is a rising trend in energy consumption, unlike the world trend.

This study can be considered one of the early attempts to investigate the impact of income distribution on environmental quality. Further studies could focus on income inequality and other indices of environmental quality. Additionally, studies could be conducted on the factors affecting environmental quality in other provinces.

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