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Investigating the effect of economic policy uncertainty on CO2 emissions using TVP-FAVAR approach

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Abstract

Environmental degradation, global warming, and climate change have become dangerous factors and pose a serious threat to global security. One of these factors is the threat of greenhouse gasses, mainly caused by the emission of CO2 carbon dioxide. In an environment of uncertainty in economic policies, energy efficiency policies are also not effectively implemented due to weak regulations. Incompatible economic policies may also lead to higher energy consumption and thus greater environmental impact. Therefore, this study investigates the role of economic policy uncertainty on carbon dioxide (CO2) emissions in Iran during the period from 1979 to 2018 using the time series method of the factor-augmented vector autoregressive (FAVAR) model and the time-varying parameter (TVP) model proposed by Koop and Korobilis (2013). In addition to investigating the impact of economic policy uncertainty, the impact of globalization on CO2 emissions is also examined. The experimental results show that first, more energy consumption leads to more pollution; second, economic policy uncertainty reduces the quality of the environment; and third, globalization increases the destructive effect of energy consumption on CO2 emissions.

Keywords: Uncertainty, Economic Policy, TVP-FAVAR Approach, CO2 Emissions, Globalization
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1 Introduction

In today's world, climate change is one of the main problems that can affect sustainable economic performance in both developing and developed countries. The main reason for climate change is the concentration of carbon dioxide and other greenhouse gasses in the atmosphere. These greenhouse gasses cause global warming and alter global warming around the world. Therefore, it is important to understand the drivers of CO2 emissions. CO2 emissions are closely related to economic activities and the burning of fossil fuels [31]. Previous studies have shown that income (usually measured by GDP per capita) has a significant impact on environmental indicators [62]. However, income can reduce the level of pollution in developed countries because policymakers in these countries can consider health and other issues that may be more important than per capita income or economic performance. In addition, pollution and greenhouse gasses lead to global warming and climate change and threaten sustainable economic growth in both developed and developing countries.

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This study aims to improve the understanding of the relationship between energy consumption, economic policy uncertainty, and CO2 emissions due to economic growth for sustainable policy decisions in Iran. This study can help economic policymakers in Iran move toward the deployment of clean technologies and reduce barriers by recognizing the role of energy sources in reducing CO2 emissions. Given the uncertainty of economic policies in Iran and decision-making under uncertain conditions, especially in recent years and the tightening of sanctions to reduce pollution, it is necessary to focus on the uncertainty of economic policies and the sustainability of these policies before proposing different energy policies. And before presenting different strategies for energy use, the need for sustainability of the policy under different conditions should be emphasized. Namely, if the uncertainty of economic policies leads to an increase in CO2 emissions, the various economic policies and energy use policies must be coordinated so that conflicting policies do not worsen environmental conditions. Moreover, this study uses the FAVAR-TVP approach, which is able to study the effects of real fluctuations on independent variables and, in fact, considers the shock effect of different variables on the dependent variable. Given the many shocks and fluctuations in the Iranian economy, some of which are permanent and some of which are temporary, applying this method can be a great help in making the right policies in this area.

The remainder of this paper is organized as follows. Section 2 is an overview of the theoretical foundations and studies related to the present study. Section 3 presents the research model, Section 4 provides the experimental results, and finally, Section 5 concludes the paper and gives some recommendations.

2 Theoretical Foundations

Economic Policy Uncertainty (EPU) is considered to be representative of macroeconomic institutions as it includes uncertainty related to monetary, fiscal, trade and other macroeconomic policies. Accordingly, EPU can affect CO2 emissions in several ways. The first research direction has shown that EPUs increase CO2 emissions. EPUs worsened economic conditions, leading industries to choose cheaper and dirtier traditional energy (such as coal and oil) for production, which increased CO2 emissions. Jiang et al. (2019) conducted a new parametric test of Granger causality to assess the impact of EPU on CO2 emissions and found Granger causality from the United States' EPU to CO2 emissions. Pirgaip and Dincergok [54] used the bootstrap panel Granger causality test to examine the causal relationship between EPUs and energy consumption and CO2 emissions in G7 countries, and argued that EPUs have negative impacts on energy savings and emission reductions. In addition, Adams et al. [2] used data from economies with rich but crisis-prone resources to show a significant relationship between geopolitical risk, EPUs, energy consumption, economic growth, and CO2 emissions in the long run. This suggests that higher levels of EPU have a negative effect on carbon sequestration. This finding is consistent with the results of Anser et al. [7]. The second line of research shows that EPU reduces CO2 emissions. Azka and Eyup [10] showed that EPU had a positive economic effect on CO2 emissions in China. By constructing the China Provincial EPU Index, Yu et al. [78] suggested that the level of China Provincial EPU had a significant impact on the CO2 emissions of manufacturing enterprises. Adedoyin and Zakari [3] examined the role of EPU in the relationship between energy consumption, economy, and CO2 emissions in the UK. The results showed that the EPU played an important role in trying to reduce CO2 emissions. Moreover, Abbasi and Adedoyin [1] pointed out that economic policy uncertainty has little impact on China's CO2 emissions. In view of this, the objective of this study is to investigate whether or not EPUs have an impact on per capita CO2 emissions.

Economic policy uncertainty is mainly due to the frequent changes in macroeconomic policies and the unpredictability of policy implementation [33]. For its part, EPU also influences environmental policy. Guo et al. [34] found that uncertainty has a significant impact on environmental policy. Lecuyer and Quirion [44] argued that high levels of uncertainty have a positive motivating effect on the effectiveness of renewable energy subsidies. Meanwhile, environmental policy and regulation play an important role in achieving green development and quality economic growth. The relationship between environmental regulation and CO2 emissions has been hotly debated in recent years. There are two views on this issue: the "green paradox" and the "curbing effect". The concept of the green paradox, first proposed by Sinn [68], refers to a myriad of measures taken by policymakers to reduce CO2 emissions, which ultimately worsens the problem. Sein attributes the backwards-looking nature of the policy to the psychological expectation that environmental regulations will be gradually tightened, thereby accelerating the exploitation of fossil fuels. In contrast, other researchers have found that environmental regulation reduces pollution, also known as the "curbing effect" hypothesis. Zhang et al. [82] and Zhao et al. [84] showed that environmental regulation has a positive effect on reducing CO2 emissions. However, there are also studies that take a more neutral view. Wang [72] suggests an inverted U-shaped curve relationship between environmental regulation and CO2 emissions. In addition, some researchers have acknowledged that environmental regulation has indirect effects on CO2 emissions through transmission channels, such as industrial structure [76], energy structure [75], technological innovation [20, 52], and foreign direct investment (FDI) [72].

2.1 The relationship between economic policy uncertainty and CO2 emissions

Wang et al.[72] presented two effects of economic policy uncertainty (i.e., consumption and investment) on CO2 emissions. First, EPU hurts the economy as a whole and prevents recession [11]; second, it can limit the consumption of energy-efficient products and reduce CO2 emissions. The dampening effect of uncertainty on CO2 emissions is called the consumption effect. When economic conditions change, the demand for energy is affected. Jiang et al. [41] showed that EPUs can indirectly affect CO2 emissions through energy demand. The EPU causes a recession, which leads to a change in energy demand, thus affecting CO2 emissions. As a result, cheaper and traditional energy (coal and oil) is chosen by more industries due to the poor economic conditions [78]. Undoubtedly, the cheaper and poorer the energy consumption, the higher the CO2 emissions. In addition, the degree of uncertainty has a significant impact on energy prices, which may also affect the type of energy chosen by consumers. Balcilar et al. [12] show that EPU is an important driver of oil price fluctuations and that there is an asymmetric relationship between uncertainty and oil returns. Yang [77] shows that EPUs significantly affect oil price shocks and the causal relationship between them becomes more intense as the time scale increases. Regarding the consumption effect, lower production due to higher EPUs has somewhat reduced CO2 emissions. At the same time, the use of cheaper and dirtier energy increases CO2 emissions. Therefore, we can say that the whole effect is uncertain.

On the other hand, higher EPU interrupts investments in renewable and green energy, leading to an increase in CO2 emissions, which is called the investment effect. There is ample evidence that it reduces the uncertainty associated with the economic policy of business investment [19, 23, 48]. According to real options theory, corporate investment projects at various levels are irreversible and usually costly. Economic policy uncertainty increases the value of the expected option value, so firms become more cautious and prefer to postpone investment until they have more information to make decisions in the face of greater uncertainty [53, 15, 48]. Renewable energy investments, such as hydroelectric, wind, and biomass power plants, have a higher degree of irreversibility, typically characterized by a larger initial investment size and a longer return cycle. Renewable energy investments result in lower costs, and renewable energy-consuming companies inevitably delay their investments due to increasing uncertainty in economic policy. There is no doubt that declining investment, especially in the renewable energy industry, has increased CO2 emissions.

Specifically, there is a Granger causality model from economic policy uncertainty (EPU) to increasing CO2 emissions in the industrial, residential, electric power, and transportation sectors, but not in the commercial sector. Thus, EPU, along with the stability of other conditions, influences the level of carbon vulnerability across the continent [41]. Given the strong demand for energy and rising CO2 emissions, the causal relationships between energy consumption, economic policy uncertainty, economic growth, and CO2 emissions need to be better understood. In addition, non-renewable energy sources such as nuclear power and renewable energy play an important role in reducing CO2 emissions [24]. Therefore, the level of uncertainty in economic policies in countries is expected to be minimized and stabilized, as this will help determine how industries can cope with enacted laws and regulations on energy consumption.

Economic policy uncertainty (EPU) is described as uncertainty related to government policies, particularly monetary and fiscal policies that affect the economic activities in which companies operate [54]. Globally, economic and political uncertainty is due to global instability, which adversely affects economic activities [18, 32]. For example, the second conflict in the Persian Gulf in 2003 led to economic uncertainty in the global market [55]. Currently, Covid-19 has led to significant uncertainty worldwide [11]. The EPU has a significant impact on business activities, which in turn influences business decisions. In addition, the EPU can affect consumption and investment costs, which in turn can affect CO2 emissions. A reduction in renewable energy consumption and research and development due to greater uncertainty in economic policies can increase CO2 emissions [6]. The current studies show the impact of EPUs on CO2 emissions through sustainable public policies that can promote or destroy environmental quality. Hassan et al. (2021) found that political risk contributes to reducing CO2 emissions less, while some other specific factors such as economic, financial uncertainty or a combination of both increase CO2 emissions.

2.2 Literature on economic factors determining CO2 emissions

Zhang and Cheng [83] studied the relationship between economic growth, energy consumption, and CO2 emissions using the Granger causality test. They showed the significant influence of energy consumption and economic growth on CO2 emissions. Some studies have tested the Kuznets curve hypothesis and demonstrated an inverted U-shaped relationship between CO2 emissions (environmental degradation) and economic growth [8]. These studies link CO2 emissions to energy consumption and identify it as one of the main drivers of CO2 emissions [4, 69]. Recently, Sahoo and Sahoo [56] investigated the impact of renewable and non-renewable energy consumption on CO2 emissions using disaggregated data for India. The ARDL model results showed that hydropower consumption does not affect CO2 emissions; on the contrary, it reduces CO2 emissions. Moreover, non-renewable energy sources emit CO2. Similarly, Ummalla and Goyari [71] showed that clean energy consumption reduces CO2 emissions. On the other hand, economic growth and consumption of non-renewable energy sources exacerbate CO2 emissions. Other studies address the role of socioeconomic indicators. For example, Bano et al. (2018) concluded that human capital can affect CO2 emissions. Zhu et al. [86] pointed to the importance of FDI, arguing that FDI determines production levels, which in turn can lead to an increase in CO2 emissions. Similarly, international trade is recognized as a driver of CO2 emissions [50, 35, 63]. Other studies emphasize the role of innovation and technology as key drivers of environmental quality. Innovation and technology enable more efficient production, which in turn can reduce CO2 emissions. Thus, an inverse relationship between CO2 emissions and innovation and technology is confirmed [45, 82, 20]. CO2 emissions are also associated with financial market development [63, 57, 25]. Demand-side policies (such as monetary and fiscal policies) can significantly affect CO2 emissions. When monetary and fiscal policies are expansionary, aggregate demand in the economy increases, which in turn increases the derived demand. Increased derived demand ultimately leads to an increase in CO2 emissions [36].

2.3 Relationship between EPU, energy consumption and CO2 emissions

Previous studies confirm that energy consumption is often considered one of the main causes of pollution [13, 22, 66, 38, 39]. Regarding the relationship between energy intensity and environment, few studies provide empirical evidence [30, 64, 65]. An important aspect that has been overlooked in the literature is the role of economic policy uncertainty that can influence pollution through higher energy intensity. Economic policy uncertainty (EPU) can affect the business environment and, in turn, influence business decisions. However, CO2 emissions are closely related to the decisions of microeconomic units [41]. In an environment with inadequate regulatory measures, energy efficiency measures are likely to be compromised. Moreover, energy efficiency measures may not have the desired environmental outcome under such circumstances [70]. Poor environmental regulations provide a loophole for rent-seeking and corruption [72], thus increasing pollution [70]. Low economic growth forces the government to propose policies to promote growth, which can lead to ignoring the EPU and increasing CO2 emissions over time[41].

Weak environmental regulations channel dirty technologies from developed countries to developing countries in the form of foreign direct investment [60]. Moreover, increased economic growth and disregard for environmental regulations can mitigate any market failures that may lead to pollution [70].

3 Methodology

Even though the vector autoregressive (VAR) is a widely used technique to assess the success of monetary policy fluctuations on macroeconomic variables [42], the conventional VAR model has significant disadvantages and mainly addresses unexpected variations in monetary policies. Moreover, it relies on comparatively little information on business activities to retain flexibility. Moreover, without a very long history of data, employing this technique for an extensive system of variables is impossible [29]. As a result, it can lead to wrong decisions, such as the “price puzzle,” provided by [67]. Therefore, Bernanke and Boivin [16] and Bernanke et al. [17] employed factor analysis to extend the VAR model by including more data to examine the effectiveness of monetary policy shocks on macroeconomic variables in an information-rich context. In addition, structural breaks and instability of the estimated coefficients provided the basis for introducing a time-varying parameter factor-augmented vector autoregressive (TVP-FAVAR) model.

The FVAR model proposed by Bernanke et al. [17] is the starting point for specifying the TVP-FAVAR technique. Given the vector $X_t = (x_{1,t}, ..., x_{n,t})$, which represents the stable variable N’s vector with high dimensions. Each element X_t is supposed to be the sum of the linear composition G of the ordinary factor $F^{'} = (f_{1,t}, ..., f_{G,t})$ and a specific component $e_{i,t}$ in the standard dynamic factor model. Therefore:

$$x_{i,t} = \Gamma_i^{'} F_t + e_{i,t} \quad i \in \{1, ..., N\} \tag{3.1}$$

Where $e_t^{'} = (e_{1,t}, ..., e_{n,t})$, which is assumed to be orthogonal factors with uncorrelated specific errors, $E(e_t) = 0$, $E(e_t, e_{t'}) = R$, where R is a diagonal matrix. These assumptions establish a paradigm found across the literature as an FVAR. A factor dynamics can also be modeled as a VAR (P) (Eq. (3.2)):

$$F_t = B_1 F_{t-1} + ... + B_p F_{t-p} + w_{t'} \quad E(w_t) = 0, \quad E(w_t, w_t^{'}) = W \tag{3.2}$$

Equations (3.1) and (3.2) do not contain an intercept since it is assumed that $X_{i,t}$ is a zero-mean process. The VAR model in Eq (3.1) can be interpreted as a reduced form of a system as shown in Eq (3.3):

$$PF_t = K_1F_{t-1} + ... + K_pF_{t-p} + \mu_{t'} \quad E(\mu_t) = 0, \quad E(\mu_t, \mu_t^{'}) = S \tag{3.3}$$

Where P is a lower triangular matrix, i.e., its diagonal consists of ones, and is a diagonal matrix. We can assume that the parameters are fixed in four dimensions now that we have learned about the conventional FAVAR model with a fixed parameter structure: (1) The dynamics of factor autoregressive $(K_1, ..., K_p)$. (2) The matrix's simultaneous relationships. (3) The variance of factor disorder as elements of S in Eq (3.3). (4) Factor loading in Eq (3.1). Therefore, time-varying variables of Eq (3.1) and Eq (3.3), we have:

$$x_{i,t} = \Gamma_{i,t}^{'}F_t + F_t + e_{i,t} \quad i \in \{1, ..., N\} \tag{3.4}$$

And

$$P_tF_t = K_{1,t}F_{t-1} + ... + K_{p,t}F_{t-p} + \mu_{t'} \quad E(\mu_t) = 0, \quad E(\mu_t, \mu_t^{'}) = S \tag{3.5}$$

The specific component of Eq (3.2) is specified as a first-order autoregressive process (Eq (3.6)):

$$e_{i,t} = p_ie_{i,t-1} + \epsilon_{i,t'} \quad E(\epsilon_{i,t'}) = 0, \quad E(\epsilon_{i,t'}^2) = \sigma_i^2, \quad i \in \{1, ..., N\} \tag{3.6}$$

The elements $\epsilon_t = (\epsilon_{1,t}, ..., \epsilon_{N,t})^{'}$ are simultaneously uncorrelated. Consider that the parameters are summed by $(P_t, k_{1,t}, .., k_{p,t}, ..., \Gamma_{N,t})$ in α vector. The parameters, which change slowly over time, are assumed to have an independent random step process. It is assumed that the parameters, which change slowly over time, have an independent random step process.

$$\alpha_t = \alpha_{t-1} + \epsilon_{t'} \quad \epsilon_t \sim N(0, Q) \tag{3.7}$$

Where is the diagonal matrix, the number of parameters in the variance of the variable parameters over time in this specification of TVP-FAVAR is equal to FAVAR with a fixed parameter [27].

4 Experimental Results

In this study, the annual data from 1979 to 2018 including the variables of globalization, GDP, energy consumption, economic policy uncertainty and CO2 emissions were used as the main variables of the model. In addition, according to Baker et al. [11], the indices of government and tax expenditures as indicators of financial sector management, liquidity volume as an indicator of the monetary sector, and exchange rate margin as an indicator of foreign exchange policy were included in the TVP-FAVAR model to calculate the hidden variable of economic policy uncertainty. In this study, to model volatility, macroeconomic variables are used to extract the uncertainty data of the stochastic volatility model. The stochastic volatility model was implemented using two chains in the software to obtain Brooks-Gelman-Rubin (BGR) statistics and investigate the convergence of the posterior estimates.

After estimating the TVP-FAVAR model using MATLAB software and using 1 interval for the model variables, the results of the instantaneous response functions of the economic policy uncertainty variables are presented as a result of a shock in the model variables up to 10 periods.

In this study, Cholesky decomposition was used to calculate the instantaneous reaction function. The instantaneous reaction function results of the present study vary over time and therefore differ from previous studies in that they are plotted in three dimensions. The vertical axis of the instantaneous response function represents the instantaneous response values of the variables to the incoming shocks, and the horizontal axes indicate the execution time of the shock and the instantaneous response time of up to 10 cycles. The results of estimating the unobservable variables of the uncertainty index with the TVP-FAVAR model, the two-stage FAVAR model introduced in the study of Doz et al. [26], is shown in Figure (1).

From Figure (1), it can be seen that economic policy uncertainty had a steady trend and no fluctuations in the period before 1993, while it constantly increased from 1993 onwards. This may be due to the increasing currency fluctuations and increased liquidity. The trend of increasing uncertainty has increased since 2008, and especially since the 2010s, there has been a sharp increase in uncertainty in economic policy due to various reasons, including increasing liquidity and rising inflation, tightening sanctions, increasing currency fluctuations and people's uncertainty about the

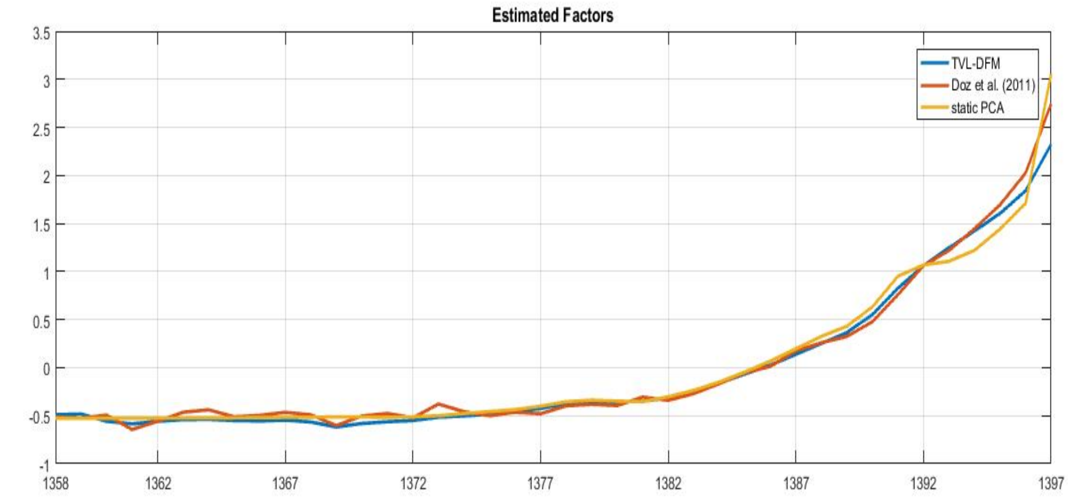

Figure 1: Uncertainty variable constructed according to the method of Doz et al. (2011)

economic situation, decreasing oil revenues due to sanctions, and the need for more tax revenues increase tax pressure on a number of companies due to the limited tax base in Iran and so on.

Figure (2) shows that applying a shock equal to one standard deviation of the economic policy uncertainty variable has led to an increase in CO2 emissions over time (on the horizontal axis). In other words, economic policy uncertainty has had a positive effect on CO2 emissions throughout the period under consideration. According to the diagram, the response function of CO2 emissions to changes in economic policy uncertainty is above the equilibrium level, which is marked zero on the vertical axis. An increase in the standard deviation of economic policy uncertainty in each period has increased CO2 emissions. As the graph with the arrow shows, the effect of the uncertainty variable on CO2 emissions has increased since the mid-2000s and has had a more intense effect on CO2 emissions since the 2010s. As uncertainty has increased since the mid-2000s, the impact on CO2 emissions has also increased. This result shows that economic policy uncertainty is stable and does not reduce CO2 emissions in Iran. These results contradict Festus Fatai Adedoyin [3] and Pirgaip and Dincergok [54] who showed that EPU is important in the short-term because it reduces CO2 emissions. Adams et al. [2] found that EPU and CO2 emissions have a strong relationship in the long run. This result is somewhat similar to that of Jiang et al. [41], although the authors found a significant correlation in the distribution sequence of CO2 emissions.

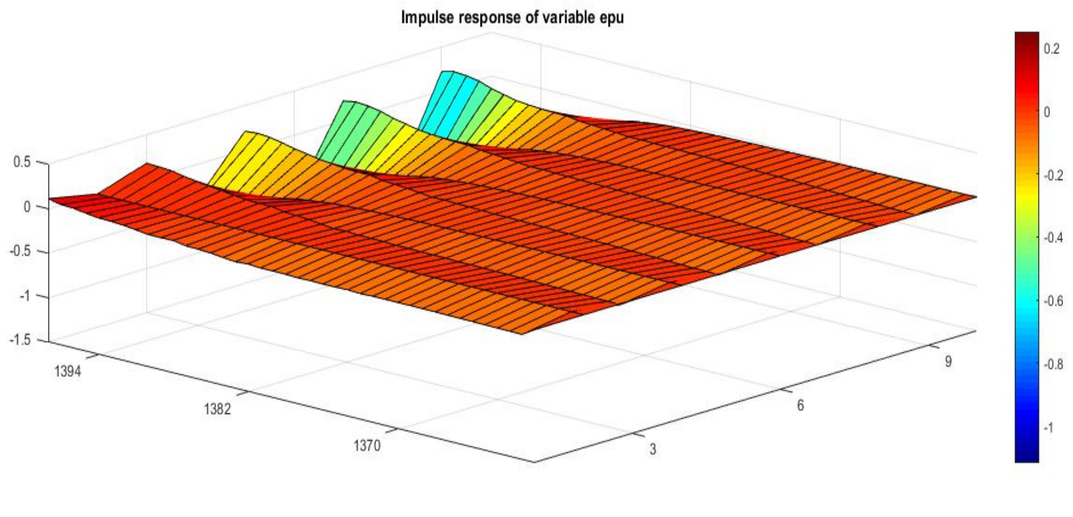

Figure 2: Instantaneous response functions of CO2 emissions to a shock to the uncertainty variable

In Figure (3), applying a shock equal to one standard deviation of energy consumption over time increases CO2 emissions over time (movement on the horizontal axis). Increasing the standard deviation of energy consumption in periods 2, 4, 7, and 10 had a higher effect on CO2 emissions. The results of Figure (3) also show that the impact of the energy consumption shock has further increased CO2 emissions since 2001. This shock, as shown by the arrow, first increased CO2 emissions slightly, then had a strong effect on pollution in the early 2010s, and then increased again smoothly from the early 2000s. In fact, with the intensification of energy consumption, CO2 emissions increased in line with energy consumption, and in the early 2010s, with the imposition of sanctions and the greater use of fossil fuels, CO2 emissions first increased sharply and then continued to increase evenly. Lin and Xu [47] found that CO2 emissions increased due to the production of nonrenewable energy. Our results also support Ãng (2007) that economic development has a long-term influence on the growth of resource consumption and emissions. Ahmad et al. [4] also pointed out that energy consumption is an important indicator of CO2 emissions and increases the growth of CO2 emissions in China.

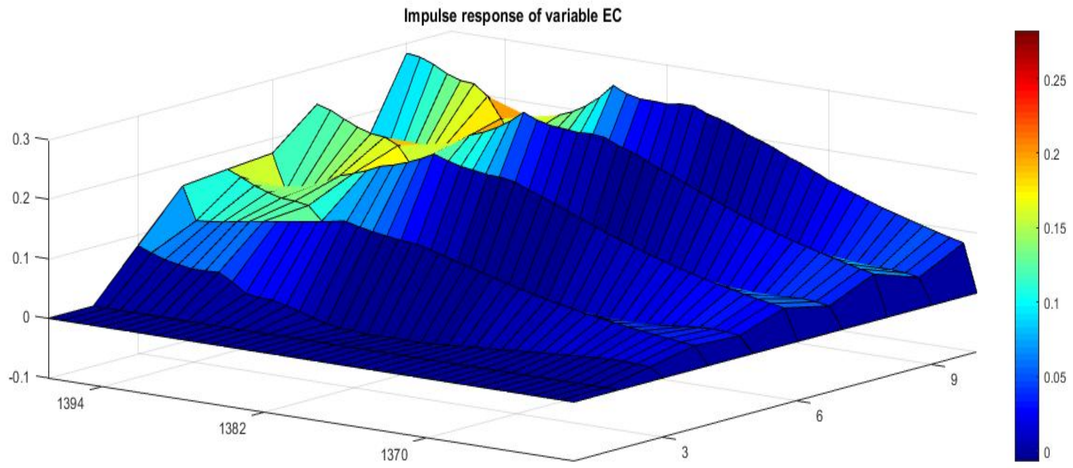

Figure 3: Instantaneous response functions of CO2 emissions to a variable energy shock

Applying a shock equal to one standard deviation in globalization has a significant effect on CO2 emissions. The diagram shows that globalization has a positive effect on CO2 emissions in the periods under study, with an upward trend in this effect in recent periods and in recent years. As shown in the graph, the globalization shock has increased CO2 emissions since the early 2000s. In the early 2010s, it had a strong effect on pollutant emissions, which is consistent with the variable results of energy consumption, and after that, this increase in pollutant emissions was rather small. In fact, with the tightening of sanctions and the withdrawal of foreign countries from exports, Iran has also shifted to more polluting industries, which has led to an increase in CO2 emissions.

As shown in Figure (5), the effect of the GDP shock on CO2 emissions is positive during the period studied. The diagram shows that there is an increasing trend depending on the time period and also on the years under consideration, with an increasing impact in periods 1, 4, 7 and 10 starting in 2004. As can be seen from the arrow, the GDP shock slightly increased CO2 emissions from 2004 and then had a strong impact on pollution in 2011, after which the shock was renewed evenly, yet more intensively than in 2001. In fact, it can be said that in the last two decades, the increase in GDP has been accompanied by an increase in the production of polluting industries, which has led to more CO2 emissions. Especially in the 2010s, this problem has worsened, which requires a change in energy use policies in the production of various industries. The experimental result confirms that there is a relationship between GDP and CO2 emissions. The correlation is positive, showing that the increase in GDP contributes to an increase in CO2 emissions. These results are consistent with those of Chen et al. [19], who showed that the growth of non-renewable resources and GDP increases CO2 emissions. Lera-López and Marco [46] showed that CO2 emissions increase as a result of economic growth. In addition, Wang et al. [73] reported that increasing GDP increases CO2 emissions.

Figure (6) shows that the application of a standard deviation shock to CO2 emissions has led to an increase in CO2 emissions over time (movement on the horizontal axis), which had no effect in the first to third periods, but has the largest effect in subsequent periods, especially in period 10. In fact, in accordance with the effects of other variables, the increase in CO2 emissions has led to more pollution and shows that the government policies to reduce pollution have not yet had an impact on reducing pollution and that it is necessary to consider fundamental changes in environmental policies.

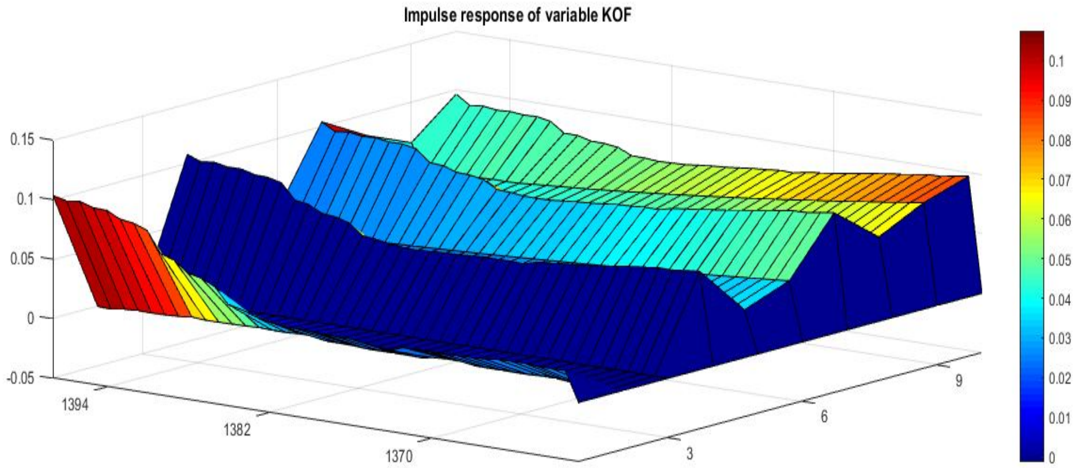

Figure 4: Instantaneous response functions of CO2 emissions to globalization variable shocks

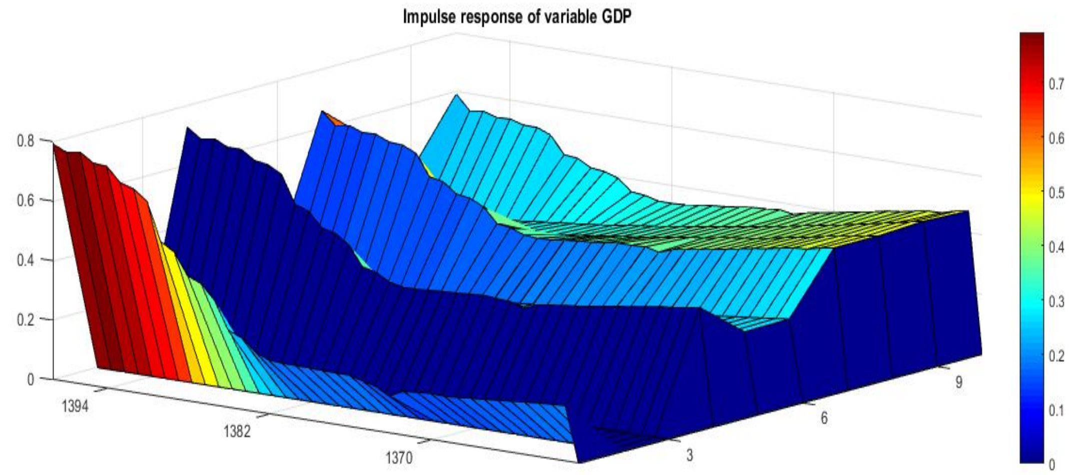

Figure 5: Instantaneous response functions of CO2 emissions to GDP variable shocks

5 Conclusions and Recommendations

In the present study, the impact of economic policy uncertainty on CO2 emissions was investigated considering energy consumption. Indeed, the role of energy policy uncertainty should also be considered in energy policy, as unpredictable shocks may prevent government energy policies to reduce CO2 emissions. Therefore, this study examines the effect of uncertainty on CO2 emissions during 1979-2018 using the TVP-FAVAR model and the variables globalization, GDP, energy consumption, uncertainty, economic policy, and CO2 emission (dependent variable) as proxies for pollution.

The results show that uncertainty shocks increase CO2 emissions. In fact, higher uncertainty discourages innovation, RandD, and technology, which in turn can increase CO2 emissions. In addition, high EPUs can shift policymakers' focus from environmental policy to economic policy. In addition, higher uncertainty may lead producers to move from the formal to the informal economy, where production is more energy-focused and has lower technological levels due to significant energy subsidies and access to cheap energy in Iran, which increases CO2 emissions. Thus, a lack of focus on environmental protection measures can increase CO2 emissions. Energy shocks increase pollution, suggesting that clean energy policies to reduce pollution have not yet been implemented in Iran or, if implemented, have predictably failed due to sanctions and lack of access to advanced technologies and innovations. Experimental results show that the shock of globalization increases CO2 emissions. As globalization increases due to global trade and investment, energy

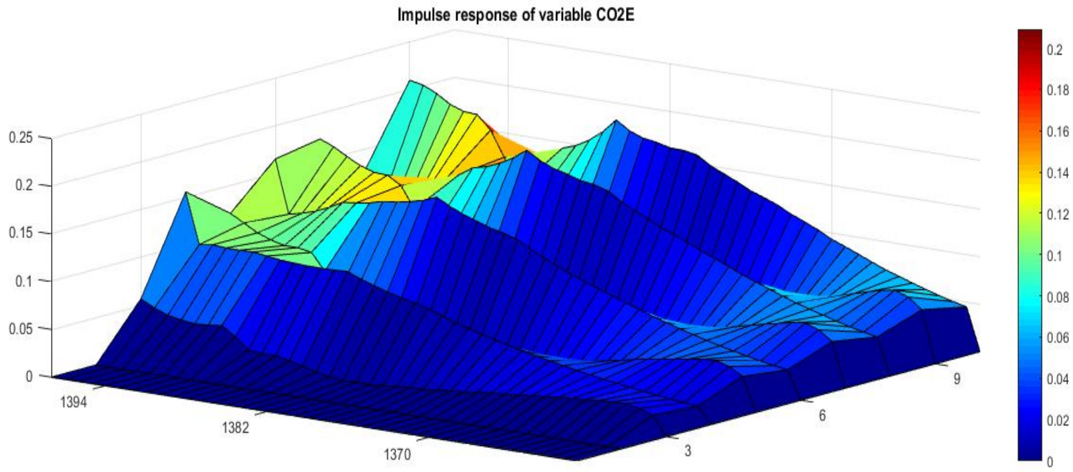

Figure 6: Instantaneous response functions of CO2 emission variable

consumption also increases because Iran mainly produces oil and petrochemical products for export, indicating that the scale effect is dominant in Iran. The government needs to take precautionary measures to shift the industry from traditional forms of energy to cleaner and renewable energy sources. Looking at the positive impact of globalization on CO2 emissions in Iran, we can say that for Iran, as for most developing countries, the pollution haven hypothesis is confirmed. A GDP shock increases CO2 emissions. These results show that CO2 emissions cannot be limited by growth and development alone, so further steps are needed. Optimizing energy quality is the best option to reduce CO2 emissions and keep economic output constant.

The results show that uncertain economic policies in Iran have increased CO2 emissions and pollution, especially in the recent decade, in which case the tightening of sanctions and reduced interaction with the global economy has also been effective. In fact, economic growth in Iran and exports have always been associated with increased pollution since the early 2000s, which shows that sustainable growth and development have indeed not been among the important goals of policymakers in Iran and have always been focused on increasing short-term economic growth. Short-term economic policies have led to a further increase in environmental pollution, which has also endangered people's health in recent years. Therefore, in implementing economic policies that use energy to increase economic growth and development and increase exports, policymakers must pay attention to reducing pollution and reducing CO2 emissions. An alternative to reduce CO2 emissions could be a combination of green energy such as solar, bioenergy, and wind energy. Also due to the fact that a large part of fossil energy consumption in Iran is in the industrial sector, in order to reduce excessive fossil fuel consumption and encourage producers to use renewable energy and green technologies, energy prices need to be raised and energy subsidies reduced. It is also necessary to increase interaction with the global economy, use and actually export new technologies that are less harmful to the environment, focus on less-polluting industries, and thereby achieve economic growth and development with less CO2 emissions. Moreover, the results show that despite the high CO2 pollution, the policies implemented by the government so far have not had an impact on reducing pollution, which needs to be revised. Instead of short-term economic policies to increase GDP and exports, long-term policies to reduce CO2 emissions while increasing economic growth and development must be considered, and economic growth and development policies must be consistent with environmental protection policies.

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