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Investigating the Asymmetric Effects of Open Economy Indicators on the Gini Coefficient of Income Deciles in Iran

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Abstract

The purpose of this article is to analyze the impact of open economy indicators including economic openness and foreign direct investment on income distribution in Iran during the years 1996 to 2018. For this purpose, we use fuzzy regression with asymmetric coefficients. The reason for using it is very high flexibility in analysis. For each income decile, an optimal model is estimated that shows the effect of open economy indicators on the Gini coefficient of income deciles. The results show that the average effect of foreign direct investment on the Gini coefficient of income deciles is zero or very small and reduces inequality. But the maximum impact of foreign direct investment on the Gini coefficient of income deciles has increased, which leads to inequality in income distribution. This is due to the lack of appropriate programs and policies in the economy, so that we can use the opportunity of foreign direct investment to reduce inequality. Also, the results show that the maximum effect of the degree of economic openness on the Gini coefficient of income deciles is zero, which means that the degree of economic openness does not increase inequality. In order to strengthen or weaken foreign relations. Therefore, the amount of subsidy paid to each of the income deciles provides the infrastructure needed to attract foreign investment and provides measures for the treasury to tax the income deciles.

Keywords: Gini Coefficient, Asymmetric Coefficients, Fuzzy Regression, Open Economy Indicators.

JEL Classification: I32, I 38, O33, O34, O38.

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1. Introduction

Today, international trade plays an essential role in economic life. The volume of world trade has increased significantly in recent decades and it can be seen that the countries that have gone ahead with the policy of export development instead of import substitution have moved towards further industrialization and development, so trade has a significant effect on progress and prosperity. Economic has an effect on income inequality by increasing trade with other countries and increasing the share of trade in GDP. The Gini index, or Gini coefficient (income inequality) is a measure of the distribution of income across a population developed by the Italian statistician Corrado Gini in 1912. Income inequality is one of the similarities between developing countries and is a problem that most societies have faced in different eras. Also income inequality is the cause of many other problems, such as increased mortality, reduced fertility, and insecurity. Poverty in any country depends on two factors: the average level of national income, the degree of inequality in income distribution. It is clear that at any level of per capita national income, the more unequal the distribution of income, the greater the poverty. Unequal income distribution increases class gaps, reduces incentives to work, widespread poverty, political conflict, and pervasive corruption Angeles (2011), Chintrakarn (2012), Akmal (2007). Today, international trade plays an essential role in economic life. The content of global trade has increased significantly in recent decades. Trade has a great impact on economic development. Many factors affect the level of income inequality. These factors are divided into five categories: economic growth and development, demographic factors, political factors, historical, cultural and natural factors and macroeconomic factors. One of the factors that has recently been considered by researchers is globalization. In most domestic studies, only the indicator of trade openness has been discussed. In addition to foreign direct investment trade is also discussed Gemmell et al (2008), Feenstra et al (1997), Nawazish et al (1998), Tsai et al (2007), Salvatore et al (2007), Unctad et al (1996), Richardson et al (1995), Spencer et al (1986).

Fuzzy sets were introduced by L. A. Zadeh (2011). After introducing this notion the use of fuzzy data for modeling uncertain information in databases were

considered, and that is where the need to expand the Takagi-Sugeno-Kang (TSK) model was felt. Most of the researchers in this area have been focused on the development of the basic model and query language in order to display and retrieve uncertain data. Since then, modeling and regression analysis in fuzzy environment have been considered by theoretical and applied researchers Draeseke et al (2002), John et al (2005), Lindström et al (1998), Ganjoei et at (2020) . Linear regression with fuzzy coefficients was first introduced by Tanaka et al. In 1982. They considered the linear regression model with fuzzy coefficients. Since then, many researchers have studied its various aspects Asai et al (1982).

The main focus of this study is to present an application of the introduction of fuzzy logic in regression discussions. For this purpose, the effect of open economy indicators and the expansion of trade relations on the Gini coefficient of income deciles is analyzed. This study is important in various ways, including examining the trend of income distribution among income deciles. Therefore, economic planners and government officials can make appropriate decisions to strengthen or weaken trade relations, Tax collection rate or Payment of subsidies. The innovation of this study is outstanding in that although many domestic and foreign studies have examined economic openness and foreign direct investment on income distribution, and by using econometric methods including classical regression, the relationship and the degree of influence of the mentioned variables They have examined the distribution of income. Including Elias et al. (2023), Fauzel (2022) and Pant (2021), econometric methods have been used in all these studies. But in this study, using fuzzy regression with symmetric coefficients, values for each parameter and output variable, which is the Gini coefficient of each of the income deciles, have been estimated. Also, with the help of fuzzy regression with asymmetric coefficients, the non-linear behavior of the variables has been investigated. In each of the mentioned estimations, the fuzzy center and width have been calculated, so it can be said that fuzzy regression works more efficiently than normal regression, because in classical regression, only one specific value is calculated for the variables. The rest of this research continues in six sections as stated in the following. In section 2, we present a literature review. Section 3, presents the data description. Section 4, presents the

methodology of the research. Section 5, empirical results. In section 6, discussion and conclusions.

2. Literature Review

World trade has dynamically transformed closed economies into open economic systems. In this regard, we can refer to Adam Smith's theory of absolute advantage in 1776, in which countries were encouraged to produce and export goods in which they had an absolute advantage. After Adam Smith, Ricardo proposed the theory of comparative advantage, known as the theory of comparative cost. In this view, Ricardo proved that any country that has a comparative advantage in the production of a good or service, even if it does not have an absolute advantage, will be successful Spencer et al (1986). Its benefits will accrue to all countries that engage in this exchange. Heckcher - Ohlin proposed the theory of abundance, and other economists such as Johnson, Jonah, Stalper, and Samuelson completed it. According to this theory, each country will export goods for the production of which it has used its abundant resources in relatively large quantities, and will import goods whose production factors are scarce in the country. Harberler proposed the theory of imperfect division of labor, arguing that the division of international labor and international trade gives any country that enters the world economy the ability to specialize in the production of goods that are better produced and exported. And it is cheaper possible. In terms of international labor sharing and world trade, it leads to economic prosperity and increased national income Stępień et al (2009).

On the other hand, the impact of trade on welfare and the reduction of poverty and inequality can be expressed in such a way that the country's trade with the outside world changes the price of tradable goods in countries. It also provides better access to new goods and products. Trade also affects government revenues from commercial taxes. If trade is free with low prices of imported goods and competition with domestically produced goods and a decrease in the general level of prices, people's real incomes will increase, especially in the lower income classes of society, and will affect income inequality. Also, increasing exports is an

incentive for more production and income, which will lead to more employment and higher wage levels. Government policies to increase trade lead to increased revenue. For example, the government reduces the perception of corruption and smuggling by lowering high tariffs. Therefore, the impact of trade on welfare and income inequality can be categorized as follows: First: changing the price of tradable goods and their better and easier access to new products, Second: the change in the relative wages of skilled and unskilled labor and the cost of capital and thus the impact on the employment of poor people, Third, the impact of government revenues from commercial taxes and its ability to finance programs for the poor; Fourth: Changing investment and innovation incentives and impact on economic growth, Fifth: The effect of economic vulnerability to negative external shocks Basu et al (2007), Minhas et al (1986), Salvatore et al (2007). Regarding the effect of foreign trade on income distribution (ID), the studies have evaluated its commercial liberalization and globalization Meschi et al (2009), Muellbauer et al (1974), Bhagwati et al (2002), Ravallion et al (2007).

Unemployment and inflation are used as an internal factor and the economic openness index is used as an external the effective factor on ID Georgiou et al (2010), Easterly et al (1999). Assuming that the economic openness to foreign trade and investment are the most important indicators for economic globalization, in recent years, the study of the relationship between poverty and globalization process and the effect of such reforms on income distribution and poverty has been considered by many economists as politicians Muellbauer et al (1974), Babazade et al (2010). In fact, no general agreement has been yet made regarding the effect of economic openness on poverty and it is become one of the controversial issues in the globalization literature Lim et al (2014). The survey of foreign trade and income distribution using the input-output model in Brazil showed that the effect of trade expansion led to more equal income distribution than the alternative policies Bhagwati et al (2002). Some researchers believe that the poor would benefit from the trade liberalization Ravallion et al (2007) , where many others disagree with this theory and believe that these benefits are achieved by wealthy individuals of the society Lim et al (2014. Moreover, in other studies on the relationship between trade openness and poverty, it is shown that there is an inverse relationship between

trade openness and poverty, but it is difficult to confirm that trade openness works as a powerful force in reducing poverty in developing countries Champernowne et al (1974), Ravallion et al (2007). Meschi et al (2009) used a sample of 65 developing countries during 1980-1999 to study the effect of trade on income inequality in developing countries and found that trade (either through imports or exports) with high income countries led to worse income distribution. Gundlach et al (2010), showed that trade improves the welfare, but its direct effect on income distribution is low. This effect should be improved using appropriate policies; however, if these policies were not made properly, the trade profit would be neutralized or minimized. Martinez et al (2010), concluded that the per capita income of people had a positive relationship with two-way trade flow and in distribution. Once a two-way trade was formed between two countries, the country with better income distribution would have higher exports and, if a country had better income distribution by 10%, it would have higher export by about 4% Nixson et al (2006). Pant et al. (2021) have investigated the dynamic effect of trade openness on poverty in India. In this study, panel data method is used. The results of this study show that the process of trade liberalization followed in India (which led to an increase in the level of exports and imports) has helped to increase the level of per capita income in the economy. This has had a significant impact on poverty reduction, as it has led to a reduction in the incidence of poverty. Rezak et al. (2022) investigated the impact of foreign direct investment (FDI) on income inequality in Egypt during the period from 1975 to 2017. The results of this study show that Egyptian policymakers should continue and strengthen the open-door policy, because it has more benefits in improving income inequality.

Fazuel et al. (2022) have investigated the impact of trade on poverty reduction in the period of 1990-2017. Vector error correction model (VECM) is used in this study. Also, the differences of opinion about the impact of trade on poverty have been analyzed because some emphasize that trade can create new jobs. The results of this study show that poverty has no effect on reducing poverty in the short term, but it will reduce poverty in the long term. Akios et al. (2022) have investigated the long-term relationship between trade liberalization and income inequality. In this study, the panel model is used for 15 EU countries in the period 1985-2017. The

results show that there is no evidence that trade liberalization and income inequality have a long-run cointegration relationship. Elias et al. (2023) have investigated the impact of foreign direct investment and trade openness on poverty using annual data for the period 1990 to 2021 in sub-Saharan African countries. ARDL model is used in this study. The results of this study show that foreign direct investment in a short period has no specific effect on poverty. The study suggests to government officials, policy makers and investors to invest more in poor countries. As FDI is very important in creating jobs for the unemployed population which leads to increase in income. Taheri Far et al. (2023) have investigated the impact of economic openness and international trade on income inequality. In this study, a panel model consisting of 71 developing and developed countries for the years 1994-2017 has been used. The results of this study show that the openness of the economy will reduce inequality up to a certain level and then it will increase inequality.

2-1. A review of theoretical foundations

One of the significant topics in the literature of international economics is the study of the relationship between international trade and income inequality. In this section, the effects of trade liberalization on income distribution from the point of view of commercial theories are considered. The Heckscher-Ohlin model, as the standard model of international trade, considers the relative abundance of production factors (land, natural resources, labor and capital) as the main factor determining the relative advantage of countries. Therefore, a country that has a relatively large amount of capital will specialize in the production of capital goods and export them, and in contrast to a country that has a relatively abundant workforce, it will export them, especially in the production of consumer goods. According to the provisions of this theory, developed countries in their trade with developing countries export goods and services that rely on skilled labor and import goods and services that rely on low-skilled labor. Following the liberalization and removal of trade barriers, the intensification of trade between these two groups of countries will decrease the demand for unskilled workers in developed countries,

and this decrease in demand, assuming the stability of other conditions, leads to a decrease in their relative wages, the magnitude of this impact Wages depend on the sensitivity of wages to changes in demand. In countries with flexible wages, increasing trade with developing countries will lead to a decrease in the relative wages of low-skilled workers, and in countries with more inflexible wages, increasing trade with developing countries will mainly lead to more unemployment of low-skilled workers. (Salvatore, 2004).

Another point of view, which was first expanded and developed by international economists, results from the Stapler-Samuelson theorem, which will be discussed briefly. According to the Stapler-Samuelson theory, the increase in the price of domestic goods due to the imposition of higher tariffs or non-tariff protections (such as the imposition of quotas) will increase the real price of institutions that have a greater share in the production of that commodity. To put it more clearly, in a small country, the tariff increases the price of imported goods compared to exported goods to the amount of the tariff. As a result, the demand and, accordingly, the relative wages of institutions that use more intensively in import substitution industries will increase compared to those that use less intensively. Since import substitute goods use more institutions, which are rarer in the country, therefore, with the imposition of tariffs, the relative price of this institution increases. Therefore, the liberalization of trade and the reduction of tariff support for factory goods that use relatively more unskilled labor will cause the real wages of this group of workers to decrease compared to the wages received by skilled workers. According to the provisions of this case, the liberalization of trade in any country will increase the demand for the production of institutions that are relatively more abundant in that country, and as a result, the price of that input will also increase. Since skilled labor is abundant in developed countries and unskilled labor is abundant in developing countries, free trade between these two groups of countries will increase the demand and wages of skilled workers in rich countries, but in developing countries, demand will increase. And the wages of unskilled workers will be increased. As a result, trade liberalization in developing countries, unlike developed countries, will reduce inequality.

On the other hand, according to the new theory of trade, in developed countries, the production of factory goods is mainly in the form of imperfect competition, and specialization in it leads to lower costs through economies of scale. Therefore, with the removal of trade barriers, export incentives will increase. One of the predictions of this theory is that trade between industries will be more among countries that have similar income, taste and production structure, and in this case, trade will be beneficial, because with the increase in production scale, production costs and therefore The price of goods will decrease, but the prediction of this theory regarding the effects of trade between industries on relative wages is vague, and the change in demand and therefore the wages of the workforce with high or low skills depends on how the production of some goods decreases and some increases. The demand for unskilled workers depends on the type of technologies used in enterprises and how these technologies change in response to changes in production levels. Therefore, it is possible for developed countries to export goods based on skilled labor, just as it is possible for them to export goods based on unskilled labor. However, it is clear that society always benefits from lower prices and higher consumption possibilities, and in this transfer of resources, a group will definitely suffer losses (Salvatore, 2004).

3. Data Description

Economists divide the population of each society into ten ranks called deciles, in terms of income and consumption. The first decile represents ten percent of the least expensive households. Here we depict ten figures. The first to fourth income deciles are represents in Figures 1-4. In Years 2011-2013 income inequality has increased compared to other years. Figures 5-7 represents the fifth to seventh income deciles. These deciles have many fluctuations. Figure 8 represent the eighth income decile, as we can see, income inequality has decreased in 2009. The ninth and tenth deciles are represents in Figures 9-10. The amount of inequality is rising in the tenth deciles. Also open economy indicators include foreign direct investment (FDI) and economic openness (OPEN). Figures 11-12 represents OPEN and FDI, where OPEN is increasing over time and FDI has unstable behavior. Income decile

analysis data during 1995 - 2018 is taken from the Central Bank of Iran website (www.cbi.ir) and Statistical Center of Iran (www.amar.org.ir).

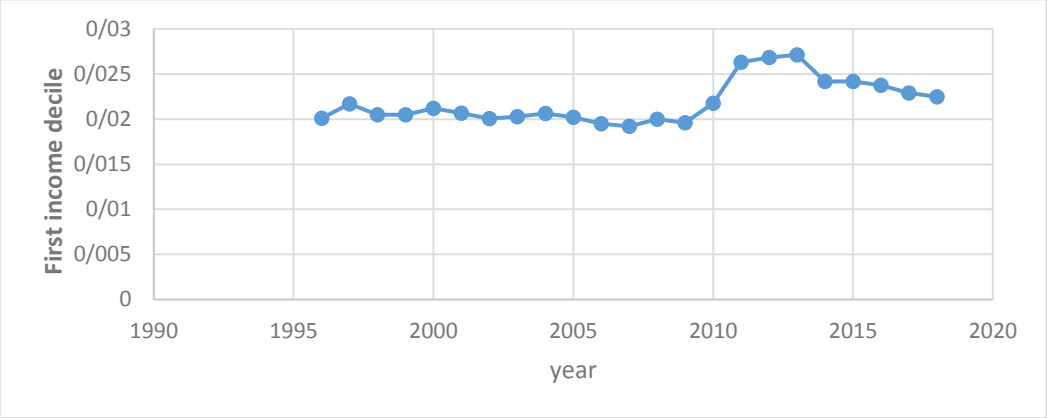

Fig. 1: First income decile

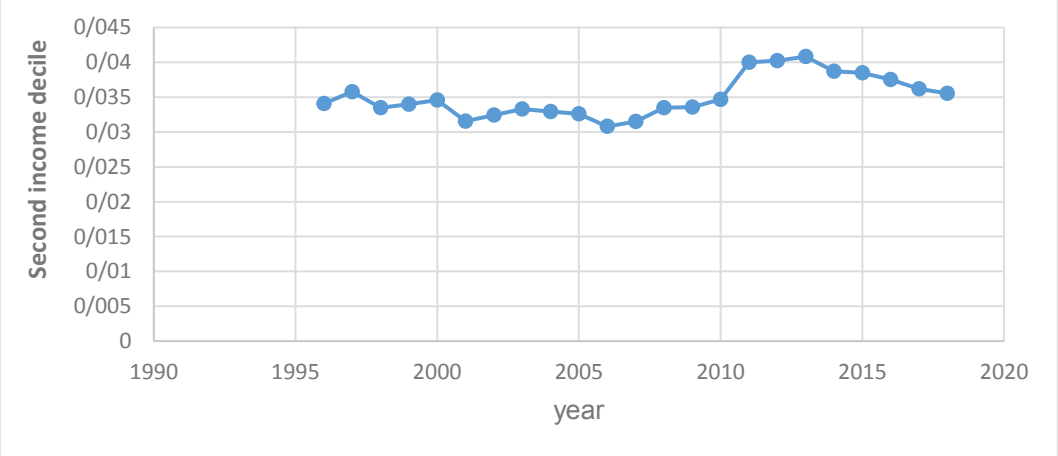

Fig. 2: Second income decile

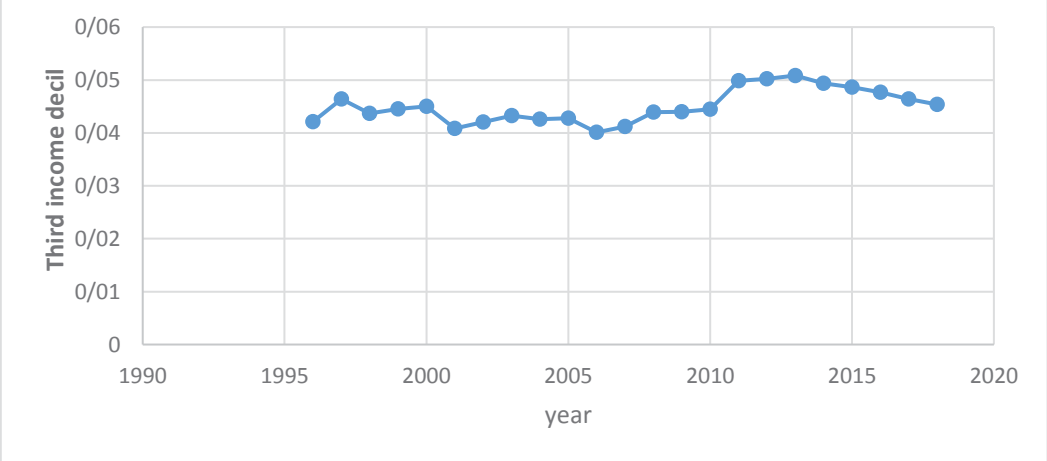

Fig. 3: Third income decile

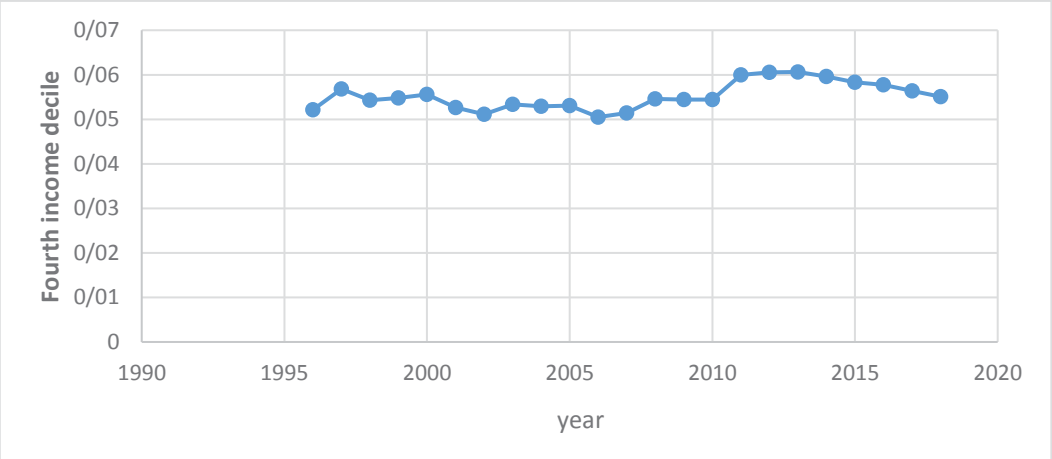

Fig. 4: Fourth income decile

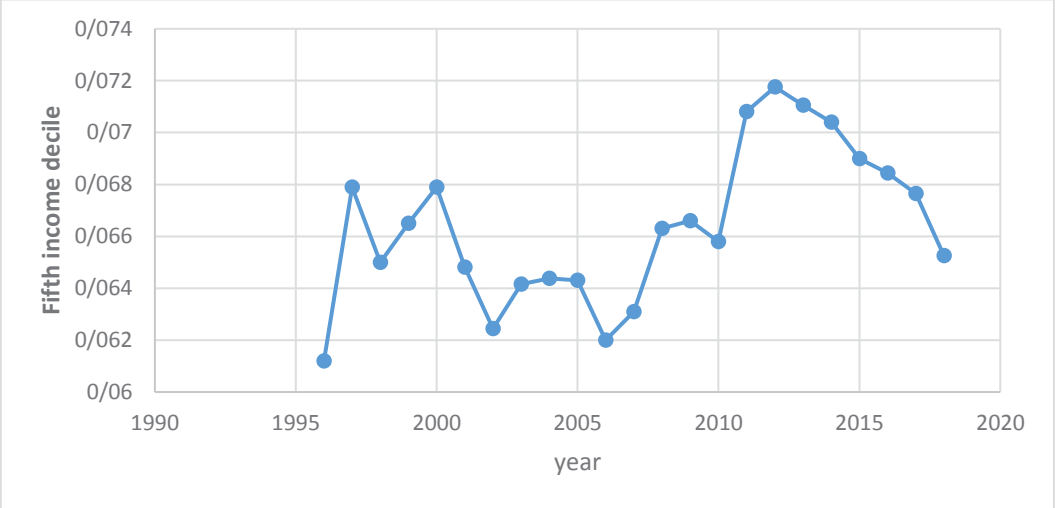

Fig. 5: Fifth income decile

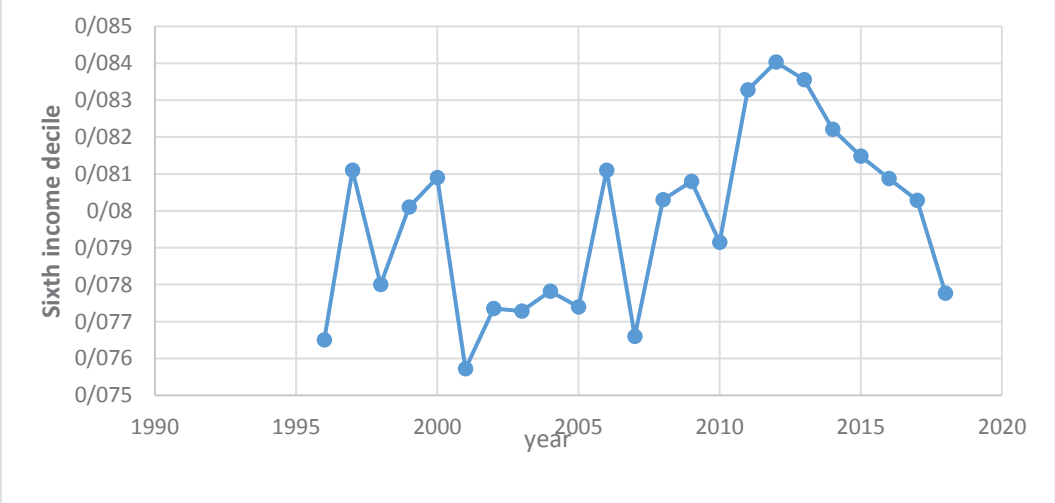

Fig. 6: Sixth income decile

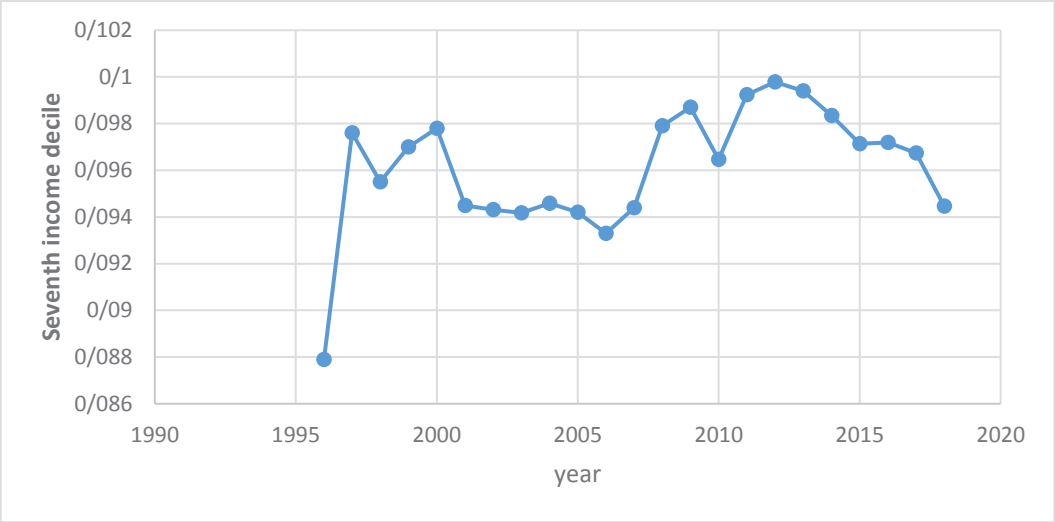

Fig. 7: Seventh income decile

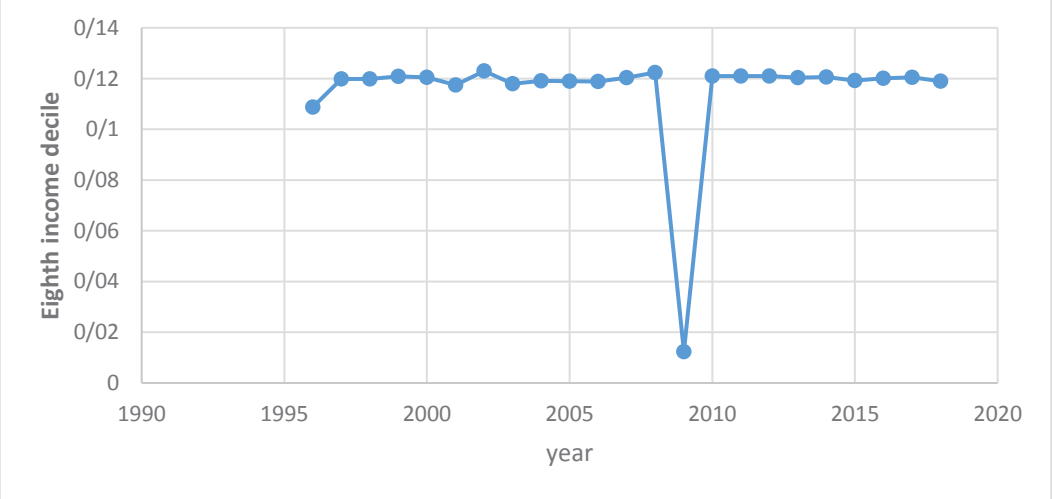

Fig. 8: Eighth income decile

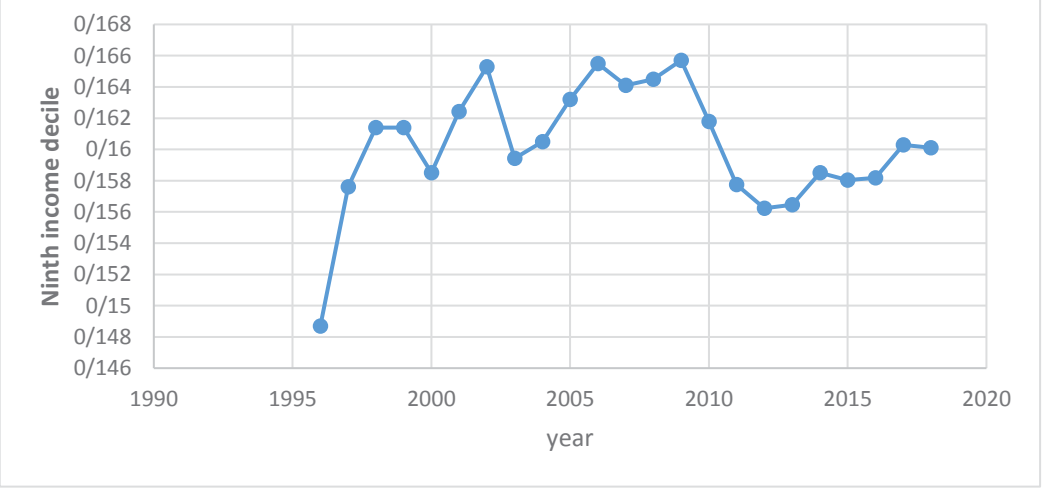

Fig. 9: Ninth income decile

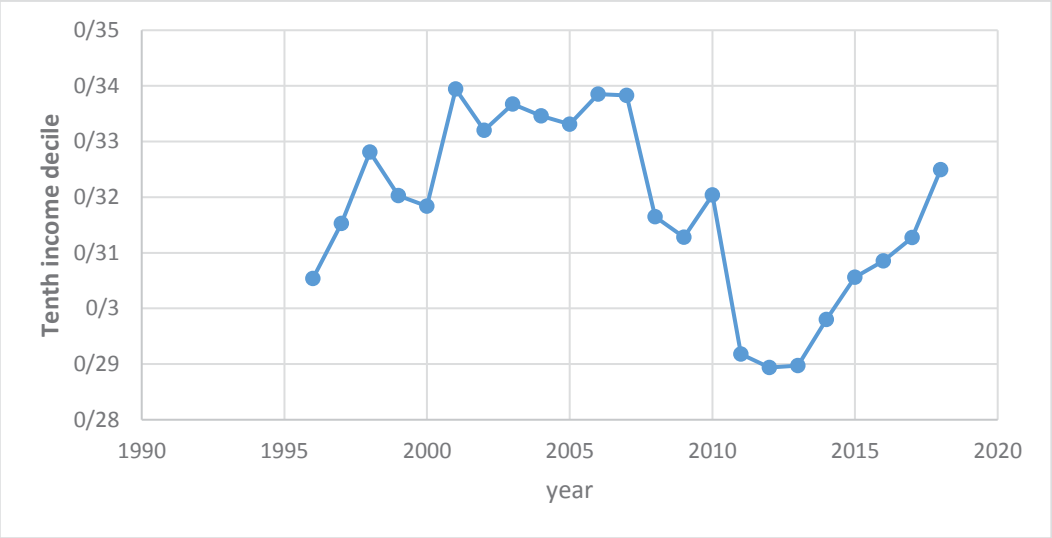

Fig. 10: Tenth income decile

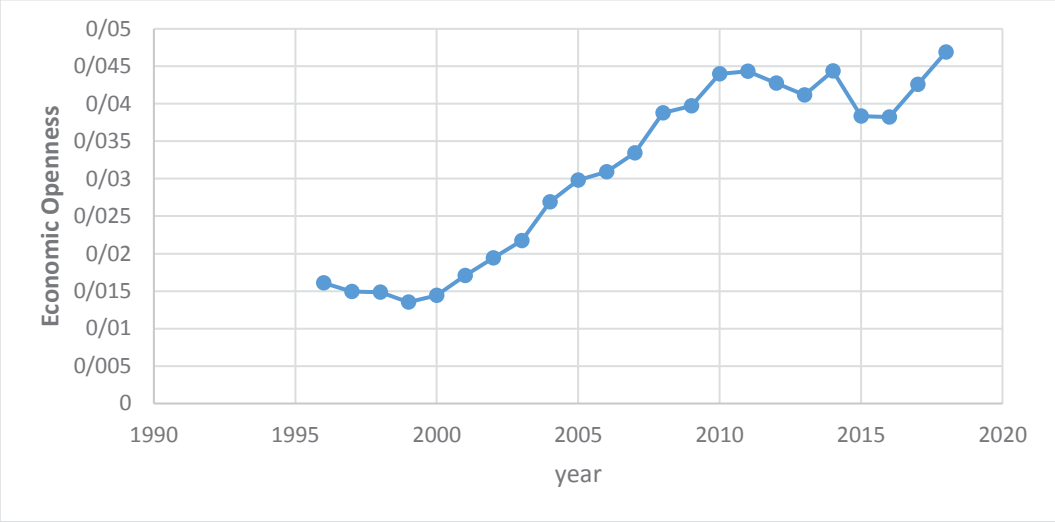

Fig. 11: Economic openness (OPEN)

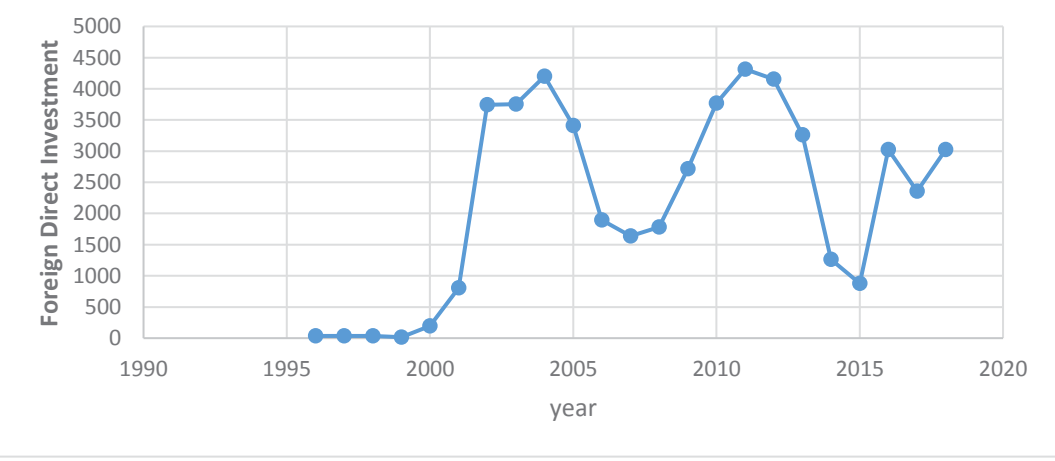

Fig. 12: Foreign direct investment (FDI)

4. Materials and Methods

Classical regression has strong assumptions for the establishment of statistical features of regression models. For example, normality or non-existence of autocorrelation and constancy of variance are part of the error of this assumption. Violation of any of these assumptions invalidates the results of classical regression analysis. In most cases, it is difficult to justify this assumption. Or in some cases they cannot be used properly. For example, in the observations or definitions of a system, inaccurate human estimates and judgments and insufficient information may be effective in the use of variables. In general, although classical regression has many uses, it will be misleading in the following conditions. 1- The number of observational data is insufficient. 2- The errors do not follow the normal distribution. 3- The relationship between independent and dependent variables is unclear. 4- There is ambiguity in relation to an event. 5- The assumptions of linearization are incorrect. In such situations where classical regression methodology and justifying its assumptions is a difficult task, the use of fuzzy regression, which provides a membership function with a possible distribution for imprecise or ambiguous, can increase our understanding of the system and provide better results. . On the other hand, in classical linear regression, for each series of input variables, a specific value is calculated for the output variable, while fuzzy regression estimates a range of possible values for the output variable. The distribution of these values is defined as a membership function. In general, there are three types of models to fit a fuzzy linear regression equation.

1- Possible fuzzy regression models

2- Least squares regression models

3- Regression models based on interval analysis

In this study, the fuzzy possibility regression model was used. This model obtains the most favorable regression equation by minimizing the degree of fuzziness. To achieve a good fit, an optimal model should be estimated. Considering that the membership functions used to display fuzzy numbers are triangular, fuzzy regression can be formulated in the form of a linear programming problem. Fuzzy regression models were first presented by Tanaka et al. in (1982).

These models obtain the best regression equation by minimizing the degree of fuzziness. This is done by minimizing the total width of the membership functions of the fuzzy coefficients of the regression equation. One of the possible fuzzy regression models is a model in which the coefficients are fuzzy and the observation input and output are non-fuzzy. In this section, we first give a brief description of fuzzy regression and then we state how to estimate the asymmetric fuzzy regression. Fuzzy regression analysis proposed by Tanaka et al (1982), where the general form of its model with fuzzy coefficients is as in (1).

$$\tilde{Y} = f(x, A) = \tilde{A}_0 + \tilde{A}_1 x_1 + \tilde{A}_2 x_2 + \cdots + \tilde{A}_n x_n \qquad (1)$$

Fuzzy coefficients for variables x_n can be indicated $\tilde{\mathrm{A}}_{\mathrm{n}} = (a_n, s_n)$. So, the general form of the membership function $\tilde{A}$ can be written as (2) with respect to three parameters as center a, low width s^L and right width s^R Tanaka et al (1982):

$$\tilde{A}(\mathrm{x}) = \begin{cases} 1 - \dfrac{a - x}{s^L} & a - s^L \le x \le a \\ 1 - \dfrac{x - a}{s^R} & a < x \le a + s^R \end{cases} \qquad (2)$$

This membership function can also be displayed in another way. That is, the high width is expressed based on low width. Thus, $s^L = k\, s^R$ is placed in the above membership function, in which k is a real and positive number known as the kurtosis coefficients. Therefore, the asymmetric triangular fuzzy number $\tilde{A}$ can also be described by $\tilde{A} = (a, s^L, k)_{\mathrm{T}}$. In this case, the membership function $\tilde{A}$ is represented by (3).

$$\tilde{A}(x) = \begin{cases} 1 - \dfrac{a - x}{s^L} & a - s^L \le x \le a \\ 1 - \dfrac{x - a}{k s^R} & a < x \le a + k s^R \end{cases} \qquad (3)$$

Generally any asymmetric triangular fuzzy coefficient $\tilde{A}$ can be plotted by its low , low width s^L, center a and right width s^R depicted in Fig.13.

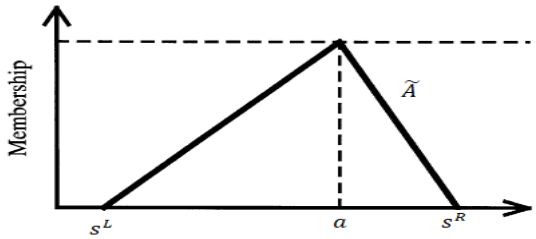

Fig. 13. Asymmetric triangular fuzzy number

In (3) if the value k = 1, then the asymmetric fuzzy number reduce to a symmetric fuzzy number depicted in Fig.14.

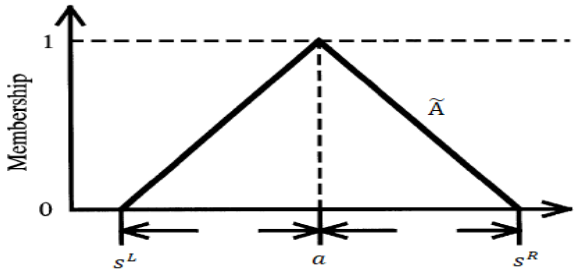

Fig. 14. Symmetric triangular fuzzy coefficient

To estimate the parameters of the fuzzy regression model (2), we consider two criterias. First, the membership value of each y_i in $\tilde{Y}_i$ should be a large number. Second, it is ensured that the fuzzy model has good fitting to the observations Tanaka et al (1982). Thus, we are looking for a model that:

(i) fuzzy output, $\tilde{Y}$ for all values $\tilde{Y}_j$, has the membership degree as large as h, that is

$$\tilde{Y}_j(y_j) \geq h \quad , \quad i = 1,2 \ldots, m \qquad (4)$$

(ii) the fuzzy coefficients $\tilde{A}_i$, are such that ambiguity of the fuzzy output $\tilde{Y}_j$ is minimized.

We summarize the steps of estimating fuzzy regression with symmetric and asymmetric coefficients in Sections 4.1and 4.2. See references Nawazish et al (1998), for further reading on fuzzy regression.

4-1. Algorithm I: Steps of linear programming algorithm for estimating fuzzy regression with symmetric coefficients.

1- First, we calculate the objective function according to Equation (5).

$$Z = 2ms_0 + 2\sum_{i=1}^{n}(s_i \sum_{j=1}^{m} x_{ji}) \qquad (5)$$

where x_{ji} means the j[th] observation of the i[th] variable

2- For estimate the width of the right, we calculate the right constraint according to Equation (6).

$$(1-h)s_0 + (1-h)\sum_{i=1}^{n}(s_0 x_{ji}) + a_0 + \sum_{i=1}^{n}(s_0 x_{ji}) \geq + y_i, \quad j = 1,2, \ldots, m \qquad (6)$$

3- For estimate the left width, we calculate the left constraint according to equation (7).

$$(1-h)s_0 + (1-h)\sum_{i=1}^{n}(s_0 x_{ji}) - a_0 - \sum_{i=1}^{n}(s_0 x_{ji}) \geq - y_i, \quad j = 1,2, \ldots, m \qquad (7)$$

4- We calculate the centers a_i , the width of the right s_i^R and the left s_i^L for the membership degree of 0.1 to 0.9 according to Equation (8).

$$f^c(\mathrm{x}) = a_0 + a_1x_1 + \cdots + a_nx_n$$

$$f_s^L(\mathrm{x}) = s_0^L + s_1^Lx_1 + \cdots + s_n^Lx_n$$

$$f_s^R(x) = s_0^R + s_1^Rx_1 + \cdots + s_n^Rx_n$$

(8)

4-2. Algorithm II: Steps of linear programming algorithm for estimating fuzzy regression with asymmetric coefficients

1- First, we calculate the objective function according to Equation (5).

2- For estimate the width of the right, we substitute $s_i^R = k_is_i^L$ in the constraint on the right according to Equation (9).

$$(1-\mathrm{h})\mathrm{s}_0^{\mathrm{R}} + (1-\mathrm{h})\sum_{\mathrm{i}=1}^{\mathrm{n}}(\mathrm{s}_{\mathrm{i}}^{\mathrm{R}}\mathrm{x}_{\mathrm{ji}}) + \mathrm{a}_0 + \sum_{\mathrm{i}=1}^{\mathrm{n}}(\mathrm{a}_0\mathrm{x}_{\mathrm{ji}}) \geq +\mathrm{y}_{\mathrm{i}}\,,\ \mathrm{j} = 1,2,.,\mathrm{m} \qquad (9)$$

3- For estimate the width of the left, we substitute $s_i^R = k_is_i^L$ in the constraint on the left according to Equation (10).

$$(1-h)s_0^L + (1-h)\sum_{i=1}^{n}(s_i^Lx_{ji}) - a_0 - \sum_{i=1}^{n}(a_0x_{ji}) \geq -y_i\ ,$$
$$j = 1,2,.,m \qquad (10)$$

4- We calculate the centers a_i , the width of the right s_i^R and the left s_i^L for the membership degree of 0.1 to 0.9 according to Equation (8).

5. Empirical Results

In this section, we first give a brief explanation of how to estimate fuzzy regression with symmetric and asymmetric coefficients. In Algorithm I, the objective function is minimized by considering constraints steps 1-3 in section 4.1. The values of s2, s1, s0, a2, a1, and a0 are calculated (step 4 in section 4.1). Algorithm II, the objective function is minimized by considering constraints steps 1-3 in section 4.2. The values of s2, s1, s0, a2, a1, and a0 are calculated (step 4 in section 4.2). The observations comprises 24 years (1995-2018). Which is 48 constraints and for estimation are used GAMS software. In this study, foreign direct investment and the degree of economic openness are represented by X1, X2, as well as fuzzy center a1, a2 and fuzzy width s1, s2, respectively.

The results of the coefficients in the symmetric fuzzy coefficient state are represents in Tables A.1-A.10, (Estimation results are in appendix A). According to the findings, the value of the objective functions (Z) and the MSE of different models are the same for different values of h. We represent the MSE values, objective function (Z), centers and spreads fuzzy regression for the first to tenth deciles of income (for h = 0.5) in Table 1.

Tab. 1: The results of the fuzzy symmetric regression for the first to tenth decile, h = 0.5

income decile	h	centers			spreads			Z	MSE
		a_0	a_1	a_2	S_0	S_1	S_2		
first income decile	0.5	0.044	0	0.056	0	0.020	0.171	0.330	10.24
second income decile	0.5	0.019	0	0.146	0	0.011	0.182	0.210	11.35
third income decile	0.5	0.068	0.710	0	0.005	0.061	0	0.284	10.38
fourth income decile	0.5	0	0.087	0.092	0.012	0	0.43	0.194	12.92
fifth income decile	0.5	0	0.801	0.594	0	0.004	0	0.361	13.08
sixth income decile	0.5	0.019	0	0.033	0.581	0.027	0	0.416	12.81
seventh income decile	0.5	0.022	0.050	0	0	0.002	0.093	0.44	12.66
eighth income decile	0.5	0.082	0	0.019	0	0.066	0.482	0.340	15.05
ninth income decile	0.5	0.160	0	0.138	0	0.091	0.084	0.351	14.07

tenth income decile	0.5	0	0	0.099	0.018	0.076	0	0.230	13.48

One of the reasons for using fuzzy regression with asymmetric coefficients in this study is its flexibility in analyzing the asymmetric effect of the investigated variables on income deciles. Which is very important in terms of economic analysis. Therefore, it is necessary to first give a brief explanation of fuzzy regression with asymmetric coefficients. In this method, by using arbitrary coefficients of elongation (k0, k1, k2), it is possible to check the asymmetric behavior of foreign indirect investment and the degree of economic openness on income inequality. This issue makes us identify the best model for each of the income deciles. For this purpose, values for elongation coefficients have been chosen arbitrarily, which are shown in Tables 2-11. In the asymmetric mode, to achieve a optimal model is solved the model for different values of k_i. A model with a lower MSE is selected as the optimal model. Assume that from the a priori information we select the following values for k_i:

k_0=l.4, k_1=1.6, k_2 =1.9.

We find that in case of asymmetric membership functions, as the skew factor increases, the variations of k_i have not influence on the MSE values, objective function (Z), centers and spreads. These results are shown in Tables B1-B10, (Estimation results are in appendix B). Further analysis generates Tables 2-11 which shows the values of the spreads and centers at different settings of skew factors. One of the important results of these analyzes is the different MSE values for income deciles. Here, in each setting we have kept the values of two skew factors fixed at 1 and changed the value of the third one. Analyzing the above results, we conclude that k_0 is the dominant skew factor. Keeping k0 constant then changing either k_1 or k_2 or both will not produce any variations in $\tilde{A}_i$.

Tab. 2: The results of the fuzzy asymmetric regression for first income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0	0.185	0	0.010	0.077	3.166	0.304	1.25
0.5	1.4	1	1	0	0.180	0	0.010	0.077	3.141	0.302	0.54

0.5	1.9	1	1	0	0.188	0	0.014	0.077	3.130	0.300	2.36
0.5	2.6	1	1	0	0.184	0	0.014	0.074	3.181	0.309	4.29
0.5	1	1.4	1	0	0.183	0	0.011	0.072	3.134	0.307	4.02
0.5	1	1.9	1	0	0.186	0	0.014	0.075	3.166	0.307	1.27
0.5	1	3.5	1	0	0.181	0	0.017	0.071	3.137	0.300	2.54
0.5	1	1	1.4	0	0.187	0	0.013	0.079	3.192	0.300	3.89
0.5	1	1	3.5	0	0.187	0	0.012	0.076	3.162	0.300	21.5

Tab. 3: The results of the fuzzy asymmetric regression for second income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0	0.244	0	0.032	0.052	0.094	0.191	2.40
0.5	1.4	1	1	0	0.250	0	0.031	0.051	0.097	0.190	1.05
0.5	1.9	1	1	0	0.261	0	0.039	0.056	0.091	0.193	3.27
0.5	2.6	1	1	0	0.288	0	0.036	0.058	0.094	0.193	2.98
0.5	1	1.4	1	0	0.269	0	0.033	0.054	0.095	0.195	2.06
0.5	1	1.9	1	0	0.255	0	0.033	0.051	0.091	0.195	0.02
0.5	1	3.5	1	0	0.270	0	0.033	0.050	0.099	0.187	1.04
0.5	1	1	1.4	0	0.270	0	0.030	0.058	0.095	0.193	2.84
0.5	1	1	3.5	0	0.270	0	0.030	0.050	0.090	0.199	1.99

Tab. 4: The results of the fuzzy asymmetric regression for third income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0	0.350	0	0.047	0	0.162	0.240	0.215
0.5	1.4	1	1	0	0.342	0	0.043	0	0.140	0.242	3.05
0.5	1.9	1	1	0	0.332	0	0.040	0	0.161	0.238	4.99
0.5	2.6	1	1	0	0.381	0	0.046	0	0.137	0.233	3.84
0.5	1	1.4	1	0	0.354	0	0.041	0	0.107	0.230	2.63
0.5	1	1.9	1	0	0.382	0	0.049	0	0.134	0.266	4.04
0.5	1	3.5	1	0	0.316	0	0.044	0	0.162	0.292	2.58
0.5	1	1	1.4	0	0.358	0	0.044	0	0.141	0.201	3.55
0.5	1	1	3.5	0	0.351	0	0.044	0	0.157	0.254	2.07

Tab. 5: The results of the fuzzy asymmetric regression for fourth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0	0.323	0	0.054	0.011	1.42	0.217	3.55
0.5	1.4	1	1	0	0.310	0	0.054	0.011	1.42	0.265	3.66
0.5	1.9	1	1	0	0.308	0	0.054	0.014	1.41	0.247	2.88
0.5	2.6	1	1	0	0.301	0	0.0540	0.010	1.48	0.202	5.01
0.5	1	1.4	1	0	0.308	0	0.050	0.013	1.44	0.227	4.28
0.5	1	1.9	1	0	0.302	0	0.057	0.016	1.46	0.237	2.99
0.5	1	3.5	1	0	0.303	0	0.057	0.013	1.49	0.211	1.27
0.5	1	1	1.4	0	0.309	0	0.053	0.018	1.47	0.214	2.64
0.5	1	1	3.5	0	0.304	0	0.051	0.012	1.42	0.215	4.02

Tab. 6: The results of the fuzzy asymmetric regression for fifth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0.004	0.163	0	0	0.065	3.97	0.308	3.31
0.5	1.4	1	1	0.004	0.163	0	0	0.065	3.97	0.308	4.22
0.5	1.9	1	1	0.002	0.163	0	0	0.065	3.97	0.308	1.58
0.5	2.6	1	1	0.008	0.163	0	0	0.065	3.97	0.308	2.68
0.5	1	1.4	1	0.005	0.163	0	0	0.065	3.97	0.308	3.79
0.5	1	1.9	1	0.004	0.163	0	0	0.065	3.97	0.308	2.94
0.5	1	3.5	1	0.004	0.163	0	0	0.065	3.97	0.308	4.33
0.5	1	1	1.4	0.004	0.163	0	0	0.065	3.97	0.308	4.09
0.5	1	1	3.5	0.004	0.163	0	0	0.065	3.97	0.308	4.88

Tab. 7: The results of the fuzzy asymmetric regression for sixth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0	0.300	0	0.078	0.090	9.59	0.220	2.01
0.5	1.4	1	1	0	0.305	0	0.078	0.097	9.66	0.220	3.87
0.5	1.9	1	1	0	0.301	0	0.078	0.095	9.31	0.264	2.55
0.5	2.6	1	1	0	0.304	0	0.075	0.092	9.20	0.220	4.81
0.5	1	1.4	1	0	0.306	0	0.071	0.094	9.41	0.263	1.08
0.5	1	1.9	1	0	0.303	0	0.076	0.091	9.73	0.208	2.21

0.5	1	3.5	1	0	0.307	0	0.072	0.090	9.46	0.291	3.61
0.5	1	1	1.4	0	0.305	0	0.078	0.095	9.08	0.288	0.52
0.5	1	1	3.5	0	0.305	0	0.074	0.096	9.27	0.234	4.55

Tab. 8: The results of the fuzzy asymmetric regression for seventh income decile

h	K_0	K_1	K_2	**S_0**	**S_1**	**S_2**	**a_0**	**a_1**	**a_2**	**Z**	**MSE**
0.5	1.25	1	1	0.01	0	0	0.099	0.042	1.58	0.446	3.45
0.5	1.4	1	1	0.01	0	0	0.053	0.042	1.01	0.446	3.58
0.5	1.9	1	1	0.07	0	0	0.007	0.043	1.83	0.453	3.40
0.5	2.6	1	1	0.04	0	0	0.053	0.041	1.91	0.416	2.99
0.5	1	1.4	1	0.02	0	0	0.002	0.044	1.74	0.457	2.05
0.5	1	1.9	1	0.01	0	0	0.044	0.040	1.91	0.411	1.66
0.5	1	3.5	1	0.09	0	0	0.043	0.047	1.38	0.466	4.08
0.5	1	1	1.4	0.02	0	0	0.060	0.047	1.86	0.407	3.88
0.5	1	1	3.5	0.05	0	0	0.057	0.045	1.60	0.400	0.09

Tab. 9: The results of the fuzzy asymmetric regression for eighth income decile

h	**K_0**	**K_1**	**K_2**	**S_0**	**S_1**	**S_2**	**a_0**	**a_1**	**a_2**	**Z**	**MSE**
0.5	1.25	1	1	0	1.939	0	0.321	0	2.900	0.338	1.25
0.5	1.4	1	1	0	1.652	0	0.321	0	2.410	0.302	1.67
0.5	1.9	1	1	0	1.530	0	0.301	0	2.128	0.396	2.04
0.5	2.6	1	1	0	1.955	0	0.301	0	2.115	0.330	0.61
0.5	1	1.4	1	0	1.438	0	0.301	0	2.642	0.364	0.08
0.5	1	1.9	1	0	1.884	0	0.331	0	2.552	0.337	1.82
0.5	1	3.5	1	0	1.722	0	0.331	0	2.912	0.338	2.92
0.5	1	1	1.4	0	1.095	0	0.381	0	2.632	0.330	1.82
0.5	1	1	3.5	0	1.631	0	0.321	0	2.002	0.364	2.38

Tab. 10: The results of the fuzzy asymmetric regression for ninth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0.052	0.045	0	0.350	0	1.973	0.284	0.52
0.5	1.4	1	1	0.036	0.036	0	0.151	0	1.350	0.426	1.36
0.5	1.9	1	1	0.049	0.020	0	0.192	0	1.973	0.421	2.55
0.5	2.6	1	1	0.066	0.012	0	0.163	0	1.973	0.420	3.45
0.5	1	1.4	1	0.010	0.084	0	0.023	0	1.866	0.458	3.40
0.5	1	1.9	1	0.018	0.041	0	0.934	0	1.530	0.552	2.87
0.5	1	3.5	1	0.092	0.036	0	0.309	0	0.973	0.501	4.61
0.5	1	1	1.4	0.001	0.091	0	0.203	0	1.658	0.582	3.82
0.5	1	1	3.5	0.094	0.068	0	0.523	0	0.950	0.588	2.51

Tab. 11: The results of the fuzzy asymmetric regression for tenth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.25	1	1	0	0.940	0	0.321	0	2.29	0.135	2.08
0.5	1.4	1	1	0	1.863	0	0.301	0	2.29	0.135	3.84
0.5	1.9	1	1	0	1.821	0	0.304	0	2.34	0.131	0.84
0.5	2.6	1	1	0	1.830	0	0.300	0	2.37	0.129	1.05
0.5	1	1.4	1	0	0.911	0	0.318	0	2.37	0.129	5.10
0.5	1	1.9	1	0	1.801	0	0.311	0	2.04	0.118	2.90
0.5	1	3.5	1	0	1.721	0	0.331	0	2.39	0.115	0.01
0.5	1	1	1.4	0	1.763	0	0.321	0	2.39	0.127	1.73
0.5	1	1	3.5	0	1.731	0	0.321	0	2.39	0.127	0.013

As stated, the purpose of this type of analysis is to select a optimal model for each of the income deciles. Therefore, according to the MSE values, the optimal model can be selected and the impact of each of the open economy indicators on income deciles can be determined. Models 11-20 show the optimal model for each income deciles. Where $Gini_i$, i= 1,2,…,10 is Gini coefficient the first to third income. FDI is foreign direct investment, $open$ is economic openness, MSE is Mean Squared Error and z is the value of the objective function (Gini coefficient).In fuzzy regression, $a_i$represents the center of the fuzzy number used in the analysis as the mean effectives of each of the coefficients, the s_i parameter shows the fuzzy

spread of a number and indicates that the higher the spread value, the impact is greater.

First income decile: $Gini_1 = (0.010\ ,0) + (0.077\ ,0.180)\ FDI + (3.141\ ,0) open$ (11)

MSE =0.54, z= 0.302

Second income decile: $Gini_2 = (0.033\ ,0) + (0.051\ ,0.255)\ FDI + (0.091\ ,0) open$ (12)

MSE = 0.02, z= 0.195

Third income decile: $Gini_3 = (0.047\ ,0) + (0\ ,0.350)\ FDI + (0.162\ ,\ 0\ ) open$ (13)

MSE = 0.215, z= 0.240

Fourth income decile: $Gini_4 = (0.057\ ,0) + (0.013\ ,0.303)\ FDI + (0.49\ ,0) open$ (14)

MSE = 1.27, z=0.211

Fifth income decile: $Gini_5 = (0\ ,0.002\ ) + (0.065\ ,\ 0.163)\ FDI + (3.97\ ,0) open$ (15)

MSE = 1.58, z=0.308

Sixth income decile: $Gini_6 = (0.78\ ,\ 0) + (0.095\ ,0.305)\ FDI + (9.08\ ,\ 0) open$ (16)

MSE = 0.52, z= 0.288

Seventh income decile: $Gini_7 = (0.057\ ,0.05) + (0.045\ ,0)\ FDI + (1.6\ ,\ 0) open$ (17)

MSE = 0.09, z= 0.400

Eighth income decile: $Gini_8 = (0.301\ ,0) + (0\ \ ,1.438)\ FDI + (2.642\ ,0) open$ (18)

MSE = 0.08, *z= 0.364*

Ninth income decile: $Gini_9 = (0.350\ , 0.052) + (0\ , 0.045)\ FDI + (1.973\ , 0) open$ (19)

MSE = 0.52, *z= 0.284*

Tenth income decile: $Gini_{10} = (0.331\ , 0) + (0\ , 1.721)\ FDI + (2.39\ ,\ 0) open$ (20)

MSE = 0.01, *z = 0.115*

According to the results, the mean effect of foreign investment is 0.077 and the maximum effect is 0.185, the average effect degree of economic openness is 3.141 and the maximum effect is 0 on the Gini coefficient of the first decile and the value of the Gini coefficient is 0.304. the average effect of foreign investment is 0.051 and the maximum effect is 0.255, the average effect degree of economic openness is 0.091 and the maximum effect is 0 on the Gini coefficient of the second income decile and the value of the Gini coefficient is *0.195*. The average effect of foreign investment is 0 and the maximum effect is 0.350, the average effect degree of economic openness is 0.162 and the maximum effect is 0 on the Gini coefficient of the third income decile and the value of the Gini coefficient is *0.240*.

The average effect of foreign investment is 0.013 and the maximum effect is 0.303, the average effect degree of economic openness is 1.49 and the maximum effect is 0 on the Gini coefficient of the fourth income decile and the value of the Gini coefficient is *0.211*. The average effect of foreign investment is 0 and the maximum effect is 0.581, the average effect degree of economic openness is 0.12 and the maximum effect is 0 on the Gini coefficient of the fifth income decile income decile and the value of the Gini coefficient is *0.308*.The average effect of foreign investment is 0.095 and the maximum effect is 0.305, the average effect degree of economic openness is 9.08 and the maximum effect is 0 on the Gini coefficient of the sixth income decile and the value of the Gini coefficient is *0.288*.

The average effect of foreign investment is 0.045 and the maximum effect is 0, the average effect degree of economic openness is 1.60 and the maximum effect is 0 on the Gini coefficient of the seventh income decile and the value of the Gini coefficient is *0.400*.The average effect of foreign investment is 0 and the maximum effect is 1.438, the average effect degree of economic openness is 2.642 and the maximum effect is 0 on the Gini coefficient of the eighth income decile and the value of the Gini coefficient is *0.364*.The average effect of foreign investment is 0 and the maximum effect is 0,045, the average effect degree of economic openness is 1,973 and the maximum effect is 0 on the Gini coefficient of the eighth income decile and the value of the Gini coefficient is 0.284.The average effect of foreign investment is 0 and the maximum effect is 1.721, the average effect degree of economic openness is 2.39 and the maximum effect is 0 on the Gini coefficient of the eighth income decile and the value of the Gini coefficient is *0.115*.

6. Discussion and Conclusions

In this study, the fuzzy regression model with symmetric and asymmetric coefficients is used. The parameters calculated in fuzzy regression are triangular. These triangular numbers consist of fuzzy center (a) and fuzzy width (s). that the fuzzy center forms the vertex of the triangle and the fuzzy width expresses the degree of fluctuation from the fuzzy center. The zero fuzzy center in each of the tables of the present study indicates that the relevant variable is only able to affect the dependent variable (income decile) as much as the fuzzy width. Now, if the fuzzy center is a number other than zero and the fuzzy width is zero, it means that the relevant variable affects the independent variable only as much as the fuzzy center. Another situation that can be imagined is that the fuzzy center and width are non-zero, which indicates that the average influence of the relevant variable was equal to the size of the fuzzy center, but it can also be effective up to the size of the fuzzy width. Finally, the last state is that for a variable, the fuzzy center and width are equal to zero, which indicates that the corresponding income decile is not affected by the said variable. According to these explanations, it can be stated that the results of fuzzy regression with symmetrical coefficients show that the effect of

the fuzzy center of foreign direct investment on the fifth, third, fourth, and seventh deciles, respectively, has the greatest impact on the inequality between income deciles. Also, the results of the fuzzy width of foreign direct investment have the greatest impact on the inequality between the ninth, tenth, eighth, third, sixth, first, second, fifth- and seventh-income deciles, respectively. The fuzzy center of the degree of trade openness has the greatest impact on the inequality between the fifth, second, ninth, tenth, fourth, first, sixth- and ninth-income deciles, respectively. Also, the results of the fuzzy width of the degree of commercial openness have the greatest impact on the inequality between the eighth, fourth, first, second, seventh- and ninth-income deciles, respectively.

The general results of the current study indicate that trade openness and foreign direct investment will increase inequality, although this measure is different for different income deciles. which with the results of studies by Tayibi et al. (2011), Azarbaijani et al. (2012), Ahmadzadeh et al. (2016), Jalai et al. (2020), Taherifar et al. (2023), Moradi et al. (2023), Castro (2010)), Basu and Georgia (2007), Herzer and Nannekamp (2011), Fazol et al. (2022) are consistent.

According to the results of this study, the impact of foreign direct investment on the Gini coefficient of income deciles is zero or very low. But the maximum (fuzzy width) effect of foreign direct investment on the Gini coefficient of income deciles has increased, which leads to inequality in income distribution. Therefore, the government should adopt important policies and create appropriate infrastructure to reduce inequality between income deciles. Since foreign direct investment strengthens the dual economic structure by increasing the wages of workers in a part of production, it also leads to the production of luxury and expensive goods that are demanded by the wealthy part of society. Other reasons for increasing income inequality include the production of inappropriate goods and designs that are not socially desirable, as well as the use of inappropriate (capital-intensive) production techniques. Also, the results show that the maximum effect of the degree of economic openness on the Gini coefficient of income deciles is zero, which means that the degree of economic openness does not increase inequality. All of these cases provide strong evidence that economic planning should be of different dimensions in order to properly absorb the effects of foreign trade.

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Conflict of Interest

The authors declare no conflict of Interest

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Appendix A

Tab. A. 1: The results of the fuzzy symmetric regression for first income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.2	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.3	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.4	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.5	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.6	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.7	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.8	0.044	0	0.056	0	0.020	0.171	0.330	10.24
0.9	0.044	0	0.056	0	0.020	0.171	0.330	10.24

Tab. A. 2: The results of the fuzzy symmetric regression for second income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.2	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.3	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.4	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.5	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.6	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.7	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.8	0.019	0	0.146	0	0.011	0.182	0.210	11.35
0.9	0.019	0	0.146	0	0.011	0.182	0.210	11.35

Tab. A. 3: The results of the fuzzy symmetric regression for third income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.2	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.3	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.4	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.5	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.6	0.068	0.710	0	0.005	0.061	0	0.284	10.38

0.7	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.8	0.068	0.710	0	0.005	0.061	0	0.284	10.38
0.9	0.068	0.710	0	0.005	0.061	0	0.284	10.38

Tab. A. 4: The results of the fuzzy symmetric regression for fourth income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.2	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.3	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.4	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.5	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.6	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.7	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.8	0	0.087	0.092	0.012	0	0.43	0.194	12.92
0.9	0	0.087	0.092	0.012	0	0.43	0.194	12.92

Tab. A. 5: The results of the fuzzy symmetric regression for fifth income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0	0.801	0.594	0	0.004	0	0.361	13.08
0.2	0	0.801	0.594	0	0.004	0	0.361	13.08
0.3	0	0.801	0.594	0	0.004	0	0.361	13.08
0.4	0	0.801	0.594	0	0.004	0	0.361	13.08
0.5	0	0.801	0.594	0	0.004	0	0.361	13.08
0.6	0	0.801	0.594	0	0.004	0	0.361	13.08
0.7	0	0.801	0.594	0	0.004	0	0.361	13.08
0.8	0	0.801	0.594	0	0.004	0	0.361	13.08
0.9	0	0.801	0.594	0	0.004	0	0.361	13.08

Tab. A. 6: The results of the fuzzy symmetric regression for sixth income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.2	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.3	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.4	0.019	0	0.033	0.581	0.027	0	0.416	12.81

0.5	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.6	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.7	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.8	0.019	0	0.033	0.581	0.027	0	0.416	12.81
0.9	0.019	0	0.033	0.581	0.027	0	0.416	12.81

Tab. A. 7: The results of the fuzzy symmetric regression for seventh income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.2	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.3	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.4	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.5	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.6	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.7	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.8	0.022	0.050	0	0	0.002	0.093	0.44	12.66
0.9	0.022	0.050	0	0	0.002	0.093	0.44	12.66

Table A. 8: The results of the fuzzy symmetric regression for eighth income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.2	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.3	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.4	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.5	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.6	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.7	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.8	0.082	0	0.019	0	0.066	0.482	0.340	15.05
0.9	0.082	0	0.019	0	0.066	0.482	0.340	15.05

Tab. A. 9: The results of the fuzzy symmetric regression for ninth income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.2	0.160	0	0.138	0	0.091	0.084	0.351	14.07

0.3	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.4	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.5	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.6	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.7	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.8	0.160	0	0.138	0	0.091	0.084	0.351	14.07
0.9	0.160	0	0.138	0	0.091	0.084	0.351	14.07

Tab. A. 10: The results of the fuzzy symmetric regression for tenth income decile

h	centers			spreads			Z	MSE
	a_0	a_1	a_2	S_0	S_1	S_2		
0.1	0	0	0.099	0.018	0.076	0	0.230	13.48
0.2	0	0	0.099	0.018	0.076	0	0.230	13.48
0.3	0	0	0.099	0.018	0.076	0	0.230	13.48
0.4	0	0	0.099	0.018	0.076	0	0.230	13.48
0.5	0	0	0.099	0.018	0.076	0	0.230	13.48
0.6	0	0	0.099	0.018	0.076	0	0.230	13.48
0.7	0	0	0.099	0.018	0.076	0	0.230	13.48
0.8	0	0	0.099	0.018	0.076	0	0.230	13.48
0.9	0	0	0.099	0.018	0.076	0	0.230	13.48

Appendix B

Tab. B. 1: The results of the fuzzy asymmetric regression for first income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0	0.183	0	0.019	0.077	3.126	0.308	5.27
0.5	1.4	1.6	1.9	0	0.183	0	0.019	0.077	3.126	0.308	5.27
0.5	1.9	2.3	2.6	0	0.183	0	0.019	0.077	3.126	0.308	5.27
0.5	2.7	2.9	3.2	0	0.183	0	0.019	0.077	3.126	0.308	5.27
0.5	1	1	1	0	0.183	0	0.019	0.077	3.126	0.308	5.27

Tab. B.2: The results of the fuzzy asymmetric regression for second income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0	0.270	0	0.033	0.056	0	0.193	5.27
0.5	1.4	1.6	1.9	0	0.270	0	0.033	0.056	0	0.193	5.27
0.5	1.9	2.3	2.6	0	0.270	0	0.033	0.056	0	0.193	5.27
0.5	2.7	2.9	3.2	0	0.270	0	0.033	0.056	0	0.193	5.27
0.5	1	1	1	0	0.270	0	0.033	0.056	0	0.193	5.27

Tab. B. 3: The results of the fuzzy asymmetric regression for third income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0	0.350	0	0.044	0	0	0.250	5.27
0.5	1.4	1.6	1.9	0	0.350	0	0.044	0	0	0.250	5.27
0.5	1.9	2.3	2.6	0	0.350	0	0.044	0	0	0.250	5.27
0.5	2.7	2.9	3.2	0	0.350	0	0.044	0	0	0.250	5.27
0.5	1	1	1	0	0.350	0	0.044	0	0	0.250	5.27

Tab. B.4: The results of the fuzzy asymmetric regression for fourth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0	0.303	0	0.054	0.11	1.42	0.217	5.27
0.5	1.4	1.6	1.9	0	0.303	0	0.054	0.11	1.42	0.217	5.27
0.5	1.9	2.3	2.6	0	0.303	0	0.054	0.11	1.42	0.217	5.27
0.5	2.7	2.9	3.2	0	0.303	0	0.054	0.11	1.42	0.217	5.27
0.5	1	1	1	0	0.303	0	0.054	0.11	1.42	0.217	5.27

Tab. B.5: The results of the fuzzy asymmetric regression for fifth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0.004	0.163	0	0	0.065	3.97	0.308	5.27
0.5	1.4	1.6	1.9	0.004	0.163	0	0	0.065	3.97	0.308	5.27
0.5	1.9	2.3	2.6	0.004	0.163	0	0	0.065	3.97	0.308	5.27
0.5	2.7	2.9	3.2	0.004	0.163	0	0	0.065	3.97	0.308	5.27
0.5	1	1	1	0.004	0.163	0	0	0.065	3.97	0.308	5.27

Tab. B.6: The results of the fuzzy asymmetric regression for sixth income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0	0.308	0	0.078	0.090	9.59	0.220	5.27
0.5	1.4	1.6	1.9	0	0.308	0	0.078	0.090	9.59	0.220	5.27
0.5	1.9	2.3	2.6	0	0.308	0	0.078	0.090	9.59	0.220	5.27
0.5	2.7	2.9	3.2	0	0.308	0	0.078	0.090	9.59	0.220	5.27
0.5	1	1	1	0	0.308	0	0.078	0.090	9.59	0.220	5.27

Tab. B.7: The results of the fuzzy asymmetric regression for seventh income decile

h	K_0	K_1	K_2	S_0	S_1	S_2	a_0	a_1	a_2	Z	MSE
0.5	1.1	1.25	1.4	0.01	0	0	0.093	0	1.60	0.446	5.27
0.5	1.4	1.6	1.9	0.01	0	0	0.093	0	1.60	0.446	5.27

0.5	1.9	2.3	2.6	0.01	0	0	0.093	0	1.60	0.446	5.27
0.5	2.7	2.9	3.2	0.01	0	0	0.093	0	1.60	0.446	5.27
0.5	1	1	1	0.01	0	0	0.093	0	1.60	0.446	5.27

Tab. B. 8: The results of the fuzzy asymmetric regression for eighth income decile

h	K_0	K_1	K_2	**S_0**	**S_1**	**S_2**	**a_0**	**a_1**	**a_2**	**Z**	**MSE**
0.5	1.1	1.25	1.4	0	1.939	0	0.321	0	2.392	0.138	5.27
0.5	1.4	1.6	1.9	0	1.939	0	0.321	0	2.392	0.138	5.27
0.5	1.9	2.3	2.6	0	1.939	0	0.321	0	2.392	0.138	5.27
0.5	2.7	2.9	3.2	0	1.939	0	0.321	0	2.392	0.138	5.27
0.5	1	1	1	0	1.939	0	0.321	0	2.392	0.138	5.27

Tab. B.9: The results of the fuzzy asymmetric regression for ninth income decile

h	**K_0**	**K_1**	**K_2**	**S_0**	**S_1**	**S_2**	**a_0**	**a_1**	**a_2**	**Z**	**MSE**
0.5	1.1	1.25	1.4	0.012	0.045	0	0.155	0	1.973	0.588	5.27
0.5	1.4	1.6	1.9	0.012	0.045	0	0.155	0	1.973	0.588	5.27
0.5	1.9	2.3	2.6	0.012	0.045	0	0.155	0	1.973	0.588	5.27
0.5	2.7	2.9	3.2	0.012	0.045	0	0.155	0	1.973	0.588	5.27
0.5	1	1	1	0.012	0.045	0	0.155	0	1.973	0.588	5.27

Tab. B. 10: The results of the fuzzy asymmetric regression for tenth income decile

h	K_0	K_1	K_2	**S_0**	**S_1**	**S_2**	**a_0**	**a_1**	**a_2**	**Z**	**MSE**
0.5	1.1	1.25	1.4	0	1.940	0	0.321	0	2.39	0.138	5.27
0.5	1.4	1.6	1.9	0	1.940	0	0.321	0	2.39	0.138	5.27
0.5	1.9	2.3	2.6	0	1.940	0	0.321	0	2.39	0.138	5.27
0.5	2.7	2.9	3.2	0	1.940	0	0.321	0	2.39	0.138	5.27
0.5	1	1	1	0	1.940	0	0.321	0	2.39	0.138	5.27

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بررسی آثار نامتقارن شاخص‌های اقتصاد باز بر ضریب جینی دهک‌های درآمدی در ایران

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چکیده

هدف این پژوهش تحلیل تأثیر شاخص‌های اقتصاد باز شامل باز بودن اقتصادی و سرمایه‌گذاری مستقیم خارجی بر توزیع درآمد در ایران طی سال‌های ۱۳۷۴ تا ۱۳۹۸ می‌باشد. برای این‌منظور از رگرسیون فازی با ضرایب نامتقارن استفاده شده است. دلیل استفاده از آن انعطاف‌پذیری بسیار بالا در تحلیل است. برای هر دهک درآمدی، مدلی بهینه برآورد می‌شود که تأثیر شاخص‌های اقتصاد باز را بر ضریب جینی دهک‌های درآمدی نشان می‌دهد. نتایج بیانگر آن است که متوسط تأثیر سرمایه‌گذاری مستقیم خارجی بر ضریب جینی دهک‌های درآمدی صفر یا بسیار کوچک است و نابرابری را کاهش می‌دهد. اما حداکثر تأثیر سرمایه‌گذاری مستقیم خارجی بر ضریب جینی دهک‌های درآمدی افزایش یافته است که منجر به نابرابری در توزیع درآمد می‌شود. این موضوع به‌دلیل نبود برنامه‌ها و سیاست‌های مناسب در اقتصاد است تا بتوان از فرصت سرمایه‌گذاری مستقیم خارجی برای کاهش نابرابری استفاده کرد. هم‌چنین نتایج نشان می‌دهد که حداکثر تأثیر درجهٔ باز بودن اقتصادی بر ضریب جینی دهک‌های درآمدی صفر است، به این معنی که درجهٔ باز بودن اقتصادی باعث افزایش نابرابری نمی‌شود؛ بنابراین به‌منظور تقویت یا تضعیف روابط خارجی باید میزان یارانهٔ پرداختی به هر یک از دهک‌های درآمدی و زیرساخت‌های موردنیاز برای جذب سرمایه‌گذاری خارجی را فراهم کرد؛ هم‌چنین اقداماتی را برای اخذ مقدار بهینهٔ مالیات از دهک‌های درآمدی فراهم می‌کند.

کلیدواژگان: ضریب جینی، ضرایب نامتقارن، رگرسیون فازی، شاخص‌های اقتصاد باز.
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