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Investigating the Relationship between Green Tax Reforms and Shadow Economy Using a CGE Model - A Case Study in Iran

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Abstract

In the past decades, the effect of different tax amendments on various economic issues has been studied. The majority of these studies have avoided considering shadow economy as part of the calculation and analysis, and an issue, which has received little attention, is the relationship between green tax reforms and shadow economy, as for informal labor, which is well-connected to unemployment rate, and, consequently, welfare. On this basis, in order to make the CGE model more compatible with the real world, this relationship has been investigated in a mathematical model. Finally, in order to perform the calculations, the presented model has been implemented and analyzed on social accounting matrix (SAM) of Iran. Computational results show impact of change in labor tax and capital tax on environment (CO2 emission), GDP, social welfare and unemployment. Based on presented analysis, change in shadow economy has a high impact on unemployment rate and informal labor. Sensitivity analysis on size of shadow economy shows that reducing CO2 emissions, bigger shadow economy leads to higher social welfare. The results indicate the efficiency of the model.

Keywords: Tax Reforms, Shadow Economy, Unemployment, General Equilibrium Model

JEL Classification: C68, E24, E26, O11, R13.

1. Introduction

In the research background, several studies on the relationship and

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impact of tax changes on workforce using financial reforms have been carried out. Clearly, the wage received by the workforce is proportional to his marginal product. On the other hand, the welfare can be defined as a function of the utility. As a result, it can be declared that the welfare will be dependent on workforce, wages and the unemployment rate. Majocchi (1996) showed that by changing the tax on labor to taxes on energy, if the rate declines, naturally, social welfare will raise, and besides the emission of gases such as CO_2 will also increase due to more consumption by the consumers.

Many researchers such as Bovenberg & Van Der Ploeg (1998); Carraro et al. (1996); Koskela & Schöb (1999) and Manresa and Sancho, (2005) have studied in this field, while the correlation of these financial reforms with the shadow economy has not been considered. However, a large proportion of the GDP economy is the shadow economy. Schneider et al. (2010) present estimations of the shadow economies for 162 countries. As for Italy, for example, in 2005, shadow economy constituted 21-29% of the total economy of the country, whereas the data for Iran in the year 1385 was 18%. One of the major tax factors in the economy is the tax for the workforce.

When companies have to pay labor taxes to the government, besides employing the formal labor force (for which governmental tax regulations apply), they are also interested in utilizing informal work force; and, thus, tax evasion phenomenon occurs. This employment enlarges the shadow economy, and, therefore, the government policies will fail to control it.

In this paper, a model is presented to study how to reduce the size of the shadow economy and the unemployment rate by green tax reforms. These reforms are applied on capital, workforce and lump sum transfers. A standard CGE general excellence model has been presented in this article, in which workforce has been divided into two categories: formal and informal workforce; and the quantity of this workforce affects wages and unemployment rate. The model presented in this paper is applied on the data of Iranian economy in the year 1385, the size of shadow economy of which was 18%. The data for the shadow economy from 1999 to 2007 has been provided by Schneider et al. (2010).

The model presented in this paper is divided into two main sections. The first section relates to the general excellence model for financial reforms presented by González-Eguino (2011). The second section concerns the shadow economy, (see González-Eguino et al. (2013); Harris & Todaro (1970) and Rutherford et al. (2002)). In this model the relationship between unemployment and workforce wage has been transformed into a wage curve; and the workforce has been divided into two categories (i.e., formal and informal workforce), the wages of which have been considered constant and equal. By combining these two models, the relationship between shadow economy and tax reforms is determined.

In this paper, the effects of CO2 tax revenues to reduce taxes on labor, capital and transfers are investigated altogether. Changes in emissions of CO2, which is declared by government policy, affects the amount of tax paid. These taxes and consumptions by consumers changes the social welfare. The procedure for exact calculation of welfare (EV) is included in the modeling section.

The remainder of this paper is organized as follows: In section 2, the modelling of general excellence model compatible with the shadow economy is presented. In section 3, the case study performed on the economy of Iran, along with parameter adjustment and model variables are discussed. In section 4, the results of the study are analyzed. Finally, conclusions and future studies are provided in section 5.

2. Mathematical Formulations

The presented model in this article consists of two sections, the general excellence model presented by González-Eguino (2011) combined with the shadow economy model by González-Eguino et al. (2013), which has been implemented on social accounting matrix (SAM) of Iran.

In this paper, to make the model more compatible with the real economy, the equations for the wage curve have also been modified. The logic of this modification is that when the parameters associated with the price of goods change, naturally, the consumer price index will also change. Accordingly, in this section, after defining the model requirements, such as model parameter and variables, the model formulation is presented.

2.1 Definition of the Sets

The model sets can be defined as Table 1.

Table 1: Model Sets

Index	Range	Description
Jj, J	1,...,J	Sectors, intermediate inputs and goods
E	Coal, oil, gas	Fossil fuels

2.2Model Parameters

Model parameters are presented in Table 2.

Table 2: Model Parameters

Parameter	Description
T_j^L و T_j^K و T_j^C	Tax rate for labor, capital and consumption for j’th section
T_*^T	Tax rate for energy-related goods (energy & electricity)
α_e	CO_2 emission rate for fossil fuels and producers
γ_e	CO_2 emission rate for a sample consumer
σ	Sensitivity rate of substitution between inputs
m	Internal parameters of the workforce mobility
Weight_j	Section weights for CPI calculation
$\bar{u}$	The unemployment rate measure

Initial values (before the enactment of tax amendments) are assumed to be 20% for labor and capital tax rates, 5% for consumer goods and 30% for energy-related goods. The values $\boldsymbol{\gamma_e}$ and $\boldsymbol{\alpha_e}$ for coal, oil and gas are considered 4.104, 2.851 and 2.187, respectively. The values have been extracted from González-Eguino et al. (2013). Unemployment rate measure in this study was assumed to be 17.9%, equal to the proportion of the shadow economy out of the total economy (the data on the shadow economy have been extracted from Schneider et al. (2010).

As for González-Eguino et al. (2013), the sensitivity rate of substitution between inputs is as Table 3**:**

Table 3: Model Substitution Rates

Substitution rate	Definition
σ^Y	Rate of substitution between inputs and capital-labor-energy
σ^{KLE}	Rate of substitution between capital-labor mix and energy
σ^{KL}	Rate of substitution between labor and capital
σ^L	Rate of substitution between formal and informal labor
σ^E	Rate of substitution between electricity and fossil fuels
σ^F	Rate of substitution between coal, oil and gas
σ^A	Rate of substitution between domestic goods and imported goods
σ^T	Rate of substitution between domestic goods and exports
σ^C	Rate of substitution between consumption of energy-related goods and non-energy-related goods
σ^{CE}	Rate of substitution between consumption of energy-related goods
σ^{CB}	Rate of substitution between consumption of non-energy-related goods

Table 4: Model Variables

Variable	Discription
Y_j	Output of j’th section
$Y_{jj,j}^{ID}$	Intermediate input demand jj in the j’th section
Y_j^D	Domestic demand for product j
Y_j^{TS}	Total supply of product j
Y_j^{TD}	Demand for product j
M_j	Imports of product j
X_j	Exports of product j
$\overline{XD}$	Trade deficit
L_j	Demand for labor in sector j
LF_j	Demand for formal labor in sector j
LI_j	Demand for informal labor in sector j
w_F	Workforce wage
P	Consumer Goods Price Index
CPI	Consumer Goods Price Index
u	Unemployment rate
K_j	Demand for capital in sector j
Ut	Sample consumer utility
C_j	Private consumption of product j
G_j	Public consumption of product j
$\overline{G}$	Public consumption
S	Saving
T	Transfers between consumers and government
I_j	Investment in sector j
P_j	The equilibrium price of product j
P_K	Market equilibrium price of capital
P_L	Market equilibrium price of Labor
P_I	Market equilibrium price of investment
P_x	The equilibrium exchange rate
P_E	Equilibrium price of CO_2 emission permits
E_j^P	CO_2 emissions in sector j
E	Final amount of CO_2 emissions
$\overline{Target}$	CO_2 emission permit amount
Y_j	Output of j’th section

2.3 Model Variables

In order to present the model, the variables, such as demand for different products, need to be defined. Along with changes in the amount of carbon dioxide emissions by the government policies different variables also change. In optimum case, due to equality constraints, these variables will become stable. Model variables are defined in Table 4.

2.4 Model Equations

The model equations are introduced in this section. These equations include the equations presented in the Appendix. A of González-Eguino (2011), and Equations 16 and 17, 18, 19 and 20 are taken from González-Eguino et al. (2013). An additional equation is also added to these equations (i.e. Eq. 21). This equation will contribute to model to be more dynamic and accurate. Elaboration on this equation is provided after presenting the equations. In this section, according to the definitions given in sections 2.1 to 2.3, the model formulation is discussed. Table 5 shows the model equations.

Table 5: Model Formulations

Producers

Production function:

$$Y_j = CES\left(Y^{ID}_{1,j}, \dots, Y^{ID}_{J,j}, K_j, L_j, E^p_j : \sigma\right), \quad \forall j \epsilon (1, \dots, J) \tag{1}$$

Zero profit condition:

$$\sum_{jj=1}^{J} Y^{ID}_{jj,j}\left(P_j + T^T_*\right) + \left(P_K + T^K_j\right)K_j + \left(P_L + T^L_j\right)L_j + P_E E^P_j = Y_j P_j, \forall j \epsilon (1, \dots, J) \tag{2}$$

Consumers

Utility function for sample consumer:

$$Ut = CES\left(C_1, C_2, \dots, C_j : \sigma\right) \tag{3}$$

Balance of income conditions:

$$P_K K_j + P_L L_j + T = \sum_{j=1}^{J} \left(P_j + T^C_j\right)C_j + S \tag{4}$$

Government

Expenditure function:

$$\overline{G} = LT\left(G_1, G_2, \dots, G_J\right) \tag{5}$$

Balance of income conditions:

$$\sum_{j=1}^{J} \left(T^L_j L_j + T^K_j K_j + T^C_j C_j\right) + \sum_{j=1}^{J} \left(P_E E_j + T^T_* Y^{ID}_{*,j}\right) = \sum_{j=1}^{J} P_j G_j + T \tag{6}$$

International Trade

The total supply from imports and goods produced:

$$Y^{TS}_j = CES\left(Y_j, M_j\right), \quad \forall j \epsilon (1, \dots, J) \tag{7}$$

The total demand from exports and demand for the goods:

$$Y^{TD}_j = Y^{TS}_j = CES\left(Y^D_j, X_j\right), \quad \forall j \epsilon (1, \dots, J) \tag{8}$$

Law of Closure:

$$\sum_{j=1}^{J} P_X\left(M_j - X_j\right) = \overline{XD} \tag{9}$$

Producers	
CO_2 emissions $E = \sum_{j=1}^{J} E_j^P + E^C = \sum_{j=1}^{J}\sum_{e=1}^{4} \alpha_e Y_{e,j}^{ID} + \sum_{e=1}^{4} \gamma_e C_e$	(10)
Market clearance Market of goods and services: $Y_j^D = \sum_{jj=1}^{J} Y_{jj,j}^{ID} + C_j + G_j + I_j\big(M_j - X_j\big), \quad \forall j \epsilon (1, \dots, J)$	(11)
Labor market $\bar{L} = \sum_{j=1}^{J} L_j$	(12)
Capital market $\bar{K} = \sum_{j=1}^{J} K_j$	(13)
Saving and Investment $S = \sum_{j=1}^{J} P_j I_j + XD, \text{along with} \quad P_K = P_I$	(14)
CO_2 emission permit market $E = \overline{Target}$	(15)
Equations of the shadow economy Workforce function $L_j = (\delta_j L_j^{F(1-\frac{1}{\sigma_L})} + \big(1-\delta_j\big) L_j^{I(1-\frac{1}{\sigma_L})})^{1/(1-\frac{1}{\sigma_L})}$	(16)
Wage curve of formal labor force $\frac{W_F}{P = CPI} = (\frac{u}{\bar{u}})^{-\theta}$	(17)
The relationship between wages of formal and informal labor $W_I = W_F(1-u)$	(18)
Mobility between formal and informal labor $L^F = L_0^F(1-u) + L_0^I(1-m)$	(19)
$L^I = L_0^I m$	(20)
Consumer Price Index $CPI = \sum_{j=1}^{J} P_j Weight_j$	(21)

Explanation of presented model in the table 5: the model equations have been divided into eight major groups. The first group is of the producers, which includes equations for the production function and zero profit conditions. Equation (1) implies that any output $\mathbf{Y_j}$ is produced by a combination of intermediate demands of the required inputs, labor, capital and energy. Combination approach of these inputs is obtained from CES[1] production function, which is demonstrated in figure1.

Producers aim to maximize their profits ($Y_j P_j$) subject to the technological constraints. At equilibrium, net profit after tax would be zero, i.e. the value of the output from each sector would be the same as the sum total value of inputs. Note that P_j is the price of the output from sector$j$, P_k is the price of capital and P_L is the price of labor. Also τ_j^K and τ_j^L are the sectoral tax rates on capital and labor. Finally, when a CO_2 instrument is implanted (with a CO_2 emission permit market or a CO_2 price) the producer has to pay (directly or indirectly) a market price (P_E) for every unit of permit/emissions used (E_j^P). Equation (2) illustrates this well.

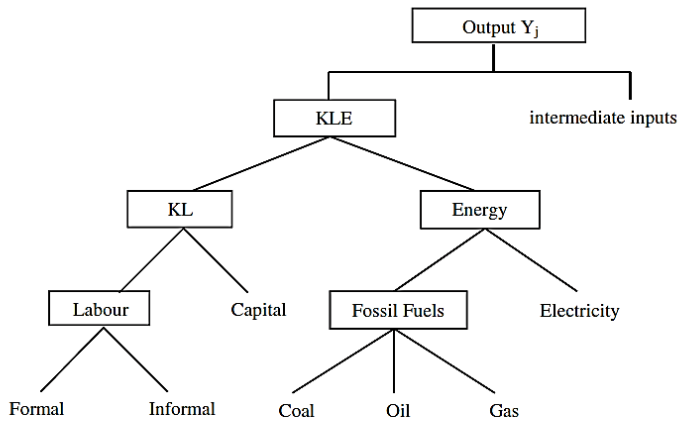

Figure 1: Production function of different outputs; See Markandya, González-Eguino et al. (2013)

In this model, consumers have been considered as a typical consumer. With every purchase, consumers expect some utility. This utility is displayed by constraint (3). Consumer would prefer to maximize the marginal utility with respect to limits on the budget. As

1. CES function is used to summarize the formulas used for production and utility. For instance, let output variable Y be produced by the input variables X1 and X2 with the formula: $\mathrm{Y} = (\mathrm{a}_1 \mathrm{X}_1{}^{1/\sigma} + \mathrm{a}_2 \mathrm{X}_2{}^{1/\sigma})^{\sigma}$. By the use of CES function, this compound is then displayed in the form: $\mathrm{Y} = \mathrm{CES}(\mathrm{X}_1, \mathrm{X}_2; \sigma)$. Even if the two inputs are outputs of another function, this function is applicable for them, as well.

is shown in equation (4), income from labor, capital and exchange between government and consumers is equal to consumption, tax on consumption and savings.

In equations (5) and (6), effort is made by the government to supply public spending by labor and consumption tax. This is displayed by a certain type of CES function, known as Leontief function. Additional government revenue from controlling the amount of carbon dioxide is injected directly to consumers. This makes the level of public spending constant.

In the area of international trade, equations (7) and (8) imply that the total demand and supply of goods is determined by the import, export and production of goods. Equation (10) determines the amount of carbon dioxide emission.

In the next section market clearance equations are given. In equation (11) it is implied that the domestic demand for each product is equal to the sum of total inputs used in its production, private consumption, public spending and the GDP. Equations (12) and (13) calculate the total amount of required labor and capital. In equation (14) calculation procedure for government saving and its relation to investments, is given, because of the global and regional pressures and strategic perspective, a certain amount of carbon dioxide emission is determined by the government, and the producers will not be allowed to increase the production of this gas. This limitation is clarified by equation (15).

So far, the equations associated with green economy model have been discussed; and equations (16) to (21) relate to the shadow economy. Equation (16) is the combination function or the production function concerning workforce, while as described in the previous sections, the labor is divided into formal and informal labor. Equation (17) shows the wage curve, the denominator of the left side of which has been assumed to be a constant in various papers like González-Eguino et al. (2013), while in this article its modification has been considered. In other words, in case of any changes in the price of the products, naturally, the consumer price index will also change.

Equation (18) presents the relation between the wages of formal and informal labor force. Mobility between formal and informal labor states that if the government increases labor tax, companies will try to utilize informal labor to pay less tax to the government. Exchange and mobility of these two types of labor are given by equations (19) and (20). Equation (21), which is the formula for calculation of consumer price index, has been introduced to make the model more compatible with the real economy.

In equations for CES functions, it should be noted that the contribution parameters for any of the parameters must also be examined (as for $\boldsymbol{\delta_j}$ in equation 16). Optimal values of these parameters have been calculated by simulation using GAMS software and their introduction in the model has been avoided.

3. Case Study on Iranian Economy

In this study, the data of social accounting matrix of Iran in 2006, after being classified, have been divided into 15 categories of production, service, commercial and non-commercial. Data such as intermediate inputs, weights, import and export, etc. can be extracted from the complete summarized matrix. The values, thus, can be used as input data for different calculations as primary values. These values are used by the software to start solving the model, and then the necessary changes in variables such as carbon dioxide emission level will make the primary values change to secondary values, and, consequently, the amount of consumption and the welfare of consumers will change.

After extracting the data required for solving the model from the summarized social matrix, the data and the assumptions that are not available in the matrix should be considered. In this study, the ratio for informal labor in Iran is considered 18%, equal to the size of the shadow economy. Size of the shadow economy in 2006 (1385 in Jalali calendar), is extracted from the paper Schneider et al. (2010). According to this paper, the size of the shadow economy in Iran in the year 2006 is approximately equal to 18%.

Index of wage flexibility in this article is assumed equal to 0.1, as for González-Eguino et al. (2013). Due to the absence of clear data, labor tax is averagely (constant) considered equal to 20%. Capital tax rate is also considered 20%, as for the labor. Consumption tax rate is assumed to be 5%. As introduced in González-Eguino et al. (2013), the unemployment rate ($\bar{u}$) is considered equal to the shadow economy, i.e. 18%. Consumer price index (P) at the beginning of the software solution is considered equal to 1, and the assumptions for the coefficients of substitution are as "Table 6". Coefficients $\boldsymbol{\alpha_e}$ and $\boldsymbol{\gamma_e}$ have been extracted from González-Eguino (2011).

Table 6: The Sensitivity Rate of Substitution between Inputs (Markandya, González-Eguino et al. 2013)

Substitution Rate	Definition	Value
σ^{Y}	Rate of substitution between inputs and capital-labor-energy	0
σ^{KLE}	Rate of substitution between capital-labor mix and energy	0.25
σ^{KL}	Rate of substitution between labor and capital	1
σ^{L}	Rate of substitution between formal and informal labor	5
σ^{E}	Rate of substitution between electricity and fossil fuels	0.5
σ^{F}	Rate of substitution between coal, oil and gas	1
σ^{A}	Rate of substitution between domestic goods and imported goods	3
σ^{T}	Rate of substitution between domestic goods and exports	3
σ^{C}	Rate of substitution between consumption of energy-related goods and non-energy-related goods	0.5
σ^{CE}	Rate of substitution between consumption of energy-related goods	1
σ^{CB}	Rate of substitution between consumption of non-energy-related goods	1

4. Results

As stated in the introduction, in this study, three approaches, i.e. Lump sum transfer, taxes on capital and labor taxes, along with reduction of CO2 emission level, have been used to assess the welfare. The analyst determines the level of carbon dioxide emission and its impact on the social welfare is calculated under the mentioned scenarios. "Table 7" shows this relationship when wages are perfectly flexible.

Table 7: Welfare Values for Zero Variability and Fully Flexible Wages *(→ ∞)*

	CO_2 emission level reduction					
Tax Recycling	5%	10%	15%	20%	25%	30%
LST	0.00	-0.11	-0.18	-0.32	-0.48	-0.67
TaxK	0.00	-0.08	-0.15	-0.26	-0.39	-0.64
TaxL	0.00	-0.09	-0.18	-0.30	-0.49	-0.65

"Table 7" shows the values of welfare for different scenarios. In this table, the values of wages are assumed to be perfectly flexible. The first row of the table shows the values of welfare for different percentages of CO2 reduction for tax reforms of type (LST). For example, if the tax reforms are performed and CO2 is reduced by

20%, welfare will decrease as much as 32%. "Figure 2" demonstrates the changes in "Table 7".

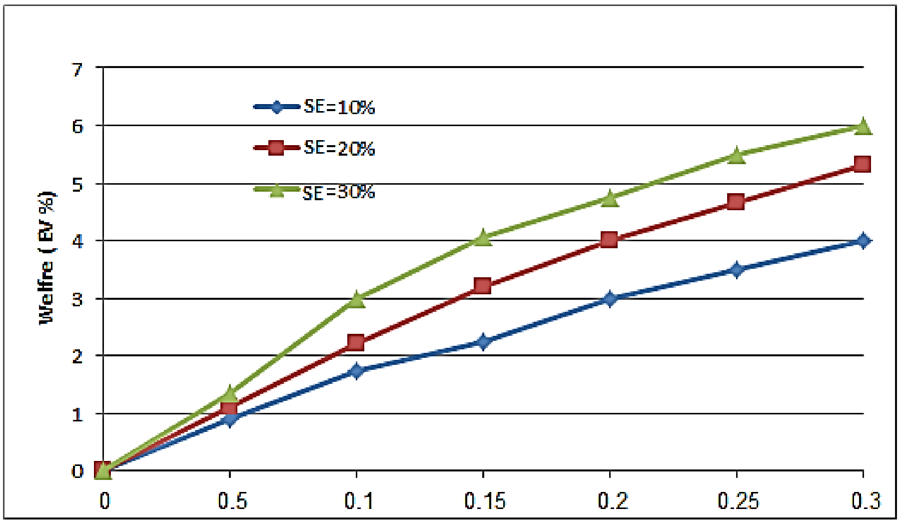

Figure 2: Welfare Changes in Terms of CO_2 Reduction for Various Amounts of the Shadow Economy

"Table 8" shows the values of welfare for different tax reforms and CO2 reduction levels. It can be noted that by the implementation of tax reforms on labor, welfare increases, and this is a point that should appear on the exchange between the shadow economy and reforms. This issue has been discussed by González-Eguino et al. (2013).

Table 8: Change in Welfare for the Substitution Rate ($\sigma_L = 3$) Wage Flexibility ($\theta = 0.1$)

	CO2 emission level reduction					
Tax Recycling	5%	10%	15%	20%	25%	30%
LST	-0.30	-0.98	-1.16	-1.87	-2.53	-3
TaxK	-0.30	-0.97	-1.16	-1.87	-2.52	-3
TaxL	0.40	1.5	2.07	2.6	3.11	3.67

"Table 9" shows the impact of the use of different financial reforms on other sectors of the economy, such as shadow economy, various industries, applications, etc. For instance, in case of CO2 emission level reduction by 15% and the capital tax reform, coal consumption reduces by as much as 19.6%. The impact of taxes on labor is noteworthy, and it is expected that it positively effects on the shadow economy variables.

Table 9: The Impact of Various Tax Recycling Options (CO_2 Reduction Equal to 15%)

	LST	TaxK	TaxL
General (Change of values in percent)			
Welfare	-1.16	-1.16	2.07
GDP (including the shadow economy)	-0.98	-0.98	2.00
General (Change of values %)			
Shadow economy	18.6%	18.6%	13.3%
Unemployment rate	19%	19%	15.4%
Private consumption			
Agriculture	-2.12	-3.25	0.93
Energy	-4.99	-5.70	1.43
Industry	-3.61	-4.43	2.26
Construction	-1.04	-1.01	2.88
Transportation	-3.32	-1.55	1.43
Service	-0.75	-0.67	4.92
Energy consumption (change in values %)			
Coal	-19.16	-19.16	-21.12
Oil	-3.54	-3.79	-4.32
Gas	-2.78	-3.51	-1.27
Electricity	-3.66	-3.56	2.48
Carbon dioxide emission (Values %)			
Carbon dioxide emission	-15.00	-15.00	-15.00
Tax on carbon dioxide emissions	39.36	39.34	56.39
Price changes in percent			
Price index of capital	-1.69	-0.22	0.98
Formal labor price index	-0.97	-1.00	0.34
Informal labor price index	-0.85	-0.85	3.37
Consumer Price Index	16.44	16.44	13.00

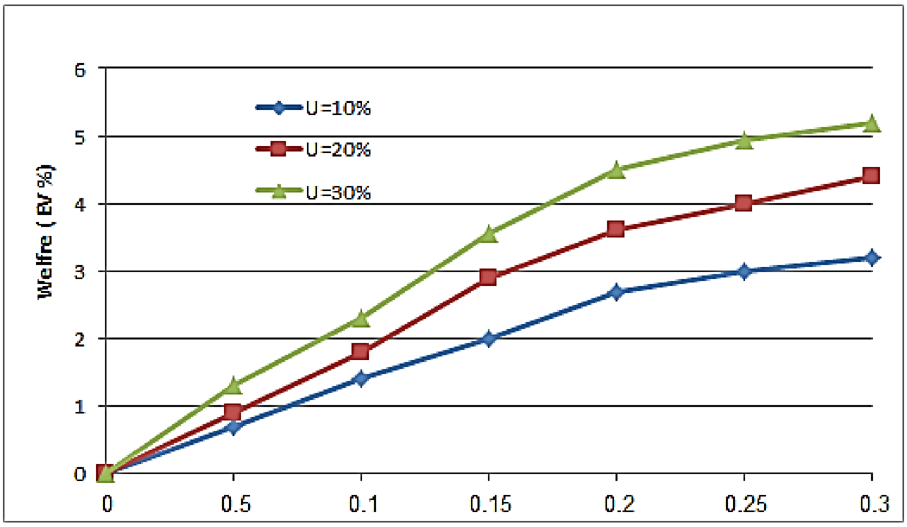

Figure 3: Welfare Changes in Terms of CO_2 Reduction for Different Rates of Unemployment

"Figure 2" demonstrates the trend of welfare change (in percent) for various values of the shadow economy. As can be seen in the diagram, if there is a shadow economy with a size equal to 10% of GDP, welfare will increase with a higher ratio compared to the similar case with the shadow economy equal to 20%. It seems that if a similar graph is drawn for the unemployment rate, the diagram will be similar. "Figure 2" and "Figure 3" illustrate this.

5. Conclusion

In this paper, a CGE model for application in Iranian economy, which has a high rate of unemployment and shadow economy, was presented. The results indicate that changes in the shadow economy lead to changes in the unemployment rate, and consequently informal labor. Considering flexibility in the model using wage curve makes the calculation of social welfare and impact of government policies on carbon dioxide emission level more realistic. For instance, in case of using tax on workforce, reduction of CO2 by 15% will increase total economy by 2%, social welfare by 2.07% and unemployment rate by 15.4%.

Computational results in section 4 shows impact of change in labor tax and capital tax on environment (CO2 emission), GDP, social welfare and unemployment. As an example if labor tax increases, then unemployment rate will be decreased and GDP, social welfare will be increased. Based on presented analysis, change in shadow economy has a high impact on unemployment rate and informal labor. Sensitivity analysis on size of shadow economy shows that by reducing CO2 emissions, bigger shadow economy will lead to higher social welfare and by a further reduction in CO2, this reflected more and more.

CGE model used in this paper is static, in other words, changes can only be assessed over a period of time, which causes the decisions made by it have some differences with reality. Thus, in order to make the model more realistic, it is suggested that a model be presented which considers the changes dynamically in different time periods and then the decision making process be carried out. Another interesting research field is considering uncertainty in SAM matrix data and representing the CGE model.

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