ECONOMIC ANALYSIS OF THE IMPACT OF CARBON TAX ON THE ECONOMY OF MAKASSAR CITY, INDONESIA

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Abstract

Makassar is the capital of South Sulawesi and the largest metropolitan city in eastern Indonesia. This city is an established of economic development for eastern Indonesia, which is characterized by a high degree of industrial development. Therefore, the carbon dioxide (CO_2) emissions generated in the city will increase. However, the government has attempted to maintain environmental quality to ensure a livable and healthy city. Unfortunately, the government's budget to support the economic development is limited, despite the increased level of economic activity in the city. As a result of these conditions, the government has elected to economize resource use by improving the efficiency of resource allocations. To this end, the government imposed a carbon tax in the city.

The purpose of this study is to analyze the impacts on the economy in Makassar resulting from the introduction of carbon taxes to reduce energy consumption in all sectors of the economy that generate CO_2 emissions. The imposition of a carbon tax is expected to reduce CO_2 emissions and to improve the city's economic potential. The study investigates the possibility of transferring carbon tax revenue to transfer to household to generate increased household income. A computable general equilibrium (CGE) model was the primary analytical methodology employed to measure the impact of the imposition of a carbon tax across all sectors of the economy. The model examined the impact of the carbon tax based on the 2006 input-output (I-O) table for Makassar City and estimated of a social accounting matrix (SAM) table the same year. In CGE models, general equilibrium is achieved via the price mechanism. The model assumes a static economy with no time-related elements. A total of twenty eight industrial sectors and two production factors, labor and capital, are used in this study. The model economy contains a single representative household that sets its consumption to maximize its utility subject to its budget constraint. The utility function used is the constant elasticity of substitution (CES) type, where the household maximizes utility subject to a budget constraint. Every industry uses an intermediate input to produce one commodity for each sector without commodity by-product. The firms are assumed to maximize their profits by managing inputs and outputs subject to their production technology. Firms are assumed to be perfectly competitive and to achieve equilibrium in 2006 through flexible price adjustments.

The carbon tax policy is assessed in two simulations. In the first simulation, a carbon tax is imposed on all industries without household transfer, and in the second simulation, the tax revenue is transferred to households. The government transfers funds to household in amount equal to the carbon tax revenue. In theory, the implementation of a carbon tax will reduce CO_2 emissions and increase government revenues. Furthermore, household welfare will also increase, output prices will increase, and the household will reduce its consumption.

The results of all simulations of the CGE model indicated that a carbon tax can reduce the volume of CO_2 emissions by 8 %. In general, output prices and production volumes decline. The demand for capital tendeds to be fixed, and labor demand declined after tax revenues were transferred to the representative household. Household consumption declined following the imposition of carbon taxes but increased in response to the transfer of carbon tax revenues. Therefore, household welfare increased after receiving transfers from the government.

It is crucial to effectively manage efforts to reduce CO_2 emissions. The such management involves not only production-side efforts concerning environmental-friendly technology; but prevention of a decline in commodity consumption preferences.

Keywords: *Carbon tax, CGE approach, CO_2 emissions, economy analysis*
JEL classification: H21, H32, H71

I Introduction

A carbon tax is one policy instrument that can be applied to address greenhouse gas emissions. Indonesia's policy goals in this respect can be found in the Ministry of Finance Indonesia's Green Paper on Climate Change Commitment of the President of the Republic of Indonesia, presented at a G-20 conference (2010). The country's target is to reduce CO_2 emissions in 2020 to the equivalent of 6 % to 24 % below 2005 levels. The tax will be introduced at a rate estimated to reduce emissions to meet long-term goal.

The degree of abatement achieved is measured based on the estimated emissions level in 2006, which is considered the business-as-usual (BAU) scenario. In principle, of abatement applies to all CO_2 emissions generated a results of economic activity in the city. The use of fossil fuel accounts for 68.7 % of total emissions in Indonesia (2010).

Under the BAU scenario, the CO_2 emissions generated by energy sector in Makassar City are estimated at 2.57 million tons for 2006. To achieve the target in the Green Paper, it will be necessary to reduce emissions by 154,000 to 616,000 tons relative to the BAU scenario. Under the scenarios considered in this study, a carbon tax is introduced at a rate that is sufficient to reduce CO_2 emissions by 7 % to 8 % relative to 2006 levels. The tax applies to all commodities consume the city. However, to avoid double taxation, tax does not apply to the export or and distribution sectors.

The study provides a detailed evaluation of the impacts of the carbon tax on production, consumption and urban economic performance. This research uses a computable general equilibrium (CGE) model, which is a quantitative method to estimates the impact of economic and policy shocks, particularly those affecting the entire economy. The model realistically reproduces the structure of the overall economy and therefore the nature of all existing economic transactions among diverse economic agents (productive sectors, household, the government, and external sectors). The results of the CGE model are expected to reveal that the carbon tax will have significant impacts throughout the economy.

The carbon tax will initially be set at rate of Rp. 10,000/t-$CO_{2,}$ wich is equivalent to US $1/t-$CO_2$. The model employs the carbon tax rate applied in India, under the assumption that Makassar city exhibits an economic structure that is sufficiently similar to that of India. The results presented below estimate the effects on the city's economic activity.

II The Model

2.1 Framework of the Model

The results of the simulations produced using the CGE comparative-static model were reported as deviations from a baseline scenario (BAU). Rather than presenting changes over time, the model reports differences with respect to the baseline scenario at a given point in 2006. Such results are generally considered to represent economic responses over a period of approximately two years (McDouugall, 1993). The model is consistent with price levels and real economic activity. The price is determined exogenously and acts as the numeraire in the model.

An example of a comparative static model is illustrated in Figure 1. The figure depicts the equilibrium relationships between demand and supply before and after the imposition of a carbon tax. This study assumed that the city's industries produced products and CO_2 emissions as a by-product. In the figure, x is a commodity, p is the price of the commodity, t is the tax per unit of the commodity, and the commodity supply function will shift upward by t.

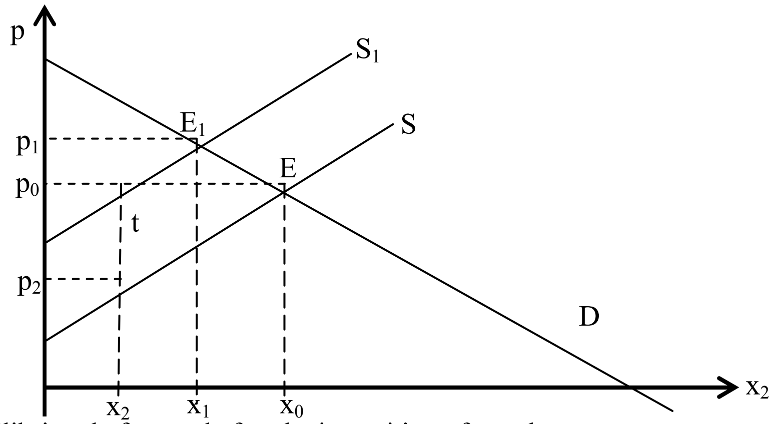

Figure 1: Equilibrium before and after the imposition of a carbon tax

This figure indicates that the price of the commodity before the imposition of the tax (x_2) is p_2 and that the price of the commodity after the imposition of the tax (x_2) becomes p_2 + t. Equilibrium is achieved when the demand function (D) and the supply function (S) intersect at point E (x_0,p_0). After the tax is introduced, equilibrium occurs at the point E_1 (x_1, p_1), which is the intersection of the demand function (D) and the supply function (S_1) after the tax has been imposed.

The model simulations indicate that the tax will result in percentage changes in industrial output of 100*(X1-X0)/X0 and demonstrate how the policy could affect industrial output and economic performance.

2.2 Setup of the Economy

In the model, production requires the use of two production factors: one unit of labor and one unit of capital. In the model economy, there are twenty-eight industry representative firms, that produce twenty-eight commodities. There is a single representative household that consumes all commodities in the economy in a way that maximizes its utility. The household supplies the firms with two production factors in return for income. The supply and demand for these commodities and production factors are in perfectly competitive equilibrium in 2006.

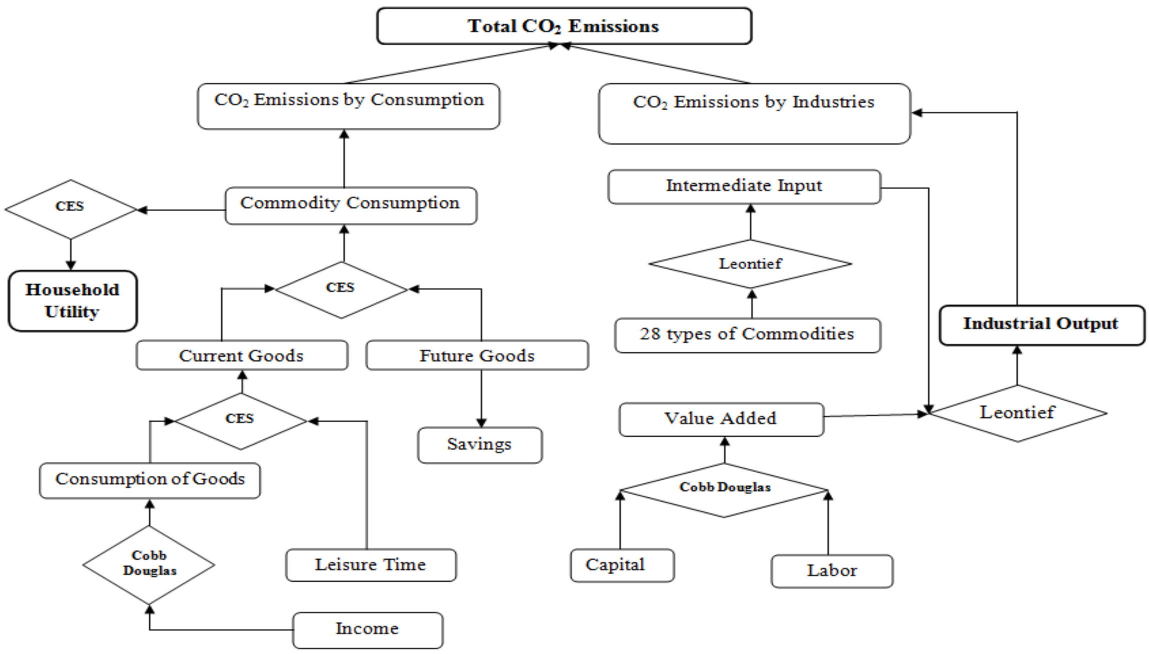

Figure 2: Hierarchical structure of the model

2.3 Behavior of Economic Agents

2.3.1 Industries

The industries use intermediate inputs, labor and capital to produce goods. Industries combine the intermediate, labor and capital inputs using the Leontief production function and apply the Cobb-Douglas production function for the value-added inputs (see Figure 3). The firm's cost minimization problem can be written as follows:

$$\min \sum_{i=1}^{28} p_i x_{ij} + (1+tp_j)(wL_j + rK_j) \qquad (j = 1,....28) \qquad (1)$$

with respect to x_{ij}, L_j and K_j

subject to

$$X_j = \min \left[\frac{1}{a_{0j}} f_j(L_j, K_j), \frac{x_{1j}}{a_{1j}},..., \frac{x_{ij}}{a_{1j}},..., \frac{x_{28j}}{a_{28j}}\right] \qquad (2)$$

$$f_j(L_j, K_j) \equiv A_{1j} L_j^{a_j} K_j^{(1-a_j)} \qquad (3)$$

where
p_i: price of commodity i
x_{ij}: intermediate input of industry i's product in industry j
tp_j: net indirect tax rate imposed on industry j's product (indirect tax rate-subsidy rate)
w: wage rate
r: capital return rate
L_j: labor input in industry j
K_j: capital input in industry j
X_j: output in industry j
a_{0j}: value added rate in industry j
a_{ij}: input coefficient
A_{ij}, α_{ij}: technological parameters in industry j

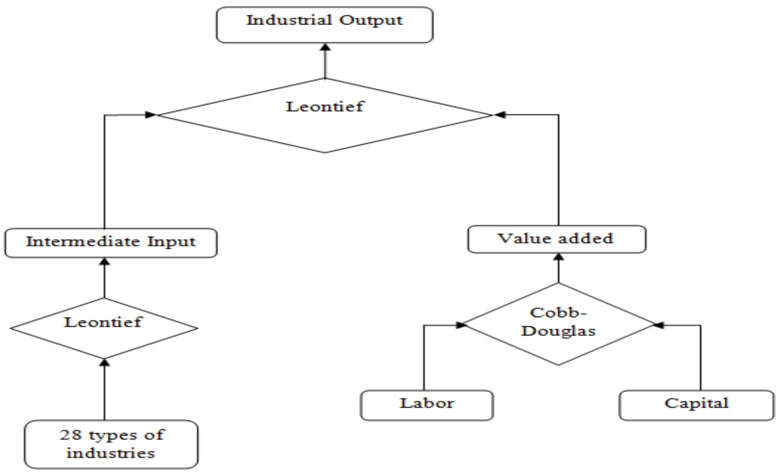

Figure 3: Hierarchical structure of industries

The conditional demands for intermediate goods, labor and capital in the production process are as follows:

$$x_{ij} = a_{ij} X_j \qquad (4)$$

$$LD_j = \left[\frac{(1-\alpha_j)r}{\alpha_j w}\right]^{\alpha_j} \frac{a_{0j} X_j}{A_j} \qquad (5)$$

$$KD_j = \left[\frac{a_j w}{(1-a_j)r}\right]^{(1-a_j)} \frac{a_{0j} X_j}{A_j} \quad (6)$$

where

LD_j: conditional demand for labor in industry j

KD_j: conditional capital demand in industry j

The industries conform to the zero profit condition under perfect competition.

$$profit = p_j X_j - \sum_{i=1}^{28} p_i x_{ij} - (1+tp_j)[w \cdot LD_j + r \cdot KD_j] = 0 \quad (7)$$

2.3.2 Households

A fixed number of households in Makassar City are assumed to be homogeneous. Thus one can assume that the households share a common aggregate utility function. The households share a *CES* utility function with respect to the consumption of current and future goods. In this model, the current good is defined as a *CES* composite of current consumption goods and leisure time and the future good is derived from savings. The household utility function illustrated in Figure 4:

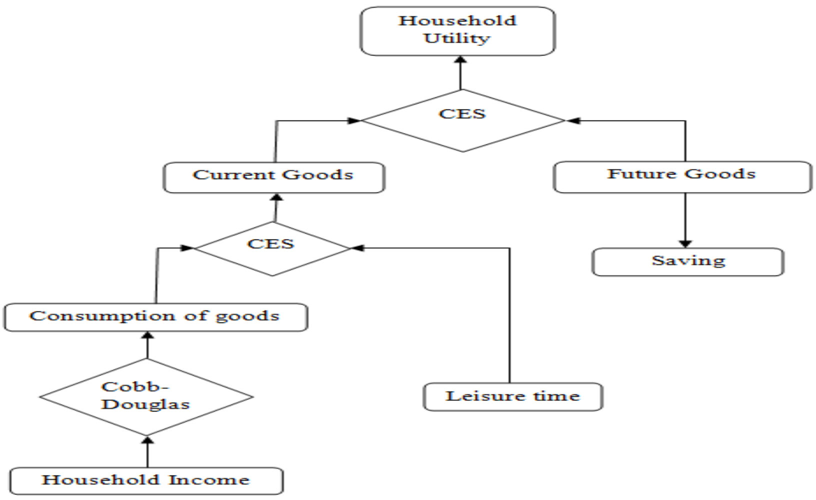

Figure 4: Hierarchical structure of households

Households select a bundle of current and future goods to maximize their utility function subject to a budget constraint. The current good is then divided into a composite consumption good and leisure time (labor supply).

Household income consists of full wage income, which is obtained when households supply their entitre labor endowment, capital income after capital depreciation, current transfers from the government, labor income, property income and other current transfers from the external sector. A share of household wage and capital income is transferred to the external sector.

A direct tax is imposed on households income after receive transfers. Households are then assumed to allocate their after direct tax income to current and future good. Here, the direct tax is assumed to include all current transfers from households to the government for simplicity.

To explain the household behavior, future goods consumption is derived here. The future good indicates future household consumption derived from household saving; however, household saving also forms the basis for capital investment. Therefore, the capital good can be interpreted as a saving good. Investment is made using produced goods, and their shares in total investment are denoted by b_i. When the price of the investment good is denoted by p_I,

$p_I I = \sum_{i=1}^{28} p_i I_i$ is realized. The price of the investment good is then expressed as $p_I = \sum_{i=1}^{28} b_i p_i$. This price can be regarded as the price of the saving good p_s.

Because the returns to capital net of the direct tax on a unit of capital investment is expressed by $(1\text{-}ty)(1\text{-}k_o)(1\text{-}k_r)\ r\delta$, the expected return rate on the price of saving good p_s, that is, the expected net return rate of household saving r_S is written as follows:

$$r_S = (1-ty)(1-k_O)(1-k_r)r\delta / p_s \quad (8)$$

where
ty: direct tax rate imposed on households
k_o: rate of transfer of property income to the external sector
k_r: capital depreciation rate
δ: ratio of capital stock in units of a physical commodity to that in units of capital service.

Here, the assumption is that the expected returns to saving finance future consumption. Interpreting the price of the future good as the price of the current consumption good under myopic expectations, and denoting real household saving S, we observe that the following equation holds.

$$p \cdot H = (1-ty)(1-k_O)(1-k_r)r\delta \cdot S \quad (9)$$

This equation yields $[p_s\, p/(1\text{-}ty)(1\text{-}k_o)(1\text{-}k_r)r\delta]H=p_s S$, and setting the price of the future good p_H associated with real saving S yields the following:

$$p_H = p_S\, p/(1-ty)(1-k_O)(1-k_r)r\delta \quad (10)$$

Then $p_s S = p_H H$ is realized.

Employing the above-mentioned future good and its price, the household utility maximization problem is now specified as follows. The maximization of household utility with respect to current good consumption will be described in a subsequent section.

$$\max_{G,H}\ u(G,H) \equiv \{\alpha^{1/v_1} G^{(v_1-1)/v_1} + (1-\alpha)^{1/v_1} H^{(v_1-1)/v_1}\}^{v_1/(v_1-1)} \quad (11)$$

subject to

$$p_G \cdot G + p_H \cdot H = (1-ty)FI - TrHO \quad (12)$$

$$FI \equiv (1-l_O)w \cdot E + LI + (1-k_O)(1-k_r)r \cdot KS + KI + TrGH + TrOH \quad (13)$$

where
α: share parameter
v_1: elasticity of substitution between the current good and future good
G: current household consumption
H: future household consumption
p_G: price of the current good
p_H: price of the future good
FI: household full income
$TrHO$: current transfers from households to the external sector
l_o: the rate at which labor income is transferred to the external sector

E: initial household labor endowment, which is specified as twice the actual working time based on actual working and leisure time in Makassar City.
LI: labor income transferred from the external sector to households (exogenous variable)
KS: initial household endowment of capital stock
KI: property income transferred from the external sector to households (exogenous variable)
TrGH: current transfers from the government to households
TrOH : current transfers from the external sector to households

By solving this utility maximization problem, we obtain the demand functions for current and future goods, yielding a household saving function.

$$G = \frac{\alpha[(1-ty)FI - TrHO]}{p_G^{v_1} \cdot \Delta} \quad (14)$$

$$H = \frac{(1-\alpha)[(1-ty)FI - TrHO]}{p_H^{v_1} \cdot \Delta} \quad (15)$$

$$S = p_H H / p_s \quad (16)$$

$$\Delta \equiv \alpha p_G^{1-v_1} + (1-\alpha) p_H^{1-v_1} \quad (17)$$

We then describe the derivation of demands for composite consumption and leisure time from the current good *G*. The current good *G* is a composite of consumption and leisure time, and *G* is obtained from the following optimization problem.

$$\max_{C,F} \; G \equiv \{\beta^{1/v_2} C^{(v_2-1)/v_2} + (1-\beta)^{1/v_2} F^{(v_2-1)/v_2}\}^{v_2/(v_2-1)} \quad (18)$$

subject to

$$p \cdot C + (1-ty)(1-l_o)w \cdot F = (1-ty)FI - TrHO - SH \quad (19)$$

where
β: share parameter
v_2: elasticity of substitution between composite consumption and leisure time
C: composite consumption
F: leisure time
p: price of the composite consumption good
SH: household nominal saving ($= P_S \cdot S$)

Solving this utility maximization problem yields the demand functions for composite consumption, leisure time, and labor supply.

$$C = \frac{\beta[(1-ty)FI - TrHO - SH]}{p^{v_2} \cdot \Omega} \quad (20)$$

$$F = \frac{(1-\beta)[(1-ty)FI - TrHO - SH]}{[(1-ty)(1-l_o)w]^{v_2} \cdot \Omega} \quad (21)$$

$$LS = E - F \quad (22)$$

$$\Omega = \beta p^{(1-v_2)} + (1-\beta)[(1-ty)(1-l_o)w]^{(1-v_2)} \quad (23)$$

where *LS* reflects the household labor supply

Substituting composite consumption (20) and leisure time (21) into (18), we derive the price index of the current good as follows:

$$p_G = \{\beta p^{1-v_2} + (1-\beta)[(1-ty)(1-l_o)w]^{1-v_2}\}^{1/(v_2-1)} \quad (24)$$

Moreover, the composite consumption good is disaggregated into produced goods by maximizing a Cobb-Douglas sub-sub utility function given household income and leisure time.

$$max \quad C \equiv \prod_{i=1}^{28} C_i^{\gamma_i} \qquad (\sum_{i=1}^{28} \gamma_i = 1) \quad (25)$$

subject to

$$\sum_{i=1}^{28} p_i \cdot C_i = (1-ty)Y - TrHO - SH \quad (26)$$

where

C_i: household consumption good produced by industry *i*

p_i: the price of good *i*

Y: household income ($=(1-l_o)w \cdot LS+LI+(1-k_o)(1-k_r)r \cdot KS+KI+TrGH+TrOH$)

From this optimization problem, consumption good *i* is derived.

$$C_i = \frac{\gamma_i}{p_i}[(1-ty)Y - TrHO - SH] \qquad (i = 1,\cdots,28) \quad (27)$$

The price of composite consumption is calculated as follows:

$$p = \prod_{i=1}^{28} \left[\frac{p_i}{\gamma_i}\right]^{\gamma_i} \quad (28)$$

2.3.3 The Government

The government sector in this study consists of the activies of the national and local governments in Makassar City. Thus, the concept of government that we employ corresponds to the definition used in the SAM framework. The government obtains its income from direct and net indirect taxes collected Makassar City and current transfers from the external sector. The government then spends this income on government consumption, current transfers to households and current transfers to the external sector. The government saves the difference between income and expenditures. Nominal consumption expenditures on commodities/services are assumed to be proportional to the government revenue with a constant sectorial share. These expenditures are denoted by the following balance of payments.

$$\sum_{i=1}^{28} p_i \cdot CG_i + TrGH + TrGO + SG = ty \cdot Y + \sum_{i=1}^{28} tp_i (w \cdot LD_i + r \cdot KD_i) + TrOG \quad (29)$$

where

CG_i: government consumption expenditures on commodity *I*

TrGH: current transfers to households
TrGO: current transfers to the external sector
SG: government savings
TrOG: current transfers from the external sector

2.3.4 The External Sector

The external sector gains its income from Makassar City's imports, current transfers from the government, labor income transfers and property income transfers. The sector then spends this income to finance Makassar City's exports and imports, current transfers to households and the government, labor (employees in Makassar City) and property income transfers. These expenditures are also expressed by the following balance of payments.

$$\sum_{i=1}^{28} p_i \cdot EX_i + TrOH + TrOG + KI + LI + SO = \sum_{i=1}^{28} p_i \cdot EM_i + TrHO + TrGO + KIO + LIO \quad (30)$$

where
EX_i: export of commodity *I*
EM_i: import of commodity *I*
SO: savings of the external sector (= national current surplus)
LIO: labor income transfers to the external sector ($= l_o \cdot w \cdot LS$)
KIO: property income transfers to the external sector ($= k_0 \cdot r \cdot KS$)

2.3.5 Balance of Investment and Savings

Savings accumulated by the representative household, the government, the local department and total capital depreciation determine the total investment.

$$\sum_{i=1}^{28} p_i \cdot I_i = SH + SG + SO + \sum_{i=1}^{28} DR_i \quad (31)$$

where
I_i: demand for commodity *i* by other investments,
DR_i: amount of fixed capital consumption in industry *i*

2.3.6 Commodity Prices

Given the zero profit condition imposed on industry, we can determine commodity prices from the following equation:

$$p_j X_j = \sum_{i=1}^{28} p_i x_{ij} + (1+tp_j)[w \cdot LD_j + r \cdot KD_j] \quad (32)$$

Given a wage and a capital return rate, we can calculate the commodity prices as follows:

$$P = (I - A')^{-1}[(1+tp_j)(w.ld_j + r \cdot kd_j)] \quad (33)$$

where
P: vector of commodity prices
A': transposed matrix of industries' input coefficients
[・]: a column vector whose elements are presented in parentheses: $ld_j \equiv LD_j / X_j$ and $kd_j \equiv KD_j / X_j$

2.3.7 Derivation of Equilibrium

The equilibrium conditions in the model can be summarized as follows:

Commodity Market

$$\begin{bmatrix} X_1 \\ \vdots \\ X_{28} \end{bmatrix} = \begin{bmatrix} a_{11} & \cdots & a_{128} \\ \vdots & \ddots & \vdots \\ a_{281} & \cdots & a_{2828} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_{28} \end{bmatrix} + \begin{bmatrix} C_1 \\ \vdots \\ C_{28} \end{bmatrix} + \begin{bmatrix} CG_1 \\ \vdots \\ CG_{28} \end{bmatrix} + \begin{bmatrix} I_1 \\ \vdots \\ I_{28} \end{bmatrix} + \begin{bmatrix} EX_1 \\ \vdots \\ EX_{28} \end{bmatrix} - \begin{bmatrix} EM_1 \\ \vdots \\ EM_{28} \end{bmatrix} \quad (34)$$

Labor Market

$$LS = \sum_{j=1}^{28} LD_j \quad (35)$$

Capital Market

$$KS = \sum_{j=1}^{28} KD_j \quad (36)$$

III Construction Data

The database used in this study is based on a 2006 I-O table for Makassar City that includes twenty-eight industries listed in Table 1. The database developed from the I-O table consists of a matrix of industry inputs, outputs and taxes. All data in the I-O table are presented in Indonesian rupiah.

Table 1: The twenty-eight sectors in the 2006 I-O table for Makassar City

No	Industries	Denoted
001	Food Crops	Sector 1
002	Plantation Crops	Sector 2
003	Livestock	Sector 3
004	Forestry	Sector 4
005	Fishery	Sector 5
006	Mining of oil and gas and non-oil and gas	Sector 6
007	Manufacture of food, beverages and tobacco	Sector 7
008	Manufacture of textiles, clothing and leather	Sector 8
009	Manufacture of wood, bamboo and furniture	Sector 9
010	Manufacture of paper and paper products, printing and publishing	Sector 10
011	Manufacture of chemicals, petroleum, coal, rubber and plastic products	Sector 11
012	Manufacture of cement and non-metallic minerals	Sector 12
013	Manufacture of basic metals	Sector 13
014	Manufacture of fabricated metal	Sector 14
015	Other manufactures	Sector 15
016	Electricity, gas and water supply	Sector 16
017	Construction/building	Sector 17
018	Trade	Sector 18
019	Hotels	Sector 19
020	Restaurants	Sector 20
021	Highway transportation	Sector 21
022	Other transportation	Sector 22
023	Communications	Sector 23
024	Banks and other financial institutions	Sector 24

025	Leasing, real estate and business services	Sector 25
026	Education	Sector 26
027	Health	Sector 27
028	Social services and other services	Sector 28

Source: Makassar City Statistical Bureau, 2008

Instead of the I-O table, the model developed in this paper considers the SAM table. Therefore, this study estimated the SAM table for Makassar City based on the 2006 I-O table for Makassar City, the 2005 SAM table for Indonesia and related data which are as presented in Table 2.

Table 2: The 2006 SAM table for Makassar City

Economic Sectors (in million rupiah)		Production Activities	Institution		Production Factors		Capital	External Sector	Total
		28 Industries	**Government**	**Households**	**Capital**	**Labor**	**Accumulation**		
Production Activities	28 Industries	450,059	181,321	1,305,500	0	0	438,340	-1,060,325	1,314,895
Institution	Government	20,171	0	46,925	0	0	0	434,623	501,719
	Households	0	180,499	0	476,730	301,787	0	523,448	1,482,464
Production Factors	Capital	476,730	0	0	0	0	0	0	476,730
	Labor	301,787	0	0	0	0	0	0	301,787
Capital Finance		66,148	139,899	130,039	0	0	0	102,254	438,340
External Sector		0	0	0	0	0	0	0	0
Total		1,314,895	501,719	1,482,464	476,730	301,787	438,340	0	

Source: Authors' calculations

Table 3: Emission Intensities and Carbon Dioxide Emissions for Each Sector in 2006

No	**Sectors**	**Intensity of CO_2 Emissions MRp/t-CO_2**	**CO_2 Emissions MRp/t-CO_2**
001	Food Crops	0.319	56,988.308
002	Plantation Crops	0.495	22,219.434
003	Livestock	0.251	6,807.967
004	Forestry	0.525	91.387
005	Fishery	1.386	294,518.322
006	Mining of oil and gas and non-oil and gas	0.495	3,130.547
007	Manufacture of food, beverages and tobacco	3.341	620,137.117
008	Manufacture of textiles, clothing and leather	1.071	4,448.002
009	Manufacture of wood, bamboo and furniture	0.126	2,826.503
010	Manufacture of paper and paper products, printing and publishing	1.782	9,232.334
011	Manufacture of chemicals, petroleum, coal, rubber and plastic products	20.364	87,726.732
012	Manufacture of cement non-metallic minerals	24.691	819,867.193
013	Manufacture of basic metals	7.173	22,680.110
014	Manufacture of fabricated metal	0.139	659.182
015	Other manufacturing	0.035	4.748
016	Electricity, gas and water supply	10.305	157,096.064
017	Construction/building	0.249	25,868.746
018	Trade	0.036	2,866.157
019	Hotels	0.044	0.972
020	Restaurants	0.168	3,122.555
021	Highway transportation	2.870	88,892.113
022	Other transportation	5.184	9,648.165
023	Communications	0.077	969.255

024	Banks and other financial institutions	0.008	639.886
025	Leasing, real estate and business services	0.037	1,955.915
026	Education	0.712	2,936.175
027	Health	0.246	131.187
028	Social services and other services	1.288	238,198.137
	Total of intermediate sectors	83.416	2,483,663.210
	Household consumption expenditures	0.065	85,264.657
	Total	83.481	2,568,927.867

Source: Authors' calculations

An additional database was compiled from data collected by Nansai et al. (2002), and the national greenhouse gas inventory guidelines published by the Ministry of Environment of Indonesia (2012) were used as a reference and to adjust the results regarding embodied energy and emissions intensity in each sector. In this database, CO_2 emissions were calculated by multiplying the energy consumption value obtained for each fuel type by its corresponding carbon dioxide emission factor. Furthermore, CO_2 emissions emanating from limestone were considered, in addition to fossil fuel emissions. The direct emissions and CO_2 emission intensity of each sector were aggregated for each sector in the I-O table.

Using data from Miyata et al. (2009), we then used I-O analysis to calculate emissions intensities for consumption expenditures in the household sector. Table 3 presents emission intensities and CO_2 emissions based on the I-O table for Makassar City.

IV Simulation Scenarios and Results

4.1 Simulation Scenarios

This article considers two representative CO_2 restriction policies, a carbon tax without transfers and a carbon tax in which all revenues are transferred to households. The impacts of these policies are compared with the BAU scenario. This study considers three scenarios:

(1) Baseline scenario (BAU): this scenario was simulated to reproduce the baseline SAM of Makassar City, Indonesia

(2) Scenario 1: a carbon tax of 0.01 MRp/t-CO_2 is imposed on all industries emitting CO_2

(3) Scenario 2: a carbon tax of 0.01 MRp/t-CO_2 is imposed on all industries, and the revenues of which are transferred to households.

4.2 Simulation Results

The effects of the simulated scenarios were analyzed in term of their impacts on economic variables.

This section presents the simulation results with respect to important economic variables which are explained below.

4.2.1 CO_2 Emissions

The manufacture of cement and non-metallic minerals and the manufacture of food, beverages and tobacco generated the greatest CO_2 emissions in the baseline scenario: 819,867.19 tCO_2 and 620,137.12 t-CO_2, respectively. The carbon tax reduced overall CO_2 emissions by 8.04 % (scenario 1) and 8.25 % (scenario 2). Households responses to the carbon tax policies resulted in increased CO_2 emissions of 7.78 % in scenario 1 and 7.94 % in scenario 2.

CO_2 emissions declined in thirteen sectors in scenario 1 and fourteen sectors in scenario 2. The decline ranged from 0.17 % to 19.81 %. The largest changes occurred in the manufacture of cement and non-metallic minerals (19.81 % in scenario 1 and 19.77 % in scenario 2) and in the manufacture of chemicals, petroleum, coal, rubber and tobacco (17.71 % in scenario 1 and 17.39 % in scenario 2).

However, CO_2 emissions increased in fifteen sectors in scenario 1 and in fourteen sectors in scenario 2. The increase from 0.002 % to 656.86 % and the largest changes were observed in other manufactures (335.42 % in scenario 1 and 656.86 % in scenario 2) and forestry (101.98 % in scenario 1 and 125.65 % in scenario 2). Figures 5 and 6 depict the changes in each sector.

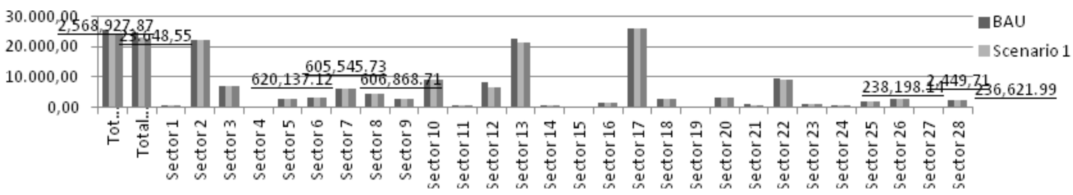

Figure 5: CO_2 Emissions

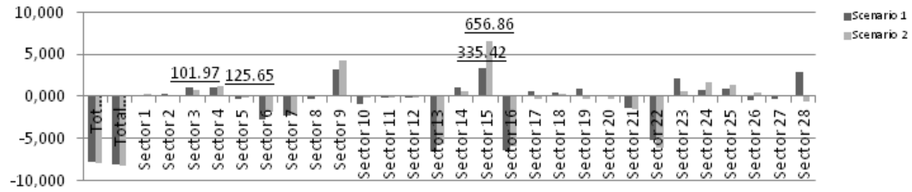

Figure 6: Changes in CO_2 Emissions

4.2.2 Industrial Outputs

The baseline scenario indicates that the largest sectors in terms of output were fishery; the manufacture of food, beverages and tobacco; and social services and other services. Convesely, the hotels, other manufactures and forestry sectors produced output slightly. The imposition of the carbon tax resulted in changes to output. The changes in industrial outputs are depicted in Figures 7 and 8. Total industrial outputs of industry declined in each scenario by: 0.38 % in scenario 1 and 0.74 % in scenario 2.

Nearly identical numbers of sectors experienced changes in output (both positive and negative) in the scenario 1 and scenario 2. The following sectors exhibited increased output: food crops; plantation crops; livestock; forestry; the manufacture of fabricated metal; other manufactures; constructions/buildings; trade; hotels; restaurants; communications; banks and other financial institutions; leasing, real estate and business services; and social services and other services. The other manufactures (335.42 %) and forestry (101.98 %) sectors exhibited the greatest increases in output in scenario 1. Small increases were observed in other sector. These increases indicates that these sectors benefited from the imposition of the tax. In contrast, the manufacture of cement and non-metallic minerals (19.81 %) and the manufacture of chemicals, paper products, printing and publishing (17.71 %) were harmed by policy, as these sectors exhibited the greatest declines in outputs. The declines observed in other sectors were relatively small.

The simulation results for scenario 2 exhibited relatively small differences from the values observed for scenario 1. Similar to scenario 1, increases in outputs occurred in food crops; plantation crops; livestock; forestry; the manufacture of fabricated metal; other manufactures; trade; communications; banks and other financial institutions; leasing, real estate and business services; education; and health. The other manufactures and forestry sectors presented the largest increases in output in response to the city's policy: 656.86 % and 125.65 %, respectively. Conversely, the largest declines were observed in the manufacture of cement and non-metallic minerals (19.77 %) and in the manufacture of chemicals, paper products, printing and publishing (17.39 %).

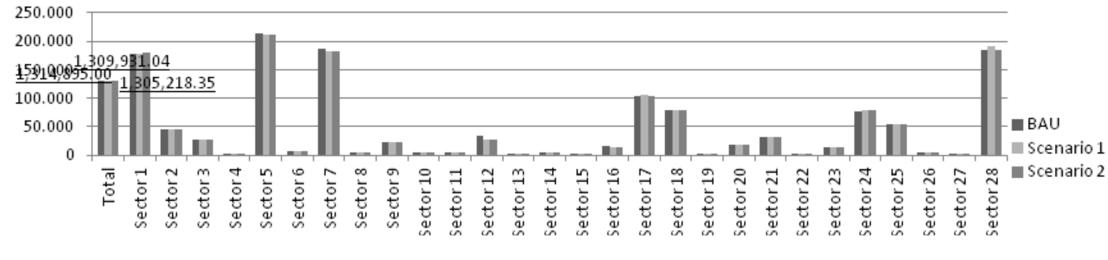

Figure 7: Industrial Output

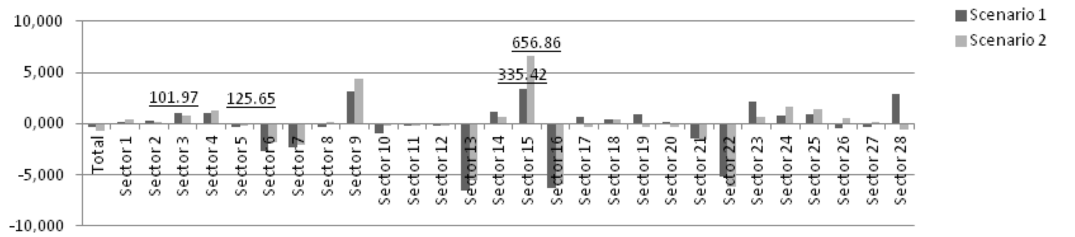

Figure 8: Changes in Industrial Output

4.2.3 Municipal GDP

The largest contributions to the municipal GDP under the BAU scenario were made by following sectors: fishery; manufacture of food, beverages and tobacco; and social services and other services. The impacts of the carbon tax policy are presented in Figure 9 and 10. Overall, the GDP has declined by more than 19 % for each scenario. In scenario 1, thirteen sectors contributed to the decline in GDP, compared with fourteen sectors in scenario 1. Sectorial declines ranged from approximately 0.17 % to 19.80 %. The manufacture of cement and non-metallic minerals and the manufacture of chemicals, petroleum, coal, rubber and plastic products exhibited the larges declines in each scenario.

However, these declines were accompanied by increases in other sectors. Contributions to increased GDP were observed fifteen sectors in scenario 1 and fourteen sectors in scenario 2, ranging from approximately 0.004 % to 656.88 %. The largest changes occurred in other manufactures (335.44 % in scenario 1 and 656.88 % in scenario 2) and forestry (101.98 % for scenario 1 and 125.66 % in scenario 2).

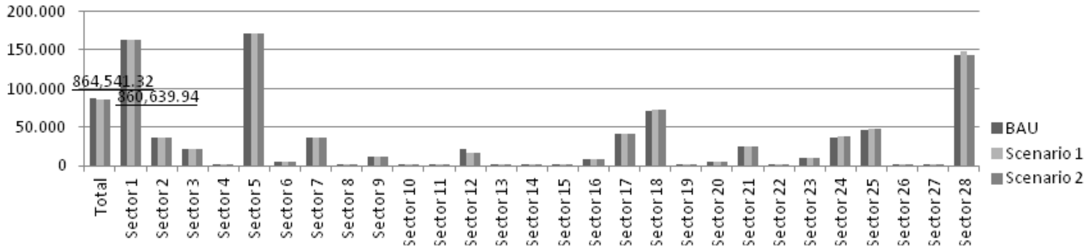

Figure 9: Municipal GDP

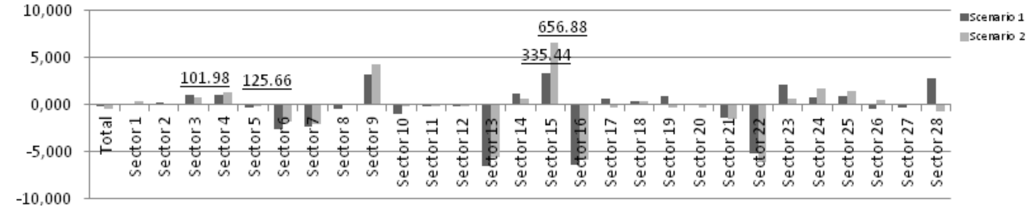

Figure 10: Changes in Municipal GDP

4.2.4 Labor Demand

Figures 11 and 12 indicate that labor demand generally responded negatively to the carbon tax policies in the sectors considered. Overall, labor demand declined by approximately 0.01 % to 1.20 %. Labor demand declined in twenty-two sectors in scenario 1 and twenty-one sectors in scenario 2. The greatest changes occurred in the manufacture of cement and non-metallic minerals (20.90 % in scenario 1 and 20.54 % in scenario 2) and the manufacture of chemicals, petroleum, coal, rubber and tobacco (18.70 % in scenario 1 and 18.09 % in scenario 2).

Certain sectors responded positively to the carbon tax policies in terms of labor demand. Specially, six sectors in scenario 1 and seven sectors in scenario 2 exhibited increased labor demand, ranging from 0.1 % to 650.73 %. The other manufactures (98.80 % in scenario 1 and 123.15 % in scenario 2) and forestry sectors (330.41 % in scenario 1 and 650.73 % in scenario 2) exhibited the greatest increases in labor demand.

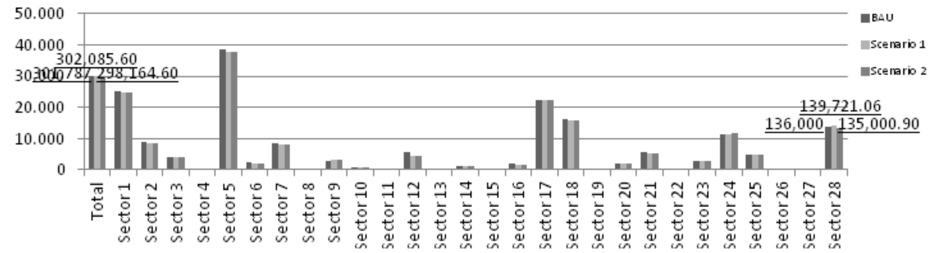

Figure 11: Labor Demand

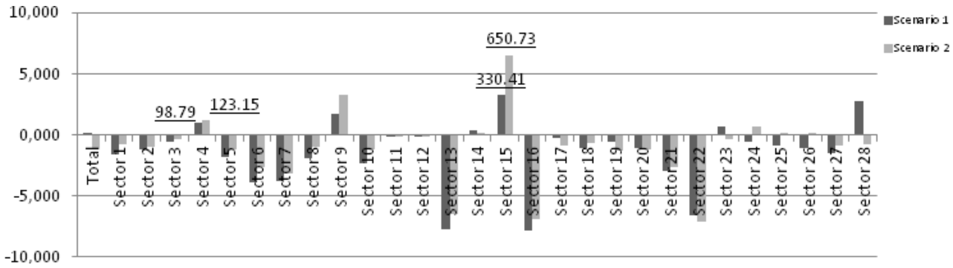

Figure 12: Changes in Labor Demand

4.4.5 Capital Demand

Regarding the changes in the demand for capital by industry despicted in Figures 13 and 14, the pattern of changes differs substantially from that observed for labor demand. Increased demand for capital is observed in nineteen sectors in scenario 1 and in twenty sectors in scenario 2. The demand for capital responded positively to the carbon tax programs. The largest positive responses were observed in the other manufactures (339.007 % in scenario 1 and 661.23 % in scenario 2) and forestry (102.77 % in scenario 1 and 126.27 % in scenario 2) sectors.

Declines in the demand for capital were observed in nine sectors in scenario 1 and in eight sectors in scenario 2, ranging from 0.44 % to 19.43 %. The manufacture of cement and non-metallic minerals (19.32 % in scenario 1 and 19.43 % in scenario 2) and the manufacture of chemicals, petroleum, coal, rubber and tobacco (17.07 % in scenario 1 and 16.94 % in scenario 2) reported the largest declines.

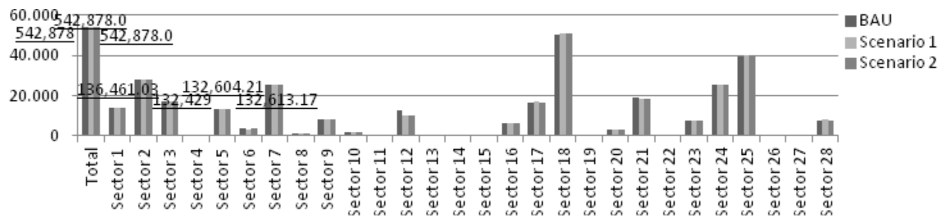

Figure 13: Capital Demand

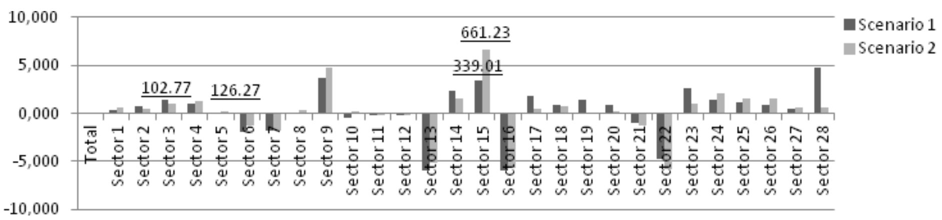

Figure 14: Changes in Capital Demand

4.2.6 Commodity Prices

The price changes in all sectors are depicted in Figure 15. The carbon tax increased output prices by an average 2.32 % in scenario 1 and 2.61 % in scenario 2, and these changes were especially pronounced in sectors characterized by the heavy use of energy-intensive commodities. The differences between scenarios 1 and 2 with respect to these changes are not large.

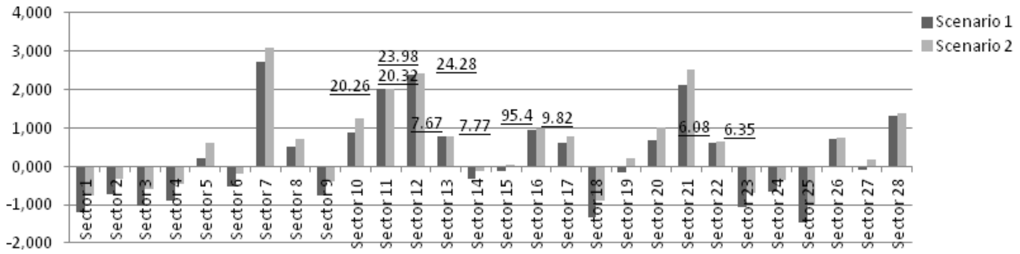

Figure 15: Commodity Prices

4.2.7 Other Variables

As despicted in Figures 16 and 17, household income did not change significantly, exhibiting an increase of 0.12 % in scenario 1. However, as the price of the composite consumption good increased by 0.34 %, household consumption declined by 0.17 %. Thus, leisure time increased 0.01 %, and household savings declined by 0.42 %. As result, equivalent variation reveals a welfare gain loss of 0.5 billion rupiah.

Regarding the government sector, in scenario 1, the imposition of a carbon tax reduced revenue from net indirect taxation by 4.3 %. However, total government revenue increased by 4.79 %, increasing government consumption and current transfers to households and the external sector except while reducing government savings.

In scenario 2, household income increased by 1.3 %, including the effect of the direct tax on households. Household income net of the direct tax increased by 1.28 % relative to the baseline scenario. Following the increase in household income, household composite consumption increased by 0.86 %, leisure time increased by 1.14 % and household savings increased by 0.82 %. As result, equivalent variation indicates a welfare gain of 1.33 billion rupiah.

Regarding the government sector, revenue from the net indirect tax declined by 3.82 %. The government revenues from households decreased by 0.26 %, whereas the total government revenue increased by 0.61 %. Because of this increase, government expenditures, current transfers to households and the external sector, and government savings increased.

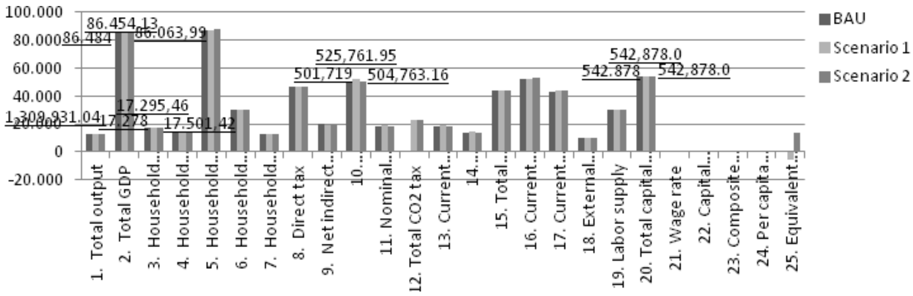

Figure 16: Other Variables

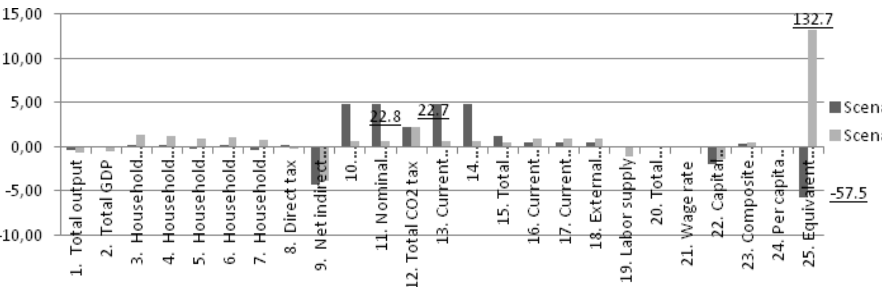

Figure 17: Changes in Other Variables

Note:

1) industrial output, 2) GDP, 3) full income, 4) household income, 5) composite consumption, 6) leisure time, 7) household saving, 8) Direct tax, 9) net indirect tax, 10) government revenue, 11) government consumption, 12) total CO_2 tax, 13) current transfers from the government to households, 14) government saving, 15) total investment, 16) current transfers from the external sectors to households, 17) current transfers from the external sector to the government, 18) external sector's saving, 19) labor supply, 20) total capital stock, 21) wage

rate, 22) capital return rate, 23) composite price, 24) per capita equivalent variation and 25) equivalent variation.

V Conclusions

There is an urban economic change affecting the welfare household changes, which are characterized by value of equivalent variation. As a result, the implementation of carbon tax policies generally had negative impacts on the economy of Makassar City in scenario 1 and positive impacts in scenario 2, despite the fact that the total municipal GDP declined in all simulation scenarios. Because of the effects of government tranfers to households, household consumption declined in scenario 1 but it increased slightly in scenario 2. As results, the savings in the external sector increased.

Government revenue increased in all scenarios. The costs of production increased following the declines in output prices. Declines in sectorial outputs resulted in a negative impact on household utility in scenario 1.

Therefore the imposition of a carbon tax had positive environmental impacts, and the municipal GDP will increase if the government institutes a carbon permit trading schemes.

VI References

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