Economic Impacts of Carbon Tax in Makassar City in Indonesia: a CGE Modeling Approach

ANY WAHYUNI
Graduate School of Environment and Life Science Engineering, Toyohashi University of Technology
YUZURU MIYATA
Graduate School of Architecture and Civil Engineering, Toyohashi University of Technology
HIROYUKI SHIBUSAWA
Graduate School of Architecture and Civil Engineering, Toyohashi University of Technology

1. Introduction

One of an instrument of greenhouse policy represents the introduction of carbon tax. The postulated policy target in Indonesia is the Ministry of Finance Indonesia Green Paper on Climate Change-commitment of the President of the Republic of Indonesia at G-20 conference, of reducing carbon dioxide emissions in 2020 to the equivalent of 6-24 per cent below of the 2005 levels.

The degree of abatement is measured by an estimated level of emissions in 2006 as a business-as-usual (BAU). In principle, of abatement applies to all urban economic activity sources of carbon dioxide emissions, estimates for the fossil fuels uses, which is a contributor to emissions by 68.7 per cent of the total emissions in Indonesia (2010).

Energy sector of carbon dioxide emissions in Makassar city under the business as usual are estimated at 2.57 million tonnes by 2006. Referring to the Green Paper target, it is necessary to cut emissions by 154 thousand – 616 thousand tonnes of the business as usual. In the scenario of the study is the introduction of a carbon tax with a rate sufficient to reduce carbon dioxide emissions by 7- 8 percent in 2006. The tax applies to all commodities as consumption within the city. This tax does not apply to the export and distribution activity to avoid double taxation.

The study provides detailed evaluated of the impacts of the carbon tax on the production, consumption and urban economic performance as well. It uses a Computable General Equilibrium (CGE) model,which is a quantitative method to estimates the impact of the economic and policy shocks, particularly the economy as a whole. The model was a realistic manner to reproduces the structure of the whole economy and therefore the nature of all existing economic transactions among diverse economic agents (productive sectors, households, government, and external sectors). A CGE modeling expected to have significant impacts throughout the economy.

2. Model

2.1Framework of Model

This study used CGE comparative-static model which the simulation results were reported as deviations from a base case (business as usual). It does not present changes over time, but differences with respect to the base case at given point in 2006. We used model of the closed-economy; that is, no international trade. The results are commonly reckoned as representing economic responses over a period of about two years (McDouugall,1993). The model is consistent with price level and real activity. The price is set an exogenously, it acts as numeraire for model.

This study assumed that industries produced products and carbon dioxide emissions by products. The price P0 equivalent with marginal cost and after applying tax will become the equilibrium price at P1. Output of industries are X1.

Simulations model will result in a percentage change of industry output by 100*(X1-X0)/X0, and presented that how the policy can impact on the industry output.

2.2 Setup of the Economy

In model, supply used two production factors namely: one labor and one capital. There are twenty eight industries representative firms, which produced twenty eight commodities in this economy. One representative household exists who consumes all commodities to maximize its utility. The household supplied two factors to the firms in return for income payments. The firms employ these factors in their production. They are demand and supply of these commodities and factors in equilibrated and perfectly competitive in 2006.

2.3 Behaviour of the Economic Agents

2.3.1 Industries

In industries, intermediate input, labour and capital are inputted to produce goods. Industries have the *Cobb-Douglas* technology with respect to intermediate input and labour and capital inputs, and Leontief technology with value added inputs. Cost minimization problem can be written as follows:

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

with respect to x_{ij}, L_j and K_j
subject to

$$X_j = min[\frac{1}{a_{0j}} f_j(L_j, K_j), \frac{x_{1j}}{a_{1j}}, ..., \frac{x_{ij}^{'}}{a_{ij}^{'}}, ..., \frac{x_{28j}}{a_{28j}}] \quad (2) \qquad f_j(L_j, K_j) \equiv A_{1j} L_j^{a_j} K_j^{(1-a_j)} \quad (3)$$

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}: technical parameters in industry j.
Conditional demands for intermediate goods, labour, and capital in the production process are as follows:

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

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

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

where
LD_j: conditional demand for labour in industry j; KD_j: conditional capital demand in industry j; Zero profit condition is realized in the industries under a perfect competition.

$$profit = p_j X_j - \sum_{i=1}^{38} p_i x_{ij} - (1+tp_j)[w.LD_j + r.KD_j] = 0 \quad (7)$$

2.3.2 Households

Households in Makassar City are assumed to be homogeneous with the fixed number of households. Thus one can consider that households share an aggregate single utility function. Households share a *CobbDouglass* utility function of the current and future goods. Here the current good is defined as a *Cobb Douglass* composite of current consumption goods and leisure time, while the future good is derived from saving.

To explain the household behavior, first, derivation of future good is described here. The future good implies the future consumption which derived from household saving, however, the saving formulates capital investment. Therefore capital good can be regarded as saving good. Investment is made by using produced goods, and let their portions in investment be denoted by b_i. Denoting the price of investment good by p_I, $p_I I = \sum_{i=1}^{28} p_i I_i$ is realized. Then the price of investment good is expressed as $p_I = \sum_{i=1}^{28} b_i p_i$. This can be regarded as the price of saving good p_s.

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 [1]; k_r: capital depreciation rate ; δ: ratio of capital stock measured by physical commodity unit to that by capital service unit.

It is assumed that the expected returns of saving finance the future consumption. Regarding the price of future good as the price of the present consumption good under the myopic expectation, and denoting the household real saving by *S*, the following equation holds.

Then we 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.

$$\max_{C,F}\ G \equiv \{\beta^{1/v_2} C^{(v_2-1)/v_2} + (1-\beta)^{1/v_2} F^{(v_2-1)/v_2}\}^{v_2/(v_2-1)} \tag{9}$$

subject to

$$p\cdot C + (1-ty)(1-l_o)w\cdot F = (1-ty)FI - TrHO - SH \tag{10}$$

where

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

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

$$C = \frac{\beta[(1-ty)FI - TrHO - SH]}{p^{v_2}\cdot\Omega} \tag{11}$$

$$F = \frac{(1-\beta)[(1-ty)FI - TrHO - SH]}{[(1-ty)(1-l_o)w]^{v_2}\cdot\Omega} \tag{12}$$

$$LS = E - F \tag{13}$$

$$\Omega = \beta p^{(1-v_2)} + (1-\beta)[(1-ty)(1-l_o)w]^{(1-v_2)} \tag{14}$$

where LS : household labor supply

Substituting composite consumption (11) and leisure time (12) into (9), the price index of the present good is derived as follows:

$$p_G = \{\beta\, p^{1-v_2} + (1-\beta)[(1-ty)(1-l_o)w]^{1-v_2}\}^{1/(v_2-1)} \tag{15}$$

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

$$\max\ C \equiv \prod_{i=1}^{28} C_i^{\gamma_i} \qquad (\sum_{i=1}^{28}\gamma_i = 1) \tag{16}$$

subject to

$$\sum_{i=1}^{28} p_i\cdot C_i = (1-ty)Y - TrHO - SH \tag{17}$$

where

C_i : household consumption good produced by industry *I; p_i* : 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.

$$C_i = \frac{\gamma_i}{p_i}[(1-ty)Y - TrHO - SH] \qquad (i = 1,\cdots,28) \tag{18}$$

The price of composite consumption is calculated as follows:

$$p = \prod_{i=1}^{28}\left[\frac{p_i}{\gamma_i}\right]^{\gamma_i} \tag{19}$$

2.3.3 The Government

The government sector in this study consists of the national and local governmental activities in Makassar City. Thus, the concept of the government corresponds to the definition of SAM framework. The government obtains its income from direct and net indirect taxes of Makassar City, and current transfers from the external sector, and then it expends the income on government consumption, current transfers to households, and current transfers to the external sector. The difference between income and expenditures is saved. Nominal consumption expenditures on commodities/services are assumed to be proportional to the government revenue with constant sectorial share. These are denoted by the following balance of payment.

$$\sum_{i=1}^{28} p_i \cdot CG_i + TrGH + TrGO + SG = ty \cdot Y + \sum_{i=1}^{28} tp_i (w \cdot LD_i + r \cdot KD_i) + TrOG \quad (20)$$

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, labour income transfers and property income transfers. Then, it expands the income on exports and transfer of Makassar, current transfers to households and the government, labour (employees in Makassar City) and property income transfers. These are also expressed by the following balance of payment.

$$\sum_{i=1}^{28} p_i \cdot EX_i + TrOH + TrOG + KI + LI + SO = \sum_{i=1}^{28} p_i \cdot EM_i + TrHO + TrGO + KIO + LIO \quad (21)$$

where

EX_i: export of commodity *I*; EM_i: import of commodity *I*; *SO:* savings of the external sector (= national current surplus); *LIO*: labour 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

Household, government, the area department's savings, and the total capital depreciation determine the total investment.

$$\sum_{i=1}^{28} p_i \cdot I_i = SH + SG + SO + \sum_{i=1}^{28} DR_i \quad (22)$$

where

I_i: demand for commodity*i* by other investments; DR_i: consumption of fixed capital amount of industry *I*.

2.3.6 Prices of Commodity

From the zero profit condition of the industry commodity prices can be determined from the following equation:

$$p_j X_j = \sum_{i=1}^{28} p_i x_{ij} + (1 + tp_j)[w \cdot LD_j + r \cdot KD_j] \quad (23)$$

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

$$P = (I - A')^{-1}[(1 + tp_j)(w.ld_j + r \cdot kd_j)] \quad (24)$$

where

P: vector of commodity prices; *A'*: transposed matrix of industries' input coefficients; [•] : column vector whose elements are 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 condition in the model can be summarized as follows:

Commodity Market

$$\begin{bmatrix} X_1 \\ \vdots \\ X_{38} \end{bmatrix} = \begin{bmatrix} a_{11} & \cdots & a_{138} \\ \vdots & \ddots & \vdots \\ a_{381} & \cdots & a_{3838} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_{38} \end{bmatrix} + \begin{bmatrix} C_1 \\ \vdots \\ C_{38} \end{bmatrix} + \begin{bmatrix} CG_1 \\ \vdots \\ CG_{38} \end{bmatrix} + \begin{bmatrix} I_1 \\ \vdots \\ I_{38} \end{bmatrix} + \begin{bmatrix} EX_1 \\ \vdots \\ EX_{38} \end{bmatrix} - \begin{bmatrix} EM_1 \\ \vdots \\ EM_{38} \end{bmatrix} \quad (25)$$

Labour Market

$$LS = \sum_{j=1}^{28} LD_j \quad (26)$$

Capital Market

$$KS = \sum_{j=1}^{28} KD_j \quad (27)$$

3. Construction Data

The database used in this study is based on Input-Output (I-O) table of Makassar city 2006. I-O table database is consists of matrix of industry inputs, productions, and tax. All database in I-O table calculated in Indonesian Rupiah. Instead of I-O table, the model constructed to by Social Accounting Matrix (SAM) table. Therefore, this study estimated of SAM table of Makassar city based on I-O table Makassar City 2006, SAM table of Indonesia 2005, and some data related.

The impact of carbon tax determined by emissions intensity for each fuel, defined as the quality of carbon dioxide emitted when the fuel is burned divided by the value of the fuel. Emissions intensities for each industry measure by the ratio of carbon dioxide emissions to output value. The industry's emission intensity can be expressed as the product of its fossil fuel intensity and an emission coefficient, representing an average ration of carbon dioxide emissions to energy delivered for the fossil used in the activity.

4. Simulation Cases and Results

4.1 Simulation Cases

This article considers two representative CO_2 restriction policies, which are carbon tax and CO_2 emission permit trading market. Effects of these policies are compared with business as usual case. Three cases are simulated in this study as follows:

(1) Base case (business as usual)

(2) Case one: introduces carbon tax to the industries by 0.01 MRupiah/tCO_2

(3) Case two: introduces carbon tax to the industries by 0.01 MRupiah/tCO_2 which the revenues are transferred to the household

4.2 Simulation Results

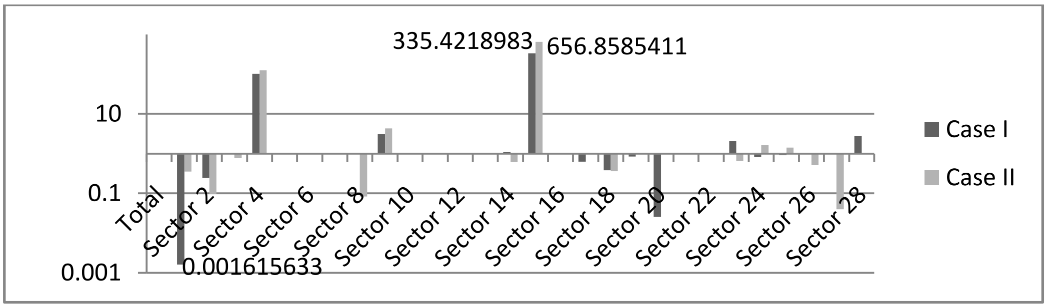

Figure 1: Change Rates in Industrial Output

The impact of government policy to the economy can be seen through to the output of industrial. The results demonstrate that after imposing carbon dioxide emissions and all revenue of tax's transfer to household, total outputs of industry down in each case by 0.38% and 0.74, respectively.Sector of other manufacture (335.42 %) and forestry (101.98%) had a greatest increase among the other sectors for case 1. The increase indicated that the sectors respond positively to the government programs. In contrast, the manufacture of cement non-metallic mineral (19.81%); and manufacture of chemical, paper product, printing and publishing (17.71%) were negative respond shown on the decreased in the highest outputs changes. Similarly with case 1, the other manufacture and forestry sector respond positively to the city's policy with larges changes, respectively: 656.86% and 125.65%. Contrarily decreasing changes most were the manufacture of cement non-metallic mineral (19.77%); and manufacture of chemical, paper product, printing and publishing (17.39%).

Applied of government policies shown that CO_2 emission productions were decreased as a whole sectors by 8.04% (case 1) and 8.25% (case 2). Households respond negatively of policies that caused increased total of CO_2 emissions became 7.78% in case 1 and 7.94% in case 2.

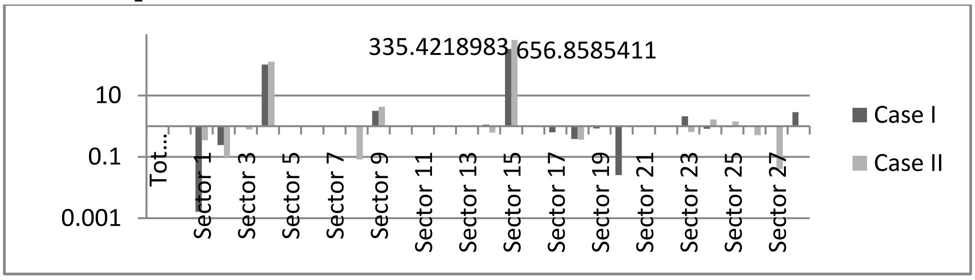

Figure 2: Change Rates in CO_2 Emissions

Changes in price of all sectors are shown in Figure 3. Prices by sectors fall down about 0.75% in case1 and 1.20% in case 2. The difference change between case 1 and case 2 does not large.

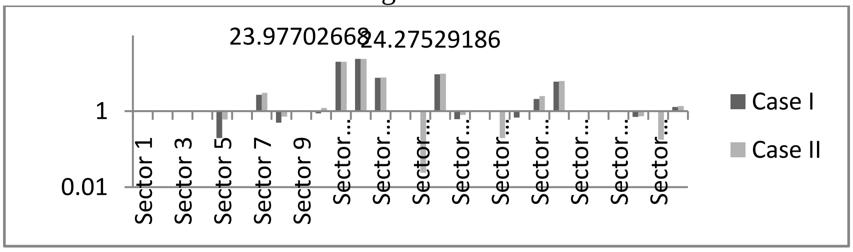

Figure 3: Commodity Price

5. Conclusions

After applying the government policies by carbon tax, in general, that simulation had negatively impact for the economy of Makassar city. Although, the other variable responded positively to that programs. The total GDP of city was decrease in all simulation cases. From the government expenditure, the households consumption down in case 1 and rise in case 2 by slightly. Following this situation, the external sector was increased saving.

As the government revenue was increased in all cases. Household income rise shown that welfare was increase. Cost of production sectors rises following the output prices increased. Output sectors were down that a negative an impact to the household utility in case 1.

Applied carbon tax will impacted to the environment and should increase GDP with carbon trading permits by the government.

6. References

[1] Hosoe, Nobuhiro.,Gasawa, Kenji., and Hashimoto, Hideo., 2010. Textbook of Computable General Equilibrium Modelling.Programmming and Simulations. Palgrave Macmillan, UK.

[2] Miyata, Yuzuru.,Hirobata, Yasuhiro., Shibusawa, Hiroyuki. And Nakanishi, Hitomi., 2009. Economy-transport-environment interactive analysis: a spatial Modeling approach, *Studies in Regional Science* , 39 (1). (pp), 109-130.

[3] Miyata, Yuzuru., 1995. A General Equilibrium Analysis of the Waste-Economic System - A CGE Modeling Approach, *Infrastructure Planning Review*, 12, 259- 270.

[4] Miyata, Yuzuru., 1997. An Intertemporal General Equilibrium Analysis of the Waste-EconomicSystem.,*Infrastructure Planning Review,* 14, 421-432.

[5] Nansai, Keisuke.,Morigichi, Yuichi. andTohno, Susumu., 2002. Embodied of Energy and Emissions Intensity Data for Japan Using Input-Output Tables, National Institute for Environmental Studies, Japan.

[6] Oktaviani, Rina., 2011. Economic Model of General Equilibrium.Theory and Application in Indonesia. IPB Press, Bogor.