The Distributional and Welfare Effects of the Emission Trading Scheme on Australian Households

Trang Minh Tran, University of New England, Australia

The Asian Conference on Sustainability, Energy and the Environment 2015
Official Conference Proceedings

Abstract

An Emission Trading Scheme (ETS) is considered as an effective cost instrument to achieve the emissions reduction target. The Australian Labor Government intended to implement the ETS from 1st July 2015, instead the carbon tax to meet the Kyoto emissions reduction target of 5% below 2000 levels by the year 2020. This paper examines the effects of a domestic ETS on the Australian economy, and mainly focuses on these effects on Australian households. A single country, static CGE model is employed with an environmental extended social accounting matrix (SAM). Households are disaggregated into 20 household groups and household data is collected from the Household Expenditure Survey, 2009-2010. The results show that the carbon price is around $20/tCO2, and the permits revenue is over $10 billion. The electricity price is estimated to increase over 13 percent and the brown coal price decreases over 30 percent. All households experience a reduction in income and expenditure in various degrees. The welfare impact is calculated in terms of the Equivalent Variation. The results show that all household groups experience absolute welfare loss of nearly $8 million for the poorest and $200 million for the richest. If the permit revenue is returned to household groups in the form of an equal lump-sum transfer per capita this creates benefits to the highest number of household groups.

iafor
The International Academic Forum
www.iafor.org

1. Introduction

In order to achieve the Kyoto emissions reduction target of 5% below the 2000 levels by the year 2020, the Australian Labor Government introduced a carbon pricing scheme that commenced with a fixed carbon price of $23 per tonne of CO2-e in 1 July 2012, then would switch to an Emissions Trading Scheme(ETS) on 1July 2015. The imposition of a price on carbon emissions induced an increase in the cost of production, especially for emissions intensive industries such as electricity generation and transportation. However, as facing with the increased production costs caused by the carbon price producers would pass forward these costs to the final consumers in the form of higher commodity prices, or backward to laborers and investors in the form of lower wages and lower rentals of capital and land. Therefore this affects household expenditure, and income, as well as welfare.

This paper examines the effects of an ETS designed to achieve the Kyoto target (equivalent to emissions reduction of 11 percent of the base year 2009) on the income distribution and welfare of Australian households. To do this, the single, static computable general equilibrium (CGE) model is employed to analyze these effects. Household data was collected from the Household Expenditure Survey, 2009-2010. In this paper, the costs caused by an ETS are assumed to pass fully to consumers in the form of higher commodity prices. An ETS is estimated to be regressive. In order to mitigate the degree of regressivity, half of the permit revenue raised from the permit auctions is used to recycle to households. The author compares the effects of three scenarios of the revenue recycling on prices, household income and welfare. These scenarios include the lump-sum transfer based on per-capita; the lump-sum transfer to low and middle income household groups (12 poorest groups); and increasing government payment to all household groups based in the Government pensions and allowance ratios.

The remainder of this paper is organized as follows: Section 2 presents previous research which has examined the impacts of an ETS on an economy, distributional income and welfare. Section 3 describes the model structure and database for the simulations. Section 4 analyzes the effects of an ETS on prices, as well as distributional income and welfare to Australian households. Section 5 concludes the paper.

2. Literature Review

There have been several studies conducted to investigate the distributional and welfare effects of a carbon tax in both developed and developing countries. It seems that the carbon tax is regressive in developed countries (Poterba, 1991; Symons, Proops, & Gay, 1994) and progressive in developing countries (Yusuf & Resosudarmo, 2007). The degree of regressivity depends on the methodological choices such as type of measurement of distributional effects and the inclusions of behavioural responses. (Büchs, Bardsley, & Duwe, 2011). Distributional effects were measured by the annual income that were shown to have greater regressive effects than those measured by the lifetime income (or current consumption) (Grainger; & D.Kolstad, 2010). When the behavioural responses are added into the model, it seems that high income households respond less to price changes than low income households (Cornwell & Creedy, 1998). Many studies examined the incidence of the emissions trading scheme (or cap-and-trade) in recent years. These studies have analyzed the impacts on households in different income groups with auctioned revenue returned in a direct way of lump-sum transfer or an indirect way of reductions income tax and other taxes.

Dinan and Rogers (2002) examined the distributional effects of cap-and-trade program aimed to achieve a emissions reduction of 15 percent. The allowance is allocated by either giving away or auctioning. The revenue is distributed by the ways of decreasing corporate taxes, reducing payroll taxes, and providing a lump-sum rebate to households. The results indicated that the lowest quintile bore the largest share of the policy cost if the government gave the allowances away. However, in the case of auctioning, households in the lowest income quintile would obtain the largest benefits from the lump-sum rebate, while households in the highest income quintile gain more benefits as the government decreases corporate taxes.

Parry (2004) compared grandfathered emissions permits with other environmental policies to control power plant emissions of CO2, SO2, and NOx by employing an analytical model with household income proxied by consumption. The results showed that low income households were worse off under grandfathered permits than under an emissions tax. The author found that grandfathered permits were highly regressive for all pollutants for emissions reductions, with the top income quintile better off while the bottom income quintile was much worse off. However, if an emission tax or the auctioned permits revenue were recycled proportionally to households, the policy looked much less regressive. If revenue was recycled in a progressive manner as in equal lump-sum transfers, the policy became progressive in the case of CO2 and NOx.

Beznoska et al. (2012) examined the effects of an EU-ETS with the emissions reduction target by 20 percent below 1990 levels until 2020 on the prices of goods and the household welfare in Germany, in both cases with and without behavioural responses of consumers to price changes. The carbon price of €25 per carbon permit induced the highest increase in the electricity price of 14 percent. The average German household had the additional cost of €16 per month in the case of no behavioural responses. Household consumption was reduced by about 6 percent in the case of adding behavioural responses, compared to the case of no behavioural responses. The effects were regressive in both cases. To offset the negative effects in both cases, the research analyzed the effects of the EU-ETS on household welfare in the case of using auctioned permit revenue return to households via lump-sum rebates and a reduction on social security contributions. The results indicated that the effects would be progressive in the form of the lump-sum rebates and was still regressive in the case of a lower on social security contributions. However, the revenue recycling in the form of lower social security contributions had a better positive impact on inequality than the other form. So, there was a trade-off between efficiency and equity of the two forms of the revenue recycling.

In Australia, the carbon tax had been implemented from 1st July 2012 to 1st July 2014. Thus, there are a number of studies that focused on analyzing the effects of the carbon tax on the Australian economy as well as on distributional income and welfare. Notable research includes (Cornwell & Creedy, 1998; Creedy & Martin, 2000; Dougall, 1993b; Meng, Siriwardana, & McNeill, 2014)

An Emission Trading Scheme was used by the former Australian Government under its proposed Carbon Pollution Reduction Scheme (CPRS), but it was not passed by the Australian Parliament. The Centre of Policy Studies (COPS) developed the MMRF-Green model based on the Monash Multi-Regional Forecasting (MMRF) model. The MMRF-Green model is a dynamic, multi-sectoral, multi-regional CGE model of the Australian economy, including 8 states/territories (or 57 sub-states), 52 industry sectors and 56 commodities. Each state has a single representative household and a regional government. The price revenue incidence simulation model and the distribution model (PRISMOD.DIST) are used to examine the distributional implication of carbon pricing to households. Buddelmeyer et al. (2012) linked between the CGE model, the MMRF-Green and the MS model, MITTS (Melbourne Institute Tax and Transfer Simulator) to assess the effects of climate change mitigation on income and inequality in Australia for the period from 2005 to 2030. A reweighting procedure is used to transmit employment change from the CGE model to the MS model. The CGE results are used as exogenous and given inputs for the MS model to produce estimated effects on income distribution. An (ETS) was assumed to implemented on July 2013 and aimed to get the emission target of 80 % below 2000 level by the year 2050 (scenario 1) and of 90 % below 2000 level by the year 2050 (scenario 2). The results indicated that income growth is expected to be slow down between 2010 and 2015, and inequality is estimated to increase. There were two types of lump-sum transfers aimed at offsetting the increased inequality. The returned permit revenue had a positive impact on low income households, but real net income growth was the highest for the top quintile and was very limited for the bottom quintile.

3. Model structure and Database

3.1 Model structure

In order to gauge the distributional and welfare effects of an ETS on Australian households, this study applied a single country and a static CGE model, based on ORANI – G (Horridge, 2003), There are some assumptions in the model, for example, the agents are assumed to be price-takers (a perfect competition), zero profit conditions are assumed to all industries, and demand and supply equations for private-sector agents are derived from the solutions to the optimization problems (cost minimization, profit maximization and utility maximization). In the model, the Australian economy is represented by 35 sectors which produce 35 goods and services, one representative investor, 20 household groups, one government and ten occupation groups. There are modifications in the production function in this model compared with the ORANI-G model.

The production function has a five layer nested Leontief-CES function, the same as in the ORANI-G model, the top level is nested by a Leontief function describing the demand for intermediate inputs, composite primary factors and other costs. The other levels are nested by various CES functions. However, there is a different treatment in electricity generation and energy sectors in the production function. The model allows for the substitution between electricity generated by different sources through substitution elasticity, and the energy sectors are combined with capital in the primary factor part.

The final demands are represented the same as those in the ORANI-G model. In particular, investment demand is a nest Leontief-CES function, the household demand function is formed by a Klein-Rubin on the top, instead of a Leontief function in the intermediate and investment demands, but by CES function on the lower level, the same as the intermediate and investment demands. Export demand depends on the price of these commodities with the assumption of a constant elasticity of export demand. Government consumption is exogenously determined. In order to analyze the effects of an ETS, the model incorporates the carbon emission accounts. Carbon emission in the model is treated as proportional to energy inputs used to the level of activity.

3.2. Database

The Social Accounting Matrix (SAM) table, that is a core database of the CGE model, is constructed using the Input-Output tables, 2008-2009, published in 2012 by the Australian Bureau Statistics. There are 111 sectors corresponding with an equal number of commodities in the original I-O tables. In this model, four energy sectors are disaggregated into 24 sub-energy sectors then aggregated into 14 sub-energy sectors. The author disaggregated energy sectors and then aggregated them to form 35 sectors (corresponding to 35 commodities) in the economy. The household income and consumption data are disaggregated into 20 household groups based on income level and labour is disaggregated into 10 occupation groups according to the Household Expenditure Survey (HES), 2009-2010.

The carbon emission data was collected from the National Greenhouse Gas Inventory in the year 2009. This emission data is expressed in metric tonne of carbon dioxide equivalent (CO2-e). The emission in the database was classified into three categories, in which, the emission that was generated from the fuel combustion was attributed to the input emission; the emission generated from the residential sector was for the household consumption or the consumption emission; and the emissions related to activities including from fugitive emission from fuels, industrial processes, agriculture, waste and land use, land-use change and forestry (LULUCF) was attributed to output emissions. The emissions from fuels combustion or from activity were put in the I-O emission tables. The emissions that were generated from household consumption were disaggregated into 20 household groups based on the consumption shares of each household group. The emission intensity is based on the GTAP database.

The behavioral responses of economic agents are explained by the elasticity parameters. The elasticity parameters that include the Armington elasticity, substitution elasticity between primary factors, among different types of labour, substitution of elasticity between electricity generated from different sources, and among energy inputs that were obtained from ORANI-G. The elasticity of substitution between energy and capital is small (Okagawa & Ban, 2008; Truong, Kemfert, & Burniaux, 2007). Burniaux et al. (1992) indicated that energy and capital are complementary in the short to medium term, and substitutable in the long term. So the substitution elasticity between composite energy and capital is assigned the value of 0.25 in the model. In order to calculate expenditure elasticity for each household group and each commodity in the model of 20 household groups and 35 commodities, the model is based on Australian household demand elasticity by 30 household groups and 14 commodities estimated by (Cornwell & Creedy, 1997), in which, 14 commodities are mapping into 35 commodities in the model, and 30 household groups mapping into 20 household groups. These elasticity values are adjusted to satisfy the unity of Engel aggregation by dividing to the total share-weighted average elasticity of each household.

4. Results

Australian Government (2013) reported that in order to achieve the emissions reduction target of 5 percent below the 2000 levels, the emissions in 2020 will be 555Mt-CO2. It is assumed that the average emissions growth rate was the same as for the period 2000-2012 of 0.71 percent that was calculated from the emissions data provided by the National Greenhouse Gas Inventory. To meet the emissions target by 2020, the emissions from the baseline year must be reduced by 11 percent. This paper examines the effects of an ETS designed to achieve the emissions reduction of 11 percent on the Australian economy, and focuses mainly on distributional income and welfare of Australian households.

4.1. Price effects

The price on emissions permits is ultimately passed forward on to consumers in the form of higher prices or passed backward on to workers and investors in the form of lower wages and lower return of production factors such as capital or land. This section analyzes the effects of an ETS on consumer prices, production factors' prices, and other prices in the cases of with or without compensation.

4.1.1 Impacts on consumer prices

As shown in Table 1, it is clear that, without compensation, most prices of goods and services are estimated to experience an increase to various degrees, in which, electricity price increases at the highest rate of 13 percent. This is explained by the fact that nearly 70 percent of electricity production in Australia is sourced from coal (World Bank, 2012). As estimated in the model, the price of black coal in the black coal-produced electricity increases 112.2 percent and the price of brown coal in the brown coal-produced electricity increased by 132.5 percent, thus leading to a higher electricity price. The price of road transportation increased by 1.81 percent, while a rise in prices of other goods and services is quite small, being less than 1 percent. In contrast, there is a reduction in black and brown coal prices, in which, the price of brown coal is estimated to decrease at the highest percentage of over 30 percent. This decrease results from the fall in demand for brown coal of more than 14 percent. Overall, the consumption price index raises 0.411 percent.

As the permits revenue is recycled to household groups, the prices of most commodities increase at various degrees. As seen in Table 1, the increased prices in the per-capita lump-sum transfer policy is higher than in other two scenarios of revenue recycling. The increased price of most goods and services in the lump-sum transfer to low and middle income household and in the increasing government payments are not too much different, except food, beverage, tobacco and textile, clothing, footwear. The prices of these products increase more in the latter than in the former. This is one reason that the middle income groups receive more compensation in the case of increasing government payments than of lump-sum transfer to the 12 poorest household groups, which will then increase their consumption as they have more income.

In contrast, the price of brown coal is reduced by 30.37 percent in the case of no revenue recycling, and continue to decrease in the cases of revenue recycling. Meanwhile, a reduction in the price of black coal still keep unchanged in all scenarios. These products are of energy-intensive. Overall, consumption price index increases at 0.504 percent in the lump-sum transfer per capita, and in both cases of increasing government payments and providing lump-sum transfer to 12 poorest groups, the consumption price index increases 0.473 percent

Table 1: The effects of an ETS on prices of goods and services (percentage change)

Commodities	**No revenue recycling**	**Lump sum transfer (12HH)**	**Lump sum transfer (per capita)**	**Increasing Government payments**
Agriculture, forestry & fishing	0.544	0.602	0.633	0.603
Black coal	-0.104	-0.103	-0.103	-0.103
Brown coal	-30.375	-30.408	-30.422	-30.407
Gas	0.027	0.042	0.048	0.042
Mining	0.822	0.841	0.850	0.841
Food, beverages & tobacco	0.289	0.345	0.374	0.346
Textile, clothing & footwear	0.228	0.303	0.345	0.306
Wood, paper & print	0.297	0.365	0.402	0.367
Automotive petrol	0.175	0.220	0.227	0.219
Kerosene	0.113	0.118	0.120	0.118
Gas oil or fuel oil	0.076	0.090	0.094	0.090
Liquefied petroleum gas	0.181	0.198	0.204	0.198
Other petroleum and coal products	0.560	0.605	0.629	0.606
Chemical	0.223	0.272	0.299	0.274
Other metal	0.198	0.242	0.266	0.243
Furniture and equipment	0.216	0.269	0.297	0.270
Other manufacturing	0.264	0.322	0.353	0.323
Electricity	13.396	13.480	13.516	13.478
Construction	0.506	0.555	0.580	0.555
Whole trade	0.013	0.053	0.073	0.053
Road transport	1.813	1.848	1.863	1.848
Air transport	0.142	0.152	0.157	0.152
Other transports	0.077	0.104	0.116	0.104
Finance and Insurance	0.024	0.112	0.169	0.114
Education and training	0.309	0.363	0.388	0.362
Health Services	0.364	0.428	0.458	0.428
Other services	0.196	0.261	0.291	0.260
Consumption Price Index	**0.411**	**0.473**	**0.504**	**0.473**

Source: Simulations from the model

4.1.2. Impact on the price of primary factors

With the target of minimizing production cost, producers adjust their usage of primary factors, thus affecting primary factors' prices. Primary factors include capital, land, and labour. In this study, the nominal wage is fully indexed to the consumer price index (CPI), thus it is as the same as the CPI. The real wage is assumed to be rigid, so its percentage change is set to be zero. In the short-run period, it is assumed that the producers' demand for capital and land are fixed, and their percentage changes are set to be zero.

Table 2: The effects of an ETS on prices of primary factors (percentage change)

Variables	**No revenue recycling**	**Lump sum transfer (12HH)**	**Lump sum transfer (per capita)**	**Increasing Government Payments**
Capital rental	-1.652	-1.594	-1.565	-1.594
Land rental	-0.963	-0.903	-0.875	-0.904
Nominal wage	0.411	0.473	0.504	0.473
Real wage	0	0	0	0
Aggregate primary factor price	**-0.562**	**-0.502**	**-0.472**	**-0.502**

Source: Simulations from the model

As seen in Table 2, in the no revenue recycling, the emissions price results in a reduction in the prices of capital and land of 1.652 percent and 0.963 percent, respectively. Meanwhile the nominal wage increases at 0.411 percent. The reduction in prices of capital and land rentals is explained by a contraction in the Australian economy because of increased prices of most goods and services as shown in Table 1. When the revenue is returned to household groups, the economy recovers mildly, thus leading to a slight increase in the prices of capital and land, but the percentage changes of capital and land rentals are still negative, which means that the recycling is not sufficient to offset the negative effects caused by the permit price. The decreased prices of capital and land in the lump-sum transfer per capita are smallest, while the changes in these prices in the cases of equal lump-sum transfer to 12 poorest household groups and of increasing Government payments are nearly the same. By contrast, a rise in nominal wages, reflecting the CPI is seen in all scenarios. Overall, aggregate primary factor price reduces in all scenarios

4.1.3 Impacts on other prices

In order to achieve the emission reduction of 11 percent, the permit price is estimated at $20.455 per tonne of CO_2-e in the case of without compensation. The permit price increases slightly in the revenue recycling scenarios because of the higher demand for energy commodities that creates more emissions generated into atmosphere, thus leading to an increase in a permit price.

Table 3: The effects of an ETS on other prices (percentage change)

Variables	No revenue recycling	Lump sum transfer (12HH)	Lump sum transfer (per capita)	Increasing Government Payments
Permit price ($ per tonne)	20.455	20.471	20.476	20.47
GNI price index	0.369	0.425	0.453	0.425
GDP price index	0.399	0.458	0.487	0.458
Export prices	0.147	0.164	0.172	0.164
Import prices	0	0	0	0
Terms of trade	0.147	0.164	0.172	0.164

Source: Simulations from the model

The GDP price index and the GNI price index are estimated to increase at 0.399 percent and 0.369 percent, respectively in the no revenue recycling. As households receive the rebate, they increase their consumption, thus leading these indices continue to rise. In the lump-sum transfer per capita both indices raise at the highest percentage of 0.487 percent and 0.453 percent. These increases result in the highest increase in nominal GDP of 0.202 percent and the smallest decrease in real GDP of 0.283 percent, compared with the other compensation scenarios. With the closure assumption of fixed import prices, the terms of trade are reflected by the change in export prices. The permit price results in the highest increases in export price of 0.172 percent in the lump-sum transfer per capita.

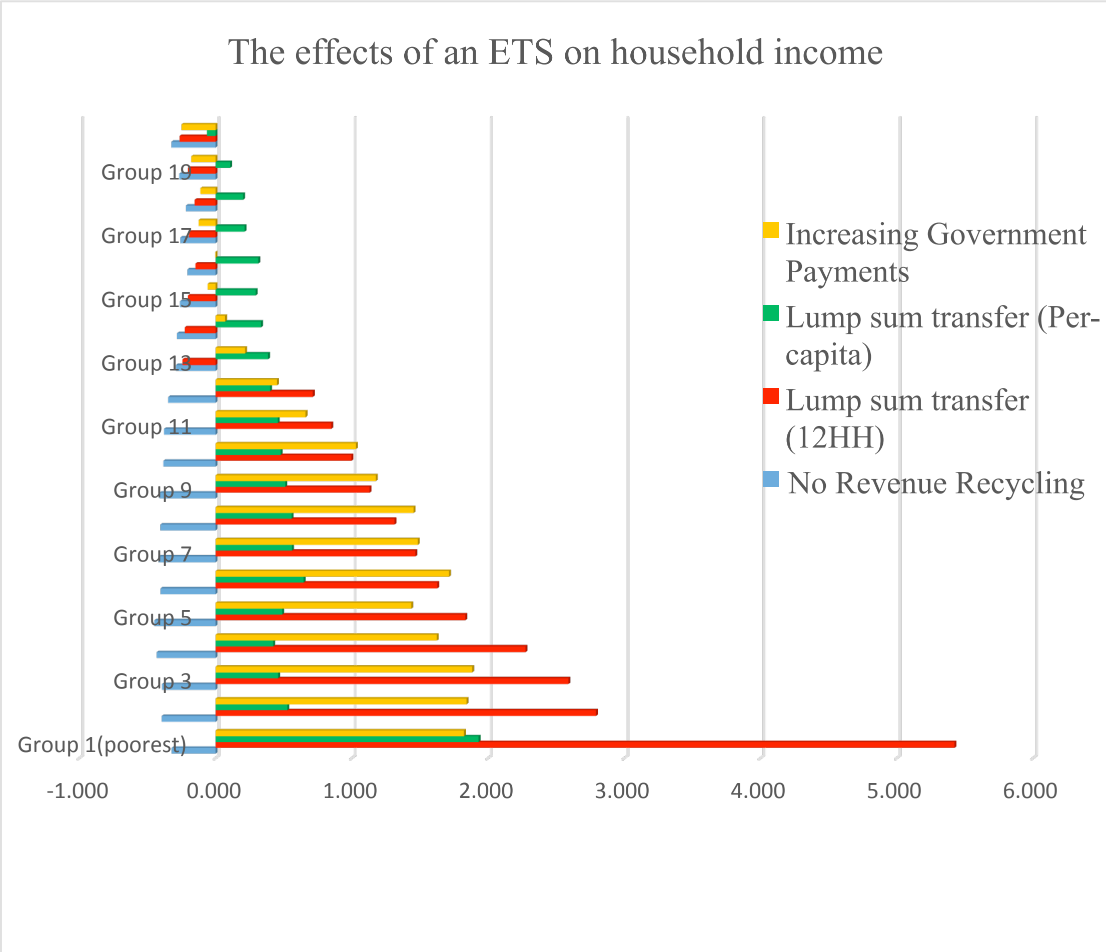
4.2. Impacts of an ETS on households

In this study, it is assumed that producers pass the full costs caused by the permit price to customers, therefore household groups would suffer from increased prices of goods and services. An increase in commodity prices may result in a reduction in household consumption. Moreover, a rise in the percentage of labour wages is smaller than the reduction in percentage of prices of capital and land rentals that produces a reduction of the income of all household groups. The following sections present more detail about the effects of ETS on the household income, expenditure and welfare in each scenario.

4.2.1. Impact of ETS on household income

Based on the Household Expenditure Survey, 2009-2010, the proportion of income sourced from labour, capital and land was 11 percent of the total income for the poorest household group and over 80 percent of the total income for the richest household group. The imposition of a permit price results in a decrease in capital and land rentals, and an increase in nominal wage in all scenarios that results in the income of all household groups change in various degrees.

Figure 1: The impacts of the ETS on income of household groups



Source: Simulations from the model

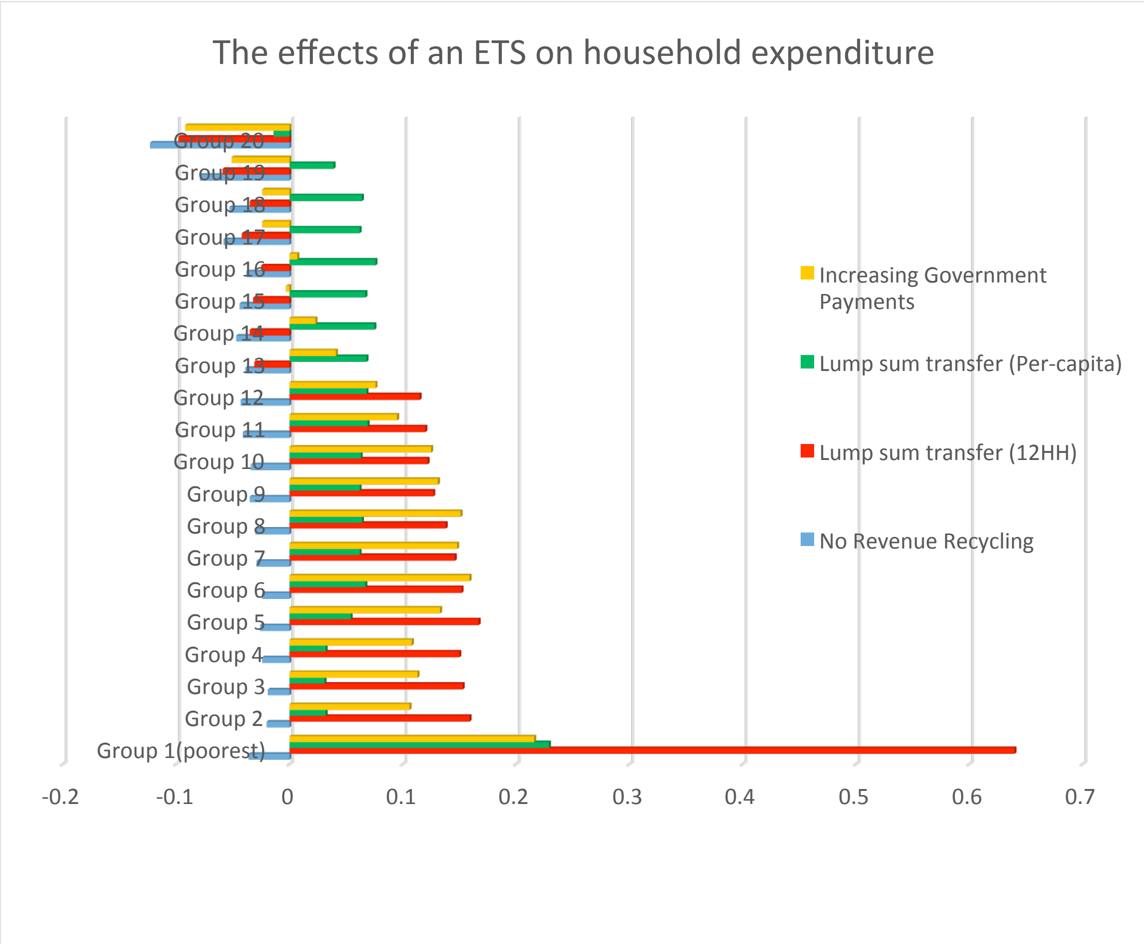
As seen in Figure 1, the income of all household groups is estimated to decline at varying degrees in the no revenue recycling. As the percentage change, the percentage reduction in income among household groups is not much different, but low income households experience a higher percentage reduction in income than rich households. As the dollar change, the wealthy household groups suffer a higher reduction than the poor groups, nearly $8 million for the latter and $200 million for the former. This income reduction across household groups is due to the decreases in the returns of capital and land, as expressed in Table 2.

When the permits revenue is returned the income of most household groups is improved. However, low income household groups receive more benefits than the rich household groups. When the revenue is returned to low and middle household groups, there are only 12 poor groups who receive a positive percentage change in their income, however when compared to an increase of Government payments 14 poor household groups experience a positive percentage change in their income. When the Government implements an equal lump-sum transfer per capita the lowest 19 groups show a positive change in their income. It means that the revenue is sufficient to offset the negative changes caused by the permit price to these household groups. For the rest of the household groups, the percentage changes in their income remain negative, but they are less than in the no compensation. The richest household group suffers an income reduction of 0.064 percent in the lump-sum transfer per capita, compared to 0.325 percent in the no revenue recycling. These reductions are explained by the smaller reductions in the returns of capital and land in the recycling scenarios, as shown in Table 2.

4.2.2. Impact of the ETS on household expenditure

Figure 2 shows the effects of an ETS on household expenditure in both with and without revenue recycling. It is clear that the permit price results in a reduction in expenditure of all household groups in a variety of degree in the no revenue recycling scenario. Rich household groups experience the higher reductions in both a dollar level and a percentage level than low household groups. As the percentage change, the poorest household group decrease by 0.036 percent, compared to 0.123 percent for the richest group. The decline in expenditure of all household groups is explained by the reduction in their income and the increased price of most goods and services.

Figure 2: Effects of the ETS on household expenditure (%)



Source: Simulation from the model

In order to mitigate these undesirable effects, the permit revenue is used to compensate to the vulnerable household groups. It is obvious that the lump-sum transfer per capita benefits equally all household groups, compared to other two revenue recycling. As the revenue is sufficient to offset the negative effects caused by the permit price to 19 out of 20 household groups, the richest household group still bears the negative change of 0.014 percent in expenditure, but it is a very small percentage compared to 0.098 percent in the lump-sum transfer to the 12 poorest groups and 0.092 percent in the increase of government payments. The revenue returned in the form of increasing government payment benefits to 15 out of 20 household groups, compared to 12 out of 20 household groups in the lump-sum transfer to 12 poorest groups. The sixteenth poorest household group in the increasing government payment improve their expenditure with a positive percentage change, this is due to the smallest percentage reduction compared with other rich household groups in the no compensation.

4.2.3. Impact of the ETS on the household welfare

The price on emissions permit induces the changes in the prices of goods and services, thus affecting the welfare of household groups. Equivalent variation (EV) is a monetary measure of welfare effect of the price change. EV measures the change in utility in terms of dollar value, in particular, the amount of money needed to achieve a new level of utility at the initial price level. The negative values of EV shows the welfare loss and the positive values represents welfare gain. As the results illustrated in Table 4, all household groups face welfare loss in varying degrees, in which the higher income household groups are estimated to have a greater welfare loss than the poorer income household groups, nearly $197 million of the richest household group compared to nearly $8 million of the poorest household group in the no revenue-recycling and the total welfare loss is $548.41 million.

If the permit revenue is recycled to household groups in the form of the lump-sum transfer per capita 19 out of 20 household groups obtain the welfare gain, with only the richest household group suffering a welfare loss of $23.08 million. The second, third and fourth poorest household groups derive the welfare gain of between $ 4 million or $5 million. This occurs because the average person in each household in these household groups is more or less than 1.1 persons, compared to 1.5 persons in the poorest household group and more than 3 persons in the four richest household groups. For the poorest group, they are not traditionally poor in the reality, because they are lost in their investment, they become the poorest household group. When the revenue is returned to households based on per-capita, due to the higher membership of people in the household they receive an increased rebate. Therefore, the rebate creates more welfare gain to the poorest household group than other poor groups.

If the permit revenue is compensated to low and middle income household groups 12 out or 20 groups obtain welfare gain, while 15 out of 20 household groups experience welfare gain with an increase in Government payments. Richest household groups still face welfare loss, except the fifth richest household group in the case of increasing government payment, they derive welfare gain. Overall, in all recycling scenarios, the Australian economy generally experience welfare gain

Table 4: The effects of an ETS on household welfare

Groups	No Revenue Recycling	Lump sum transfer (12HH)	Lump sum transfer (Per-capita)	Increasing Government Payments
Group 1(poorest)	-7.87	140.41	50.28	47.50
Group 2	-3.27	26.25	5.29	17.45
Group 3	-2.72	22.15	4.42	16.27
Group 4	-3.62	23.06	4.85	16.66
Group 5	-5.44	34.94	11.22	27.92
Group 6	-5.20	32.91	14.54	34.51
Group 7	-6.69	33.68	14.30	34.04
Group 8	-7.48	34.89	16.30	38.31
Group 9	-8.81	31.50	15.38	32.68
Group 10	-9.97	35.20	18.25	36.23
Group 11	-13.84	40.69	23.30	32.30
Group 12	-16.51	44.25	26.43	29.18
Group 13	-16.58	-13.17	29.23	17.79
Group 14	-25.06	-18.99	40.29	12.44
Group 15	-25.11	-18.29	38.02	-1.98
Group 16	-24.44	-16.04	48.99	4.49
Group 17	-44.20	-31.80	47.21	-18.13
Group 18	-45.47	-30.29	54.89	-20.20
Group 19	-79.45	-59.18	39.45	-51.66
Group 20(richest)	-196.69	-156.79	-23.08	-147.60
TOTAL	**-548.41**	**155.38**	**479.56**	**158.21**

Source: Simulation from the model

5. Conclusion

In order to achieve the Kyoto target of 5% below 2000 levels by the year 2020, this paper examines the effects of emission reduction of 11% in the baseline through the Emission Trading Scheme between industries generated carbon emissions into the atmosphere. The price is estimated at over $20 per tonne of CO2-e. The application of an emissions price results in an increase of over 13 percent in the price of electricity, with a decrease in the price of brown coal of over 30 percent. This emissions price is also estimated to reduce income, expenditure, and welfare across household groups. All permits are auctioned that generate an amount of permit revenue to the government. The permit revenue is used to compensate households in order to mitigate the undesirable effects caused by the emissions price.

This paper analyzes the effects of three scenarios of the revenue recycling on prices and on Australian households. The results show that the revenue recycling in the form of an equal lump-sum transfer per capita would create a higher consumer price increases, but create a smaller price decrease of capital and land rentals. This scenario also creates an increase in household expenditure and household income of most household groups, except the richest income group. In this scenario, 19 out of 20 household groups experience welfare gain, compared to other two scenarios. However, for low income household groups, the level of increasing their income, expenditure, as well as welfare in the form of lump-sum transfer per capita are smaller than those in other two scenarios. The highest increased level is achieved in the lump-sum transfer to 12 poor household groups.

References

Beznoska, M., Cludius, J., & Steiner, V. (2012). The incidence of the European Union Emissions Trading System and the role of revenue recycling: Empirical evidence from combined industry-and household-level data.

Büchs, M., Bardsley, N., & Duwe, S. (2011). Who bears the brunt? Distributional effects of climate change mitigation policies. *Critical Social Policy*, 0261018310396036.

Buddelmeyer, H., Hérault, N., Kalb, G., & van Zijll de Jong, M. (2012). Linking a microsimulation model to a dynamic CGE model: Climate change mitigation policies and income distribution in Australia. *International Journal of Microsimulation, 5*(2), 40-58.

Burniaux, J.-M., Nicoletti, G., & Oliveira-Martins, J. (1992). Green: A Global Model for Quantifying the Costs of Policies to Curb CO~ 2 Emissions. *OECD Economic Studies*, 49-49.

Cornwell, A., & Creedy, J. (1997). *Environmental Taxes and Economic Welfare: reducing carbon dioxide emissions*: E. Elgar.

Cornwell, A., & Creedy, J. (1998). *Measuring the welfare effects of tax changes using the LES: an application to a carbon tax*: Springer.

Creedy, J., & Martin, C. (2000). Carbon taxation, fuel substitution and welfare in Australia. *Australian Economic Review, 33*(1), 32-48.

Dinan, T. M., & Rogers, D. L. (2002). Distributional effects of carbon allowance trading: how government decisions determine winners and losers. *National Tax Journal*, 199-221.

Dougall, M. (1993b). *Short run effect of a carbon tax*. Paper presented at the Centre of Policy Study and the Impact Project, Eleventh Floor Menzies Building, Monash University.

Government, A. (2013). Australia's Sixth National Communication on climate change, a report under the United Nations Framework Convention on Climate change (pp. 24). the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Grainger;, C. A., & D.Kolstad, C. (2010). Who Pay a Price on Carbon. *Environmental and Resource Economics, 46*, 359-376.

Horridge, M. (2003). ORANI-G: A generic single-country computable general equilibrium model. *Centre of Policy Studies—COPS. Monash University. Austrália.*

Meng, S., Siriwardana, M., & McNeill, J. (2014). The Impact of the Australian Carbon Tax on Industries and Households. *Margin: The Journal of Applied Economic Research, 8*(1), 15-37.

Okagawa, A., & Ban, K. (2008). Estimation of substitution elasticities for CGE models. *Discussion Papers in Economics and Business, 16*.

Parry, I. W. (2004). Are emissions permits regressive? *Journal of Environmental Economics and Management, 47*(2), 364-387.

Poterba, J. M. (1991). Tax policy to combat global warming: on designing a carbon tax: National Bureau of Economic Research.

Symons, E., Proops, J., & Gay, P. (1994). Carbon taxes, consumer demand and carbon dioxide emissions: a simulation analysis for the UK. *Fiscal Studies, 15*(2), 19-43.

Truong, T. P., Kemfert, C., & Burniaux, J.-M. (2007). GTAP-E: An Energy-Environmental Version of the GTAP Model with Emission Trading: DIW-Diskussionspapiere.

World Bank. (2012). Electricity production from coal sources, World Bank Data, http://data.worldbank.org/indicator/EG.ELC.COAL.ZS.

Yusuf, A. A., & Resosudarmo, B. (2007). On the distributional effect of carbon tax in developing countries: the case of Indonesia. *Papers No. EEN0706, Economics and Environment Network, the Australian National University, 70*.