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The Distributional and Welfare Effects of the Australian Emissions Trading Scheme

Abstract

The Australian Labor Government introduced a carbon pricing scheme that commenced with a fixed carbon price of $23 per tonne of CO2-e on 1st July 2012, then would switch to an emissions trading scheme on 1st July 2015. The objective of this scheme was to achieve the Kyoto emissions reduction target of at least 5 percent below 2000 levels by 2020. We examine the effects of a domestic emissions trading scheme on prices, distributional income and welfare of Australian households. To do this, a single country, static CGE model is employed with an environmentally-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 indicate that the emissions price is estimated at around $20 per tonne of CO2-e, and the permit revenue is over $10 billion. The electricity price increases at the highest percentage of 13.55 percent. The consumer price index mildly increases at 0.42 percent. All households experience a reduction of income and expenditure in varying degrees. Such changes affect negatively the welfare of all household groups. To mitigate these effects, half of the permit revenue is returned to all household groups in four alternative ways. We find that an equal lump-sum transfer has positive effects on welfare for most household groups.

1. Introduction

The Australian Labor Government introduced a carbon pricing scheme that commenced with a fixed carbon price of $23 per tonne of CO_2-e on 1 July 2012. It was intended that the carbon tax would switch to an emissions trading scheme on 1 July 2015. The objective of the Labor Government's policy was to achieve the Kyoto emissions reduction target of at least 5 percent below 2000 levels by 2020. However, a new Coalition Government, elected in November 2013, repealed the carbon tax with effect from 1 July, 2014 and proposed a subsidy scheme, known as Direct Action Plan from July 2015. Some economists and politicians are skeptical about the achievement of the Direct Action Plan. Freebairn (2014) compared both price and subsidy strategies to reduce emissions and concluded that the price strategy will have a larger effective base and lower transition costs, and together will lead to lower cost per unit emission reduction than the subsidy strategy.

A carbon pricing mechanism is popularly known as a carbon tax, or an emissions trading scheme. Under a carbon tax, a price for carbon emissions is fixed at an amount of dollars per tonne of CO_2 with the emissions quantity determined by the market. Conversely, under an Emissions Trading Scheme (ETS), the quantity of carbon emissions is given as a fixed amount, while the emissions price is determined by the market. Therefore, an ETS is to be preferred to a carbon tax as it is considered an effective instrument to achieve the emissions reduction target at the lowest possible cost.

The main issue in an ETS is how to allocate emissions permits. There are three options, such as free permit allocation (called grandfathering), or permits auctioning, and or combination of grandfathering and auctioning. The difference between them is the distribution of emissions reduction costs. If permits are given out for free for the polluters, the polluters pay only for the extra permits bought from other polluters and the Government does not raise any revenue. If permits are auctioned, the carbon market that is created by the sellers and the buyers of permits indicates the lowest price for emissions reduction and the Government raises permits revenue from the auctions. Cramton & Kerr (2002) concluded that the emissions auction is preferred to the grandfathering because the emissions auction creates reduced tax distortions and promotes technological innovations as well as shares cost effectively. In addition, an ETS allows to link between the domestic emissions market and the international emissions market that helps reduce the cost of abatement via a lower carbon price.

The costs caused by an emissions price are fully or partly passed forward to consumers in the form of higher commodity prices and backward in the form of price of capital and land rentals and wages through lower rentals and wages. The income sourced from labour, capital, and land contributes mainly to the total household income. Therefore, the change in commodity prices, labour wages and capital rentals, affects household income and expenditure, which together affects household welfare. Fullerton (2011) presented six distributional effects of environmental policy and concluded that the distributional effects are regressive. The degree of regressivity depends on the methodological choices such as the type of measurement of distributional effects and the inclusion of behavioural responses (Büchs, Bardsley, & Duwe, 2011). Distributional effects measured by the annual income tend to have a greater regressive effect than those measured by the lifetime income (or current consumption) (Corbett A. Grainger, 2010; Walls, 2009). When 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). Therefore, low income households will be more responsive to a carbon price than high income households.

This paper examines the effects of an ETS designed to achieve the emissions reduction of 11 percent from the baseline (equivalent to 5% below 2000 levels by 2020) on the prices of goods and services, then on household income, household expenditure, and household welfare. In this study, the costs caused by an ETS are assumed to pass fully in to consumers in the form of higher commodity prices. All emissions permits are auctioned among the emitters. The auctioned permit revenue is estimated to accrue to the Government. The results show that placing a price on emissions causes an increase to the commodity prices and a decrease in the prices of primary factors, thus leading to a decrease in household income, household expenditure, and household welfare. In this analysis, half of the permit revenue is redistributed to all household groups by four alternative ways such as providing an equal lump-sum transfer to all household groups (LST); increasing the Government payment to all household groups based on the Government pensions and allowances ratios (GOT), reducing the goods and services tax (GST), and decreasing personal income tax based on equal marginal tax rate cut (INT). This study compares the effects of each scenario on prices, as well as on distributional income and household welfare.

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 simulations. Section 4 analyzes the effects of an ETS on prices as well as distributional income and welfare of Australian households. Section 5 concludes the paper.

2. Literature Review

An emissions trading scheme has been introduced and implemented in the U.S. named the U.S. Sulfur Dioxide Trading System and in the European Union known as European Union Emissions Trading Scheme. Therefore, there are a number of studies that have gauged the effects of an ETS on various economies as well as on distributional income and welfare. Some of these are presented in the following sections.

Parry (2004) used an analytical model with lifetime income proxied by consumption to examine the distributional effects of different environmental policies. The author compared grandfathered emissions permits with other environmental policies to control power plant emissions of CO2, SO2, and NOx. The price elasticity for electricity was assumed at -0.25 and the marginal abatement cost functions were assumed to be linear. The households were divided into quintiles according to household consumption. The results showed that low income households were worse off under grandfathered permits than under an emissions tax. The author also found that grandfathered permits were highly regressive for all pollutants for emissions reductions, in which the top income quintile was better off while the bottom income quintile was much worse off, excepting input tax. The burden imposed on low income households was lower under other policies than under grandfathered permits because the Government had no revenue to alleviate the regressive effects of the price rise. Moreover, the social costs of grandfathered permits can be substantially increased as society has an aversion to inequality. However, if an emission tax or the auctioned permit revenue were recycled proportionally to households, the policy looked much less regressive. The bottom income quintile received more income compensation from the Government under the emissions tax than under grandfathered permits. However, the quintile 1 was worse off with input tax than with grandfathered permits under proportional recycling but better off with the input tax under lump sum recycling. If revenue was recycled in a progressive manner as in equal lump-sum transfers, the policy became progressive in the case of carbon and NOx.

Rogers (2002) examined the distributional effects of a carbon allowance policy designed to achieve an emissions reduction of 15% from a business-as-usual baseline. The allowance was allocated by giving away and auctioning with the revenue distributed through decreasing corporate tax, reducing payroll tax, and providing a lump-sum rebate to households. The research was analyzed in the domestic trading level and the international trading level by applying the partial equilibrium model. The results showed the price was estimated to be a domestic allowance price of $100 and an international price of $60. In the case of the domestic emissions trading, with different sources of data from the expenditure side or the wealth side, the results were quite different, the cost impacts were highly regressive for the former and slightly regressive for the latter. The policy effects appeared less progressive in the case of the auction/lump-sum rebate and more regressive in other cases when the consumption-to-income ratios were calculated from expenditure data. The results also indicated that the lowest quintile would bare the largest share of the policy cost if the government gave allowances away. However, in the case of auctioning, the average household income in the lowest quintile would increase, especially, their receipts would be greater than their payments for increased costs caused by the increased pricing policy in the form of the lump-sum rebate policy. The highest income quintile would gain more benefits when the government decreased corporate tax than when it decreased payroll tax but they experienced the largest loss in the case of the lump-sum rebate.

In the case of the international emission trading, the results were obtained from expenditure data, households were better off under the international trading compared with the domestic trading. In the case of an auction/lump-sum rebate, low income households were made worse off under an international trading. The limitation of this research is that it did not account for the effects of carbon prices on the relative returns to labour and capital and because of a static analysis, it did not account for the changes in capital accumulation, invention, and diffusion of technologies.

Martin & Viktor (2012) examined the effects of the EU-ETS with the emissions reduction target by 20% below 1990 levels until 2020 on the prices of goods and household welfare in Germany. The carbon price was assumed to be €25 per carbon permit. The effects on the prices of goods were classified in the case of with and without accounting for behavioral responses of consumers to price changes caused by the EU-ETS. In the former, the EU-ETS resulted in an increase of 14% in the electricity price, and on average, German households would face an additional cost of €16 per month. In the latter, household expenditure would be reduced by about 6% and tax burden reduced by 2.7% as compared to the former. However in both cases the effects were regressive. 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 the 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 remained 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 in 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 (Dougall, 1993), (Cornwell & Creedy, 1998), (Creedy & Martin, 2000), (Meng, Siriwardana, & McNeill, 2014). An Emissions Trading Scheme was proposed 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 Australian economy, including 6 states and 2 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, Hérault, Kalb, & van Zijll de Jong, 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.

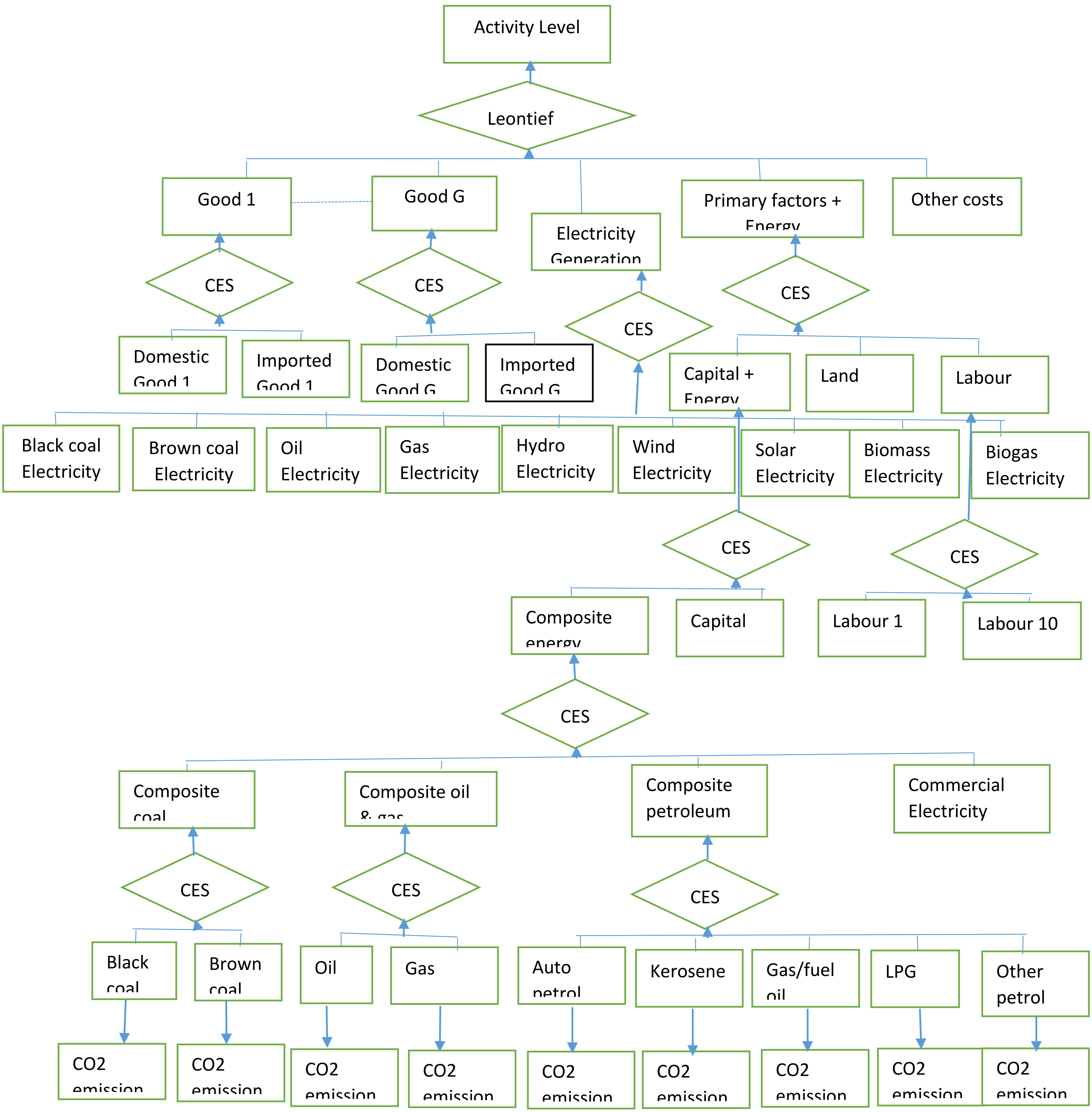
A reweighting procedure is used to transmit employment change from the CGE model to the MS model. The CGE results are used as exogenous and given inputs for the MS model to produce estimated effects on income distribution. An ETS was assumed to be implemented in July 2013 and aimed to get the emission target of 80 % below 2000 level by 2050 (scenario 1) and of 90 % below 2000 level by 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 has a positive impact on low income households, but real net income growth is the highest for the top quintile and was very limited for the bottom quintile.

3. Model structure and Database

In order to gauge the distributional and welfare effects of an ETS on Australian households, the study applied a single country, 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 45 sectors which produce an equal number of 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 is a five layer nested Leontief-CES function, as shown in Figure 1. As 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. For electricity generation, due to energy source used, electricity generation is disaggregated into nine types, including electricity generated from black coal, brown coal, oil, gas, hydro, wind, solar, biogas and biomass. The model allows the substitution between electricity generated by different sources through substitution elasticity. The composite electricity generation is formed by a CES function.

Figure 1: The structure of production function



For energy sectors, the model treats energy and non-energy sectors separately, in particular, the energy sectors are combined with capital in the primary factor part. There are substitutions between energy sectors and capital, as well as among energy sectors. The substitution between energy inputs and capital in primary factors illustrated the flexibility of the Australian economy's ability to adopt and utilize energy saving technology as the energy input costs are affected by the application of the carbon price mechanism. 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 run. For labour, the model allows the substitution between different types of labour.

In order to analyze the effects of an ETS, the model incorporates the carbon emissions accounts and the emissions price determined by the market. The carbon emissions that is generated from fuel combustion, fugitive emissions from fuels, industrial processes, agriculture, waste and land-use is aggregated into three main sources, such as carbon emissions from stationary sources (input emissions), from production activities (output emissions), and from household consumption (consumption emissions). The carbon emissions from all sources is disaggregated into emissions from domestic products and imported products. Carbon emissions in the model is treated as proportional to energy inputs used to the level of activity.

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 export commodities with an assumption of a constant elasticity of export demand. Government consumption is exogenously determined.

The carbon emissions is generated from both the production and consumption processes but it is assumed that an ETS occurs among industries generating carbon emissions in the Australian economy. All industries are assumed to be incorporated in an ETS. The block of industries related to the emissions trading scheme is set.

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 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 18 sub-energy sectors. In particular, coal mining is separated into the black coal and brown coal sectors, the oil & gas extraction is disaggregated into the oil and gas sectors, the petroleum and coal products is divided into five sectors- auto petrol, kerosene, gas/fuel oil, LPG, and other petroleum, electricity generation sector is disaggregated nine sub-sectors based on energy produced electricity. The energy sectors are disaggregated and then aggregated to form 45 sectors (corresponding to 45 commodities). 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 emissions data was collected from the National Greenhouse Gas Inventory in the year 2009. This emissions data is expressed in metric tonne of carbon dioxide equivalent (CO2-e). The emissions in the database were classified into three categories, including input emissions, output emissions, and consumption emissions. The emissions that were generated from the fuel combustion was attributed to the input emissions. The emissions generated in the residential sector were assigned for the household consumption or the consumption emissions. The emissions related to activities including from fugitive emissions from fuels, industrial process, agriculture, waste and land use, land-use change and forestry (LULUCF) were attributed to output emissions. The emissions from fuels combustion or from activity were put in the I-O emissions 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 emissions intensity was calculated for three emissions categories, including input emissions intensity, output emissions intensity, and consumption emissions intensity. Based on the carbon emissions from domestic products and imported products by firms and private households provided by GTAP database, 57 sectors and 4 types of fuels are mapping into 132 sectors and 12 types of fuels, then this emissions data is aggregated into 45 sectors in the model. The emissions intensity for domestic products and imported products for each sector by fuel are computed by dividing the emissions from domestic products (imported products) to the domestic purchases (import purchases) by firms or households. The ratio of emissions intensity from domestic products and that from imported products is used to calculate the emissions intensity for domestic and imported energy goods in the model.

The behavioral responses of economic agents are explained by the elasticity parameters. These parameters that include the Armington elasticity, substitution elasticity between primary factors, different types of labour, substitution of elasticity between electricity generated from different sources, and between energy inputs obtained from ORANI-G. As explained above, composite energy and capital are quite difficult to substitute especially in the short run, 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 45 commodities, the model is based on Australian household demand elasticity by 30 household groups and 14 commodities estimated by Cornwell and Creedy (1997). In which, 14 commodities are mapping into 45 commodities in the model, and 30 household groups mapping into 20 household groups by mapping each 3 household groups into 2 household groups in the model. 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. Simulation Analysis

According to the report provided by the (Australian Government, 2013), in order to achieve the emissions reduction target of 5% below the 2000 emissions level, 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. This emissions growth rate was calculated from emissions data provided by the National Greenhouse Gas Inventory, published in 2014. To meet the emissions reduction 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 the distributional income and welfare of Australian households.

4.1. Impacts of an Emissions Trading Scheme on macroeconomics

A permit price is incurred by the auction between buyers and sellers and thus it is determined by the market. The production costs may increase, in which case who carries the burden of these costs? In general, the producers, in order to maximize their profits, attempt to pass these costs on to customers as much as possible. Thus, it is estimated that an ETS affects all aspects of the Australian economy.

4.1.1 Impacts on prices of consumption goods and services

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

	NRR	LST	GST	INT	GOT
Agriculture, Forestry & Fishing	0.54	0.62	-0.43	0.67	0.60
Black coal	-0.11	-0.11	-1.07	-0.10	-0.11
Brown coal	-30.98	-31.02	-31.50	-31.05	-31.01
Gas	-0.07	-0.05	-0.92	-0.04	-0.05
Mining	0.84	0.86	0.05	0.88	0.86
Food, beverages & tobacco	0.29	0.36	-0.89	0.41	0.34
Textile, clothing & footwear	0.22	0.32	-0.94	0.39	0.29
Wood, paper & printing	0.30	0.39	-0.96	0.45	0.36
Automotive petrol	0.17	0.22	-0.91	0.22	0.21
Kerosene	0.23	0.23	-0.67	0.24	0.23
Gas oil or fuel oil	0.06	0.07	-0.95	0.08	0.07
Liquefied petroleum gas	0.18	0.20	-0.75	0.21	0.20
Other petroleum & coal products	0.55	0.61	-0.52	0.65	0.60
Chemical products	0.22	0.28	-0.83	0.33	0.26
Other metal products	0.19	0.25	-0.87	0.29	0.24
Furniture & equipment	0.21	0.28	-0.95	0.33	0.26
Other manufacturing	0.26	0.33	-0.86	0.39	0.31
Electricity	13.55	13.66	12.68	13.72	13.63
Gas supply	-0.58	-0.49	-2.10	-0.43	-0.51
Water & sewerage services	0.83	0.98	-0.88	1.05	0.94
Construction services	0.51	0.58	-1.32	0.62	0.56
Wholesale trade	-0.01	0.05	-1.63	0.09	0.04
Accommodation and restaurant	0.27	0.35	-1.28	0.40	0.33
Road transport	1.85	1.90	0.50	1.92	1.89
Other transports	0.09	0.11	-1.06	0.12	0.11
Communication services	0.08	0.18	-1.31	0.24	0.15
Finance and insurance	0.05	0.17	-1.85	0.26	0.13
Property and business services	0.10	0.19	-1.46	0.24	0.17
Public services	0.35	0.43	-1.69	0.48	0.41
Education and training	0.31	0.38	-1.66	0.43	0.36
Health and community services	0.37	0.46	-1.74	0.51	0.43
Art and recreation services	0.21	0.34	-1.48	0.42	0.30
Other services	0.62	0.70	-1.22	0.75	0.68

Consumer price index	**0.42**	**0.50**	**-1.05**	**0.56**	**0.48**

Source: Simulations from the model

A permit price may induce changes in the prices of consumer goods and services, especially in the prices of energy commodities. This section compares effects of emissions reduction of 11 percent on the prices of goods and services in the cases of with and without compensation to household groups. As shown in Table 1, it is clear that in four out of five scenarios, the prices of most goods and services are estimated to experience an increase to various degrees, except black coal, brown coal and gas. The electricity price is estimated to increase with the highest percentage of 13.55 percent under the NRR policy. Nearly 70 percent of electricity production in Australia is sourced from coal (World Bank, 2012). As estimated in the model, the price of coal in the electricity industry increases 72.7 percent. Thus, this coal price rise causes an increase in the electricity production costs, thus leading to a higher electricity price. A permit price also causes an increase in the price of road transport services by nearly 2 percent. However, the change in the prices of other goods and services to households are small, being less than 1 percent.

In comparison, the prices of most goods and services increase at the highest percentages under the reduction in personal income tax (INT) policy, meanwhile under the increased Government payments (GOT) policy the commodity prices rise at the lowest percentages compared to the INT and LST policies, but still higher than those in the NRR policy. These price increases are explained by a higher demand of all household groups for goods and services when their incomes increase due to the compensation policy. Under the INT policy, due to a reduction of income tax, the disposal income of all household groups increases, in which a rise in disposal income of middle and rich household groups is higher than that of poor household groups. The highest price increase under the INT policy indicates that the purchasing power of middle and rich household groups in Australia is likely to be very high, their disposal income increases this further supports to higher consumption rate.

In contrast to the price increases of most goods and services under the scenarios of with and without the revenue recycling, the prices of black coal, brown coal, and gas are estimated to decrease, in which brown coal experiences the highest percentage reduction of over 30 percent in the NRR policy, and continues to decrease by over 31 percent in all compensation scenarios. As seen in Table 1, under the GST policy, most goods and services experience price decreases, excerpt electricity and road transport prices increase at over 12.68 percent and 0.50 percent, respectively. Overall, the consumer price index (CPI) under the GST policy decreases at 1.05 percent. The price decreases under the GST policy mean that the fall in price caused by the GST reduction is greater than the rise in price induced by a permit price. By contrast, the CPI under the other three revenue recycling scenarios rises significantly, compared to the NRR policy.

4.1.2. Impact on the price of primary factors

In their target of minimizing production costs, the producers adjust their usage of primary factors, thus affecting the primary factors' prices, including capital and land rentals, and wages. In this study, the nominal wage is fully indexed to the consumer price index, thus the nominal wage is the same as the CPI. In the short-run period, the real wage is assumed to be fixed, so the percentage change of real wage is set to be zero and producers' demand for capital and land are fixed, so their percentage changes are set to be zero.

As seen in Table 2, the prices of capital and land decline with a varying degree in all scenarios. The reduction in the returns of capital and land is greater in the NRR policy than in all compensation scenarios. It seems to be true because the compensation results in an increase in household disposal income, which, in turn raises the household demand for goods and services. This leads to production recovery and the demand for primary factors would increase. However, the percentage changes of capital and land rentals are still negative, which means that the recycling is not sufficient to offset the negative percentage change of capital and land rental caused by the emissions price.

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

Variables	NRR	LST	GST	INT	GOT
Capital rental	-1.64	-1.56	-1.61	-1.51	-1.58
Land rental	-0.95	-0.87	-0.93	-0.82	-0.89
Nominal wage	0.42	0.5	-1.05	0.56	0.48
Real wage	0	0	0	0	0
Aggregate primary factor price	-0.55	-0.47	-1.31	-0.42	-0.49

Source: Simulations from the model

Under the NRR policy, the returns of capital and land decrease at 1.64 percent and 0.95 percent, respectively; the nominal wage, reflecting the CPI increases at 0.42 percent. Overall, aggregate primary factor price declines 0.55 percent. Under all compensation scenarios, the prices of primary factors increase to varying degrees. Under the GST policy, prices to all primary factors decrease that results in the payments to aggregate primary factors decrease by around 1.31 percent. For the other three revenue recycling scenarios, an increase in the nominal wage induces payments to aggregate primary factor lesser decrease, compared to the GST policy. The changes in primary factors' prices affect the income of all household groups, because the income from labour, capital and land are the main sources of the total household income.

4.1.3Impacts on other macro-economic indices

Other macro-economic variables are categorized into environmental variables, quantity variables and price variables. As seen in Table 3, to achieve the emissions reduction of 11 percent, equivalent to 63.32 million tonne of CO2-e, the emissions price is estimated at \$20.54 per tonne of CO2-e under the NRR policy. This emission price increases slightly in all revenue recycling scenarios, in which it rises the highest price at \$20.92 per tonne of CO2-e under the GST policy. The higher emissions price in the GST policy can be explained by the higher carbon emissions generated when more goods and services are supplied to the economy, compared to other revenue recycling. The auctioned emissions revenue is calculated by multiplying the emissions price and the emissions quota. Due to the higher emissions price, the permit revenue in the GST policy is the highest, at nearly \$10.44 billion.

Table 3: The effects of an ETS on other macro-economic indices (percentage change)

Macro Variables	NRR	LST	GST	INT	GOT
Environmental variables					
Emissions price(\$)	20.54	20.56	20.92	20.57	20.56
Emissions reduction (Mt)	63.32	63.32	63.32	63.32	63.32
Permit revenue(\$ million)	10250.51	10259.32	10440.52	10262.63	10257.34
Quantity variables (%)					
Nominal GDP	0.122	0.218	-0.759	0.277	0.193
Real GDP	-0.286	-0.271	-0.004	-0.262	-0.275
Real household consumption	-0.07	0.069	-0.25	0.152	0.034
Aggregate employment	-0.427	-0.411	0.168	-0.401	-0.415
Export volume	-1.4	-1.617	0.366	-1.75	-1.561
Import volume	-0.277	-0.223	-0.235	-0.193	-0.236
Price variables (%)					
GDP price index	0.41	0.49	-0.755	0.541	0.469
Price of exports	0.143	0.166	-0.04	0.18	0.16
Price of imports	0	0	0	0	0
Terms of trade	0.143	0.166	-0.04	0.18	0.16

Source: Simulations from the model

The results shown in Table 3 indicate that there is an increase in the nominal GDP of 0.122 percent and a decrease in real GDP of 0.286 percent in the NRR policy. When the revenue is returned to all household groups in the forms of providing lump-sum transfer, or reducing the personal income tax, or increasing government payments to household groups, there is a higher increase in nominal GDP and smaller decrease in real GDP. The reason is that due to the compensation, households have more money to spend, thus leading to an increase in household consumption. As seen in Table 3, real household consumption increases under three of the four scenarios of revenue recycling. Moreover, Table 1 presents that the higher price increases of most goods and services in these compensation policies would make nominal GDP increase more than in the NRR policy.

In contrast, this trend is reversed under the GST policy, the nominal GDP decreases by 0.759 percent. This reduction is explained by a decrease in prices of goods and services as seen in Table 1. Meanwhile, a reduction in the real GDP under the GST policy is smaller than in other revenue recycling. As seen in Table 2, under the GST policy the reduction in the prices of all primary factors results in a decrease in the income of all household groups, thus leads to a reduction in real consumption of 0.25 percent. However, there is a positive signal in the labour market as aggregation employment increases at 0.168 percent under the GST policy. By contrast, the inflationary effects and the increase in nominal wages induce producers to cut their production, therefore the aggregate employment reduces in the LST, the INT, and the GOT policies

For international trade, with the closure assumption of the fixed import price, the terms of trade are reflected by the change in export prices. As shown in Table 3, the GST policy improves the export competitiveness due to lower export prices compared to other policies, thus leading to an increase in export volume. Meanwhile all other revenue recycling policies experience reduction in export levels. Moreover, these reductions are higher than in the NRR due to the higher price increases in these revenue recycling policies. By contrast, the import volume experiences a lower rate of reduction in all revenue recycling policies than in the NRR policy.

4.2. Impacts of an ETS on households

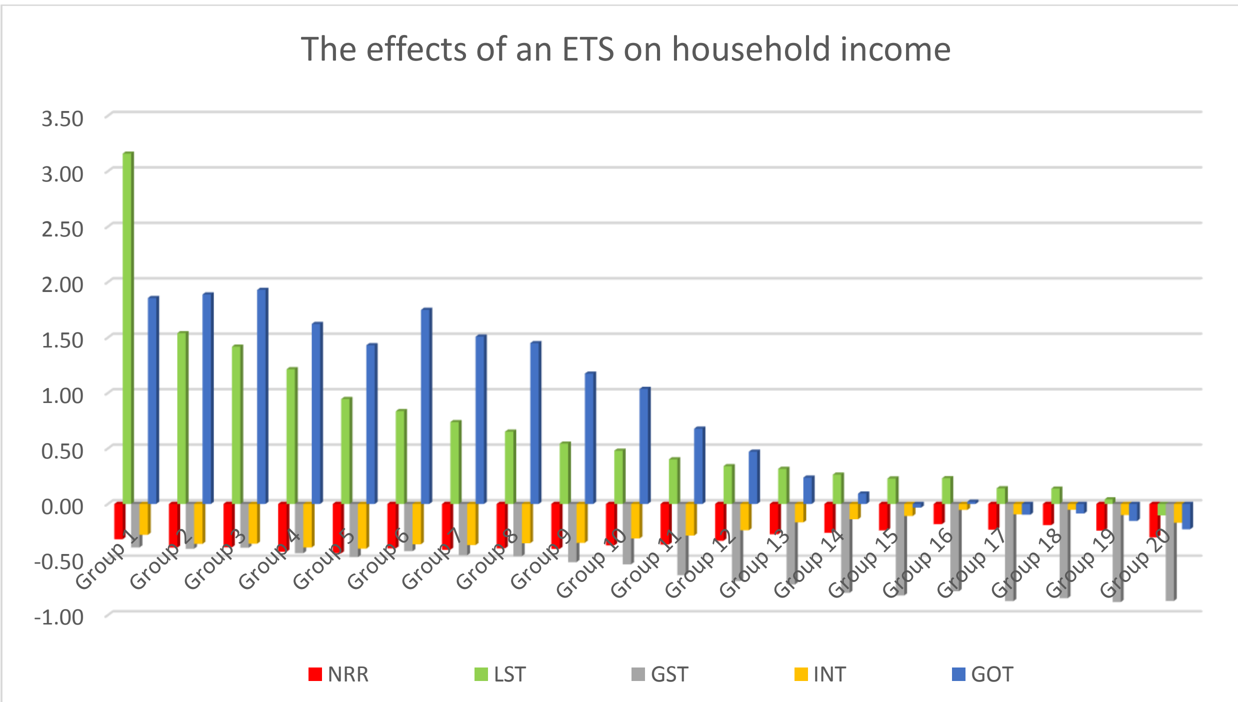
The emissions price is included into production costs. In order to maximize profits, the producers pass this cost on to customers as much as possible, indeed household groups would suffer from the increased prices of goods and services. The increase in commodity prices may result in a reduction in household consumption. Meanwhile, 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 in the total income of all household groups. Thus, the emissions price affects the distributional income and welfare of all household groups. The following sections present more detail about these effects 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 is higher for the high income household groups than the low income household groups. In particular, the income from these sources accounted for over 20 percent of the total income for the poorest household group, and over 80 percent of the total income for the richest household group. As seen in Table 2, the emissions price results in a decrease in capital and land rentals in the all five scenarios and in labour wage in the GST policy. Thus, income of all household groups is estimated to change with various degrees due to the ETS with or without revenue recycling.

As seen in Figure 2, all household groups experience a reduction in their income at varying degrees in the NRR policy. It seems that lower income household groups suffer a greater burden with a reduction in their income when compared to rich household groups. For the fifth and third richest household groups, because of a smaller proportion of their income sourced from capital rental compared to other rich household group, their incomes reduce to only 0.18 percent and 0.19 percent, respectively. In order to offset the negative effects of the ETS on household income, four scenarios of revenue recycling policies are proposed. Their effects on household income are quite different.

Figure 2: The impacts of the ETS on income of household groups



Source: Simulations from the model

The results shown in Figure 2 indicate that the LST policy benefits the highest number of household groups. The compensation is enough to offset the reduction in income of 19 out of 20 household groups caused by the emissions price. Thus, the percent changes in their incomes are positive, in which low income household groups receive more benefits from the LST policy than high income household groups. Only the richest household group still experience a negative percent change in their income of 0.1 percent, compared to 0.3 percent in the NRR policy. Under the GOT policy, the compensation results in the positive percent changes in the income of 14 household groups. Six richest household groups still remain the negative percent changes in their incomes.

However, all household groups suffer reductions in their incomes under the GST and INT policies. Compared to the NRR policy, all household groups experience less reductions under the INT policy but higher decreases under the GST policy. This is due to the difference in the prices of capital, land, and wages in each scenario as seen in Table 2. The INT policy is designed to reduce proportionally the marginal income tax rates to all household groups, thus increases the disposal income of household groups. The percent changes in the disposal income of 8 richest household groups are positive. By contrast, under the GST policy, high income household groups suffer a higher rate of income reduction than low income household groups. The reason is that the emissions price contributes to lower prices of primary factors. As seen in Table 2, the prices of all primary factors, including capital, land and labour decrease under the GST policy, while income sourced from these factors constitutes to mainly total income of rich household groups. Thus, the reductions in the returns of these factors results in the declines of income for all households.

4.2.2. Impact of the ETS on household consumption

It is assumed that the burden of the emissions price is passed fully to consumers through higher commodity prices when producers are faced with increased production costs. The prices are expected to increase for most commodities which, in turn, results in a reduction in household consumption in both dollar change and percentage change. Especially, for the energy commodities which are carbon intensive products, their prices and quantity are directly affected by the emissions pricing policy.

Table 4: Household consumption in the case of no revenue recycling (NRR) (percentage change)

	Electricity Consumption	Energy Consumption	Real Consumption	Percentage Cost Burden
Group 1(poorest)	-0.95	-0.30	-0.04	1.28
Group 2	-0.55	-0.19	-0.02	0.41
Group 3	-0.44	-0.13	-0.02	0.35
Group 4	-0.40	-0.12	-0.03	0.32
Group 5	-0.22	-0.09	-0.03	0.37
Group 6	-0.28	-0.09	-0.03	0.34
Group 7	-0.44	-0.15	-0.03	0.33
Group 8	-0.50	-0.17	-0.03	0.32
Group 9	-0.62	-0.19	-0.04	0.28
Group 10	-0.70	-0.22	-0.04	0.28
Group 11	-0.86	-0.27	-0.04	0.28
Group 12	-1.01	-0.31	-0.05	0.26
Group 13	-1.18	-0.36	-0.04	0.24
Group 14	-1.43	-0.46	-0.05	0.25
Group 15	-1.51	-0.46	-0.05	0.23
Group 16	-1.76	-0.54	-0.04	0.22
Group 17	-2.09	-0.65	-0.07	0.20
Group 18	-2.41	-0.76	-0.07	0.19
Group 19	-3.17	-0.95	-0.11	0.14
Group 20(richest)	-4.10	-1.60	-0.19	0.10
Aggregate	-1.23	-0.40	-0.05	0.32

Source: Simulation from the model

For other goods and services, energy commodities are used in their production processes, prices of these goods and services are indirectly affected by the emissions carbon policy, and depending on the magnitude of usage energy commodities. Therefore, all household groups are estimated to reduce their consumption on goods and services. As shown in Table 4, the real consumption of all household groups decline to a variety of degrees, from 0.04 percent (the poorest households) to 0.11 percent (the richest households). It is apparent that all household groups decrease their consumption on electricity in particular and energy commodities in general, in this field, the percentage reduction of high income household groups is larger than that for low income household groups.

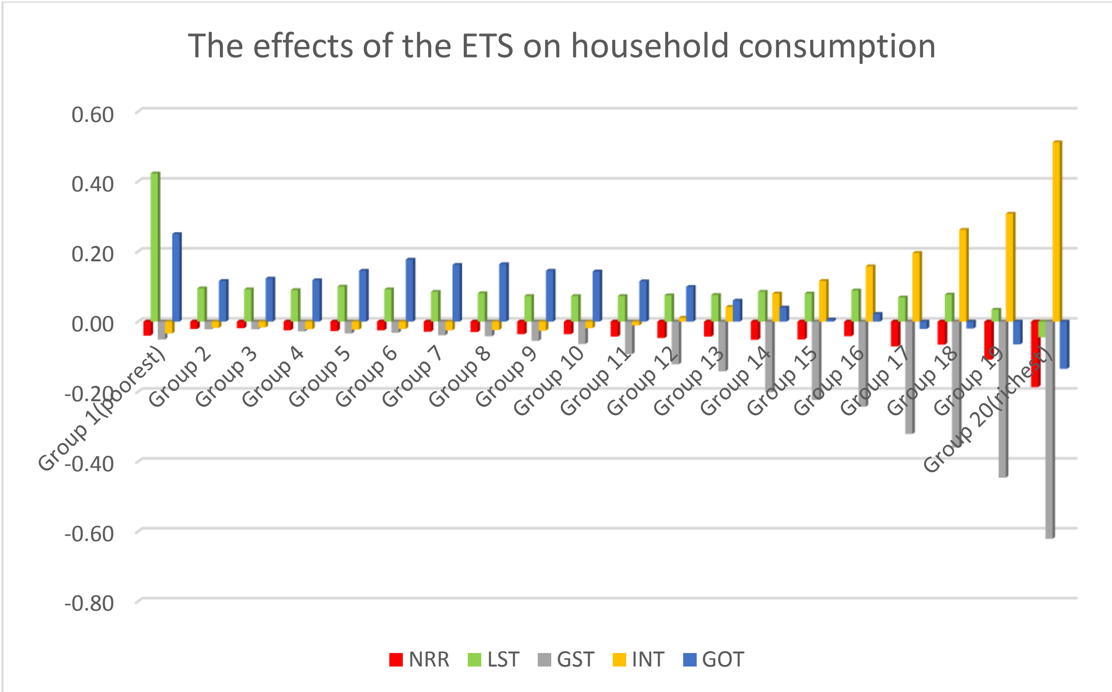
In regard to energy commodities, low income households tend to spend a greater proportion of their income on energy-intensive goods than high income households. For example, as seen in the model, the poorest household group spends 6.6 percent and 22.6 percent of their disposal income on electricity and energy commodities, respectively, while the richest household group uses only 0.9 percent and 2.3 percent of their disposal income, respectively. Therefore, it is seemingly more difficult to reduce the percentage of household income spent on energy consumption of low income household groups than of rich household groups. As shown in Table 4, the richest household group can cut nearly 4.10 percent of their electricity consumption and 1.60 percent of their energy consumption, but the poorest household group may reduce only 0.95 percent of their consumption on electricity and 0.30 percent of their energy consumption.

Table 4 shows the percentage cost burden on each household group as a result of an ETS. The percentage cost burden is calculated by taking the ratio of extra consumption after the emissions price to average disposal income in each household group. It is clear that the emissions price impose increased cost to low income household groups than to high income household groups. That cost would account for 1.28 percent of disposal income for the lowest household group, compared to 0.14 percent of disposal income for the highest household group. Therefore the emissions price is regressive.

Figure 3 displays the effects of an ETS on the household consumption in the no-revenue recycling option as well as in the different options of revenue recycling. It is clear that the imposition of the emissions price results in a reduction in the consumption of all household groups. The LST and the GOT policies are optimal choices to increase positively consumption of largest number of household groups. In contrast, the revenue returned by reducing GST leads to higher declines in consumption of all household groups, around 0.05 percent for the poorest household group and 0.62 percent for the richest household group, compared to 0.04 percent and 0.19 percent in the NRR policy, respectively. The reason for household consumption decreases is that reducing GST leads to a decrease in the commodity prices, but the reduction in prices does not lead to an increase in quantity, because a reduction in the prices of capital and land rentals and labour wage results a reduction of the total household income, therefore the decline in both prices and quantity results in the reduction of household consumption. Moreover, household consumption in the GST policy scenario experiences a higher reduction than in the NRR policy.

Under the INT policy, reducing personal income tax usually results in an increase in the disposal income for all household groups, therefore leading to an increase in household demand for goods and services. However, this policy give more benefits to high income household groups than to low income household groups. Therefore, the percentage changes in the consumption of nine richest household groups are positive, meanwhile, other poor household groups still experience a negative percentage change in their consumption.

Figure 3: Effects of the ETS on household consumption



Source: Simulation from the model

4.2.3. Impact of the ETS on the household welfare

The imposition of a price on emissions alters the prices of goods and services, thus affecting household expenditure and utility as well as to the welfare of household groups. The 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 the welfare gain.

As the results illustrated in Table 5, all household groups face welfare loss with a varying degree under the NRR policy, in which high income household groups are estimated to suffer the higher welfare loss than low income household groups. The absolute welfare loss is nearly $7.7 million for the lowest income household groups, compared to around $173 million for the highest income group. On average, all Australian households experience an aggregate loss of $474.7 million. When the permit revenue is compensated to households through providing an equal lump-sum transfer to all household groups, it seems that most household groups are better off, compared with no revenue recycling policy. But the richest household group suffers the welfare loss of $41.7 million, and this loss is smaller than in the NRR policy. Under the GOT policy, the welfare of all household groups has significantly improved, compared to the NRR policy, but these improvements are smaller than in the LST policy. For example, the four richest household groups still remain the welfare loss.

Table 5: The effects of an ETS on household welfare

	NRR	**LST**	**GST**	**INT**	**GOT**
Group 1(poorest)	-7.69	82.03	-9.82	-6.63	48.42
Group 2	-3.19	14.71	-3.46	-2.86	17.94
Group 3	-2.62	12.47	-2.94	-2.31	16.72
Group 4	-3.51	12.72	-4.02	-3.09	16.72
Group 5	-5.24	19.40	-6.64	-4.38	27.96
Group 6	-4.98	18.26	-6.35	-4.13	35.35
Group 7	-6.34	18.33	-8.40	-5.28	34.80
Group 8	-7.03	18.92	-9.83	-5.70	38.54
Group 9	-8.24	16.58	-12.62	-5.96	33.01
Group 10	-9.20	18.76	-16.51	-4.91	36.94
Group 11	-12.66	21.46	-27.12	-3.31	33.69
Group 12	-14.81	23.72	-38.33	3.52	31.10
Group 13	-14.33	25.48	-47.51	14.03	20.12
Group 14	-21.25	34.36	-82.27	32.55	16.24
Group 15	-20.69	32.26	-90.36	46.97	2.50
Group 16	-18.95	39.51	-108.33	70.64	9.64
Group 17	-36.78	35.45	-165.37	100.97	-10.65
Group 18	-36.19	42.28	-198.46	144.41	-11.28
Group 19	-67.94	21.25	-277.88	192.34	-40.32
Group 20(richest)	-173.04	-41.67	-572.66	472.16	-124.42
Aggregate	**-474.68**	**466.27**	**-1688.85**	**1029.01**	**233.02**

Source: Simulation from the model

When the permit revenue is returned to households in the form of reducing personal income tax, the INT policy creates more benefits to wealthy household groups, but less benefits to poor household groups. Under this policy, proportional marginal income tax rate is reduced to all household groups, so rich household groups pay a higher rate of income tax thereby receiving greater benefits. As a result, the nine richest household groups obtain the welfare gain. On average, all household groups are estimated to experience the highest aggregate gain of $1029.01 million under the INT policy, compared to $466.27 million under the LST policy and $233.02 million under the GOT policy. By contrast, under the GST policy, all household groups are estimate to suffer more welfare loss at $1688.85 million. This welfare loss could possibly be explained by the higher reduction in household consumption under the GST policy as seen in the Figure 2.

5. Conclusion

In order to achieve the Kyoto target of 5% below 2000 levels by the year 2020, the authors have examined the effects of emission reduction of 11% in the baseline through an Emission Trading Scheme between industries that generated carbon emissions into the atmosphere. The price is estimated at over $20 per tonne of CO2-e. The permit revenue raised from auctioning are returned partly to all household groups under different scenarios of revenue recycling.

The prices of most goods and services are estimated to change due to the imposition of the emissions price. The electricity price is estimated to increase at the highest percentage at 13.55 percent, while the price of coal reduces at around 30 percent. The reduction in coal price is caused by the high decrease in coal demand because it is an emission–intensive energy. The increase in prices of goods and services, together with the reduction in prices of capital and land rentals lead to a decline in both household income and consumption. The reduction in income of the high income household groups is larger than the low income household groups in the dollar change but is smaller in the percentage change.

To offset the undesirable effects of the carbon pricing policy, half of the auctioned permit revenue is transferred to all household groups in the form of providing equal lump-sum transfer, reducing GST, reducing income tax, and increasing government payments. The results show that the revenue recycling in the form of providing equal lump-sum transfer and increasing Government payments would create equity through increasing income, expenditure and welfare for most number of household groups. Meanwhile the reducing income tax would results in more benefits for rich household groups, but fewer benefits for poor household groups. In contrast, the revenue recycling in the form of reducing GST would cause the worse effects on income, expenditure and welfare of all household groups. Therefore, revenue recycling in the forms of providing equal lump-sum transfer the optimal choices to compensate vulnerable households for the equity and revenue recycling in the form of reducing personal income tax creates more efficiency to the economy than other scenarios.

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