Will the direct action plan work?

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Abstract:

The current Australian government has repealed the previous government's carbon pricing policy and proposed a direct action plan to reduce carbon emissions. According to this plan, the government will use a A$2.55 billion emissions reduction fund to pay industries for emissions reduction so as to achieve the target of a 5% emissions reduction on 2000 levels by 2020. The funding for emissions reduction is allocated through reverse auction. Using a CGE approach, this paper models this reverse auction and assesses the effectiveness of the government-funded emission reduction activity. The modelling results show that the direct action plan can reduce emissions but its effectiveness and efficiency are in doubt. Assuming that industry capacity to reduce emissions is a portion of its activity emissions base and that the emission abatement cost is the forgone profit per megatonne of emissions abated, a fund of A$2.55 billion can generate 56.597 megatonnes of carbon abatement credits, or 81% of Australia's emission reduction obligation, but real GDP will decrease by 0.137% when labour supply is unconstrained, or by 0.276% if total employment is fixed. To achieve Australia's obligation, the emissions reduction fund needs to be increased to A$6.117 billion. The blow-out in cost is due to the limited emissions abatement capacity of industries of low abatement cost. The involvement of industries of high abatement cost in emission reduction activities contributes considerably to the inefficiency of the direct action policy. The other sources of ineffectiveness and inefficiency may include the short-term nature and budgetary cost of this policy, the credibility of carbon abatement credits, and the auditing and other administration costs associated with the direct action policy.

Key words: emissions reduction, direct action plan, reverse auction, CGE modelling,

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1. Introduction

A carbon pricing scheme – the Clean Energy Plan –passed both houses of the Australian Parliament in 2011. The Scheme stipulated a fixed carbon price at $23 per tonne of CO2e commencing 1/7/2012, with the carbon price increasing to $24 per tonne in 2013 and further increasing to $25 per tonne in 2014. However, a newly elected federal government repealed the Scheme and proposed a direct action plan in 2013. According to this plan, the government will use an emission reduction fund of A$2.55 billion to pay for emissions reduction activities so as to achieve the target of a 5% emissions reduction on 2000 levels by 2020. The funding for emissions reduction is to be offered in a series of reverse auctions. That is, all interested entities will submit project proposals for emissions reductions, detailing the cost of the planned reductions and the amount of emissions reduction that will be achieved. Based on the reversed order of the proposed abatement cost per tonne of emissions, the government will fund the qualified projects, starting from the lowest cost, until the entire emission reduction fund is depleted.

Political opponents of the policy argue against the direct action policy, saying that the government is paying polluters not to pollute. Many people are suspicious of the policy. Since the direct action policy contains no cap on the emissions and thus no pressure on industries, and no price signals to energy users, emissions are likely to go up as the size of economy grows over time. Even if the direct action can reduce emissions, it is questionable that it can achieve the 5% emissions reduction target. Facing this scepticism, the government has repeatedly claimed that the direct action will achieve the emissions reduction target and will not have a negative impact on the economy. After the first emissions reduction fund auction in mid-April 2015, the government announced that 107 carbon abatement contracts were awarded to 43 contractors covering 144 projects, with total contract value at $660.472 million and an average carbon price of $13.95 per tonne of carbon emission. The contracted emissions abatement totalled 47.333 megatonnes.

In theory, both carbon pricing and subsidized carbon abatement should reduce emissions. According to the Coase theorem, the optimal outcome can be achieved as long as the property rights are clearly defined. In the case of carbon emissions, if industries have no right to emit carbon dioxide freely, a carbon price will achieve the low emissions level required by the government. On the other hand, if the industries have the right to emit carbon dioxide, a government subsidy can induce industries to emit less. A suitable amount of subsidy can also achieve the required low emissions level. This reasoning is illustrated by Freebairn (2014) in a comprehensive way. Freebairn (2014) showed that the subsidy approach may be less effective and less efficient because the subsidy is generally greater than the abatement cost, however, the reverse auction proposed by the government can equalize the subsidy to the abatement cost and thus successfully overcome this hurdle on effectiveness as well as efficiency. In this reasoning, the direct action plan may work and may also be efficient. The potentially intriguing outcome of the government policy motivates the authors to model the reverse auction and assess the effectiveness of government-funded emissions abatement activities.

The balance of the paper is organised as follows. Section 2 reviews recent studies on Australian carbon policies using CGE modelling. Section 3 describes the model structure and database for the simulations. Section 4 presents and discusses the simulation results. The final section summarises the results and provides some comments.

2. Literature review

The effect of a carbon tax is a well-researched topic internationally. Notable research includes Beausejour et al. (1992), Hamilton and Cameron (1994), Zhang (1998), Labandeira et al. (2004), Wissema and Dellink (2007), and Devarajan et al. (2011). Due to the space limitations, here we focus on recent studies on Australian carbon pricing as well as on subsidized carbon abatement activities.

Adams (2007) simulated the cost of an Australian emission trading scheme as insurance against catastrophic climate change. The core model used in this study is the Monash Multi-Regional Forecasting (MMRF) CGE model while a suit of micro models by McLennan, Magasanik Associates (MMA) is used to model the electricity industry. The integration of the two types of models are achieved through iteratively feeding the modelling results into each other: the MMA models informed the MMRF model of the changes on generation mix and capacity while the MMRF model provided the MMA models with the changes in electricity demand. The carbon permit price was also determined by the MMA models based on a specific abatement target and this carbon permit price was converted to an ad valorem tax on emission sources (e.g. coal, oil, gas, etc.). With a carbon emissions permit price rising from \$18.30 per tonne of CO2-e in 2010 to \$50.20 per tonne of CO2-e in 2030, the study suggested that, compared with the baseline (business as usual) case, real GDP in 2030 will fall by 1.3% and real household consumption will fall by 1.4%. Whilst employment will fall by 0.6% in the short run, it will recover in 2030, but the real wage rate will decrease by about 3.3%. Total carbon emissions in 2030 will decrease by 21.1% (or 169.6 megatonnes) compared with the baseline case.

The work of Adams (2007) became a foundation for the Australian Treasury modelling in 2008 and 2011. To accompany the proposed carbon tax in Australia, the Treasury carried out a complex, large-scale carbon price modelling. It consisted of a number of models including the GTEM model, which provided the international economic and emissions context for modelling of the Australian economy, and the MMRF model, which projected the national, regional and sectoral impact of carbon taxes. With the world carbon price paths being set, the model for the assessment of greenhouse-gas-induced climate change (MAGICC) was used to estimate the greenhouse gas atmospheric concentration levels. The ROAM model by ROAM Consulting and the SKM MMA model by the Sinclair Knight Merz group were used to provide detailed bottom-up information of the Australian electricity generation sector. The Energy Sector model (ESM) by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to model the road transport sector. The price revenue incidence simulation model and distribution model (PRISMOD.DIST) were used to examine the distributional implications of carbon pricing for households. The final modelling framework and results were included in the Treasury report: Strong growth, low pollution – modelling a carbon price (The Treasury, 2011).

Clarke and Waschik (2012) investigated the carbon pricing strategies of Australia in a global context. Using a single-country static CGE model and the GTAP database version 7, they simulated the results of carbon pricing in order to reduce Australian carbon emissions by 27%. Without any border tax adjustment or compensation for energy-intensive and export trade-exposed sectors, the 27% emission abatement target resulted in a carbon price of US$26.41 per tonne. The social welfare measured by Hicksian equivalent variations fell by 0.39% and the returns to labour and capital reduced by 1.1% and 1.6%, respectively. Free emissions permits or compensation to energy-intensive and trade-exposed sectors led to a higher carbon price. Their sectoral results suggested that, while compensation is justified in the case of the non-ferrous metals industries because of relatively high potential for carbon leakage, border tax adjustments and export exemptions are unnecessary and potentially harmful because carbon leakage and adverse competitiveness effects are generally small.

Meng et al (2013) built a 35-sector (commodity) CGE model and simulated the effects of the Australian carbon tax on the environment as well as on the economy. According to the simulation results, the carbon tax of AS23 per tonne of CO2e can cut emissions effectively, but would cause a mild economic contraction. Although both nominal GDP and GNP demonstrate substantial growth in the carbon tax only scenario, the economy contracts mildly when it is measured by real GDP and real GNP. However, real GNP registers significant positive growth under a carbon tax combined with a household compensation policy. The return on capital and on land decreases substantially in both scenarios. The return on labour drops only slightly under the carbon tax only scenario and increases significantly when household compensation policy is in place. In the absence of household compensation, the government's fiscal position improves substantially. Household consumption decreases marginally in the carbon tax only scenario, but it increases significantly when compensation is provided by the government. Importers benefit slightly under the tax only policy and benefit significantly in the carbon-tax-plus-household-compensation scenario, while exporters fare badly, with an almost 3% drop in real exports in the tax only case, and a more than 6% drop in the compensation scenario. Similar results with detailed agricultural sectors were also demonstrated in Meng (2015).

The work by Adams and his team shifted back to emissions trading after the new government came into power and repealed the carbon tax policy in 2013. Adams et al (2014) detailed their simulation design and modelling results. In this study, the carbon permit price is projected by GTEM and converted to real Australian dollars in MMRF, starting from $24.3 per tonne in 2012 and reaching $49.3 per tonne in 2030. Electricity inputs are from an electricity model by Frontier Economics, WHIRLYGIG, which allows the electricity sector to respond to the permit price by switching technologies of electricity generation, changing the utilisation of existing capacity, and replacing old plants with more efficient plants. Road transport inputs were taken from the Australian Bureau of Infrastructure, Transport and Regional Economics (BITRE) and the CSIRO. The inputs on forestry production and forest bio-sequestration were from ABARES. Their study projected a deviation from the baseline in 2030 of -0.2% for employment, -2.6% for real wages, -1.1% for real GDP, -2.3% for household disposable income, and -1.5% for real household consumption. The emissions were projected to decrease by 25.6% in 2030.

As the Australian carbon tax policy was replaced by the direct action plan, researchers were attracted into studies on subsidized emission abatement activities. Freebairn (2014) for example, described and compared a price and a subsidy to reduce carbon emissions. Assuming an aggregate marginal abatement curve for the economy, the paper showed that a carbon price is more cost-effective even in an ideal world of broad emissions abatement potential and minimal transaction costs. Since a subsidy policy will lead to a smaller base for emission abatement and higher transaction costs, the subsidy policy will be even more inefficient when the transaction cost is taken into account. The paper also pointed out the budgetary advantage of a carbon price over a subsidy policy.

Clarke et al (2014) were concerned whether the emissions reduction fund proposed by the Australian government can meet its international obligation on emissions reduction. Using the CGE modelling results on emissions reduction under different levels of carbon pricing, the paper generates an aggregate marginal abatement curve for the economy. Based on this marginal abatement curve, the paper claimed that a GDP reduction of 0.33% is the cost to achieve Australia's international emission reduction target. Since the $2.55 billion emission reduction fund is only about 0.16% of GDP, the concluded that the direct action plan can achieve only about 50% of Australia's obligation.

Although it is valid to build an aggregate marginal abatement curve through CGE simulation, a marginal abatement curve generated in this way implies that all industries are facing the same carbon price or abatement subsidy and that all industries may participate in abatement activities. As a result, the aggregate marginal abatement curve generated in Clarke et al (2014) is not applicable to the direct action plan, where only a small number of firms (or industries) participate in the abatement activity and they face different subsidy rates achieved through the reverse auction procedure. To bridge this research gap, this paper will build a sector-wide marginal abatement cost curve, model the reverse auction procedure, and simulate the government-funded emission reduction activities.

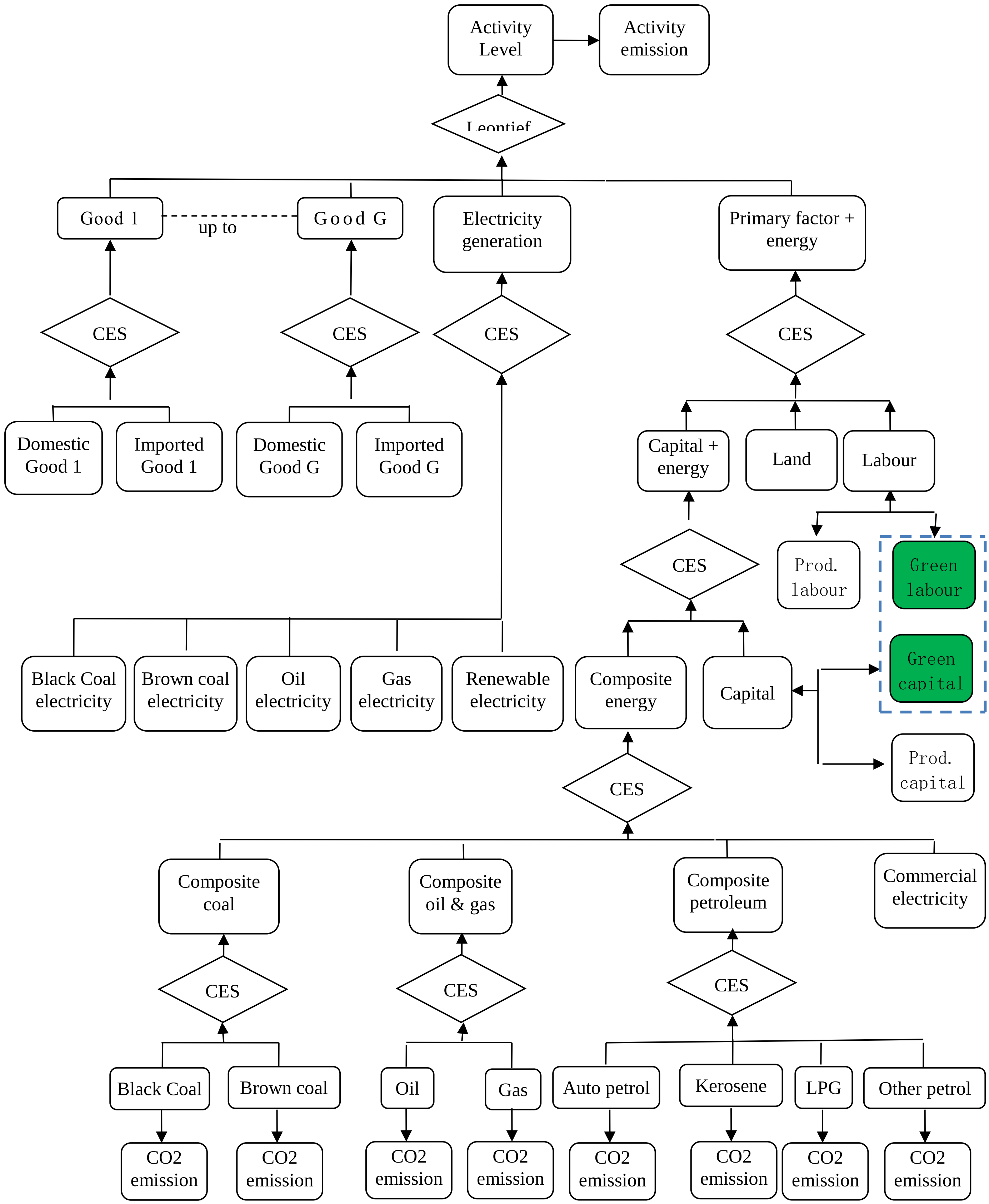
3. Database, model, and simulation design

The main data used for the modelling include input-output data, carbon emissions data, and various behaviour parameters. The input-output data used in this study are from Australian Input-output Tables 2004-2005, published by ABS (2008a). There are 109 sectors (and commodities) in the original I-O tables. For the purpose of this study, we disaggregate the energy sectors and aggregate other sectors to form 44 sectors (and commodities). In considering the fact that the agricultural industry is very important for the direct action plan, 10 agricultural sectors are included in the 44 sectors in the model. The carbon emissions data are based on the 2005 greenhouse gas emission inventory published by the then Department of Climate Change and Energy Efficiency. The income and expenditure data for final demands (e.g. household, government and financial and non-financial corporates) are from the Australian System of National Accounts (ABS, 2008b).

Most of the behavioural parameters in the model are adopted from ORANI-G, e.g. the Armington elasticities, the primary factor substitution elasticity, export demand elasticity, and the elasticity between different types of labour. The substitution effect between different types of electricity in forming 'commercial electricity' is assumed to be very large, so we assign a large value of 50 to their substitution elasticity. The substitution effects among energy inputs and between composite energy and capital are considered very small, so small elasticity values between 0.1 and 0.6 are commonly used in the literature. In our model, we assume the cost of energy-saving investment is very high given the fixed technology assumption and thus there is a very limited substitution effect between capital and composite energy. Consequently, we assign a value of 0.1 for this substitution elasticity. There are two levels of substitution among energy goods in our model. At the bottom level, the energy inputs have a relatively high similarity, so we assign a value of 0.5 for substitution between black and brown coal, between oil and gas and between various types of petroleum. At the top level, we assume the substitution effect between various types of composite energy inputs is very small, and assign a value of 0.1.

The model developed for this study is a static CGE model, based on ORANI-G (Horridge, 2000). With the exception of the production function, we have adopted the functions used in the multi-households version of ORANI-G. Overall, the production function is a five-layer nested Leontief-CES function, as shown in Figure 1.

Figure 1: The structure of the production function



As in the ORANI model, the top level is a Leontief function describing the demand for intermediate inputs and composite primary factors and the remainder are various CES functions at lower levels. For energy inputs, CES functions are used at the bottom level to combine black coal and brown coal to form composite coal; oil and gas to form composite oil&gas; automobile petrol, kerosene, LPG and other petrol to form composite petroleum. At the second level, composite coal, oil&gas, petroleum and commercial electricity are combined by a CES function to form composite energy. At the third level, a CES function is used to combine composite energy and capital to form the capital-energy composition. At the fourth level, a CES function is used to combine capital-energy composition, labour and land to form the primary factors. At the fifth (or top) level, the primary factors, electricity generation and general intermediate inputs are combined by a Leontief function to create sectoral output. To model the government-funded emission abatement activity, the capital and labour of the participants of abatement activity are split into two: capital and labour used for normal production purpose and the capital, and labour for emission abatement activity, i.e. green capital and green labour (the green shaded parts in Figure 1). The way of modelling emission reduction activity is detailed shortly.

The functions for final demands are similar to those in the ORANI model (Dixon et al., 1982). For example, investment demand is a nested Leontief-CES function, the household demand function is a nested LES-CES function. Export demand is dependent on the price of exports, and government demand follows household consumption. However, unlike the assumption of exogenous either total or supernumerary household consumption in ORANI-G, we assume that household consumption is proportional to household income.

The way of modelling reverse auction can be described as follows: Based on the emissions reduction cost and capacity of each industry, the model ranks industries according to the reversed order of the emissions reduction cost and then use this ranking to build up the accumulated emissions reduction capacity sequence. The government uses the emission reduction fund to finance the emissions reduction activities according to this capacity sequence, until the accumulated emissions reduction satisfies the government target or until the total cost of emission reduction depletes the emission reduction fund. In order to model the reverse auction, we need a marginal abatement cost curve. The key elements of such a curve are marginal abatement cost and abatement capacity.

Theoretically, the marginal abatement cost for each industry may change with the amount of abatement, so it is difficult (if not impossible) to rank industries according to abatement cost. To simplify the problem, we assume constant marginal abatement cost for each industry. Marginal abatement cost involves two measurements: the measurement of cost and measurement of carbon emissions. Based on the direct action plan, the government has imposed no cap on the firms' emissions so it has no intention to require the firms to reduce their stationary emissions, i.e. emissions from combustion of fuels, but focuses on reducing non-stationary or activity emissions by planting trees, cleaning up factories, etc. Thinking in this line, we included only the activity emissions in calculating abatement capacity.

The abatement cost measurement is more complicated. The first and straightforward way to measure abatement cost is to use the output per emissions for each sector. This approach will produce a low abatement cost for sectors with a high activity emissions base and/or low output level. Another popular measurement of abatement cost is the amount of value-added per emission. Like the first measurement, this measurement considers the abatement cost from the point view of the economy (or society). However, in the case of the direct action plan, we need to think about the abatement cost from the point view of industry (or firms) because it is the firms who decide whether or not submit project proposals for emission reduction. Since the purpose of firms' production is to make profit, so the cost of carbon abatement for a firm is the profit foregone because of the reduced production resulting from the emission reduction requirement. In this reasoning, we use the profit per emission, or capital rental per emission , as abatement cost for each sector.

Abatement capacity for each industry is entirely dependent on each proposal. Although some abatement capacities of projects winning a grant from the emission reduction fund this year are known, it is difficult to translate these capacities at the project level into the abatement capacity for each industry in the model. This paper assumes the abatement capacity is related to the activity emissions base of the industry because the larger emitters tend to have high potential to reduce emissions. The ratio of abatement capacity to the activity emissions base varies depending on the nature of the industry. According to the direct action auction results, the forestry sector and the other agriculture sectors have high potential in emission abatement (e.g. through tree plantation, soil as a carbon sink, and bio digesters for waste), so we sign a ratio of 1 and 0.8 for these two sectors, respectively. The rest of the agricultural sectors (e.g. sectors producing sheep, cattle, fishing and grain) have limited capacity to reduce emissions, so a ratio of 0.1 is assigned for them. The road transport sector has also shown potential in emissions abatement in the auction results, so a ratio of 0.5 is assigned for this sector. A ratio of 0.2 is assigned for all the other sectors.

In short, the abatement cost is calculated by dividing capital rental of each sector by its activity emission base; the ratios specified above times the activity emission base of corresponding sectors gives the emission abatement capacity for each sector; and the emission abatement capacity times the abatement cost forms the funding bids of each sector in a reverse auction. To simulate the reverse auction, the emission abatement capacity and the funding bids are ordered based on the emission abatement cost from lowest to the highest. The ordered abatement capacity and funding bids are added accumulatively from the top to bottom to produce an accrued abatement capacity and accrued funding steps, which are used in the reverse auction to determine which sectors can obtain assistance from the emission reduction fund. The abatement cost, accrued abatement capacity and funding allocation step for each industry is shown in Table 1.

Generally, the agriculture sectors have low abatement costs, e.g. 9.97 $/tonne for the dairy cattle sector, 15.82 $/tonne for the beef cattle sector, 16.95 $/tonne for the forestry sector, 22.17 $/tonne for the sheep sectors, and 26.30 $/tonne for the pigs sector. These abatement costs are broadly of the same magnitude to those revealed in the first auction for direct action funding in 2015. Some agricultural sectors such as the grain sector, the poultry sector, the hunting sector and the fishing sector, have very high abatement costs because of their very small emission base. Most of non-agricultural sectors have high emission abatement costs because of high profitability and/or because of low activity emission base. A few sectors have relatively low abatement costs due to their large emission base, e.g., 46.47 $/tonne for the brown coal sector and 121 $/tonne for the road transport sector. The reordered industry list based on the abatement costs from low to high is shown in the third column, and the accumulated abatement capacity and funding steps are shown in the fourth and final column. Given a fixed emissions abatement target, the accumulated abatement capacity is used to determine the sectors to be funded. For example, given a 12% (or 68 megatonnes) emission reduction target, sectors from dairy cattle to gas distribution in the third column will be fully funded and the accommodation sector will be funded partially. Similarly, the accrued funding steps are used to determine the funded sectors when the emissions abatement fund is fixed. A fixed fund of $2.55 billion means sectors from dairy cattle to other agriculture will be fully funded while the road transport sector will be funded partially.

Table 1: Emissions abatement cost, accrued abatement capacity and fund allocation

Industry	Abatement cost	Industries ordered by abatement cost	Accrued abatement	Accrued funding

	($/tonne)	from low to high	capacity (MT)	steps ($Billion)
1 Sheep	22.17	4 Dairy cattle	2.54	0.03
2 Grains	809.29	3 Beef cattle	8.46	0.12
3 Beef cattle	15.82	9 Forestry	24.65	0.39
4 Dairy cattle	9.97	1 Sheep	26.56	0.44
5 Pigs	26.30	5 Pigs	26.78	0.44
6 Poultry	449.16	12 Brown coal	28.49	0.52
7 Other agriculture	52.12	7 Other agriculture	48.42	1.56
8 Hunting	3040.16	40 Road transport	61.56	3.15
9 Forestry	16.95	26 Iron & steel	63.39	3.55
10 Fishing	6360.38	25 Cement	64.34	3.76
11 Black coal	504.45	31 Electricity-oil	64.36	3.76
12 Brown coal	46.47	6 Poultry	64.47	3.81
13 Oil	4692.64	11 Black coal	67.53	5.36
14 Gas	1020.07	35 Gas distribution	67.94	5.59
15 Other mining	313022.74	39 Accommodation	70.16	6.90
16 Food &beverages	9661.88	23 Chemical products	71.15	7.57
17 Textile	21446.43	2 Grains	71.24	7.65
18 Wood & printing	32342.45	14 Gas	72.35	8.78
19 Automotive petrol	2599.65	27 Other metal products	73.27	9.83
20 Kerosene	2026.35	41 Other transport	75.01	12.31
21 Liquefied petrol	1537.80	21 Liquefied petrol	75.02	12.33
22 Other petroleum	9056.47	36 Water & sewerage	75.47	13.13
23 Chemical products	672.73	20 Kerosene	75.49	13.18
24 Plastic & rubber	54388.94	19 Automotive petrol	75.54	13.31
25 Cement	218.29	8 Hunting	75.57	13.40
26 Iron & steel	217.52	32 Electricity-gas	75.59	13.47
27 Other metal products	1150.80	30 Electricity-brown coal	75.62	13.60
28 Other Manufacturing	40293.84	13 Oil	75.97	15.24
29 Electricity-black coal	9544.58	10 Fishing	75.97	15.24
30 Electricity-brown coal	4248.81	33 Electricity-renewable	75.97	15.24
31 Electricity-oil	375.30	22 Other petroleum	75.97	15.24
32 Electricity-gas	3952.04	29 Electricity-black coal	76.00	15.57
33 Electricity-renewable	6594.36	16 Food &beverages	76.16	17.06
34 Commercial electricity	124116.84	17 Textile	76.16	17.18
35 Gas distribution	579.04	18 Wood & printing	76.20	18.36
36 Water & sewerage	1813.60	43 Public services	76.26	20.61
37 Construction services	236591.81	28 Other Manufacturing	76.29	21.66
38 Trade services	55484.36	24 Plastic & rubber	76.29	21.66
39 Accommodation	590.57	38 Trade services	76.37	25.87
40 Road transport	121.09	34 Commercial electricity	76.37	25.87
41 Other transport	1423.01	44 Other services	76.37	25.87
42 Communication	1373889.65	37 Construction services	76.37	25.87
43 Public services	33516.78	15 Other mining	76.37	25.87
44 Other services	153863.53	42 Communication	76.38	43.61

Table 2: Funding ($m) and emissions reduction task (thousand tonne) for each industry

Industry	Fixed fund of A$2550 million	Fixed 12% emission reduction

	Fund allocation	CO2 reduction	Fund allocation	CO2e reduction
1 Sheep	42.291	1907.276	42.291	1907.276
2 Grains	0	0	0	0
3 Beef cattle	93.728	5923.202	93.728	5923.202
4 Dairy cattle	25.312	2538.514	25.312	2538.514
5 Pigs	5.945	226.006	5.945	226.006
6 Poultry	0	0	50.996	113.536
7 Other agriculture	1038.463	19926.150	1038.463	19926.150
8 Hunting	0	0	0	0
9 Forestry	274.406	16188.330	274.406	16188.340
10 Fishing	0	0	0	0
11 Black coal	0	0	1544.963	3062.698
12 Brown coal	79.383	1708.078	79.383	1708.078
13 Oil	0	0	0	0
14 Gas	0	0	0	0
15 Other mining	0	0	0	0
16 Food &beverages	0	0	0	0
17 Textile	0	0	0	0
18 Wood & printing	0	0	0	0
19 Automotive petrol	0	0	0	0
20 Kerosene	0	0	0	0
21 Liquefied petrol	0	0	0	0
22 Other petroleum	0	0	0	0
23 Chemical products	0	0	0	0
24 Plastic & rubber	0	0	0	0
25 Cement	0	0	207.759	951.772
26 Iron & steel	0	0	396.321	1822.012
27 Other metal products	0	0	0	0
28 Other Manufacturing	0	0	0	0
29 Electricity-black coal	0	0	0	0
30 Electricity-brown coal	0	0	0	0
31 Electricity-oil	0	0	7.506	20.000
32 Electricity-gas	0	0	0	0
33 Electricity-renewable	0	0	0	0
34 Commercial electricity	0	0	0	0
35 Gas distribution	0	0	234.138	404.354
36 Water & sewerage	0	0	0	0
37 Construction services	0	0	0	0
38 Trade services	0	0	0	0
39 Accommodation	0	0	523.954	887.207
40 Road transport	990.471	8179.316	1591.896	13145.89
41 Other transport	0	0	0	0
42 Communication	0	0	0	0
43 Public services	0	0	0	0
44 Other services	0	0	0	0
Total	2549.999	56596.875	6117.061	68825.031

Table 2 shows the emissions reduction task and the funding allocation for each industry for a given emission reduction fund of A$2.55 billion or for a given 12% emission reduction target. When the emission reduction fund is fixed at A$2.55 billion, some sectors, including sheep, beef cattle, dairy cattle, pigs, other agriculture, forestry, and brown coal, are funded to reduce emissions to their full abatement capacity. The transport sector is funded to reduce emissions by 8.179 megatonnes. The amount of the emissions reduction task is very high for the forestry sector (16.188 megatonne) and the other agriculture sector (19.926 megatonne) because of the assumption that these sectors have a high capacity of emission reduction. With the same magnitude of emissions reduction task, the funding allocated is quite different: $274.406 million for the forestry sector and $1038.463 million for the other agriculture sector. This is due to the much cheaper abatement cost of the forestry sector compared with the other agriculture sector. The total funding of $2.55 billion can reduce emissions by 56596 thousand tonnes. With the fixed 12% emission reduction target, there is no change to previously funded sectors, but the road transport sector is now funded fully. Many other sectors such as poultry, black coal, cement, iron & steel, oil electricity, gas distribution and accommodation, join in the emissions reduction activities. The total emissions reduction increased to 68825 thousand tonnes while the emissions reduction fund has to be increased to $6.117 billion. Compared with the case of a fixed fund of $2.55 billion, the increase in emissions reduction is small, but the emissions reduction fund is more than doubled. This results from the much higher abatement cost of the newly joined sectors.

The emissions abatement activity is modelled through creating a dummy abatement subsector for each sector. Ideally, each abatement subsector will have specific input tailored to the abatement method (e.g. soil carbon), but this kind of information is hard to obtain at the beginning stage of the direct action policy. Nevertheless, the abatement activities are totally different from the normal production activities, so the inputs of the abatement subsectors are vastly different from the inputs of the parent sectors and thus it is inappropriate to shift proportionally some inputs of the parent sectors to the subsectors. Moreover, since the emissions abatement activities are totally new, it is very likely the industry has to use its liquid capital to purchase inputs for emission abatement activities. In this reasoning, it is appropriate to shift some capital in the parent sectors to the subsectors. Last, according to the direct action plan, labour will be an essential element, so the parent sectors have to provide some workers for the subsectors.

In taking into account the above consideration, each industry in the model is split into two subsectors: the production subsector and the dummy abatement subsector. If an industry wins funding from the emissions reduction fund in the reverse auction, the dummy abatement subsector becomes alive and the capital and labour in the industry are proportionally split to two subsectors based on the amount of funding won by the industry.

The abatement subsector will use these labour and capital inputs to generate carbon credits and sell to the government. The production subsector will use the remaining capital and labour to produce goods and services. The value-added created by the abatement subsector, i.e. the value of carbon credits created, is added to the value-added created by the production subsector to form the value-added for the parent sector. The capital income and labour income for each subsector are also summed up for the parent sector.

However, how to treat the abatement activity in the calculation of both output and the value-added is an issue. Since the government funding provides income to labour and capital, the funding should have contributed to the value-added for each sector. However, the outcome of government funding – the carbon credit – is not goods or services by normal definition. To treat carbon credits as a normal commodity will inflate the output and GDP in an ordinary economy. Our solution is to include carbon credits in nominal value but exclude them from the real value of GDP and GNP. Since sectoral output is measured in real terms, it is exclusive of carbon credits.

The macroeconomic closure for the model and the simulation design are tailored to the direct action plan. Since the direct action plan provides only a short-term solution to the emissions reduction issue in Australia, a short-run macroeconomic closure is used in this study. This means fixed and immobile capital for each sector, but free movement of labour among sectors. In a typical short run closure, employment is flexible and the real wage is fixed to reflect the 'stickiness' of wages in the short run. This is the case for three scenarios in this study. To simulate the impact of labour shortages in Australia, the authors have also designed a scenario where the aggregate employment is fixed while the real wage is flexible. In all cases, the nominal wage is 50% indexed to CPI and the exchange rate is fixed.

Two shocks are used for the simulations. One is that the emissions reduction fund of $2.55 billion is used to award the emissions reduction activities through reverse auction. The other is the target to be achieved by the direct action plan. The Australia's international obligation on emission reduction is 5% reduction of 2000 levels by 2020. Since the emissions tend to increase as the size of the economy grow over time, the targeted emissions level in 2020 has to be converted to the base year. Based on average economic and emission growth rates in recent years, 5% emissions reduction of 2000 levels by 2020 is converted to an equivalent 12% emissions reduction in the base year.

Since the direct action plan will cause a government budget deficit, the emissions reduction fund provided by the government has to be matched by an increase in government income eventually. Thus, a scenario is designed to demonstrate the case where the government is to neutralize the budget through increasing GST on household Four scenarios in this study can be summarised as follows:

(A): carbon abatement with fixed real wage and flexible employment, fixed emissions reduction funding at $2.55 billion.

(B): carbon abatement with fixed aggregate employment and flexible real wages, fixed emissions reduction funding at $2.55 billion.

(C): carbon abatement with fixed real wages and flexible employment, fixed emissions abatement target at 12% of emission base.

(D): scenario (C) plus an increase in GST on household consumption on goods and services in order to raise revenue to neutralize the government budget effects.

4. Results analysis

The macro and sectoral simulation results for the above-mentioned four scenarios are listed in Tables 3 to 6. The macro results include aggregate emissions reduction, aggregate prices, employment, and GNP and GDP as well as their expenditure-side components. The full sectoral results are very lengthy. Considering the length limit and the focus of this study, the authors list the results on sectoral emissions reduction, sectoral output, and sectoral capital rental. To facilitate the reader to comprehend the sectoral results, industries participating in the abatement activities are marked in Tables 4 to 6. Sectors marked * are fully funded for their abatement activity in scenarios (C) and (D); sectors marked ** are fully funded for their abatement activity in all scenarios; sectors marked ^ are partially funded for their abatement activity in scenario (C) and (D); sectors marked ^* are partially funded for their abatement activity in scenario (A) and (B) but are fully funded for their abatement activity in scenario (C) and (D). Unless specified, all results are shown in percentage changes.

The first panel (first 6 rows) of Table 3 displays the emissions reduction fund used and the emissions reduction achieved. With an emissions reduction fund of $2.55 billion, the claimed emissions reduction (or carbon credit) is 56.597 megatonnes (or 9.87% of the emissions base) in scenarios (A) and (B). To achieve the 12% emissions reduction target, the emissions reduction fund needs to be increased to $6.117 billion in scenarios (C) and (D). The large increase ($3.567 billion) in the required fund and small increase (2.13%) in emissions reduction reflect the feature of reverse auction procedure that the the cost increases rapidly as the task of emission abatement becomes bigger. However, the emissions reduction claimed by direct action is in the form of carbon credits generated in activities such as carbon farming, so the credibility of the carbon credits is the key for the success of the direct action plan.

The direct action policy can also generate real emissions reductions. Because the emissions abatement activity will use resources (such as capital and labour) in the economy, the reduced resources for economic activity necessitate a scale back of production. Thus, the real emissions in the economy will decrease, but at much smaller magnitude. For the listed four scenarios, the industrial stationary emissions reduction ranges from 4.02 to 6.64 megatonnes. The industrial non-stationary emissions reduction is slightly larger – about 4.50 – 9.76 megatonnes. The total emissions reduction for the economy (including changes in the industrial stationary and non-stationary emissions, as well as changes in household emissions which have not been listed here) is about 8.45 to 16.22 megatonnes, only accounting for 1.45% to 2.79% of emissions base.

The second panel shows the effect on prices and on aggregate employment. It is not surprising that all price indexes are positive. On one hand, the crowding-out effect leads to a decrease in goods and services supply; on the other hand, the emissions reduction funds will eventually be channelled to household and thus cause an increase in demand. A reduced supply and an increased demand necessitate a rise in price. The degrees of change in the GDP price index, consumer price index and exports price index are different because these price indices measure the commodity prices from different perspectives. While an increase in household demand affects both the GDP deflator and CPI, an increased production cost due to the crowding-out effect affects the GDP deflator more because of the broader base of the GDP basket. As a result, the GDP price index increases more than CPI in scenarios (A), (B), and (C). The much higher CPI in scenario (D) results from the simulation design: the government budget balance is achieved by increasing the GST rate on households and this will have a direct and pronounced impact on CPI. Compared with changes in the GDP deflator and CPI, the changes in the export price index are much milder in all scenarios. This may be due to two contributing factors. One is that the export basket is small – not all types of commodities are exported. The other reason is that, the higher price of exports will reduce foreign demand, which will in turn reduce the pace of export price rises. Since a fixed exchange rate regime is assumed for all simulations and the price of imports are assumed unchanged in a single country model, the increase in export prices means the Australia's terms of trade improves.

The prices of primary factors also increase significantly. The nominal wage is 50% indexed to CPI, so the changes in the nominal wage index is half of changes in CPI in scenario (A), (C) and (D), where the real wage is fixed. In scenario (B), the change in the nominal wage includes two components: the change in real wages and 50% of the change in the CPI. Given the 0.353% increase in CPI in scenario (B), we can calculate the real wage change: 0.588% - 0.176%=0.412%. The zero change in aggregate employment in scenario (B) stems from the fixed employment assumption for this scenario. The 0.262% increase in employment in scenario (A) is easily understood considering the labour requirement of the emissions abatement activities and the fixed real wage assumption. However, it is somewhat puzzling to see that the increase in employment in scenario (C) is smaller than that in scenario (A). The emissions abatement task in scenario (C) is bigger and thus total employment should increase more. It is even more surprising to see the negative change in employment in scenario (D) where the amount of emissions abatement activity is the same as in scenario (C). These seemly counter-intuitive results are due to the 'sticky' wages assumption for the short run. Since the money wage is 50% indexed to the CPI, the large increase in CPI in scenario (C) compared with scenario (A) means a considerable increase in the labour price. Under this circumstance, the firm will substitute some labour with capital, so employment will increase less. The substantial increase in CPI in scenario (D) will generate large substitution effects and thus lead to a decrease in total employment.

The positive changes in capital prices in all scenarios is generally the results of, on the one hand, the fixed capital assumption in the short run and, on the other hand, the increased demand for capital due to the emissions abatement activities. The significantly bigger increase in capital price in scenarios (C) and (D) is explained by the much higher demand for capital due to the bigger emissions abatement task in these scenarios. Interestingly enough, the changes in capital prices in scenario (B) and (D) are smaller than those in scenario (A) and (C), respectively. This may be because of the large increase in nominal wages in scenario (B) and (D). A wage hike will use much of the firm's budget and thus the payment to capital will decrease relatively compared with scenarios (A) and (C). Because the primary factor price is the aggregate price of labour, capital and land, the primary factor price increases in all scenarios. The degree of change becomes higher from scenario (A) to scenario (D), but the sizes of all changes in primary factor prices are between those for labour price and those for capital price.

Table 3: The environmental and macroeconomic results

Description	(A) Fixed real wages ($2.55b)	(B) Fixed labour ($2.55b)	(C) Fixed real wages (-12% CO2)	(D) Budget neutral: (C)+GST hike (-12% CO2)
Total funding for direct action ($Billion)	2.550	2.550	6.117	6.117
Total CO2e cuts claimed by direct action (MT)	56.597	56.597	68.825	68.825
Change in industrial stationary emissions (MT)	-4.018	-4.074	-6.595	-6.628
Change in industrial non-stationary emissions (MT)	-4.499	-5.021	-9.138	-9.755
Change in economy-wide carbon emissions (MT)	-8.446	-9.005	-15.594	-16.222
Percentage change in total emissions base	-1.453	-1.549	-2.682	-2.790
GDP price index	0.171	0.419	0.675	1.595
Consumer price index	0.164	0.353	0.635	1.915
Exports price index	0.142	0.243	0.515	0.641
Nominal wage	0.082	0.588	0.317	0.953
Aggregate employment	0.262	0	0.126	-0.194
Capital rental price	0.349	0.252	1.354	1.225
Primary factor price	0.176	0.437	0.704	1.030
Nominal GDP	0.033	0.140	0.068	0.814
Real GDP	-0.137	-0.278	-0.602	-0.766
Nominal GNP	0.270	0.533	0.839	1.761
Real GNP	0.128	0.165	0.268	0.316
Real household consumption	0.225	0.291	0.474	0.557
Real exports	-1.420	-2.387	-4.826	-5.989
Real Imports	0.065	0.097	0.061	0.106
Contribution of net exports to real GDP	-0.267	-0.447	-0.876	-1.089

The last panel (the last 8 rows) of Table3 shows the changes in GDP and GNP, as well as their expenditure-side components. Although nominal GDP increases in all scenarios, real GDP decreases significantly and the degree of change increases from scenario (A) to scenario (D). The negative change in real GDP is comprehendible considering the crowding-out effect of the emissions abatement activities. The limited labour supply (fixed employment) in scenario (B) necessitates a bigger real GDP reduction than in scenario (A). Similarly, the greater crowding-out effect in scenarios (C) and (D) sees a great reduction in real GDP. The highest real GDP reduction in scenario (D) manifests the negative impact of

GST: part of GST burden will be passed on to the firms and this increases production cost and reduces real GDP further. Both the nominal and real GNP increase and the degree of change become greater from scenario (A) to scenario (D). By definition, GNP is GDP plus the net income inflow from abroad minus the net income outflow to abroad. In the ORANIG model, the income flows are not modelled directly, instead, the imports are viewed as income inflow (the ability to import rests on the foreign exchange obtained from abroad) and exports are viewed as income outflow. So GNP in the model is broadly defined as GDP after excluding net exports (or trade balance). Since household consumption is the most important component of GNP, the behaviour of GNP is consistent with that of real household consumption in Table 3. The divergence between real GDP and real GNP is also consistent with the significantly decreased net exports: exports decrease sharply while the imports increase mildly.

The positive increase in household real consumption is not surprising because of the increase in household income due to the emissions reduction funding. However, the highest household consumption in scenario (D) seems counterintuitive: the impact of a GST hike is supposed to reduce household consumption. The key lies in the sticky wage assumption in the short run. A GST hike will push up nominal wages and thus increase household income significantly. As the effect of an increase in income outweighs the effect of an increase in commodity prices, the household consumption will increase further in scenario (D). The decrease in exports and increase in imports are consistent with the increase in the export price index and GDP deflator. The impact of net exports on real GDP is indicated by the last row. The contribution of net exports decreases considerably, ranging from 0.267% to 1.089%.

All results in Table 3 look reasonable, except that imports increase less in scenario (C) than in scenario (A). A higher emissions abatement task in scenario (C) sees a higher commodity prices indicated by CPI or the GDP deflator, so imports should be relatively cheaper compared with scenario (A) and thus imports should increase more. The result can be explained by comparing the imports basket and the CPI basket. In the case of scenario (C), the gas supply sector enters the emissions abatement activities. The small labour and capital inputs in this sector means the emissions abatement activity will use considerable portion of labour and capital resources of this industry and push up the capital rental price. This will lead to more than double the gas price (an increase of 158%, not listed in this paper). Meanwhile, Australia imports little gas so the gas price hike will induce minimal gas imports. However, households use substantial amount of gas, so the gas price rise will absorb much of the household budget. As a result, the household income used for purchasing imports decreases and this leads to a milder increase in imports in scenario (C) than in scenario (A).

Due to length limitations, the authors have not included a comparable scenario of carbon tax or emissions trading scheme so as to compare the efficiency of different policies. However, by comparing the results of scenario (D) in this paper with those of the carbon-tax-plus-compensation scenario in Meng et al (2013) we can find out the difference between the efficiency of direct action and that of the carbon price. Since both papers use a database of the same base year and provide revenue neutral scenarios, the results of these two studies are broadly comparable. The total emissions reduction of the revenue neutral scenario in Meng et al (2013) is 70.33 megatonnes with a reduction of real GDP by 0.48%. Total emissions reduction claimed by the direct action in scenario (D) is 68.825 megatonne with 0.766% reduction in real GDP. The extra real emissions reduction of 15.222 megatonnes means the total emission reduction for the direction action policy is 68.825+15.222=84.047 megatonnes. However, in considering the temporal nature of the direct action plan, i.e. the emissions reduction fund can buy emission reduction credits only once while a carbon pricing will work all the time when the policy is in place, the effect of the direct action on emissions reduction should be much smaller than 84 megatonnes. Because of this consideration, we regard the effect on emissions reduction as roughly the same for both scenarios. Since the real GDP reduction in scenario (D) of this paper is much greater than that in Meng et al (2013), we conclude that the direct action plan is more costly to the economy. An important reason for the lower efficiency of direct action plan may be that this plan only focuses on non-stationary (or activity) carbon emissions. Since activity emissions are only a small part of Australian emissions base, in order to achieve the 12% emission reduction target, some sectors with quite high emissions abatement costs have to participate in the emissions abatement activities. This is evident by the fact that the real GDP reduction is very small (-0.137%) when the emissions reduction fund is fixed at $2.55 billion in scenario (A), but it becomes considerable (-0.602%) in order to achieve the 12% emission reduction target in scenario (C). Neutralizing the government budget deficit by increasing GST contributes a further significant reduction (-0.164%) in real GDP. Other factors contributing to the inefficiency of the direct action plan will be discussed in the concluding section of the paper.

Table 4 shows the actual change in emissions for all industries. It is not surprising to see that, when an industry takes part in the direct action policy, its emissions decrease significantly – the crowding-out effect of the emissions reduction activities reduces the production level and thus reduces the emissions level. The size of emissions reduction for these sectors is positively related to the funding received and to their emissions base. This explains the large amount of emissions reduction in the black coal sector in scenarios (C) and (D) and, the beef cattle sector, the other agriculture sector, the brown coal sector, and the transportation sector in all scenarios.

Most of the sectors not participating in the direct action policy also experience mild emissions reduction. This may result from the direct or indirect flow-on effects. As the direct action participants scale back production and increase the prices of output due to reduced resources and increased primary factor prices, the downstream industries have to reduce production. This flow-on effect is significant for a number of sectors such as food & beverages, wood & printing, other Petroleum, chemical products, plastic & rubber, other transport, and public service. The flow-on effect can be dramatic. The brown coal sector participates in direct action in all scenarios, so its emissions reduce by about 850 thousand tonnes. Its downstream sector – the brown-coal electricity – reduces emissions by more than 5500 thousand tonnes. This large emissions reduction is because that the brown-coal electricity sector relies heavily on brown coal and that brown coal has a high emissions intensity (i.e. brown coal releases a large amount of emissions during electricity generation).

A few sectors experience a growing emissions level, notably, the black coal electricity sector increases its emissions by more than 1400 thousand tonnes in scenarios (A) and (B), and the gas electricity sector increases its emissions by about 200 thousand tonnes in all scenarios. The substitution effect is the key to understanding these results: as the brown coal electricity sector reduces its output due to the flow-on effect, other electricity generators have to increase production to meet the electricity demand. It is of interest to notice that the black coal electricity sector increase its emissions only very mildly in scenarios (C) and (D). This can be explained by the fact that, in these two scenarios, the big electricity users – the iron & steel sector – participate in the emissions abatement activity and reduce production. Consequently, the demand for electricity decreases considerably and the increase in output for the black coal sector is much smaller in scenario (D) than in scenario (B). Comparing the emissions reduction in different scenarios, it is apparent that emission levels decrease significantly from scenario (A) to scenario (D) for most sectors. This is consistent with the fact that the level of production generally decreases from scenario (A) to scenario (D) due to limited labour supply in scenario (B), the increased emissions abatement task in scenario (C) and the increased GST burden in scenario (D).

The pattern of changes in sectoral output listed in Table 5 is similar to that of changes in sectoral emissions. However, Table 5 gives a snapshot of the sectors in percentage change form. For the given $2.55 billion emissions reduction fund, the sectors participating in direct action will reduce their output by 0.37% to 8.60% in scenario (A). The output reduction of the brown coal sector is highest (-8.60%), followed by the forestry sector (-4.73%), the other agriculture sector (-4.37%), the brown coal electricity sector (-3.83%) and the road transport sector (-3.04%). Due to the limited labour supply, the output reduction for the participants of emissions abatement in scenario (B) is 0.57% to 8.64%, which is slightly higher than the corresponding figures in scenario (A). To achieve the 12% emissions reduction target, the output reduction for the emissions reduction fund participants is much higher, ranging from 0.95% to 14.68% in scenario (C) or 1.18% to 14.77% in scenario (D). In these two scenarios, the black coal sector reduces its output to the greatest degree, followed by the second group including the brown coal sector, the iron&steel sector, and the oil electricity sector, which reduce output by 6.80% to 8.80%. Because of the higher abatement cost and higher abatement capacity for the black coal sector than for the brown sector, output reduction in the black coal sector is considerably higher. This is an undesirable outcome because black coal has much lower emissions intensity than brown coal. Significant output reduction (-2.89% to -5.19%) is also found in the third group consisting of the gas distribution sector, the road transport sector, the forestry sector, the other agriculture sector, the brown coal electricity sector, the cement sector, and the other petroleum sector.

Table 4: Change in industrial emissions (thousand tonne)

Industry	(A) Fixed real wages ($2.55b)	(B) Fixed labour ($2.55b)	(C) Fixed real wages (-12% CO2)	(D) Budget neutral: (C)+GST hike
1 Sheep**	-260.94	-298.40	-296.09	-342.65

2 Grains	-0.93	-2.69	-2.54	-4.75
3 Beef cattle**	-497.25	-617.54	-739.73	-884.71
4 Dairy cattle**	-151.63	-212.76	-293.53	-368.11
5 Pigs**	-8.35	-12.84	-21.40	-26.71
6 Poultry*	-3.29	-5.23	-13.30	-15.63
7 Other agriculture**	-1133.80	-1181.59	-1184.50	-1243.21
8 Hunting	-4.44	-5.46	-5.27	-6.55
9 Forestry**	-805.63	-842.64	-871.26	-916.28
10 Fishing	-0.17	-0.28	-0.62	-0.74
11 Black coal*	-2.89	-15.27	-2460.68	-2475.84
12 Brown coal**	-847.07	-850.86	-866.94	-871.02
13 Oil	-0.19	-1.13	-0.11	-1.28
14 Gas	0.04	-0.94	-0.60	-1.83
15 Other mining	-1.05	-2.47	-15.95	-17.71
16 Food &beverages	-13.20	-18.38	-46.05	-52.02
17 Textile	0.47	0.02	-1.73	-2.26
18 Wood & printing	-3.69	-5.33	-21.84	-23.63
19 Automotive petrol	1.36	1.53	3.03	3.37
20 Kerosene	-2.83	-3.41	-3.41	-4.09
21 Liquefied petrol	-1.46	-1.68	-2.04	-2.28
22 Other petroleum	-6.76	-6.88	-13.73	-13.87
23 Chemical products	-2.04	-19.21	-87.41	-107.66
24 Plastic & rubber	-0.85	-4.23	-18.21	-21.78
25 Cement*	-4.83	-5.13	-317.86	-314.84
26 Iron & steel*	-12.71	-45.07	-906.53	-942.00
27 Other metal products	26.74	-0.90	-199.13	-230.95
28 Other Manufacturing	0.37	-0.78	-2.58	-3.97
29 Electricity-black coal	1433.33	1443.92	1.61	40.97
30 Electricity-brown coal	-5504.92	-5530.61	-5626.20	-5655.59
31 Electricity-oil*	1.20	1.14	-8.85	-8.92
32 Electricity-gas	200.72	205.06	192.03	198.47
33 Electricity-renewable	0.00	0.00	0.00	0.00
34 Commercial electricity	0.00	0.00	0.00	0.00
35 Gas distribution*	-0.65	-2.17	-177.48	-179.11
36 Water & sewerage	-1.07	-2.43	-4.46	-6.06
37 Construction services	0.53	1.75	0.01	1.56
38 Trade services	-0.97	-2.99	-7.98	-10.27
39 Accommodation^	6.11	-13.55	-154.60	-170.22
40 Road transport^*	-890.30	-985.81	-1498.40	-1609.36
41 Other transport	-6.35	-32.71	-39.80	-72.79
42 Communication	0.36	0.41	-0.32	-0.23
43 Public services	-18.03	-17.67	-18.96	-18.39
44 Other services	0.00	0.00	0.00	0.00
Total	-8517.05	-9095.20	-15733.39	-16382.94

Table 5: Percentage change in Output by sector

Industry	(A) Fixed real wages ($2.55b)	(B) Fixed labour ($2.55b)	(C) Fixed real wages (-12% CO2)	(D) Budget neutral: (C)+GST hike

1 Sheep**	-1.36	-1.55	-1.54	-1.79
2 Grains	-0.07	-0.24	-0.20	-0.42
3 Beef cattle**	-0.83	-1.03	-1.24	-1.49
4 Dairy cattle**	-0.60	-0.84	-1.15	-1.45
5 Pigs**	-0.37	-0.57	-0.95	-1.18
6 Poultry*	-0.29	-0.45	-1.13	-1.32
7 Other agriculture**	-4.37	-4.56	-4.57	-4.79
8 Hunting	-1.50	-1.86	-1.78	-2.23
9 Forestry**	-4.73	-4.95	-5.12	-5.37
10 Fishing	-0.07	-0.33	-0.38	-0.68
11 Black coal*	-0.02	-0.09	-14.68	-14.77
12 Brown coal**	-8.60	-8.64	-8.80	-8.84
13 Oil	-0.01	-0.03	-0.02	-0.05
14 Gas	0.00	-0.01	-0.01	-0.02
15 Other mining	-0.03	-0.14	-0.21	-0.34
16 Food &beverages	-0.61	-0.87	-1.37	-1.68
17 Textile	-0.08	-0.36	-0.59	-0.92
18 Wood & printing	-0.29	-0.51	-0.65	-0.91
19 Automotive petrol	-0.04	-0.02	-0.08	-0.05
20 Kerosene	-0.03	-0.06	-0.18	-0.22
21 Liquefied petrol	-0.03	-0.06	-0.24	-0.26
22 Other petroleum	-1.12	-1.18	-2.89	-2.95
23 Chemical products	-0.19	-0.41	-0.93	-1.21
24 Plastic & rubber	-0.17	-0.47	-1.07	-1.43
25 Cement*	-0.09	-0.15	-3.66	-3.68
26 Iron & steel*	-0.14	-0.43	-6.89	-7.21
27 Other metal products	-0.10	-0.37	-1.11	-1.43
28 Other Manufacturing	-0.09	-0.47	-0.74	-1.20
29 Electricity-black coal	0.74	0.70	0.22	0.17
30 Electricity-brown coal	-3.83	-3.89	-4.06	-4.12
31 Electricity-oil*	0.93	0.88	-6.79	-6.84
32 Electricity-gas	0.95	0.94	0.89	0.87
33 Electricity-renewable	0.67	0.60	-0.25	-0.31
34 Commercial electricity	-0.32	-0.36	-0.82	-0.87
35 Gas distribution*	-0.03	-0.09	-5.19	-5.25
36 Water & sewerage	-0.05	-0.12	-0.20	-0.28
37 Construction services	0.00	-0.02	-0.03	-0.05
38 Trade services	-0.07	-0.29	-0.34	-0.61
39 Accommodation^	0.04	-0.14	-1.29	-1.43
40 Road transport^*	-3.04	-3.38	-5.10	-5.49
41 Other transport	-0.08	-0.33	-0.38	-0.69
42 Communication	-0.01	-0.12	-0.14	-0.26
43 Public services	-0.02	-0.19	-0.16	-0.35
44 Other services	0.05	-0.02	0.05	-0.04

Most of the sectors not participating in direct action reduce output slightly due to the flow-on effect. However, thanks to the substitution effects, there is an increase in output for a few sectors, for example, black coal electricity and gas electricity in all scenarios, oil electricity and renewable electricity in scenario (A) and (B), and the accommodation sector and the other services sector in scenario (A). The output reduction becomes greater from scenario (A) to (D) because of the increased production cost implied by scenario design. An exception is the automotive petrol industry. The decrease in output of this sector is slightly less in scenario (B) compared with that in scenario (A), and is less in scenario (D) than in scenario (C). This may indicate that the substitution effect is more pronounced in scenarios (B) and (D).

Table 6 displays the percentage change in capital rental for each sector. It is clear that the participants in the direct action are winners because their return to capital increases considerably. In scenario (A), the biggest winners are the forestry sector, the other agriculture sector and the brown coal sector. Their capital rental increases by 81.05%, 49.29% and 48.15%, respectively. The partially funded emissions abatement also brings a 17.66% increase in profit for the road transportation sector. Other participants in scenario (A) also benefit significantly, for example, the sheep sector increases its profit by 4.902%, beef cattle by 6.42%, dairy cattle by 3.621%, and the pig sector by 3.274%. The increased profit for the emissions abatement participants not only comes from the emissions reduction fund but also comes from the increased output prices of these industries. The relatively smaller increase in capital rental for the remaining agricultural sectors may be due to their low emissions abatement price and their small capacity for emissions abatement. The capital rental increase in scenario (B) is slightly smaller than in scenario (A) because the high labour price due to the fixed labour supply in scenario (B) will erode some of the profit.

The results for the above-mentioned emissions abatement participants in scenarios (C) and (D) are similar to those in scenarios (A) and (B), but the results for the sectors newly entering the emissions abatement activity change considerably. Remarkably, the capital rental for the gas distribution sector increases by more than 3 times (331.6%). This dramatic increase may be due to the small capital base of this sector. The now fully funded road transport sector also experiences about a 10% further increase in capital rental, in addition to the 17% increase in scenario (A) and (B). The other new recipients of emissions reduction funds also enjoy a significant increase in their capital rental. For example, the poultry sector increases capital rental by 17.274%, the cement sector by 21.896%, the oil electricity sector by 9.558%, and the partially funded accommodation sector by 5.437%.

Table 6: Percentage change in capital rental by sector

Industry	(A)	(B)	(C)	(D)

	Fixed real wages ($2.55b)	Fixed labour ($2.55b)	Fixed real wages (-12% CO2)	Budget neutral: (C)+GST hike
1 Sheep**	4.902	4.307	4.11	3.381
2 Grains	-0.344	-0.818	-0.867	-1.454
3 Beef cattle**	6.42	5.889	4.548	3.945
4 Dairy cattle**	3.621	3.099	1.419	0.813
5 Pigs**	3.274	3.049	1.335	1.112
6 Poultry*	-1.116	-1.33	17.274	17.004
7 Other agriculture**	49.289	48.887	48.516	48.041
8 Hunting	-4.528	-5.119	-5.144	-5.871
9 Forestry**	81.053	80.689	79.548	79.145
10 Fishing	-0.126	-0.458	-0.903	-1.275
11 Black coal*	-0.068	-0.274	3.621	3.363
12 Brown coal**	48.152	48.19	46.405	46.525
13 Oil	-0.043	-0.114	-0.15	-0.238
14 Gas	0.027	0.005	-0.093	-0.117
15 Other mining	-0.149	-0.455	-1.259	-1.633
16 Food &beverages	-2.2	-2.667	-4.752	-5.277
17 Textile	-0.213	-0.653	-1.722	-2.235
18 Wood & printing	-0.984	-1.28	-2.045	-2.366
19 Automotive petrol	-0.159	-0.057	-0.315	-0.166
20 Kerosene	-0.115	-0.252	-0.855	-1.014
21 Liquefied petrol	-0.148	-0.234	-1.097	-1.185
22 Other petroleum	-4.757	-4.893	-11.902	-12.025
23 Chemical products	-0.723	-1.228	-3.714	-4.281
24 Plastic & rubber	-0.469	-0.956	-3.157	-3.654
25 Cement*	-0.291	-0.042	21.896	22.41
26 Iron & steel*	-0.492	-1.171	6.764	6.014
27 Other metal products	-0.276	-0.785	-3.715	-4.278
28 Other Manufacturing	-0.207	-0.816	-1.894	-2.624
29 Electricity-black coal	5.111	5.161	2.198	2.322
30 Electricity-brown coal	-12.201	-12.218	-13.502	-13.48
31 Electricity-oil*	5.055	5.135	9.558	9.637
32 Electricity-gas	5.736	5.867	5.384	5.578
33 Electricity-renewable	5.137	5.089	-1.517	-1.43
34 Commercial electricity	-1.781	-1.714	-4.829	-4.693
35 Gas distribution*	-0.672	-1.994	331.628	323.69
36 Water & sewerage	-0.211	-0.084	-0.835	-0.646
37 Construction services	0.069	0.555	0.249	0.864
38 Trade services	-0.121	-0.259	-0.693	-0.836
39 Accommodation^	0.216	0.136	5.437	5.132
40 Road transport^*	17.066	16.226	27.772	26.774
41 Other transport	-0.26	-0.881	-1.349	-2.119
42 Communication	0.015	0.023	-0.324	-0.302
43 Public services	0.003	0.144	-0.07	0.129
44 Other services	0.218	0.532	0.448	0.855

With an increase in GST in scenario (D), capital rental changes moderately compared with scenario (C). For most sectors, capital rental decreases slightly due to the increased production cost. However, for a few participants such as the brown coal sector, the oil electricity, and the gas electricity, capital rental increases marginally. These results are largely related to substitution effects and the elasticity of demand. a highly inelastic demand for some commodities means the bulk of the burden of the GST increase will be borne by the consumer and thus an increase in GST will have less impact on the profit of these sectors. Meanwhile, in the face of a GST increase, a high substitution effect may lead to an increase in demand for some goods at the expense of a decrease in demand for other goods. This may lead to a higher profit for the firm when GST increases.

The results in Table 6 show that most of the non-participants of direct action will be worse off. In scenario (A), the capital rental decreases by12.201% for the brown coal electricity sector, 4.757% for the other petroleum sector, 4.528% for the hunting sector, and 1.781% for the commercial electricity sector. The negative impacts on non-participants become larger when the emissions abatement task increases. In scenario (C), capital rental decreases by 13.502% for the brown coal electricity sector, 11.902% for the other petroleum sector, 5.144% for the hunting sector, 4.829% for the commercial electricity sector, 4.752% for the food & beverages sector, 3.71% for both the chemical products sector and the other metal products sector, and 3.157% for the plastic & rubber sector. These negative effects are closely related to the flow-on effect of the reduced production of the direct action participants. However, a few non-participants increase their profit. For example, black coal electricity, oil electricity, gas electricity, and renewable electricity increase their profit by more than 5.00% in scenario (A). This can largely be explained by substitution effects.

5. Conclusions

Using a CGE approach, this paper models the reverse auction and emission abatement activities supported by the emission reduction fund. Assuming that the industrial emissions reduction capacity is a portion of its activity emissions base and that the emissions abatement cost is the forgone profit per emissions abated, the modelling results show that a fund of A$2.55 billion can generate 56.597 megatonnes of carbon abatement credits, or 81% of the government emissions reduction target. To achieve Australia's international obligation on emissions reduction, the emissions reduction fund needs to be increased to A$6.117 billion. Moreover, the policy will have negative impacts on the economy. Although nominal GDP increases in all scenarios, real GDP will decrease by 0.137- 0.276% if the emissions reduction fund is fixed at A$2.55 billion, or by 0.602%-0.766% if the emissions reduction fund is increased to achieve the government emissions reduction target. Real household consumption will increase significantly due to the stimulatory effects of the emissions reduction fund, but exports will decrease considerably because the increased prices of Australian commodities make Australian exports less competitive.

While the modelling results show that the direct action plan can work, the study also casts considerable doubt on the effectiveness and efficiency of this policy. Many factors may contribute to this conclusion. First, the policy focuses only on activity emissions. Since there is no cap on emissions reduction, industry has no pressure to change input mix (e.g. use less emission-intensive or less energy-intensive inputs, or use renewable energy) to reduce stationary emissions. As stationary emission is the major part of the Australian emissions base, ignoring this type of emissions will make emissions reductions policy less effective. On the other hand, the fact that the emission reduction activity only focuses on activity emissions – a small part of the total emissions base – limits the emission abatement capacity of industries with low abatement cost. To achieve the 5% abatement target, the industries with high abatement cost have to be funded to reduce emissions. This will cause considerable inefficiency in the economy. Secondly, the short-term nature and the financial cost of this policy places much constraint on its efficiency and effectiveness. The emissions reduction funds can buy the emission abatement credits only once. When the fund is used up, there is no emissions reduction in the future. To fulfil the emissions reduction target, continuing funding is necessary and this requirement becomes a growing burden on government. Eventually, the government has to balance this funding with an increase in its income, very likely through an increase in taxation. Reducing emissions by increasing general taxes (e.g. GST or income tax) will be much less efficient and less effective than imposing a carbon price. Last, the temporality and the credibility of carbon abatement credits and associated costs are also a hurdle for effectiveness and efficiency. The credibility of a carbon credit is the key for emission abatement activity, so the auditing of carbon credits is a must. A number of auditions are needed in any carbon abatement activities and thus the auditing cost and other administration cost are considerable. Considering that a valid carbon credit requires that the carbon is sequestrated permanently, the cost of auditing and administration may increase substantially further because the auditing activity may need to be extended beyond the life of the carbon abatement projects if the carbon credits generated in the direct action plan can fulfil this requirement. For example, the forestation carbon credit requires that the forest will remain there for 100 years, or for 25 years for a discounted carbon credit option. There is no guarantee that the emissions abatement participants will fulfil this requirement once they have received government funding. In theory, this credibility issue can be solved by auditing, but this will prolong the already expensive auditing to 25 or 100 years.

The limitations of this study largely reside in the limited information on government funded emissions abatement activity and in the nature of a static CGE model. In the early stages of the direct action plan, the information on inputs for emissions abatement activities is not available. Although the authors used labour and capital as a reasonable approximation of emission abatement cost, inability to include intermediate inputs may make the simulation results less realistic. Moreover, the study did not model the emissions abatement activity at the micro level due to lack of information on emissions abatement projects. The authors used justifiable assumptions about abatement costs and abatement capacity, but any deviation in reality from these assumptions may affect the modelling results greatly. Finally, the static model used in this study may overstate the emission reduction cost and/or underestimate the emission reduction effect because the model did not include any technological changes and capital dynamics. Although this limitation is rather minor since the study is focussed only on short-run effects, the study can be improved by employing a dynamic model to simulate long-run effects.

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