Endogenous carbon price in New Zealand: A forest-CGE analysis

1. Introduction

New Zealand implemented a domestic emissions trading scheme (ETS) with the aim of reducing its greenhouse gases (GHG) emissions over the period 2008 to 2012. Agriculture is the largest producer of GHG emissions and forestry represents a major carbon sink sector which contributed 23,836 Gg carbon dioxide equivalent (CO_2e) sequestration in 2007 (MFE, 2009). At the latest global convention on climate change (COP 21), held in Paris at the end of 2015, participants agreed on a global treaty of reducing emissions aimed at limiting the rise of global warming. NZ government announced a target aimed at reducing domestic GHG emissions to 30 per cent below the 2005 level by 2030 (MFE, 2016).

Agriculture has yet to be included within the NZ ETS and the current market price of carbon price is relatively low. The price of emission reduction units (ERU) was about NZ$0.2/t CO_2e in year 2013, and NZ's primary permit - NZ Unit (NZU) was NZ$2.5/t CO_2e in 2016 (carbon forest services, 2016). A low price reduces the incentive for afforestation and emissions reductions by other sectors. Forest owners enjoy revenue from carbon sequestration and face liability if they decide to harvest trees. Energy, industrial processes, waste, refined fuels, and synthetic gases sectors have to pay for their emissions. Given the significant role agriculture plays in NZ economy, and its dominant role in NZ's emissions profile, it is important to understand the impact of including agriculture in the ETS, as originally intended.

The carbon stock associated with the forestry sector is estimated as a function of the net change in forest area, age, and a pickle factor that accounts for the carbon in the wood that has been harvested (Hertel *et al.* 2009, Lubowski *et al.* 2006, Gardiner 2009, and Sohngen *et al.* 2009). Optimal forest rotation age is determined by growth rate, carbon sequestration during the growth cycle, the value of harvested timber and carbon price up to and including the time of harvest (Hartman, 1976).

Computable general equilibrium models (CGE) have used an exogenous carbon permit price to evaluate the impact on the economy (e.g. NZIER 2008, Callan *et al.* 2009). However, few CGE studies calibrate the equilibrium carbon permit price. Diukanova *et al.* (2008) study the impact of the NZ ETS on NZ's macro-economy, and find that agricultural output is reduced given an emissions abatement cost of NZ$13.2 per tonne CO_2e. Adams & Parmenter (2013) analyse the impact of the Australian ETS on the Australian economy. They link a dynamic Monash Multi-Regional Forecasting model (MMRF) to a Global Trade and Environment Model (GTEM), which projects an increase in the global permit price from AU $24.3 in 2012 to AU$49.3 in 2030. Permit price is treated as a tax in the MMRF model. The MMRF model determines competitive equilibria and allows for physical capital accumulation. Their study finds that Australia may need to import permits due to a short fall in domestic abatement.

Using an input-output model Tang *et al.* (2016) estimated an average marginal abatement cost (MAC) of AU$29.3 per tonne CO_2e over the 1998 – 2005 period for a broadacre farming system in the Great Southern region of Western Australia..

To the best of our knowledge, the impact of endogenous carbon price on optimal harvest age, land use and the NZ economy has yet to be examined. This paper selects a timber yield function from Van Kooten *et al.* (1995), based on Faustmann that includes carbon sequestration benefits (Sands and Kim, 2009). Optimal rotation age is endogenous, and an equilibrium carbon price is calibrated assuming a closed NZ carbon market. The economy-wide impact and associated changes in land use is reported under three scenarios of the ETS.

The rest of the article is organised as follows. Section 2 describes the forest-CGE model. We then introduce two scenarios: first, a pure ETS in which forestry is the only source of carbon permits; second, an alternative "carbon pool" where government sells international permits purchased from the world market, along with forestry. In each scenario, forestry supplies permit from growing trees. In section 3, we present the key results including the carbon price, land use change, the impact of the ETS on economy, and conduct sensitivity test. Section 4 draws a conclusion.

2. Model

In this section, we first introduce the model and then the scenarios used for simulation.

2.1 Model description

The forest-CGE model is static with 16 aggregated sectors and 15 commodities spanning the economy based on the ANZSIC (Australian and New Zealand standard industrial classification) standard (Statistics New Zealand, 2006). The 16 sectors are: forestry, stationary energy, industrial processes, synthetic gases, waste, horticulture and fruit growing, sheep, beef cattle and grain farming, dairy cattle farming[1], other agriculture, forestry manufacturing, agriculture manufacturing, retail and wholesale trade, manufacturing, non-renewable electricity, renewable electricity, and service.

All sectors are characterized by a nested production structure. Domestic production, is based on the Leontief function, incorporating aggregated intermediate and value-added inputs. Domestic and imported goods are components of intermediate use; primary factors, such as labour and capital, are value-added inputs. We assume five types of land (forest, grass, crop, scrub, and other) with substitution other across five sectors: forestry, horticulture, sheep-beef,

[1] Sectors "horticulture and fruit growing", "sheep, beef cattle and grain farming", and "dairy cattle farming" are written as "horticulture", "sheep-beef", and "dairy farming" in later sections.

dairy farming, and other agriculture. The elasticities of substitution between each type of land are drawn from Strutt & Rae (2011) and Rutherford (2003). Land use areas were obtained by merging geographic (LCDB V2) and industrial use data (Agribase dataset).

The electricity sector is disaggregated into non-renewable and renewable sources of energy. The non-renewable sector uses coal, oil, and gas as intermediate inputs, whereas renewable electricity sector uses three types of renewable resources: geothermal, wind, and hydro. Renewable resources are only used in the renewable electricity sector. Domestic goods are transformed to exported goods according to a constant elasticity of transformation (CET) function.

A representative household and central government choose their optimal level of consumption by maximizing utility subject to an expenditure constraint. In the commodity market, total output is allocated to exports and the domestic market in terms of CET. Both imported goods and domestic production are sold in the domestic market. Imported and domestic goods are heterogeneous, and are not perfect substitutes. The Armington function is used to depict substitution.

GHG emissions are output-based measured by CO_2e. Carbon permits can only be traded in the domestic carbon market. Two scenarios are examined: (1) pure ETS policy, all carbon permits are supplied by forestry; (2) carbon pool, refers to two suppliers in the market: government and forestry; government sells international permits at a fixed price to the market. In both scenarios, forest owners supply permits to the market but face liability at deforestation. An equilibrium carbon permit price is determined by equalizing the supply and demand of permits.

An optimal rotation age of post-1989 radiata pine under a “pruned, without production, thinning” regime is estimated from a partial equilibrium forest model by maximizing net present value (NPV) from three paths: timber sales, carbon sequestration, and carbon emission liability payment (Sands and Kim 2009; Van Kooten *et al*. 1995). It is assumed that forestry is in a steady-state, implying that forestry profits are equalized each year from planting to optimal rotation age. Harvesting and replanting costs which include land transition costs are endogenous in the model.

Linking the forest model to CGE is a significant contribution made by this paper. The forest growth model is partial equilibrium, and the timber yield function has a single variable, rotation age per hectare. First, the forest model calculates an optimal rotation age by maximizing forest owner's NPV including tree planting and carbon sequestration. Second, profit maximisation follows, at this rotation age, within the CGE model. Other variables such as timber price, timber yield, and carbon emissions per hectare are determined by endogenous terms of trade in CGE model. These variables take effect in determining rotation age in forest growth model until unique equilibrium results are generated by both models.

In order to reach a general equilibrium, both commodity and factor markets clear. Factor endowments are fixed. Capital is immobile internationally but can move freely in NZ. Investment is fixed and savings are endogenous in the model. Foreign saving (FSAV) is determined by the model for balancing the international trade account.

2.2 Scenarios

Two scenarios are used to investigate the impact of government policy on the equilibrium carbon permit price and the consequential effect of the ETS on NZ's economy. In the first scenario "pure ETS", forest owners are the only source of carbon permits. The "carbon pool" scenario assumes government purchases permits on the international market; these permits enter the market along with permits supplied by forest owners.

2.2.1 Pure ETS

The economy is constrained by a carbon market based entirely on forest sequestration; total carbon sequestration from forestry equals total carbon emissions. Equations 1 and 2 outline the zero profit condition for sector i and forestry.

$$\pi_i = PA_i * QA_i - [PINT_i * QINT_i + w * L_i + r * K_i + P_{land}^{i} * Q_{land}^{i} + P_{carbon}^{d} * E_i] \qquad (1)$$

$$\pi_{for} = PA_{for} * QA_{for} + P_{carbon}^{s} * E_{for} - [PINT_{for} * QINT_{for} + w * L_{for} + r * K_{for} + P_{land}^{for} * Q_{land}^{for}] \qquad (2)$$

Where i refers to sector, π_i is profit of sector i, π_{for} is profit of forestry sector, PA_i is price of product, QA_i is production amount, $PINT_i$ is price of intermediate goods, $QINT_i$ is amount of intermediate goods for sector i, w and L_i are wage and labor use for sector i, r is rental price of capital K_i, P_{land}^{i} is price of composite land Q_{land}^{i} used for sector i, P_{carbon}^{s} is carbon price from supply side, and P_{carbon}^{d} is carbon permit price for carbon emissions E_i. Perfect competition is assumed, thus, there is one price for factor use in each sector.

By maximizing sector i's profit, optimal demand for carbon permits E_i , and supply for permits E_{for} is calculated as a function of carbon permit price and other variables as shown in Equations 3 and 4.

$$E_i = \frac{PA_i * QA_i - PINT_i * QINT_i - PVA_i * QVA_i}{P_{carbon}^{d}} \qquad (3)$$

$$E_{for} = \frac{PA_{for} * QA_{for} - PINT_{for} * QINT_{for} - PVA_{for} * QVA_{for}}{-P_{carbon}^{s}} \qquad (4)$$

The market clears when carbon permit demand ($\sum E_i$) equals supply E_{for} as shown in Equation 5.

$$\sum E_i = E_{for} \qquad (5)$$

The equilibrium carbon permit price is derived from Equation 6.

$$P_{carbon} = f(\overline{P^i_{lk}, P^i_{land}, PA_i, PINT_i, Q^i_{lk}, Q^i_{land}, \alpha_1, \alpha_{3,}} E_{i,} E_{for}) \quad (6)$$

Factor ($P^i_{lk}, P^i_{land}, PINT_i$) and commodity ($PA_i$) prices are determined when the commodity market clears, i.e. commodity supply from producers is equal to consumption from household, government, and the ROW. Q^i_{lk} is the amount of value-added input (labour and capital) in sector i, and Q^i_{land} is the composite land input used in sector i. α_1 and α_3 are Leontief coefficients of intermediate input ($QINT_i$) and emissions (E_i). All sectors are price takers. Equations are solved using MPSGE syntax in GAMS.

2.2.2 Government enters the carbon market

Government can participate in the carbon market under the “carbon pool” strategy, where government purchases 9.1 Mt of international permits and sells the total amount at NZ$25/t. The remaining permits are supplied by forestry sector. The permit price is set at NZ$25/t because under the existing ETS polluters have to pay for their emissions at NZ$25/t from NZ government. This scenario is consistent with Informetrics (2007), where they presented a scenario that had a total value of government purchased emissions units from offshore as $228m per annum, which is equivalent to 9.1 Mt at $25/t.

3. Results

This section presents key results for each scenario, the impact on the NZ economy, and land use change between forestry and agriculture. Section 3.1 shows baseline and data of sectoral emissions and land use in hectares for the base year 2007, section 3.2 analyses impact on carbon market including equilibrium carbon price and net emissions, section 3.3 depicts impacts on forest variables including rotation age, timber yield, and NPV, section 3.4 examines land use change between forestry and agriculture sectors, and section 3.5 describes the impacts on macroeconomic variables.

3.1 Baseline and Data

The social accounting matrix is based on the 2007 supply-use table, the latest available. We set the baseline scenario where carbon permit price is NZ$0/t. The Ministry for the Environment (MFE) reports the CO_2e emission data by sector and source (MFE, 2015). Total GHG emissions in 2007 were 75550.2 Gg CO_2e. A negative sign is attached to carbon sequestration shown in Table 1. The total agriculture sector contributed 36430 Gg CO_2e emissions, which was 48.2 per cent of the total emissions. Because of limited data on horticulture emissions, we assume that emissions for this sector come from direct and indirect nitrogen loss from agricultural soils, and from the use of nitrogenous fertilizer. Under the agriculture soil category, direct N_2O soil emissions contribute 1680.7 Gg CO_2e, and indirect N_2O from nitrogen used emits 3270.7 Gg. Total emissions form horticulture and fruit growing sector are calculated by summing up the data.

Sectoral emissions measured in gigagrams (Gg) CO_2e are shown in Table 1 (MFE, 2015). In this paper, we convert Gg to metric tonne (Mt).

Table 1: Carbon emissions by sector in 2007

Sector	**Emissions (Gg CO_2e)**
Forestry	-23,836
Stationary energy	7,867
Industrial processes	4,602
Synthetic gases	1,499
Waste	1,822

Horticulture and fruit growing	4,951
Sheep, beef cattle and grain farming	8,789
Dairy cattle farming	8,531
Other agriculture	14,158
Forestry manufacturing	0.8
Agriculture manufacturing	360
Retail and wholesale trade	1,499
Manufacturing	4,521
Non-renewable electricity	1,761
Renewable electricity	366
Service	14,823
Total emissions	75,550
Net emissions	51,724

Energy sector emissions were the second largest in 2007 and represented 43.2 per cent of the total emissions, or 32653.1 Gg CO_2e. Public electricity, heat production, and road transportation contributed the largest share. We extracted non-renewable and renewable electricity emissions from the energy category in NZ's GHG inventory report (MFE, 2015). Under the renewable category, geothermal operations contribute 365.9 Gg CO_2e. Coal emissions are disaggregated from coal combustion, and contributed 261.8 Gg, oil and gas together contributed 1499.2 Gg in 2007.

Manufacturing includes iron and steel, other non-ferrous metals, chemicals, pulp, paper and print, food processing, beverages and tobacco, and other uses. We tracked the manufacturing emissions by splitting the total emissions of manufacturing and construction. Total emissions for both sectors are 5380.9 Gg and the construction sector accounts for 860.4 Gg. Hence, we estimate 4520.5 Gg as manufacturing sector emissions.

Five types of land can be utilised by the five land-based sectors. Land use in the baseline scenario is shown in Table 2.

Table 2: Land use in baseline (hectare)

Carbon price =0	Forest land	Other land	Grass land	Scrub land	Crop land	Total
Forestry	1105949	11330	64567	116454	904	1299204
Horticulture	8728	3063	38990	5304	66955	123040
Sheep-beef	989838	582505	7275154	1120353	285177	10253027
Dairy farming	133221	19572	1296734	52325	26121	1527973
Other agriculture	40552	14812	270028	38257	11048	374697
Total	2278288	631282	8945473	1332693	390205	13577941

In the baseline scenario, forestry uses the most forest land (85 per cent), some scrub land (9 per cent), grass land (5 per cent), and other land (1 per cent). Most crop land (54 per cent) is used in the horticulture sector, and 32 per cent of grass land is also used for horticulture. Grass land dominates agricultural activities, especially the sheep-beef (71 per cent), dairy farming sectors (85 per cent) and other agriculture (72 per cent).

3.2 Impacts on equilibrium carbon price and total emissions

In the pure ETS scenario, where only forest owners supply carbon permits, the equilibrium carbon price is NZ$24/t of CO_2e. In carbon pool scenario, where government supplies the permits purchased from the overseas market. As expected, the equilibrium price decreases if permit supply increases. Table 3 shows the change in carbon permit price and change of sectoral emissions in both scenarios.

Table 3: Change in carbon permit price and sectoral emissions (percentage of baseline)

	Baseline	Pure ETS	Carbon pool
Equilibrium carbon price	0	24	-0.3%*
Stationary energy	8	-7%	-7%
Industrial Processes	5	-3%	-2%
Synthetic gases	1	-3%	-3%
Waste	2	-7%	-7%
Horticulture and fruit growing	5	-15%	-15%
Sheep, beef cattle and grain farming	9	-11%	-11%
Dairy cattle farming	9	-12%	-11%
Other agriculture	14	-12%	-12%
Forestry manufacturing	0	6%	7%
Agriculture manufacturing	0	-12%	-11%
Retail and wholesale trade	1	-0.1%	0%
Manufacturing	5	-0.1%	-0.04%
Non-Renewable Electricity	2	-5%	-4%
Renewable Electricity	0	0%	0%
Service	39	1%	1%
Sequestration (forestry)	23	17%	17%
Total emissions	76	-7%	-7%

Note:* -0.3% falls from $24.

As seen in Table 3, the equilibrium carbon permit price drops slightly in the carbon pool and free allocation scenario. Assuming other conditions are constant, an effect on carbon permit price and emissions is similar under both scenarios. With a carbon pool, the decrease in carbon price is lower (0.3 per cent) than in pure ETS scenario. This is largely due to decreasing sectoral outputs in the carbon pool scenario leading to less demand for carbon permits. Most sectors' emissions decrease due to the emission cost. The percentage change under both scenarios are similar, this is because the change in equilibrium carbon permit price is small.

3.3 Impact of carbon price on forestry

We assume forest owner maximizes NPV over all future periods (NPV4) by three paths: timber sales (NPV1), carbon sequestration (NPV2), and emission liability (NPV3). With an assumed interest rate of 8 per cent, the equilibrium rotation age is 20 years across all scenarios. Timber price increases from baseline NZ$88 to NZ$90 in all scenarios. This is partly due to profits derived from selling carbon permits, and decreased terms of trade (-1.4 per cent), leading to a rise in timber production. Results for forest variables across the three scenarios are shown in Table 4.

Table 4: Forest variables results (per hectare)

Variables	Baseline	Pure ETS	Carbon pool
Rotation age	18	20	20
Timber yield	299	350	350
Timber price	88	89	89
NPV1	6034	6281	6272
NPV2	0	1927	1920
NPV3	0	-1166	-1162
NPV4	7820	8828	8814

NPV1 decreases slightly in the carbon pool scenario (rounded to zero decimal), compared to pure ETS. This is associated with a lower equilibrium carbon price. A lower carbon price reduces demand for planting trees and supplying carbon permits, leading to a fall in NPV2. NPV3 implies that less timber production results in a lower carbon emissions liability.

3.4 Impacts on land use change

In order to differentiate forest land from other types of land, we set a low elasticity at 2 for other lands converting to forest land, and a high elasticity of 20 which makes land conversion much easier with agricultural sectors than with forestry. This high elasticity of substitution is drawn from Strutt & Rae (2011). Low elasticity drives an increase in forest land for sector use.

Compared with the baseline, where the carbon permit price is NZ$0, the equilibrium carbon price of $24 would provide motivation for obtaining and selling carbon permits. Two main factors affect land use among sectors: sectoral output; and, elasticity of substitution among land.

Increasing output leads to rising demand for production factors such as land, labour, and capital. If the elasticity of substitution is low between two types of land, e.g. forest land and other land, then it reduces the ease with which other land can be converted to forestry use. Again, in this paper we set a low elasticity of substitution between forest land and other four types of land, which makes forest land relatively expensive.

Table 5: Percentage change in land hectare (percent of baseline)

Pure ETS	Forest land	Other land	Grass land	Scrub land	Crop land
Forestry	62%	140%	143%	118%	148%
Horticulture	-60%	-9%	-7%	-17%	-6%
Sheep-beef	-58%	-3%	-1%	-11%	1%
Dairy farming	-59%	-3%	-2%	-12%	0%
Other agriculture	-58%	-2%	0%	-11%	1%

Carbon pool	Forest land	Other land	Grass land	Scrub land	Crop land
Forestry	62%	138%	142%	117%	146%
Horticulture	-60%	-9%	-7%	-17%	-6%
Sheep-beef	-58%	-2%	-1%	-11%	1%
Dairy farming	-59%	-3%	-2%	-12%	0%
Other agriculture	-58%	-2%	0%	-11%	1%

The overall change in land use between both scenarios by sector and type is illustrated in Table 5. A clear trade-off between forestry and agricultural sectors shows that pricing carbon is beneficial to the forestry sector, but is a production cost to agriculture. Between both scenarios, the effect of equilibrium carbon price on sectoral land use is almost same under pure ETS and carbon pool. This is because all producers need to buy carbon permits from the market. For the forestry sector, the potential profits from selling carbon permits decrease in carbon pool compared to the pure ETS scenario.

3.5 Impacts on macro-variables

Figure 1 illustrates the change in macro variables including real GDP, terms of trade, export, import, factor price, household and government consumption across the two scenarios, compared to the baseline where carbon permit price is NZ$0.

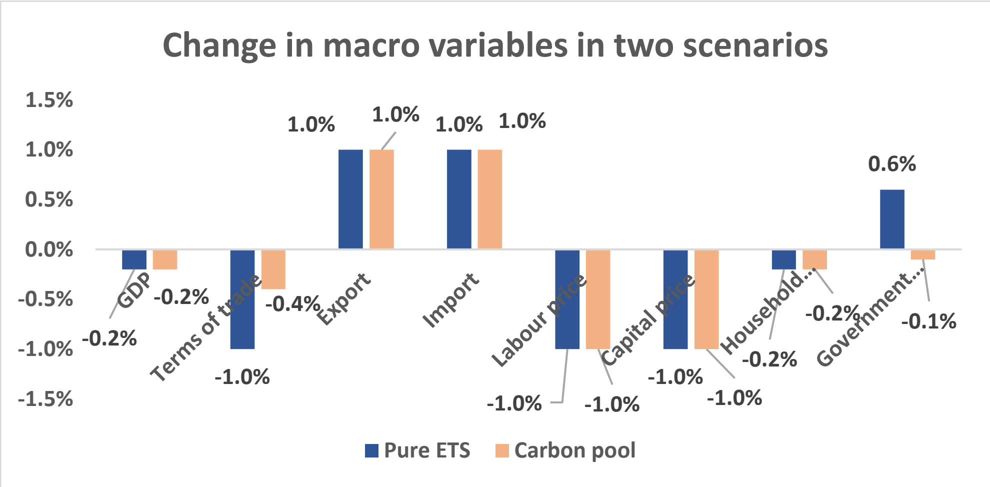

Figure 1. Change of macroeconomic variables in both scenarios

As shown in Figure 1, real GDP declines by 0.2 per cent across all scenarios. This is in line with Diukanova *et al*. (2008) where the GDP falls by 0.3 per cent in all scenarios. This effect is caused by decreased sectoral output. The reduction in sectoral output leads to an increase in domestic commodity prices, which makes domestic supply relatively expensive to imported goods. Therefore, imports increase in both scenarios. The decreased terms of trade implies a fall in the exported price, resulting in an increase in exports.

The reduction in sectoral output decreases the demand for factor use in most of sectors except for forestry and its related sectors. Overall, the price of labour and capital decrease. Household consumption does not decrease much in both scenarios, because high income from supplying renewable resource compensates for the decrease in factor prices. Government consumption falls by 0.1 per cent in the carbon pool scenario, because the market based carbon price is lower than its purchase price ($25/t). The purchase price is measured in NZD adjusted by an exchange rate.

3.6 Sensitivity test

To test the effect of ETS on equilibrium carbon price at different permit purchase prices and volumes from the government, a sensitivity test is conducted in this section.

Four more initial carbon permit prices (NZ$5/t, NZ$10/t, NZ$15/t, and NZ$25/t) at an amount of 9.1 Mt, 10 Mt, 20 Mt, 25 Mt, and 50 Mt purchased by the government are used to examine the change in proportion of permits supplied by government to total permits and equilibrium carbon permit price. Results are shown in Table 6.

Table 6: Sensitivity test

Amount (Mt)	Price (NZD)	Equilibrium permit price (NZD)
9.1	5	23.503
	10	23.487
	15	23.471
	25	23.438
10	5	23.502
	10	23.484
	15	23.466
	25	23.43
20	5	23.484
	10	23.448
	15	23.413
	25	23.344
25	5	23.475
	10	23.43
	15	23.386
	25	23.299
50	5	23.43
	10	23.344
	15	23.254
	25	23.076

As illustrated in Table 6, increased total permits lead to a decrease in the share of permits supplied by government under increased purchased price and amount, as well as carbon price.

The scale of change in each variable is not large, indicating that carbon price is not sensitive to government spending on carbon permits.

4. Conclusion

This paper calculated a carbon permit price at an equilibrium level under two policies. The pure ETS policy assumed a closed carbon market without government intervention. The carbon pool policy assumed government sells the surplus of international permits with forestry. The permits trade is on the principle of “1 tonne emission equals 1 unit of permit”.

Without government intervention, at an equilibrium level, the carbon permit price is NZ$24/t CO_2e. Compared with the pure ETS, the price is 0.3 per cent lower than in the carbon pool scenario. The lower carbon price follows from an increase in the supply of carbon permits.

Our results show that the ETS contributes to a 7 per cent reduction in total emissions, about one fifth of NZ’s emissions reduction target in 2030 (30 percent below 2005 levels). Achieving the 30 per cent reduction target by 2030 will require investment in technology aimed at lowering emissions from agriculture and reductions in emissions from land transport.

The design of ETS impacts land use significantly. There is a clear trade-off of land use change between forestry and agriculture sectors, but the difference between a closed (pure ETS) and open carbon market (carbon pool) is small. This is due to a similar equilibrium carbon permit price.

Although the equilibrium carbon permit price is invariant with respect to design of the ETS, government consumption is different in both scenarios. It gives negative impact on government spending if it enters carbon market. Agriculture production decreases in both scenarios because of the carbon emission cost. Retail, renewable electricity, and service sectors are not sensitive to the change in carbon price. At the baseline, retail and renewable sectors do not generate much emission. With a carbon price, the mobility of factors among sectors leads to an increase in production and emissions in the low emissions sectors such as service. The positive relationship between production and emissions leads to fewer emissions in the carbon pool scenario than under a pure ETS scheme.

The main contribution of this study is the calculation of an endogenous carbon permit price under the NZ ETS policy which includes agriculture as a source of emissions and forestry as a source of permits. Most studies use a fixed carbon price (i.e. carbon tax) because it is relatively easier for model calibration. The equilibrium carbon permit price calculated by this study is for all ETS sectors, with an endogenous forest sector linked to a CGE model.

Regarding to future research, we will investigate an optimal carbon permit price with respect to a global carbon market. In addition, we will compare the NZ ETS and potential carbon tax, and highlight which policy performs better for NZ economy in terms of macro-economic variables such as GDP, international trade, and carbon emissions abatement.

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