The Paris Agreement and its Economic Impact on New Zealand

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Abstract

The Paris Agreement (PA) asserts that greenhouse gases (GHG) emission pathways should be consistent with holding the increase in global temperature below 1.5˚C or 2˚C above pre-industrial levels. New Zealand (NZ) committed to reduce emissions to 30% below 2005 levels by 2030. The purpose of this paper is first, to estimate the economic costs for NZ of meeting the PA terms, and second, to characterize the mitigation potential of accounting for forestry carbon sequestration (FCS), pricing agricultural emissions, and linking the New Zealand Emissions Tradable Scheme (NZ ETS) to the European Union ETS. We use a general equilibrium model and "soft-link" it with the Global Timber Model. We found that NZ can meet the PA terms; however, important GDP decreases may arise. FCS plays a significant role in mitigating the negative impacts, where the benefits of FCS outweigh those of pricing agricultural emission and linking the NZ ETS.

Keywords: Forest carbon sequestration, carbon market linking, agricultural emissions, general equilibrium

JEL codes: C68, Q51, Q54, Q56,

1. Introduction

Negotiations towards a new international climate change agreement under the United Nations Framework Convention on Climate Change (UNFCCC) concluded in Paris in December 2015. The Paris Agreement (PA) asserts that future greenhouse gases (GHG) emission pathways should be consistent with holding the increase in the global average temperature below 1.5°C or 2°C above pre-industrial levels. The PA is due to enter into force by 2020 and seeks for global emissions to peak as soon as possible and then to undertake rapid reductions thereafter. It also entails for each country to adopt their own intended nationally determined contributions (INDCs), which will reflect each country's ambition for reducing emissions, taking into account domestic circumstances and capabilities (UNFCC 2015). Though INDCs are not yet enough to keep global warming below 2°C, the PA traces the way to achieving this target (European Commission 2016).

New Zealand (NZ) committed to reduce GHG emissions to 30% below 2005 levels by 2030 (59.2 MtCO2e) and also announced a target of reducing emissions to 50% of 1990 levels by 2050 (33.4 MtCO2e). Meeting these reduction targets requires the implementation of mitigation policies, e.g., carbon markets, environmental taxes, and incentives to develop clean technologies. Policies imply limits on emissions and, consequently, impacts on GHG-emitting production systems and usage of GHG-intensive inputs across the economic sectors. Other countries have also submitted their own INDCs, which may imply further changes in trade flows and the competitiveness of NZ as a small and open economy. Thus, there are multiple effects to be considered to evaluate if NZ could cost-effectively meet its INDCs. Hence, the purpose of this paper is twofold; first, to estimate the economic costs derived from the commitment under the PA, and second, to characterize the mitigation potential of forestry carbon sequestration (FCS), pricing agricultural emissions, and linking the NZ Emissions Tradable Scheme (NZ ETS) to the European Union ETS (EU ETS).

Although the costs of meeting GHG reduction targets have been analysed in previous work, the implications from the PA and the role of FCS have not yet been addressed. Daigneault (2015) explores possible INDCs that NZ might put forward under the PA over the period 2021 to 2030: With a reduction target of 10% below 1990 levels and an emissions permit price up to \$50/tCO2-e by 2030, domestic GHG emissions are estimated to reduce by 10.6% relative to the baseline by 2030 (approximately 90 Mt CO2-e of domestic abatement). Thus, to meet the target, NZ would need to purchase 170 million international carbon units, costing NZ\$6.7 billion. Infometrics (2015) estimates that for a global price of carbon that reaches NZ\$50/tonne by 2030 and a decadal emissions reduction target for NZ of 260 Mt (equivalent to 10% below 1990 levels by 2030), the reduction in real gross national disposable income is 1.2% relative to business as usual levels. Only about one-fifth of the target is met through domestic abatement; the rest is met by purchasing emission units from offshore. Schilling (2011) estimates in turn that if an agreement similar to the Kyoto Protocol is negotiated, and for an emissions permit price of \$NZ100/ton, an extra 15% Assigned Amount Units on top of 1990 levels would increase welfare by around 0.7% and GDP by 0.2%.

To estimate the economic impacts from the PA we used the Climate and Trade Dynamic General Equilibrium (CliMAT-DGE) model developed by Landcare Research. Then, to estimate forestry sequestration we used the Global Timber Model (GTM). We first developed emissions pathways consistent with holding the increase in the global average temperature below 1.5°C above pre-industrial levels. For all countries except NZ the emissions trajectory is derived from the Representative Concentrations Pathways (RCP) 2.6, which is associated with a temperature change between 1.5°C and 1.7°C (IPCC 2014). The emissions trajectory for NZ was constructed based on the submitted INDCs.

We simulated eight cap-and-trade scenarios where we allow accounting/not accounting for FCS to calculate net emissions, pricing/not pricing agricultural emissions, and linking/not linking the NZ ETS with the EU ETS. Carbon prices are then fed into GTM to provide FCS that is then fed back into CliMAT-DGE. This soft-link process converges to a steady state GHG price to achieve the reduction target pathway using both models. We found that, for 2030, NZ can meet the reduction targets set in the PA; this has negative impacts, however, on Gross Domestic Product (GDP) and welfare. These impacts are mitigated if FCS is accounted for when calculating net emissions, and if agricultural emissions are priced. Linking the NZ ETS with the EU plays a major role only if FCS is not accounted for and agricultural emissions are not priced. For the rest of scenarios, linking the NZ ETS with the EU may not be advantageous, because of effects on competitiveness. Furthermore, benefits from accounting for FCS outweigh benefits from linking and pricing agricultural emissions.

The paper is structured as follows: Section 2 describes the modelling approach. Section 3 presents the results. Section 4 discusses our results in the light of previous research and the current NZ political context. Section 5 concludes.

2. Modelling Approach

In the following, we present the quantitative framework of our economic analysis. We first introduce the modelling approach and then the scenarios for simulation.

2.1 CliMAT-DGE

CliMAT-DGE is a multiregional, multi-sectoral, forward-looking dynamic general equilibrium model with a relatively long time horizon of 100 years or more (Fernandez and Daigneault 2015). This model is suited to studying the efficient (re)allocation of resources within the economy and response over time to resource or productivity shocks. CliMAT-DGE primarily uses the Global Trade Analysis Project (GTAP) version 8 dataset. The base year of the benchmark projection is 2007. The model then develops a benchmark projection of the economic variables and GHG emissions, and simulates scenarios to evaluate the impacts of mitigation policies. Based on long-run conditions and constraints on physical resources, which restrict the opportunity set of agents, the model predicts the behaviour of the economy, energy use, and emissions by region and sector (Fæhn et al. 2013). CliMAT-DGE is coded using the Mathematical Programming System for General Equilibrium (MPSGE) package in GAMS (Rutherford 1999).

The model incorporates projections of key macroeconomic (e.g. labour productivity) and other variables (e.g. energy efficiency). The economic baseline is constructed from a growth scenario developed by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) (Fouré, Bénassy-Quéré, and Fontagné 2010). The sectors covered in this study are listed in Table 1. Coal, oil, gas, petroleum refining, renewable (carbon-free) electricity and fossil electricity sectors are defined as separate sectors. Renewable and fossil electricity generation sectors are disaggregated from the single electricity GTAP sector.

Table 1: CliMAT-DGE Aggregated GTAP Production Sectors

Primary Production Sectors	Energy and Transport Sectors
Grains including rice	Coal
Other crops	Oil
Oil seeds and sugar cane	Gas
Plant based fibres	Petroleum, coal products
Cattle, sheep and goats, horses	Fossil electricity
Raw milk	Carbon-free electricity
Forestry	Transport
Logs	
Manufacturing and Value added Sectors	
Food products: meat, dairy, oils, rice, sugar, beverages and tobacco	
Harvested wood products	
Energy-intensive manufacturing	
Non-energy-intensive manufacturing	

All production sectors are modelled using nested Constant Elasticity of Substitution (CES) production functions, which capture the potential substitution between production technologies. The nesting structure in CliMAT-DGE partly follows Paltsev et al. (2005).

Model dynamics follow a forward-looking behaviour where decisions made today about production, consumption and investment are based on future expectations. The economic agents have perfect foresight and know exactly what will happen in all future periods of the time horizon. Thus, households are able to smooth their consumption over time so that the savings rate varies endogenously. As expectations about the future affect current behaviour of agents, the forward-looking approach adds flexibility to adjust savings and consumption over time to partially mitigate the negative impacts of an environmental policy in the short run. Therefore, the model is capable of addressing policy issues such as banking and borrowing of GHG allowances, international capital flows, and optimal emissions abatement path (Babiker et al. 2008; Dellink 2005).

The supply of labour in each region is undifferentiated by skill level and exogenously specified as part of the baseline scenario. We assume a full employment model closure, where a shock to the economy causes wages and rents to adjust until the fixed supply of each factor is again fully employed. If labour is fully employed, then producers must compete for workers with other industries in order to expand production. This competition drives up wages and increases manufacturers' costs of production, which are passed on to consumers through higher prices (Burfisher 2011). An exogenous growth of labour supply is assumed to reflect increases in the population and more efficient use of labour due to improving technology. Similarly, the supply of land and natural resources are assumed to be fixed in each period. Rents vary accordingly to keep full employment.

Because of the forward-looking dynamics, the representative household in each region chooses its path of consumption versus saving over time to maximize the discounted value of the utility attained from consumption in each period. Utility maximization is subject to an income constraint over the time horizon (Babiker et al. 2008). This constraint implies that in a policy scenario, the present value of all future changes (positive and negative) in a region's current account balance must be zero. Any region may run a current account surplus or deficit in any period but subject to the constraints that (i) global savings must equal global investment and (ii) the present value of a region's current and future surpluses must equal the present value of its current and future deficits. For this, capital flows are allowed among regions in response to differences in real rate of returns. Model closure regarding the balance of payments requires the capital flows to be equal to the current account deficit (or surplus), and equal to the differences between aggregate expenditures (private and public consumption plus investments) and aggregate income (returns to labour, capital, energy resources and tax revenues). That is, if one country has a current account deficit, there must be a compensating current account surplus in other countries. Furthermore, in every region any excess of aggregate expenditure over aggregate income today must be paid back in the future so that there is no net change in indebtedness over the model horizon (Fernandez and Daigneault 2015).

In common with other CGE models, international assets positions are not explicitly modelled in CliMAT-DGE. Financial stocks and flows of financial assets (debt, equity, currency) are not modelled either. Thus, while a current account deficit is financed by a capital account surplus, we cannot say anything about the composition of the capital account. Foreign trade allows countries to temporarily run foreign accounts imbalances in response to environmental policies, as long as that imbalance is made up for in later years (Babiker et al. 2008).

Carbon capture and storage (as backstop technology) is an acceptable form of GHG emissions reduction for all policy scenarios. For further technical details see Fernandez and Daigneault (2015).

2.2 Global Timber Model

The Global Timber Model (GTM) is an economic model capable of examining global forestry land-use, management, and trade responses to policies. In responding to a policy, the model captures afforestation and forest management, and avoids deforestation behaviour. The model estimates harvests in industrial forests and inaccessible (virgin) forests, timberland management intensity, and plantation establishment – all important components of both future timber supply and carbon flux. The model also captures global market interactions, global timber supply, and the associated carbon accounting, including carbon stored in harvested wood products.

GTM tracks more than 200 forest types across 17 timber regions. The NZ region includes 12 regional *Pinus radiata* and other exotic forest plantation areas as well as native forest. It solves in 10-year increments to 2150, taking into account the long-run dynamics of forest growth and harvest schedules. The model has been used in a variety of forest and climate change policy assessments internationally (Daignault, Sohngen, and Sedjo 2012). More details on GTM can be found in Sohngen and Mendelsohn (2003).

For this analysis, we feed the regional emissions permit prices estimated with CliMAT-DGE into GTM. GTM can then estimate the change in regional forest stock and FCS as a result of the emission reduction targets. The endogeneity effect of the carbon price affects FCS, which then reduces required emissions reductions from other sectors of the economy, which would then lower the carbon price coming out of CliMAT-DGE that we feed back into GTM until we converge to a steady state GHG price to achieve the reduction target using both models. This approach we refer to as a soft link.

2.3 Policy Scenarios

CliMAT-DGE develops a baseline scenario where the global economy is projected from the base year of 2007 to 2082, in 5-year periods, in the absence of mitigation policies for climate change. The impacts from the PA are analysed in terms of deviations (or percentage changes) of the variables of interest relative to the baseline. We imposed caps on the baseline emissions pathways so that they followed a trajectory consistent with a temperature increase of 1.5°C by 2100. For all countries except NZ the emissions trajectory is derived from the Representative Concentrations Pathways (RCP) 2.6, which is associated with a temperature change between 1.5°C and 1.7°C (IPCC 2014).

Policy scenarios are constructed around the possibility of incorporating FCS to calculate net emissions, pricing agricultural emissions, and linking the NZ ETS with the EU ETS (Table 2). These three items play a role in the functioning of the NZ ETS and, consequently, in the ability for NZ to find cost-effective means to meet the reduction targets.

The NZ ETS is NZ's main policy response to climate change. It requires all sectors of the economy to report on their emissions and, with the exception of agriculture, purchase and surrender emission units to the Government for those emissions (Jiang, Sharp, and Sheng 2009). The price of emissions is intended to create a financial incentive for investment in technologies or practices that reduce emissions, and for carbon removals from forestry by allowing foresters to earn New Zealand Units as their trees grow and absorb carbon (Climate Change Information 2012). In fact, carbon removals from forestry are one of NZ's largest and most cost-effective domestic abatement options (Ministry for the Environment 2015a), and FCS is becoming the dominant strategy for mitigation worldwide (Golub et al. 2009). Thus, carbon prices derived from the modelled policy scenarios may influence foresters' decisions to afforest and liberate carbon, which consequently affect the required abatement from the rest of economic sectors. In addition, NZ is in a unique position as a developed country because of its unusual emissions profile. That is, agricultural non-carbon dioxide emissions (e.g. methane and nitrous dioxide) make up about half of NZ's gross emissions, and a large share of electricity generation (80%) comes from renewable (carbon-free) sources (Ministry for the Environment 2015b). Hence, the stringency of the reduction targets and the impacts on many sectors of the economy may be high should NZ rely only on non-agricultural domestic sectors to abate (Daigneault 2015).

Linking the NZ ETS with the EU means that permits allocated in the EU ETS can be used for compliance with environmental policies in NZ (Gruell and Taschini 2012). The Ministry for the Environment (2015a) notes the expectation that international purchasing will be important in the NZ ETS in the future, thus linking options need to be assessed. We select the EU ETS for the policy scenarios as it became the next option (Ministry for the Environment 2012) after Australia's repeal of its ETS in 2014.

Linked markets for GHG emissions may be a cost-effective path to climate change mitigation (Alexeeva and Anger 2015; Babiker, Reilly, and Viguier 2004), compared with a fragmented approach under which emission reduction targets are met in isolation (Dellink et al. 2010). In theory, linking the NZ ETS would lower the overall cost of meeting reduction targets by allowing higher-cost emission reductions in the NZ ETS to be replaced by lower-cost emission reductions in the EU ETS (Burniaux 2009), leading to harmonisation of carbon prices (Lanzi et al. 2013). However, because of changes in competitiveness positions and distortions in trade, linking may not be welfare enhancing (Flachsland, Marschinski, and Edenhofer 2009a, b). For example, though carbon price shocks within one system may be absorbed and cushioned within a larger overall market, volatility might also be imported (McKibbin et al. 1999). Thus, the benefits of spreading domestic price volatility over a larger market needs to be weighed against the costs of imported additional volatility (Flachsland, Marschinski, and Edenhoffer 2009a).

Table 2: Policy Scenarios

Forestry sequestration	NZ ETS linking	Agriculture priced
Yes/No	No linking/linking with European Union	Yes/No

3. Simulation Results

This section presents the simulation results of the environmental, macroeconomic and competitiveness impacts of NZ meeting the emission pathway compatible with the PA. We first present the baseline (Section 3.1), then report the effects for emissions abatement and purchase of permits (Section 3.2), the associated macroeconomic impacts (Section 3.3), and the competitiveness effects (Section 3.4).

3.1 Baseline

We take as focal year 2030 where GDP reaches NZ$ 349.3 billion, aggregate consumption is NZ$ 15.12 billion, and terms of trade are 1.023. Greenhouse gas emissions are 94.4 MtCO2e, and FCS is 13.8 MtCO2e at a GHG permit price of $0; for simulations we consider only additional sequestration given price changes.

3.2 Impacts on emissions market

Alexeeva and Anger (2015) note that a region's position on the emissions market is determined by the level of marginal abatement costs (MAC) in the covered sectors prior to linking. Regions with relatively low-cost abatement options will increase their emissions reductions in order to export permits to regions with relatively high marginal abatement costs, which in turn will decrease emissions abatement. We assume a competitive emissions market where the MAC equals the regional carbon permit price. The effects on domestic abatement and the import of permits are presented in Table 3.

If FCS is not accounted for and agriculture emissions are priced, permit price resulting from a non-linked NZ ETS is approximately \$314/tCO_2e, whereas linking with the EU slightly decreases the permit price to \$307/tCO_2e. This small decrease implies that, under this scenario, sectors in the EU exhibit marginal abatement costs as high as NZ. If agriculture emissions are not priced and if the NZ ETS remains unlinked, permit price reaches almost \$3,000/tCO_2e, whereas linking with the EU decreases the price to \$414/tCO_2e. These results show that even if a large sector such as agriculture is not being priced, linking with the EU alleviates pressure on priced sectors and partially offsets the stringency of the reduction target. On the other hand, accounting for FCS is NZ's option to introduce a significant degree of flexibility under the PA because permit prices are lower compared to the scenarios where FCS is not accounted. If agriculture is priced, the permit price is \$111/tCO_2e whether the NZ ETS remains unlinked or is linked with the EU; and, in turn, if agriculture is not priced, the permit price reaches \$158/tCO_2e whether the NZ ETS remains unlinked or is linked with the EU. That is, linking may be redundant or unnecessary under the presence of FCS accounting.

The mechanisms to meet the reduction target are different across scenarios. The required abatement for NZ in 2030 is 34.9 MtCO2e and Table 3 shows that NZ is capable of meeting this target without trading, although this approach could be costly. If FCS is not accounted for and agriculture is priced, no permits are imported from the EU because of the high price, and the opportunities to spread part of the mitigation burden on agriculture. If agriculture is not priced, the importation of permits from the EU should occur because it is cheaper than relying only on domestic abatement. The bulk of domestic abatement comes from energy and transport if the NZ ETS remains unlinked, but if linked with the EU ETS the burden on energy and transport almost halves as importation of permits relaxes the stringency of the reduction target. Moreover, primary sectors do not abate emissions but instead are above the baseline. On the other hand, if FCS is accounted for and agriculture is priced, no permits would need to be imported from the EU as FCS represents half of the mitigation efforts by 2030. Note that the mitigation burden across sectors is the same regardless of whether or not linking with the EU ETS occurs. In turn, if agriculture is not priced the permit price increases, which leads to further FCS and it becoming responsible for more than half of the abatement. Compared to not accounting for FCS, the mitigation burden for all sectors is consistently lower.

Overall, results show that not pricing agriculture and not accounting for FCS create a highly constrained environment where NZ relies on a small number of sectors to meet reduction targets. This is the only case where linking the NZ ETS with the EU plays an important role; however, if agriculture is priced, results are equivalent whether or not the NZ ETS is linked with the EU, implying that linking with the EU may be unnecessary, particularly if FCS is accounted for.

Table 3: Environmental impacts of alternative policy scenarios in 2030

	Forest C sequestration not accounted for		Forest C sequestration accounted for	
	NZ ETS not linked to EU	NZ ETS linked to EU	NZ ETS not linked to EU	NZ ETS linked to EU
GHG emissions permit price (in $NZ per ton of CO2e)				
Agriculture priced	314	307	111	111
Agriculture not priced	2995	414	158	158
NZ's 2030 GHG emissions reduction sources (MtCO2e/yr)				
Agriculture priced				
Domestic abatement	34.9	34.9	17.6	17.6
Energy and Transport	11.9	11.6	7.8	7.8
Primary sectors	16.6	16.9	6.1	6.1
Value added	6.4	6.4	3.7	3.7
Forest C sequestration	0	0	17.3	17.3
International permits	0	0	0	0
Agriculture not priced				
Domestic abatement	34.9	18.1	13.2	13.2
Energy and Transport	22.5	12.4	8.6	8.6
Primary sectors	2.3	-1.4	0.1	0.1

Value added	10.1	7.0	4.5	4.5
Forest C sequestration	0	0	21.7	21.7
International permits	0	16.8	0	0

3.3 Macroeconomic impacts

From a general equilibrium perspective, the economic effects of climate change policies surpass the emissions market (Alexeeva and Anger 2015), as the PA induces adjustments of production and consumption patterns towards less carbon intensity and associated energy use. The particular features of NZ are that agricultural non-carbon dioxide emissions (e.g. methane and nitrous dioxide) make up about half of the country's gross emissions, and a large share of electricity generation (80%) comes from renewable (carbon-free) sources (Ministry for the Environment 2015b; Kerr and Sweet 2008). Thus, the interaction of FCS, pricing agricultural emissions, and linking the NZ ETS leads to different impacts on GDP and welfare across the scenarios.

If FCS is not accounted for but agriculture is priced, linking the NZ ETS with the EU would lead to a 5.0% decrease in GDP below the baseline, a slightly greater decrease than with an unlinked NZ ETS (Table 4). Our estimates also indicate that the EU may not be a good match for the NZ ETS because of the significantly different sizes of both economies, likely distortions in the permit trade (Doda and Taschini 2015), the EU's own commitment to meet reduction targets, and high MACs in the EU, which lead to high carbon prices. That is, when agriculture is priced, linking with the EU does not add value to NZ, and the country could be worse off compared to with an unlinked NZ ETS. In turn, if agriculture is not priced and the NZ ETS remains unlinked, GDP decreases by at least 7% below the baseline. However, in this case, linking with the EU adds flexibility for the non-primary sectors to meet their emissions reduction requirements as the GDP impact is lower than when the NZ ETS is linked to the EU. On the other hand, if FCS is accounted for, GDP impacts decrease across all scenarios as FCS is a cost-effective mitigation option. Interestingly, GDP impacts, if agriculture is not priced, are actually lower than if agriculture is priced. That is, though non-pricing agriculture constrains non-primary sectors with a higher carbon price ($158), at the same time the high price leads to further FCS, which effectively reduces the mitigation burden in a greater degree than pricing agriculture where carbon price is lower ($111).

Predictions about the likely impact and the performance of NZ depend on the details behind the pattern of trade flows and responses from economic sectors. If FCS is not accounted for and agriculture is priced, welfare increases for NZ regardless of whether the NZ ETS is linked with the EU or not. Those welfare increases may result from the lower import prices for food commodities and increases in the domestic production of petroleum commodities. If agriculture is not priced, welfare decreases because of loss in competitiveness in non-primary sectors. More importantly, welfare decreases are greater if the NZ ETS is linked with the EU due to trade effects. On the other hand, if FCS is accounted for, welfare increases for all scenarios, which reflects the significant role of FCS in helping NZ meet its reduction target without introducing further distortions on competitiveness such as linking with the EU.

Table 4: Macroeconomic impacts of alternative policy scenarios in 2030

	Forest C sequestration not accounted for		Forest C sequestration accounted for	
	NZ ETS not linked to EU	NZ ETS linked to EU	NZ ETS not linked to EU	NZ ETS linked to EU
GDP Impact (% Change relative to baseline)				
Agriculture priced	–4.94	–5.01	–0.96	–0.96
Agriculture not priced	–7.12	–5.41	–0.58	–0.58
Social welfare impact - Hicksian equivalent variation (% change relative to baseline)				
Agriculture priced	2.83	2.83	0.75	0.75
Agriculture not priced	–2.85	–6.81	0.70	0.70

3.4 Effects on international competitiveness

This section assesses the implications of the PA terms on competitiveness. Table 5 shows economy-wide competitiveness effects as measured by changes in the terms of trade (ToT) and sectoral impacts through the Revealed Comparative Advantage (RCA) indicator. The RCA examines the export specialization pattern and compares the trade performance of an economic sector with the performance of all sectors within the region (Balassa 1965; Malmberg and Maskell 2007). It relates the ratio of a region's exports in a specific sector over the world's exports in this sector to the ratio of a region's exports in all sectors over the world's total exports (Alexeeva and Anger 2015). In the baseline, the RCA for primary sectors is 1.016, and for non-primary sectors is 0.995.

Table 5 shows that if FCS is not accounted for and agriculture is priced, NZ faces a ToT loss of 1.7% when the NZ ETS is not linked to the EU. This loss decreases to 0.9% if NZ links with the EU. If agriculture is not priced, linking with the EU leads to competitiveness losses, whereas gains occur if the NZ ETS remains unlinked. Thus, though linking the NZ ETS mitigates the negative impacts on GDP, it does not necessarily improve the aggregate trade competitiveness of NZ. That is, though linking decreases the permit price, the stringency of the reduction targets still affects import and export activities by increasing the costs of domestic production and, consequently, aggregate consumption (Alexeeva and Anger 2015). In turn, if FCS is accounted for, equivalent competitiveness losses result whether the NZ ETS is linked with the EU or not. Those losses, however, are lower if agriculture is not priced because of the decreased mitigation burden as FCS contributes to an important share of total abatement.

To decompose the national competitiveness effects at the sectoral level we use the RCA indicator. If FCS is not accounted for and agriculture is priced, there are gains in the agriculture sector but losses in the other sectors, with slightly different values depending on whether or not the NZ ETS is linked to the EU. When agriculture is priced, competitiveness gains may be due to the higher exports of cattle products and grains. In turn, losses in the competitiveness of the value added sector may be due to greater imports of food products. If agriculture is not priced, primary sectors gain competitiveness if the NZ ETS remains unlinked, but slight losses occur if it is linked to the EU. Energy and transport suffer heavy losses in competitiveness if these are the only priced sectors in the NZ ETS and there is no added flexibility through importing emissions permits, which is reflected in a weaker loss when the NZ ETS is linked. On the other hand, if FCS is accounted for and agriculture is priced, primary, and energy and transport sectors gain competitiveness regardless of the linking scheme. If agriculture is not priced, gains in competitiveness for primary and value added sectors are less than 1.3% above the baseline. Energy and transport still suffer losses although these are weaker compared to when FCS is not accounted for. FCS makes linking with the EU redundant as effects on competitiveness are similar to an unlinked NZ ETS.

A review of results in Table 5 indicates that competitiveness effects depend on the exposure of a sector to the world market. Agriculture in NZ is highly exposed to the world market but this sector may be outside the NZ ETS. The percentage changes of the RCA show that even when agriculture is not priced, the primary sectors are responsive to the stringency of the reduction target. Linking the NZ ETS with the EU helps to protect the competitive position of energy and transport sectors where FCS is not accounted for. But linking may worsen the trade position of primary and value added sectors if agriculture is not priced. Thus, negative distortionary or terms-of-trade effects may outweigh the efficiency gains for the whole economy from enabling international emissions trading.

Table 5: Competitiveness impacts of alternative policy scenarios in 2030

	Forest C sequestration not accounted for		Forest C sequestration accounted for	
	NZ ETS not linked to EU	NZ ETS linked to EU	NZ ETS not linked to EU	NZ ETS linked to EU
Terms of trade impacts (%) vs business as usual for entire economy				
Agriculture priced	–1.71	–0.87	–1.91	–1.91
Agriculture not priced	9.54	–2.69	–1.08	–1.08
Relative comparative advantage (%) vs business as usual				
Agriculture priced				
Primary sectors	18.8	17.97	10.62	10.62
Energy and Transport	–2.43	–0.10	1.73	1.73
Value added	–1.06	–1.46	–0.87	–0.87
Agriculture not priced				
Primary sectors	8.55	–0.51	–0.18	–0.18
Energy and Transport	–58.44	–13.50	–2.47	–2.47
Value added	7.23	1.40	0.27	0.27

4. Discussion

NZ has committed to reduction targets within the context of the PA; meeting these targets requires policy measures and, consequently, responses from economic sectors. Thus, the purpose of this paper is twofold; first, to estimate the economic costs derived from the commitment under the PA, and second, to characterize the mitigation potential of accounting for FCS, pricing agricultural emissions and linking the NZ ETS to other carbon markets.

Our results show that FCS plays a significant role in mitigating the stringency of reduction targets, with further implications on NZ's forest stock. NZ's total forest stock in 2015 is about 8.2 million hectares, and is estimated to remain relatively constant to 2030. About 6.4 million hectares are native or protected forests, while 1.8 million hectares are exotic forest plantations that are harvested about every 30 years. If forests are accounted for under the NZ ETS and thus can receive payments for carbon sequestration, then GTM estimates that the plantation area in 2030 could increase by 170 000 hectares where agricultural emissions are priced and by 230 000 hectares where agricultural emissions are not priced. This equates to about 13 500 ha/yr over the next 15 years, which is in line with estimates by Manley (2016) of what could feasibly be planted in NZ as a result of an increasing carbon price.

Prior research has focused on the effects on welfare and competitiveness of ETS linking. Lanzi et al. (2013) show that in the global climate mitigation scenarios presented in the OECD Environmental Outlook to 2050, macroeconomic and sectoral competiveness impacts are the largest when emissions trading schemes are not linked and the stringency of mitigation action varies substantially across countries. Linking can thus smooth distortions across the countries taking action on climate change (Jaffe and Stavins 2007). However, in this paper we found that linking the NZ ETS with the EU may not be welfare enhancing and, even more, may be unnecessary if proper accounting of FCS is implemented. That is, even though linking with the EU slightly mitigates the negative impacts from the PA if agriculture is not priced, proper accounting of FCS outweighs the benefits of linking as it can serve as a large and cost-efficient mitigation source for NZ.

Our results expand those of Infometrics (2015) and Daigneault (2015), using a global carbon market as an alternative for environmental policy. We simulate a regional market with the EU. Benefits of linking depend on the stringency of targets, which affect abatement efforts and compliance costs (Anger, Brouns, and Onigkeit 2009), modelling assumptions, and the regional and institutional context. We found that linking with the EU is advantageous only when agriculture is not priced and FCS is not accounted for. For the rest of the modelled scenarios we found that linking with the EU may not be a Pareto improvement relative to not linking the NZ ETS (Anger 2008). Our results agree with McKibbin, Shackleton, and

Wilcoxen (1999) as we demonstrate how NZ may become subject to falling terms of trade after engaging in international emissions trading. Hence, though the creation of a larger carbon market leads to more players and allowances, and thus to higher liquidity, it may not particularly benefit smaller countries such as NZ (Flachsland, Marschinski, and Edenhoffer 2009a).

Pricing agricultural emissions has a significant role in mitigating the stringency of the PA if FCS is not accounted for. In this case, agricultural emissions become a large pool to distribute the burden of mitigation efforts. Not pricing agriculture in turn is welfare decreasing, and when linking with the EU ETS, the primary gains from trading may be outweighed by pre-existing distortions and market imperfections such as distorted agricultural and energy markets in the EU, and EU countries being heavily dependent on trade (Babiker, Reilly, and Viguier 2004). On the contrary, if FCS is accounted for the stringency of the reduction target is significantly reduced and welfare actually increases. Even more, impacts on GDP are less than 1% relative to the baseline whether agriculture is priced or not.

Our modelling assumes that agriculture enters the NZ ETS by 2020 and is responsible for surrendering NZ units to match all emissions. In policy terms, however, the question remains about when NZ will set up its emissions profile after the PA comes into force. Although the agricultural sector has reported its emissions under the NZ ETS since 2012, there is currently no legislated date for when agricultural emissions will be priced under the ETS (Climate Change Information 2012). In addition, the Ministry for the Environment (2015a) notes that no progress has been made in finding economically viable and practical technologies to reduce agricultural emissions both in NZ and its trading partners.

We show results for 2030 as focal date for the INDC set by NZ. An extensive analysis for 2050 would be desirable, but technological and other developments may increase uncertainty around the results. However, we must note that the version of CliMAT-DGE used in this paper failed to find a numerical solution for the scenarios where FCS is not accounted for, the NZ ETS remains unlinked and agriculture is not priced. In other words, it was infeasible for NZ to meet the PA beyond 2030 if these three alternatives simultaneously applied. Other caveats are worth mentioning. First, we included Carbon Capture and Storage as backstop technology for non-agriculture sectors. Other new technologies would certainly lower costs and will be incorporated in CliMAT-DGE in future research. Second, we assumed that forest carbon sequestration in NZ is additional and permanent. Future research will seek to incorporate partial entry of agriculture into the NZ ETS and hybrid systems for emissions reductions (e.g. taxes and tradable permits, price floors/ceilings), linking with other ETS schemes (e.g. California, Japan or China), and issues of the compliance of FCS to the additionality and permanence criteria.

5. Conclusions

In this paper we analysed the economic costs for NZ of meeting the terms of the PA. We introduced three issues that affect the likelihood of achieving the committed reduction targets, namely, accounting for FCS, linking the NZ ETS with the EU ETS, and pricing agricultural emissions. We found that accounting for FCS plays the greatest role in mitigating the economic impact from the PA, whereas linking the NZ ETS with the EU is not necessarily desirable given its likely redundancy and the complex competitiveness implications. Hence, benefits from accounting for FCS largely outweigh those from linking with the EU. We also found that agricultural emissions are a large pool for emissions that distribute the burden of the mitigation effort, and play a significant role on the likelihood of meeting the PA if FCS is not accounted for. Overall, this paper shows that important benefits arise from our policy scenarios; consequently, an open research path is whether and how those gains can be reaped in reality given implementation, design and transaction costs.

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