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Pricing greenhouse gas emissions from Agriculture

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This paper provides an overview of the possible macroeconomic effects of the He Waka Eke Noa pricing proposals and the inclusion of agricultural emissions in the NZ ETS. The analysis is based on theory and results from previous general equilibrium (GE) modelling.

We start with a general discussion of GE modelling. This followed by an outline of options for pricing agricultural emissions, which leads into the results of the previous modelling. The paper finishes with some observations on the split-gas approach and presents some conclusions.

GE Modelling

What insights might a GE analysis provide beyond a partial equilibrium analysis?

One of the main uses of GE models is to ascertain how different GHG mitigation policies affect important macroeconomic prices, such as the terms of trade and the carbon price, and how these prices in turn affect economy-wide variables such as gross domestic product (GDP), national income and wage rates. This was the focus of previous research.

A GE analysis is also useful in situations where feedback effects from the wider economy generate changes in variables (for example input prices) that are typically held constant in partial equilibrium analysis techniques such as CBA. In the present context, whatever pricing proposal is introduced to cover agricultural GHG emissions could affect the amount of mitigation required by other industries if there is an overall carbon reduction target. Or it could affect the number of emission units New Zealand needs to purchase on international markets (if and when such markets are available). Important macroeconomic prices such as the exchange rate and the domestic NZU price would likely be affected. That in turn could alter the CBA of the He Waka Eke Noa proposals as farming profitability and land use is affected by the exchange rate.

GE analysis reflects the impacts of emissions charges at an economy-wide scale, it does not reflect the impacts on or between regions or individual farmers and growers.

Pricing Options for Agriculture

We refer loosely to agricultural emissions as covering emissions of biogenic methane (CH_4) and nitrous oxide (N_2O), recognising that farms also face GHG prices on the use of fossil fuels. Also the waste industry is a source of biogenic methane emissions.

Backstop option

Under the 'backstop option' it is expected that agricultural (dairy and meat) processors, fertiliser manufacturers and importers would be the points of obligation for emissions of methane and nitrous oxide from farms. They would be allocated emission units in the same way as emissions-intensive trade-exposed (EITE) industrial participants. Free allocation is set to start at 95% in 2025 and it is expected it would be phased out, initially by one percentage point per year.

As discussed below this configuration is formally equivalent to making farms (or groups of farms) the points of obligation for on-farm emissions. The real-world difference of course is that the price signal at the farm level would be blunted under the backstop option. This brings us to the He Waka Eke Noa options.

He Waka Eke Noa options

He Waka Eke Noa proposed two main options. Using the nomenclature in the report by Resource Economics (RE)[1]:

1. Processor Hybrid (PH): A levy at processor level with the funds used to pay for on-farm emission reductions via Emissions Management Contracts (EMC).
2. Farm Level Levy (FLL): Farmers pay a price on emissions measured at the farm level. This could be supplemented with payments for on-farm emission reductions.

Both approaches raise revenue which is assumed to be hypothecated to the agriculture sector and used to fund R&D, sequestration (generally of natives) and emission reductions, including assisting with the cost of using new technologies.

In the context of the discussion on points of obligation (see Appendix 1), from a GE modelling perspective the main difference between these options is not the point of obligation per se, but what GHG price is seen by those paying it, including how the various payment schemes (EMCs, rebates) influence the amount of emissions abatement.[2]

Previous GE Modelling

Earlier modelling (in 2011)[3] – prior to the introduction of the Zero Carbon Bill in 2019 and the setting of separate targets for CO_2 and CH_4 reductions – looked at some simple GHG pricing scenarios with agricultural CH_4 and N_2O emissions included or excluded. GHG prices were levied at industry level; for example agriculture (on-farm emissions) and processing (mostly emissions from fossil fuel combustion). The implicit assumption is that

[1] Resource Economics (2022) *Pricing agricultural GHG emissions: impacts on dairy, sheep & beef and horticulture industries.* Draft report to He Waka Eke Noa, January 2022.

[2] We understand that further research into payment schemes for abatement is currently underway.

[3] NZIER and Infometrics (2011) Macroeconomic impacts of the New Zealand Emissions Trading Scheme: A Computable General Equilibrium analysis. Report to Ministry for the Environment.

an industry response to GHG pricing is a valid aggregation of responses at the sub-industry individual firm/farm level.

The main aspects of the previous modelling were:

- Modelling focussed on the year 2020, as viewed from 2011.
- A fixed international emissions reduction obligation.
- Carbon prices of \$25 and \$100 per tonne of CO_2e, corresponding to \$0.625 and \$2.50/kg CH_4 respectively, at GWP_{100} GHG exchange rates.
- Free allocation set at 90%, declining at 1.3% pa from 2015 (the policy at the time).
- Modelling based on the 2005/06 input-output tables.

Given the above assumptions, by 2020 the prices on agricultural emissions would have been and were modelled at \$0.10/kg CH_4 and \$4/t CO_2e, and \$0.40/kg CH_4 and \$16/t CO_2e. Table 1 on the following page shows results for the latter set of prices, relative to a scenario where agricultural CH_4 and N_2O emissions are not priced – that is, completely exempt from the NZ ETS or any pricing scheme.

Note that those prices are very close to the default values used in some of the analysis in the RE report of \$0.35/kg CH_4 and \$13.80/t CO_2e. Differences in results would be within error margins.

Agricultural CH_4 and N_2O emissions decline by 2.7%, contributing to a decline in total emissions of 1.3%. The 2.7% is more than the emissions reductions at similar prices under the He Waka Eke Noa options with no incentives (i.e., technology payment/EMC). However, with the incentives for actions to reduce emissions, the He Waka Eke Noa options drive greater emissions reductions. The reduction in dairy output is slightly smaller and the sheep & beef reduction somewhat larger than in He Waka Eke Noa's PH option with similar GHG prices projected to 2030.[4] The FLL option has smaller output reductions for both sectors.

Table 1: Changes compared to no pricing of agricultural CH_4 and N_2O emissions (at \$16/t CO_2-e)

	% change v no agr price
Total emissions CO_2e	-1.3%
Agr CH_4 & N_2O	-2.7%
GDP	0.0%
RGNDI[5]	+0.4%
Real wage rate	+0.3%
Dairy output	-3.0%
Sheep & Beef output	-2.6%

Reiterating a key point, the output reductions are relative to a baseline with no price on agricultural emissions. The reductions were not large enough to represent an absolute

[4] Comparing results for 2020 and 2030 is reasonably valid as in each case the modelling is projecting forward a decade from a base year.

[5] RGNDI is real gross national disposable income, being GDP plus adjustments for net offshore factor payments (such as interest and dividend flows) and for changes in the terms of trade.

reduction relative to the starting year, 2011. In other words the rate of growth of output was lower than what it would otherwise be, but it was not negative. This is different from some of the results in the RE report as baseline output in 2030 is projected to be below output in 2017, largely as a result of water quality standards as per the National Policy Statement on Freshwater Management (NPS-FM).

Potentially a reduction in output from current or recent levels could lead to surplus processing capacity and thus, in retrospect, an inefficient allocation of capital, with macroeconomic consequences. We would expect investment plans for new processing facilities to take the risk of future surplus capacity into account.

In the GE modelling emissions of nitrous oxide are partly linked to fertiliser use while methane emissions are treated as process emissions. This means that although there is some substitutability between inputs (labour, capital, animal feed etc) which helps to reduce costs under GHG prices, the primary endogenous mechanism the model has to reduce agricultural emissions is by changing the output mix; for example more horticulture and less dairy. It is, however, possible to incorporate specific emission-reduction measures such as a methane inhibitor, or indeed on-farm sequestration.

As shown in Table 1 GDP does not change between scenarios, but RGNDI increases because the reduction in domestic emissions means that less of the nation's income has to be spent on international emission units – which cost the full $100/tonne. Unsurprisingly, any reduction of agricultural emissions at a cost of $13.80/t CO_2e is preferable to buying the equivalent reduction from overseas at $100/t CO_2e.

Overall though, the macroeconomic effects are small, and would be even smaller with lower emission prices elsewhere in the economy. At $25/t CO_2e they are almost negligible.

The drop in agricultural emissions of 2.7% is comparable to that in the He Waka Eke Noa options. Thus distinguishing between the two He Waka Eke Noa options in general equilibrium modelling runs the risk of producing spuriously accurate results – at least with GHG prices of $0.35/kg CH_4 and $13.80/t CO_2e.

Higher prices (greater than $0.35/kg CH_4 and $13.80/t CO_2e in 2030) such as those examined in the draft RE report seem to generate larger differences in emissions between the He Waka Eke Noa options, so could be worth analysing with new GE modelling. Furthermore the results could be sensitive to the relative price of CH_4 and CO_2 – see below.

Caveats

- The CGE model does not know the difference between say, all farms reducing output by 5%, and 5% of farms reducing output by 100%, or any scenario in between these extremes. Farms at the margin of profitability may well be forced to sell at a loss, but land use will not necessarily change.
- There is no sudden GHG price shock. It was assumed that GHG prices rise slowly over time. A price that gradually increases over 20 years or more will not necessarily lead to any falls in production from current levels. Rather the expansion in production from current levels would be less than under a scenario with no GHG price. Accordingly the risk of stranded assets is low.
- The same logic applies to employment. In medium-long term GE modelling total employment is typically held constant, but labour can move between industries. However, over 20 years or so farmers do not become solar panel engineers or insulation installers – although some might. Instead fewer people take up pastoral

farming than under a 'business as usual' scenario and more people enter industries such as solar power.

- The cost and industry-wide effectiveness of new technologies such as methane inhibitors was not modelled. This implies that the earlier modelling presented a sort of worst-case picture with regard to emissions abatement potential in agriculture. Thus the macroeconomic consequences of pricing agricultural GHG emissions may also have been overstated.

- Any effects that mitigation action by New Zealand might have on foreign willingness to buy New Zealand products – positive or negative – was not modelled. The Lincoln Trade and Environment Model might be useful in that regard (AERU, Lincoln University).

- Forestry emissions from land use change were assumed unchanged across scenarios. In reality a price on agricultural GHG emissions might induce some additional land use change, but the main incentive to planting is the existing recognition in the NZ ETS of carbon sequestration by forests. This was included in the GE model baseline.

- Similarly there was no account of on-farm sequestration, although the RE analysis estimates only a small contribution to overall emissions reduction from this activity and depending on what sort of sequestration outside current NZ ETS criteria might eventually be recognised.

Split-gases

The earlier modelling combined CH_4 and N_2O into CO_2e, as a split-gas approach was not a policy option considered at the time.

The government has set an international target to reduce greenhouse gas emissions by 50% below 2005 levels by 2030 and a domestic target of net zero emissions by 2050, excluding biogenic CH_4 emissions. These have a separate target of a 24-47% reduction below 2017 levels by 2050, incorporating a 10 per cent reduction below 2017 by 2030.

For He Waka Eke Noa the 2030 methane target is the objective and some of the scenarios in the RE report meet the objective, taking into account other methane reductions due to the NPS-FM that are in the baseline, and that the waste industry is also included in the target.

The international target does not currently distinguish between GHG gases. However the domestic targets do take in to account the different reductions required by short- and long-lived gases. There are implications for the wider economy if the domestic methane target is not reached and additional reductions are required from long-lived gases in order to reach the combined international greenhouse gas emissions target.

From a modelling perspective the split-gas approach is straightforward, but from a macroeconomic perspective what matters is how different mixes of GHG prices affect the economy-wide cost of meeting a given emissions target.

Conclusion

Although the 2011 modelling looked a decade ahead to 2020, was based on what is now an old set of input-output tables, and analysed emissions policies that were being debated at that time, the relative effects of different pricing regimes for agricultural emissions would likely be very similar if the analysis is repeated with the new 2019/20 input-output tables, also projecting forward a decade or so to 2030.

The key conclusion from the modelling was that the macroeconomic effects of imposing a low effective price (via free allocation) on agricultural emissions versus complete exclusion from GHG pricing are very small, albeit pointing in favour of pricing agricultural emissions.

For similar GHG prices the differences between the two He Waka Eke Noa options are smaller than the differences between a low effective price and a zero price – as previously modelled. Therefore GE modelling of the He Waka Eke Noa options would risk spuriously accurate result with regard to their macroeconomic effects. However, new modelling would be potentially useful if some of the following conditions applied:

- Much higher effective GHG prices.
- More variation between the He Waka Eke Noa options in terms of effective GHG prices, that is taking into account rebates and payments for EMCs.
- A longer forward time horizon, say 2-3 decades to 2040 or 2050 (by which time there could be higher effective GHG prices).[6]
- Relative price on methane that is very different to GWP_{100} relativities.
- The existence of viable specific emission reduction technologies such as methane inhibitors.

[6] Some GE modelling looking out to 2050, mostly in the context of freshwater reforms was undertaken for DairyNZ in 2019. See https://www.dairynz.co.nz/media/5792339/aciton-for-healthy-waterways-dairynz-submission.pdf

Appendix 1: GE Modelling – technical information

How are emissions charges modelled?

In GE modelling of emission charges a GHG price is usually levied where the emissions occur. For example households are modelled as paying the charge when they use private vehicles, even though the point of obligation is the companies that supply the fuel.

Theoretically the point of obligation is irrelevant with regard to the effects of a tax. A charge at the processor level would be passed upstream to suppliers (and downstream to consumers) in accordance with standard theory on the incidence of a tax. A GE model cannot distinguish between pricing regimes that differ only in their point of obligation.

A strength of GE models is that they can distinguish between a low standard GHG price and the same effective price delivered by free allocation in the context of a high standard price. For example a price of \$20/t CO_2e is not the same as a price of \$100/t CO_2e with 80% free allocation.

In the NZ ETS if an industry receives free allocation of emission units it still faces the incentive of the full GHG price to lower the emissions intensity of its production, but the costs of doing so are offset (partially or wholly) by the free allocation. This reduces the pressure on firms to raise output prices to cover the cost of switching to less emissions-intensive inputs or production processes.

There is, however, a national economic cost of free allocation. Because consumers of the products made by manufacturers that receive free allocation do not face higher prices, they have no incentive to switch to less emissions-intensive goods. Hence the impact of an emissions price is stymied and so the total reduction in emissions is less than what it would be without free allocation. GE models capture these effects and compare them with the possible decline or loss of some industries.

Completely exempting an industry from a price on emissions leads to even smaller reductions in emissions than under free allocation as there is no price signal at all.

In both situations then, if there is a national emissions reduction target and an industry (such as agriculture) faces a lower emissions price than that faced by other industries, either the domestic GHG price has to be higher so that other industries undertake bigger emissions reductions, or more emissions units need to be bought from overseas. The latter is the more attractive option if international emissions units can be bought at a price that is less than the domestic emissions price.

Wider economic effects and adjustment

It is usually assumed in GE modelling that paying for international emission units is not covered simply by borrowing foreign currency, which would put pressure on New Zealand's Balance of Payments current account. That cannot be sustained indefinitely and, in any case, could place an unfair burden on future generations.

Pressure on the current account is usually met with a depreciation of the exchange rate, which is what occurs in GE modelling. That leads to an increase in net exports (more exports and/or less imports), thereby generating the additional foreign exchange that is needed to purchase the international emissions units.

Inevitably much of the increase in exports would come from agriculture, especially if it is exempt from an emissions price or has substantial free allocation. Hence a vicious circle arises; agricultural exports are relatively emissions intensive, so more emission units need to be bought, requiring yet more exports – and so on.

Further, as more agricultural exports are put into the world market, diminishing returns can be expected. Returns to land decline and so do the terms of trade. Hence there is a progressively increasing cost to aggregate economic wellbeing from free allocation, or from limiting prices to less than that faced by other sectors, and especially, from outright exemption from GHG pricing.

At the same time as a lower exchange rate assists exports, it also raises the cost of imports, which lowers the standard of living, as do lower terms of trade. Inter-industry linkages multiply these effects throughout the wider economy in the form of upstream and downstream impacts. Some exporters would invest in expansion while simultaneously household spending may contract, leading to more demand for labour in some industries and in some places, and less demand for labour elsewhere.

Naturally there are always other forces and events that affect the exchange rate and the terms of trade. At any point in time they may be favourable or unfavourable to agriculture. We do not know what the price for milksolids will be in 2030 for example. The point of modelling is to try and understand what the forces would be on the exchange rate and the terms trade (and many other variables) from a price on agricultural GHG emissions.

Empirically the issue is how quickly the national cost (lower terms of trade and thus a drop in real national income) of sheltering an industry from a full emissions price increases, relative to the cost of more domestic abatement in response to a higher emissions price.