Micro-level Employment Impacts of Climate Policies

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Abstract

We develop and apply techniques to estimate the micro-level employment impacts of climate policies in New Zealand. Our approach links an economy-wide model with a micro simulation module to calculate employment changes for different groups of the population across several dimensions (and combinations of dimensions), including sectoral, geospatial, demographic, and socio-economic categories. By simulating the linked modelling framework out to 2050 for proposed climate policies, we estimate which industries, workers and jobs are expected to be most affected by these policies. Industries that experience the largest negative employment impacts include coal mining, oil and gas extraction, and some manufacturing activities. Employment in Taranaki and West Coast - which have high concentrations of negatively affected industries – fall, while employment in most other regions increases. On the net positive side, reflecting the deployment of labour-intensive abatement options, some agriculture industries experience the largest employment increases. Overall, the net employment effects are predicted to be relatively small, though some industries will be more affected than others.

Keywords: Climate Change, Just Transition, Distribution Impacts

JEL classifications: C68, Q40, Q54, Q58.

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1. Introduction

As countries develop and implement policies to combat climate change, there has been demand for a parallel framework to protect the livelihoods of workers. The International Labour Organization (ILO) states that a 'just transition' towards environmentally sustainable economies should 'promote the creation of more decent jobs, including as appropriate: anticipating impacts on employment, adequate and sustainable social protection for job losses and displacement, skills development and social dialogue' (ILO, 2015, p. 6).

Early concerns for worker outcomes when curbing greenhouse gases (GHGs) were expressed in the Paris Agreement (UNFCCC, 2015) preamble, which urged parties 'to promote a just transition of the workforce and the creation of decent work and quality jobs'. Subsequently, at the 24th Conference of the Parties (COP24) of the United Nations Framework Convention on Climate Change (UNFCCC) in 2018, over 50 countries signed the Solidarity and Just Transition Silesia Declaration. The Declaration encouraged nations to consider 'the issue of just transition of the workforce and the creation of decent work and quality jobs' when 'developing 'long-term low greenhouse gas emission development strategies' (UNFCCC, 2018, p. 9). It also stressed that a just transition was needed to enhance public support for achieving the goals of the Paris Agreement. In 2021, at the 26th Conference of the Parties (COP26) the Just Transition Pledge (UNFCCC, 2021) was adopted by the European Union and 14 countries.[1] The Pledge recognized that reducing emissions risks exacerbating gender, racial, age and other inequalities, advocated the need to support workers in the transition to new jobs, and required countries to include information on just transition efforts in national Biennial Transparency Reports.

Most literature relating to within-country distributional impacts of climate change policies primarily assesses the impact of carbon pricing on household energy bills, household incomes, or overall employment levels (Goulder et al., 2019; Longhi, 2015; Nikodinoska & Schröder, 2016; Preston et al., 2010; Rausch et al., 2011; Schaffrin & Reibling, 2015; Wang et al., 2016; García-Muros et al., 2022). In recent examples, (1) García-Muros et al. (2022) use an economy-wide model of the US coupled with household microdata on consumption patterns and income to evaluate the distributional impacts of carbon pricing under alternative revenue recycling schemes, and (2) Chepeliev et al. (2021) use a global economy-wide mode linked to a micro simulation model to analyze the poverty and distributional impacts of Nationally Determined Contribution goals under alternative emission trading scenarios. Although expenditure and fiscal transfers are important distributional issues, these studies do not consider employment changes at the heart of the just transition movement.

[1] Signatories to the Just Transition Pledge include Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Italy, the Netherlands, New Zealand, Norway, Poland, Spain, Sweden, the UK, and the US.

A handful of studies estimate detailed employment changes due to climate policy. For example, Hafstead & Williams (2019) focus on employment effects by industry using a search-CGE model (based on US labour markets) They found that short-run differences (less than 18 months) in unemployment rates (including size and duration) between the policy and the business-as-usual scenarios largely depend on two things: (1) the ease with which workers could change industries, and (2) the magnitude of reallocation across industries caused by environmental policies. Moreover, some sectors with high business as usual worker turnover and unemployment rates in business-as-usual (e.g., coal mining) had lower unemployment rates in policy scenarios as environmental policies accelerated workers movement into lower-turnover sectors.

The literature review by Hafstead & Williams (2020) obverse that changes in jobs due to environmental policies are primarily reallocations across industries as opposed to substantial aggregate effects such as large net job gains or net job losses. Moreover, they find that most job reallocation occurs via less hiring rather than through separations. Overall, Hafstead & Williams (2020) conclude that environmental policies have little effect on overall employment, particularly in the long run, and that pre-announcements and phasing-in policies have can counter the short-term negative effects of environmental policies. An open question for future research identified by the authors is, how do policy-induced job changes affect different types of workers? That is, do workers easily transition from one industry to another, or are some types of workers harmed or advantaged?

To address the gap between existing research and the needs of policy makers, this paper develops and applies techniques to calculate the micro-level employment impacts of climate policies in Aotearoa New Zealand, a signatory to the Just Transition Pledge. Additionally, focusing on New Zealand allows us to exploit a unique dataset that links employees and their demographic information to employers. Our approach connects an economy-wide climate policy analysis model with micro data simulations to calculate employment changes for different groups of the population across several dimensions (and combinations of dimensions), including sectoral, geospatial, demographic, and socio-economic categories. Ultimately, the modelling framework can be used to inform the development of complementary policies to assist a just transition to a low carbon future. The modelling tools developed in this research are open source are available from the (New Zealand) Climate Change Commission (CCC).

This paper has three further sections. Section 2 outlines our modelling framework. Section 3 presents and discusses the results. Concluding remarks are offered in Section 4.

2. Modelling framework

Our analysis uses the Climate PoLicy Analysis (C-PLAN) model (Winchester and White, 2022) to estimate the aggregate and broad sectoral impacts of climate policy, and the Distributional Impacts Microsimulation for Employment (DIM-E) module (Riggs and Mitchell, 2021a, 2021b) to calculate employment impacts for workers with different characteristics. The two models are linked by mapping employment changes in the 38 sectors in the C-PLAN model to the 213 three-digit industries represented in the 2006 Australia and New Zealand Standard Industrial Classification (ANZSIC) (Trewin and Pink, 2008).

2.1 The CLimate Policy Analysis (C-PLAN) model

The C-PLAN model is a global computable general equilibrium (CGE) model built for the analysis of New Zealand climate policies. In its base configuration, the model represents two regions (New Zealand and the Rest of the World), 38 production sectors (see Table 1), and three sources of final demand (household consumption, government expenditure, and investment). For each production and expenditure activity, the model tracks four GHGs (carbon dioxide, CO_2; methane, CH_4; nitrous oxide, N_2O; and aggregated fluorinated gases, F-gases) measured in tonnes of CO_2-equivalent (CO_2e) units. The model is recursive dynamic and is solved annually from 2014 to 2050. For each year and scenario, the equilibrium solution in the model projects, among other variables, production, employment, GHG emissions, imports and exports for each sector.

Reflecting the prominence of agricultural and forestry activities in the New Zealand economy, salient features of the C-PLAN model include (1) methane-reducing technologies for livestock in dairy farming and beef and sheep farming, (2) land-use change, and (3) emissions sequestered from afforestation. The model also represents electric vehicles, geothermal electricity with carbon capture and storage (CCS), and heat produced from biomass. The C-PLAN model is described in detail by Winchester and White (2022) and the model is freely available from the CCC.[2]

Calibration of the model in the benchmark year (2014) uses economic data from Version 10 of the Global Trade Analysis Project (GTAP) Power Database (Peters, 2016; Chepeliev, 2020), and GHG emissions data from New Zealand's GHG Inventory 1990–2017 (MfE, 2019a). The C-PLAN model is coded using the Mathematical Programming Subsystem for General Equilibrium (MPSGE) (Rutherford, 1999), a subsystem of the in the Generalized Algebraic Modeling System (GAMS, 2021), and utilizes data aggregation tools provided by Lanz and Rutherford (2016).

[2] The code for the C-PLAN model can be obtained by contacting the CCC via their web site: https://www.climatecommission.govt.nz/.

Table 1. Sectors represented in the C-PLAN model.

Agriculture, forestry, and fishing		**Manufacturing**	
rmk	Dairy farming	crp	Chemical, rubber, and plastic products
b_s	Beef and sheep farming	nmm	Non-metallic minerals (e.g., cement)
oap	Other animal products	nfm	Non-ferrous metals (e.g., aluminum)
hor	Horticulture	i_s	Iron and steel
frs	Forestry	fmp	Fabricated metal products
fsh	Fishing	mil	Dairy processing
		mtp	Meat products
Energy extraction, production & distribution		ofd	Other food products
col	Coal mining	w_p	Wood and paper products
cru	Crude oil extraction	mvh	Motor vehicles and parts
oil	Refined oil products	omf	Other manufacturing
gas	Natural gas extraction and distribution		
oxt	Other mining	**Construction and services**	
ecoa	Coal electricity	cns	Construction
egas	Gas electricity	afs	Accommodation and food services
enuc	Nuclear electricity*	ser	Other services
ehyd	Hydro electricity		
ew_s	Wind and solar electricity	**Commercial transport**	
eoth	Geothermal and other electricity	rtp	Road transport
tnd	Electricity transmission and distribution	wtp	Water transport – domestic
		wtpi	Water transport – international
		atp	Air transport – domestic
		atpi	Air transport – international
		Household transport	
		hht	Household transport

Note: * Nuclear electricity is only represented in the Rest of the World.

2.2 Linking C-PLAN and DIM-E

The C-PLAN model estimates employment indexes for 38 sectors and the DIM-E categorizes production according to 213 ANZSIC three digit industries. C-PLAN sectors are built on sectors in the GTAP Data Base and there is not a concordance between GTAP and ANZSIC sectors. Consequently, sectoral results from the C-PLAN model are first downscaled using a concordance from GTAP to International Standard

Industrial Classification (ISIC) sectors (Center for Global Trade Analysis, 2019), and then a concordance from ISIC sectors to ANZSIC 3-digit groups (Australian Bureau of Statistics, 2008). In this procedure, most C-PLAN sectors map exactly to one or more ANZSIC codes. In these cases, the proportional change in the C-PLAN sector is assigned to all ANZSIC groups that correspond to that sector.

Six ANZSIC 3-digit groups map to more than one C-PLAN sector (Table 2). In these cases, the proportional employment change in each ANZSIC group is calculated as an employment-weighted average of employment changes in the corresponding C-PLAN sectors. For example, employment changes for the ANZIC group 'Mining and resource extraction' (070) is an employment-weighted average of changes in the C-PLAN sectors 'Crude oil' and 'Natural gas extraction and distribution'.

Table 2. ANZSCI 3-digit groups that map to more than one C-PLAN sector.

ANZSIC 3-digit group	C-PLAN sectors
052	Dairy farming, Beef and sheep farming, Other animal products, Horticulture, Forestry, Fishing
070	Crude oil extraction, Natural gas extraction and distribution
101	Crude oil extraction, Natural gas extraction and distribution, Other mining
109	Crude oil extraction, Natural gas extraction and distribution, Other mining
261	Coal electricity, Gas electricity, Hydro electricity, Wind and solar electricity, Geothermal and other electricity, Electricity transmission and distribution
501	Road transport, Water transport – domestic, Water transport – international, Air transport – domestic, Air transport – international

2.3. The Distributional Impacts Microsimulation for Employment (DIM-E) module

The DIM-E module consists of two components: the first component estimates industry-level employment effects, and the second simulates the characteristics of impacted workers and jobs. The module is described in detail in Riggs and Mitchell (2021b).

The DIM-E module uses data sourced from Statistics New Zealand's Integrated Data Infrastructure (IDI) and Longitudinal Business Database (LBD). These data include population-wide, administrative, census, and survey data for people and businesses. Each individual person or entity is given a unique identification number which allows them to be linked across different data sets. This allowed us to observe enterprise-level (the tax-reporting legal entity) and establishment-level (geographic units such as retail shops or warehouses) related to the business or businesses for which an individual works as well as information about employees (e.g., age, gender, ethnicity).

The unit of observation in the data set is a worker-job, which we define as the employment relationship between a worker and a single enterprise. Each worker-job is assigned to an establishment, and the industry and region for each worker-job is based on the establishment's industry and region.

Using linked employer-employee data, we calculate the number of worker jobs in each ANZSIC three-digit industry in 2014 (the benchmark year for our analysis). For each worker-job, we also observe the following worker-job characteristics: gender, ethnicity, age, highest qualification attained, earnings from wages and salaries, region of employment (for 17 geographical areas), level of effort (measured full-time equivalent, FTE, units). As worker characteristics typically differ for short spell worker-jobs (a worker-job relationship of fewer than three months) and other worker jobs in the same industry, we also identify whether each worker-job was a short spell or a non-short spell worker-job. DIM-E estimates employment of worker-job equivalents (WJEs) in each industry by multiplying the employment indexes (downscaled from C-PLAN sectors to ANZSIC three-digit industries) by base-year-worker jobs in each industry.

The DIM-E module also estimates changes in employment by worker characteristics (e.g., age, gender, region of residence). In the baseline scenario, worker characteristics in each industry are assumed to move in fixed proportions with industry employment (e.g., if industry employment doubled, there would effectively be two of each individual). In the policy scenario, employment changes are expressed relative to those in the baseline. The types of worker-jobs that leave contracting industries (or are added to expanding industries) are estimated, using a two-level simulation procedure. First, the module simulates if each worker lost (or added) was a short-spell or non-short-spell worker-job. Second, for each type of worker-job, the characteristics of each lost (or added) worker are determined using a series of simulations (one for each characteristic) using the Mersenne-Twister random number generator (Matsumoto & Nishimura, 1998) and an appropriate distribution for each characteristic – see Riggs and Mitchell (2021b) for details. Using this approach, for short-spell and non-short spell worker-jobs, the DIM-E module provides the gender, age, highest qualification, and ethnicity of lost (or added) workers, and the average earnings, and region of each lost (or added) worker-job.

2.4 Scenarios

To evaluate the impact of climate policies, we simulate the modelling framework for the 'baseline' and 'policy' scenarios consider by Winchester and White (2022). The baseline scenario simulates current policies, anticipated changes in technology and socioeconomic drivers, and resource and regulatory constraints that limit the expansion of certain sectors. In the policy scenario, we simulate two Emissions Trading Schemes (ETSs) that begin in 2022 and impose caps on GHG emissions consistent with the Climate Change Response (Zero Carbon) Amendment Act 2019 (New Zealand Government, 2019). Biogenic methane emissions are include in one ETS. The cap on these emissions is gradually lowered over time so that they are 24% below their 2017 level in 2050. All other GHG emissions, except emissions from international transportation, are included in the other ETS. The cap on these emissions is reduced over time so that net emissions (gross emissions minus emissions sequestered by forests) are zero in 2050. The impacts of climate policy are evaluated by comparing results from the policy scenario to those from the baseline scenario.

3. Results and discussion

Summary results from the C-PLAN model in selected years are presented in Table 3. In 2050, GDP in the Policy scenario is 0.34% lower than in the baseline and welfare, measured using the Hicksian equivalent variation in income, is 0.26% lower. Reflecting advances in technologies for reducing biogenic methane emissions, the ETS price for these emissions falls from \$115 per tCO_2e in 2035 to \$53 in 2050. In contrast, driven by tightening of the emissions cap, the ETS price on other GHGs rises consistently over time and reaches \$338/ tCO_2e in 2050.

Table 3. Summary results for 2035 and 2050.

	2015	2035		2050	
		Baseline	**Policy**	**Baseline**	**Policy**
GDP and welfare					
GDP, billion 2017$	252.0	396.0	395.4	512.1	510.4
Consumer welfare, billion 2017$	120.7	190.4	190.2	247.0	246.3
CO2 prices, 2017\$/tCO_2e					
Biogenic methane ETS	-	35.00	114.68	35.00	53.44
Other GHGs ETS	3.37	35.00	120.81	35.00	337.79

As noted above, we map employment changes for C-PLAN sectors to ANZSIC three-digit industries and use the DIM-E module to assess the impact of the climate policies on employment. Table 4 reports cumulative employment gains for the ten industries with the largest (absolute) increases. In addition to reporting the number WJEs gained, the table also displays the change as a percentage of employment in that sector, and selected average worker characteristics in each industry. As emissions from international transportation are excluded from climate policies, some of the largest employment increases are in sectors related to this activity (e.g., Air and space transport and Water transport support services). There are also relative large employment increases in Sheep, beef cattle and grain farming; and Dairy cattle farming. This is because the methane-reducing technology used in policy scenario results in more labor-intensive farming (e.g., additional workers to administer methane vaccines) than in the baseline scenario. There are also relative large employment increases in tourist-related industries (Cafes, restaurants and takeaway food services, and Accommodation).

The average worker characteristics reveal that, with exception of transport-related industries, workers in expanding industries have relatively: low FTE appointments, low annual earnings, and a high number of jobs. Also, workers in Cafes, restaurants and takeaway food services are relatively young.

Table 4. Industries with the largest employment increases between 2022 and 2050 and average worker characteristics.

ANZSIC three-digit sector		Employments changes		Average worker characteristics			
Code	**Description**	**Number (WJE)**	**Percent**	**Annual FTE**	**Annual earnings**	**Jobs per worker**	**Age**
I490	Air and Space Transport	967	10.38%	0.80	70,476	1.14	37.8
A014	Sheep, Beef Cattle and Grain Farming	751	4.16%	0.40	23,427	2.69	35.2
I521	Water Transport Support Services	607	11.78%	0.78	66,253	1.15	43.7
H451	Cafes, Restaurants and Takeaway Food	569	0.53%	0.48	21,466	1.30	28.3
A016	Dairy Cattle Farming	562	2.29%	0.65	38,663	1.25	32.9
A052	Agriculture and Fishing Services	470	2.24%	0.46	25,868	1.52	31.9
I552	Air Transport Support Services	255	10.38%	0.80	70,476	1.14	37.8
C239	Other Transport Equip. Manufacturing	229	2.34%	0.88	75,646	1.08	41.6
H440	Accommodation	183	0.53%	0.54	26,145	1.29	34.1
A041	Fishing	148	9.24%	0.67	51,087	1.21	38.0

The ten industries that experienced the largest employment decreases between 2022 and 2050 and the average characteristics of these workers are display in Table 5. The list includes nine manufacturing industries and oil and gas extraction. There is also a large proportional decrease in coal mining worker-jobs (not listed in Table 5) but, due to the size of this sector, a modest absolute decrease. Compared to positively impacted industries, worker-jobs in the top negatively affected industries are higher paid, have higher FTE levels, and workers are older and have higher jobs per worker. Worker-jobs in oil and gas extraction are paid significantly more and are older than workers in other industries.

Table 5. Industries with the largest employment losses between 2022 and 2050 and average worker characteristics.

ANZSIC06 three-digit sector		Employments changes		Worker characteristics			
Code	Description	Number	Percent	Annual FTE	Annual earnings	Jobs per worker	Age
C249	Other Machinery and Equipment Manufacturing	-606	-4.66%	0.81	59,127	1.13	36.7
C149	Other Wood Product Manufacturing	-341	-3.00%	0.83	52,401	1.11	32.4
C161	Printing	-305	-3.00%	0.77	49,716	1.14	30.1
C251	Furniture Manufacturing	-304	-4.66%	0.80	47,712	1.11	31.0
C222	Structural Metal Product Manufacturing	-271	-2.23%	0.85	57,686	1.10	34.0
C246	Specialised Machinery and Equipment Manufacturing	-270	-4.66%	0.85	63,686	1.11	31.6
C141	Log Sawmilling and Timber Dressing	-257	-3.00%	0.84	53,158	1.11	33.7
B070	Oil and Gas Extraction	-247	-26.85%	0.94	211,722	1.04	45.9
C241	Professional and Scientific Equipment Manufacturing	-220	-4.66%	0.90	72,723	1.08	33.4
C133	Textile Product Manufacturing	-207	-4.66%	0.80	47,913	1.12	32.4

Turning to regional impacts, Figure 1 presents aggregate employment changes in the policy scenario relative to the baseline for 17 geographic areas. The largest employment decreases are in Taranaki and the West Coast. This is because key negatively impacted industries are concentrated in these regions – Oil and gas extraction for Taranaki and coal mining for the West Coast – and those industries account for large shares of GDP in those regions.

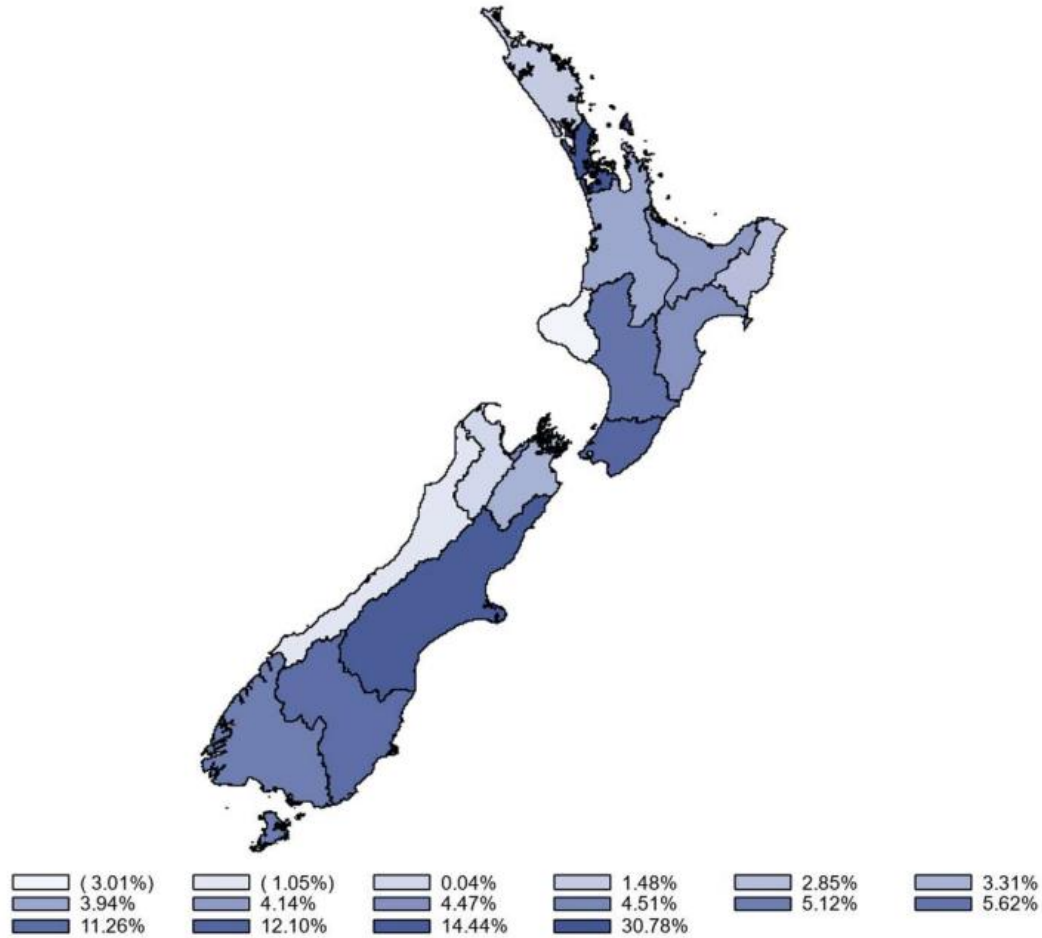

Figure 1. Aggregate employment changes by region in the policy scenario relative to the baseline, 2022-2050.

4. Conclusions

We developed a modelling framework to estimate detailed employment effects due to climate policy. The tool suite used a CGE model to estimate the economy-wide and employment impacts of climate policy for 38 aggregated sectors. These employment changes were mapped to the 213 industries. A micro dataset and a simulation model were then used to estimate employment changes for workers across several dimensions. Industries that experience the largest negative employment impacts include coal mining, oil and gas extraction, and some manufacturing activities. Employment in Taranaki and West Coast - which have high concentrations of negatively affected industries – fell, while employment in most other regions increased. On the net positive side, reflecting the deployment of labour-intensive abatement options, some agriculture industries experienced the largest employment increases. Overall, the net employment effects are predicted to be relatively small, though some industries will be more affected than others. The modelling tool suite is currently used by the CCC to provide climate policy advice to the New Zealand government. It is hoped that the models can be used to inform the development of complementary policies to assist a just transition to a low carbon future in New Zealand and, by making them open source, other countries.

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