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Understanding structural change from transitioning to a low-carbon economy: an integrated multi-model approach for Australia

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Abstract: Using an integrated modelling approach, we model the structural change associated with net zero emissions (NZE) for Australia along with global action to limit warming to 1.5°C by the end of the century. This scenario is implemented using a two-stage integrated approach that links two computable general equilibrium (CGE) models – one representing the world economy at a broad level and the other representing the Australian economy in greater detail. Results indicate that achieving NZE would contract the global and Australian economy. The NZE pathway is transformative for the energy sector but disruptive to other industries. Electricity generation increases as the Australian economy shifts from fossil-fuel-based energy to renewable energy. Economic activity of the non-energy sector contracts due to higher production costs related to the cost of abatement. Sensitivity analysis indicates that the GDP effects are rather sensitive to the speed with which NZE is reached.

Keywords: *computable general equilibrium; model integration; net-zero transition; energy mix; structural change; Australia*

1. INTRODUCTION

As concern about global warming has increased, the scientific focus has rapidly evolved from understanding the magnitude of climate change to developing and applying tools that manage the most pressing risks associated with it. Climate risks are typically classified as either physical or transition risk. Physical risk can be further classified as comprising chronic risks (e.g., temperature changes) and acute risks (e.g., floods, cyclones, bushfires). In contrast, transition risk arises from the structural change required to move towards a low carbon economy. This risk encompasses shifts in energy generation and use, transport modes, material flows, production technologies and consumption preferences. Scientists now recognise that understanding and managing this multifaceted economic transition will be one of the most important adaptations to climate change. Using an integrated modelling approach, this study explores the potential economic effects of global and Australian transition pathways to net zero emissions (NZE). More specifically, the NZE scenario implements a global setting where coordinated action is taken to limit warming to 1.5°C. Within this global setting, Australia reaches NZE in 2040 and then moves to negative net emissions by 2050.

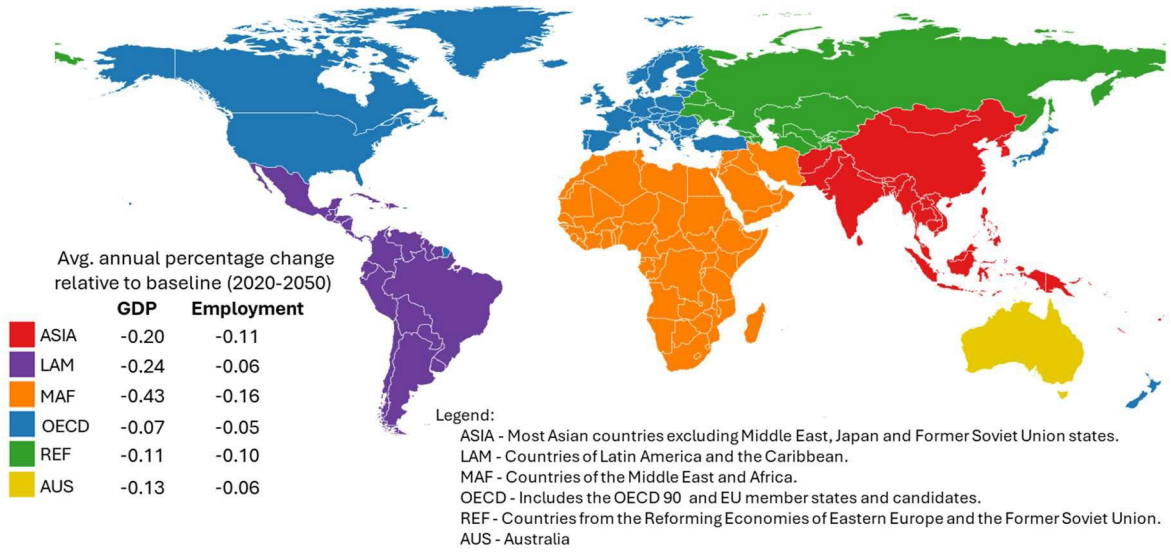
2. METHODOLOGY

To inform policy makers, scientists and economists have developed a suite of tools known as integrated assessment models (IAMs). Macroeconomic modelling, especially the computable general equilibrium (CGE) framework, has been an integral part of IAMs. CGE-based IAMs capture the interactions between physical and economic systems by linking geophysical data with economic flows. This study integrates two CGE models to conduct NZE scenario analysis - one representing the global economy with multiple regions (GTEM - Global Trade and Environment Model), and the other representing the Australian economy with greater sectoral resolution (ATEM - Australian Trade and Environment Model). The two models are integrated in a two-stage process. In the first stage, we run GTEM to simulate the economic effects of NZE at the global level and explore how the global macroeconomic effects influence the Australian economy through international investment and trade. In the second stage, we apply the GTEM results for Australia as an input to ATEM. This linkage captures the interaction of the domestic economy with the world market. As ATEM has a more precise specification of the domestic economy, the second pass of our economic modelling generates detailed and fine-tuned results of the economic effects for Australia.

3. RESULTS

The results show that achieving NZE causes a negative shock to the economy as it requires substantive transformation of the Australian and global economy. The abatement cost of decarbonising the economy raises the cost of production thereby increasing consumer prices, which in turn leads to a reduction in total output and employment. The results show that global CPI is 0.18 percentage points higher per year under the NZE scenario relative to baseline. This causes the annual growth in global real GDP to fall by 0.17% and employment 0.10% relative to baseline. Figure 1 decomposes the macroeconomic results across broad global regions. Overall, the global NZE pathway causes a higher reduction in economic activity for low- and middle-income countries than high-income countries. For Australia, the CPI is 5.67% higher (or 0.19% p.a.) in the NZE scenario relative to baseline over the 30-year simulation period. Real GDP is 3.95% lower (or 0.13% p.a.) and employment is 1.97% (or 0.06% p.a.) lower relative to baseline. We test the sensitivity of economic results to three parameters: (1) the timeframe of achieving the NZE target, (2) the cost of carbon-price induced emissions reduction, and (3) the size of the productivity loss due to temperature increases. The results are most sensitive to the first parameter, with the GDP loss 42% higher when the NZE target is achieved 5 years earlier.

Figure 1. Macroeconomic results across broad global regions



The NZE pathway causes significant structural change in the Australian economy. First, there is a significant change in the electricity fuel mix as the economy transitions from non-renewable to renewable energy sources. The energy transition impacts coal production, and to a lesser extent gas, as energy generation from wind and solar increases. Second, there is a significant change in the energy mix across sectors as driven by relative prices in energy commodities. The initial energy mix of most sectors is dominated by oil-derived fuels such as petroleum and diesel. The share of fossil fuels declines over time in both the business as usual (BAU) and NZE scenarios and is offset by an increase in the use of electricity with a much stronger switch to electricity under the NZE pathway. Third, the sectoral emissions pathway is transformative for the energy sector but disruptive to other industries. Electricity generation expands by 1.45% per year on average, while the non-energy sector contracts due to higher production costs related to the cost of abatement. The disruption effects vary widely across sectors with an annual average output loss ranging from 0.05 to 0.60 percentage points.

4. CONCLUSION

This study explores the economywide effects of a global and Australian net zero emissions (NZE) trajectory using an integrated CGE modelling approach. The NZE scenario envisions a global setting in which coordinated action is taken to limit warming to 1.5°C. Within this global setting, Australia reaches NZE in 2040 and then moves to negative net emissions by 2050. Modelling results show that achieving NZE brings a negative shock to the economy as it requires substantive transformation of the Australian and global economy.

