The Economic Incidence and Interactions of Climate Change Impacts in the United States Across Regions, Sectors, and Households

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Abstract
The Fourth US National Climate Assessment cites two studies that examine the economic impacts of climate change within the United States using multi-sector frameworks: EPA's Climate Impacts and Risk Analysis (CIRA) Project and the Climate Impact Lab's American Climate Prospectus. The present study explores the incidence and interactions of these sectoral climate impacts in a 29-region computable general equilibrium of the United States. The present study builds upon previous work by 1) developing the distribution of impacts across a range of climate scenarios, 2) exploring the interactions of the impacts across regions and sectors, and 3) assessing impacts across households with different income levels.

1. Introduction

Estimating the economic impact of climate change is an essential but challenging task. The numerous studies tackling this issue over the past few decades have taken various approaches. The Intergovernmental Panel on Climate Change (IPCC 2001) categorizes assessment methodologies examining the linkages between the economy and specific GHG emitting sectors into 'bottom-up' engineering oriented approaches (i.e. partial equilibrium, simulation and partial forecasting approaches) and 'top-down' economic approaches (i.e. macroeconomic and computable general equilibrium (CGE) models.

We estimate the costs of climate impacts and adaptation at the level of US regions in an economy-wide, computable general equilibrium model, USREP. This study begins with a cross-model comparison of climate impacts from the six sectors explored by Hsiang et al. (2017), also known as the American Climate Prospectus (ACP). The most recent comprehensive and spatially resolved study of the impact of climate change on the economy by Hsiang et al. (2017) is based on an integrated, dynamic and flexible architecture, the Spatial Empirical Adaptive Global to-Local Assessment System (SEAGLAS). This system estimates the value of market and nonmarket damages for agriculture, crime, coastal storms, energy, human mortality, and labor at the county level in response to global mean temperature.
Previous work introduced the median damage estimates from RCP8.5 and RCP4.5 from the ACP into USREP. This effort uses damage estimates from specific climate models from the CMIP5 archive as reported in Hsiang et al. (2017).

2. The USREP Model

This version of the USREP model (Yuan et al., 2019) represents the US economy as 29 regions, 11 sectors, and 9 households in a recursive dynamic computable general equilibrium framework. Social accounting matrices are based on IMPLAN. Physical energy flows and energy prices are based on EIA's State Energy Data System.

3. ACP climate impacts in USREP

We use median estimates of mortality death age, labor and crop yields as used in Hsiang et al. (2017)'s study (henceforth called ACP impacts). Those estimates are provided in relative (%) changes in physical quantities indexed to 2012=0 for each RCP, climate model, and state. To use these estimates as input into the USREP model, we convert them at the USREP regional level with a 2015 base year.

ACP impacts on mortality, labor productivity and agriculture are depicted in Figure 1 and 2 at the USREP regional level for the RCP8.5 scenario in 2100. Figure 1 shows ACP impacts on total labor productivity weighted by sectoral demand. In 2100 under RCP 8.5, labor productivity losses lower consumption by almost $1.7 trillion and GDP by $2.7 trillion. Agricultural impacts lower consumption and GDP by $200 billion and $500 billion, respectively. Heat mortality effects lower consumption by $400 billion, but have much less of an effect on GDP. When all impacts are introduced simultaneously, the consumption effects are less than the sum of the separate effects. GDP is roughly additive.

Figure 1. ACP changes in consumption and GDP due to mortality, agriculture, and labor productivity impacts in 2100 under the RCP8.5 scenario

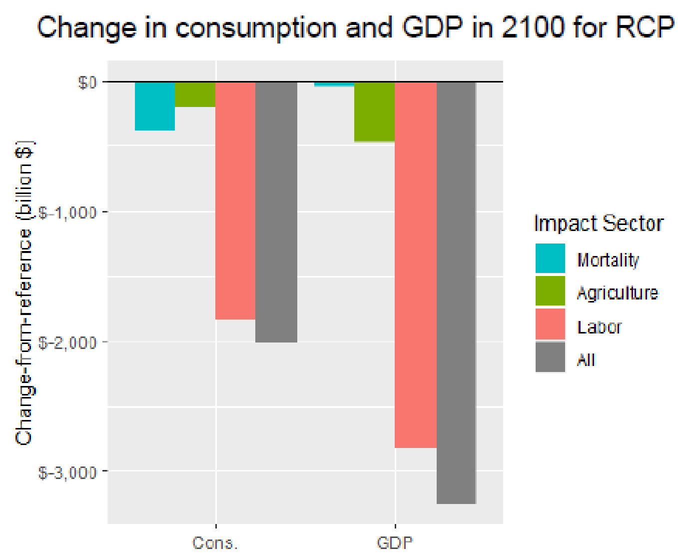
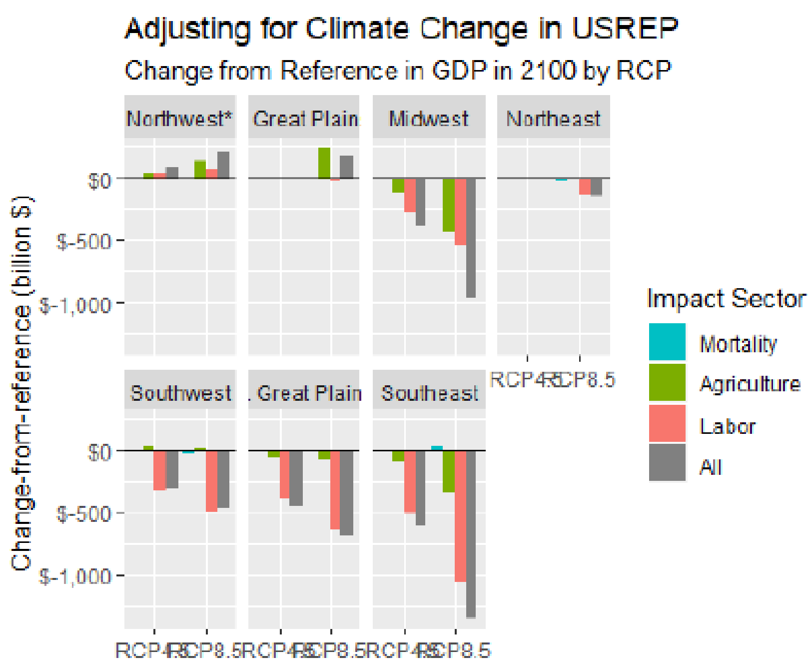


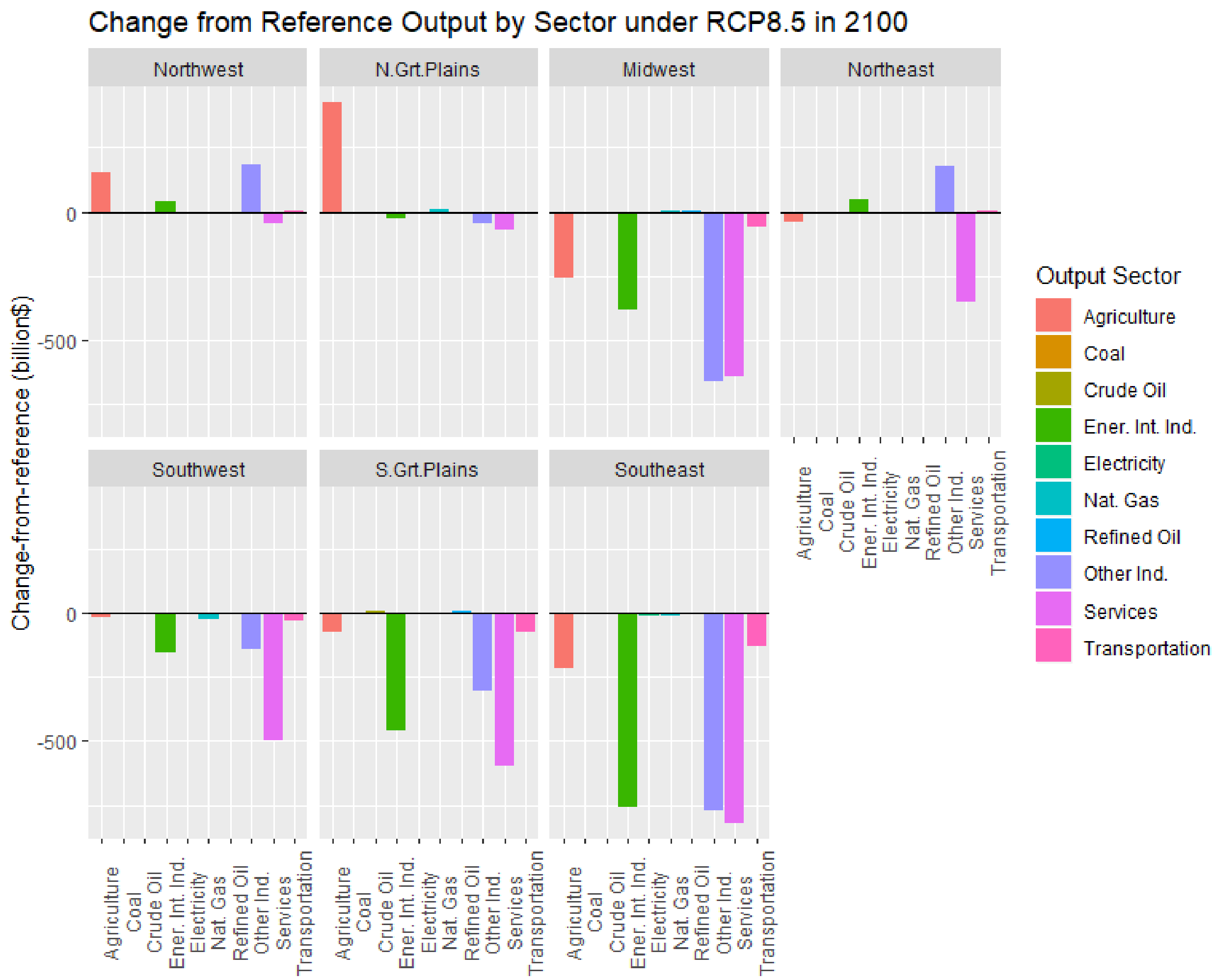
Figure 2 illustrates the impacts to GDP across regions as well as for RCP 4.5. Impacts are substantially lower under RCP 4.5 than RCP 8.5 with some regional variation. Impacts across the Northwest, Northern Great Plains, and Northeast are minimal under RCP 4.5. In fact, improved agricultural productivity in the Northwest and Great Plains raises consumption and GDP under RCP8.5. This effect is muted under RCP 4.5. Labor impact in the Midwest, Southwest, and Southeast are reduced by roughly 50% under RCP4.5, yet the reductions in the Southern Great Plains are only 30%.

Figure 2. Regional impact on GDP under RCP4.5 and RCP8.5



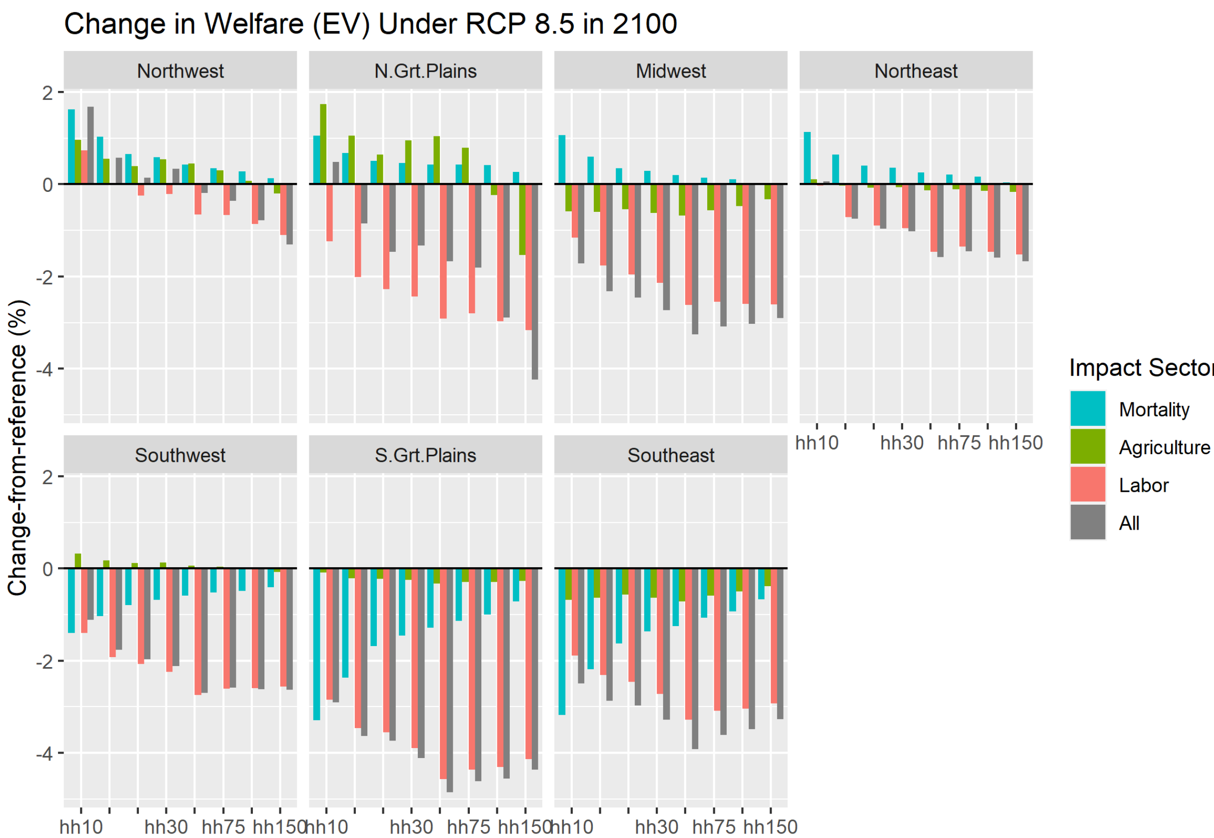
The impacts of the climate change shocks across sectors are shown in Figure 3. The largest impacts in absolute terms, in 2100 under RCP 8.5 are in Services, Other Industries, Energy Intensive Industries, and Agriculture. These sectors use significant intermediate inputs which makes them more susceptible to the labor productivity shock. The aggregate national effects on output miss important regional shifts, including positive effects on output in some northern regions for agriculture, energy intensive, and other industries.

Figure 3. Sectoral impacts under RCP8.5



At the household level, welfare effects, as measured by equivalent variation differ across both regions and income levels. Labor impacts have the strongest effects in the Plains and southern regions (loss of 2% to 5%). Counterintuitively, labor and agricultural damages are not regressive, that is, the damages rise with income. The single labor market in USREP does not differentiate exposure to labor impacts by income group. Mortality effects are regressive.

Figure 4. Household mpacts under RCP8.5 in 2100



4. Conclusions

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5. References

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