KEYNES FUND FINAL REPORT

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Project title: Climate Change Mitigation Policies: Distributional and Allocative Effects[1]

Round: Twelfth Round

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Part 1: Summary of work and results for the Fund's webpage

In 2015, countries around the world rallied to set their nationally determined contributions to the Paris Agreement in which they laid out their plans at combating climate change. However, grave concerns regarding the distributional effects of climate change mitigation policies have challenged the public's acceptability of measures that increase the price of carbon, as witnessed from recent events across the world (e.g. the gilets jaunes in France).

As such, in order for countries to implement sound policies to reduce emissions and transition into a low-carbon future, it is crucial to understand the economic and distributional aftermath of climate change mitigation policies. In a recent working paper (Cavalcanti et al. 2021), we evaluate the aggregate and distributional effects of carbon taxation across and within countries.

We develop a multi-sectoral general equilibrium Roy model with heterogeneous workers and endogenous human capital accumulation.[2] On the household side, individuals in the economy live for two periods. In the first period, individuals draw an ability vector that determines their productivity for working in each sector of the economy. Individuals take into account relative wages and their sector-specific abilities to optimally choose: (i) in which sector to work, and (ii) the time and resources invested in schooling. In the second period, individuals supply their labour inelastically to the chosen occupation and consume. On the production side, the model economy consists of 18 distinct sectors, including four energy-producing activities: oil, coal, natural gas and green.[3] There is also a final good sector.

We introduce a carbon tax to the "dirty" energy producers, which in turn affects their prices. These changes in relative prices cascade to the rest of the economy through the intersectoral linkages and induce sectoral reallocation of inputs including labour. The overall impact of the tax will depend on the size of the tax and on whether and/or how the tax revenue is rebated back to the economy.

We start our quantitative analysis with the United States and estimate that a carbon tax of 32.3% is needed for the US to achieve its original Paris pledge of 26-28% emission reduction.[4] This carbon tax costs the United States at most a 0.6% drop in output, which is the worst-case scenario when the government does not recycle its tax revenue.

Aggregate Effects of Carbon Tax Across Countries

In order to capture heterogeneity in responses across countries, we apply the same tax rate to five different advanced and emerging economies: Brazil, Canada, China, India and Mexico. Figure 1 shows the effects of a 32.3% tax on emissions, GDP and welfare (measured by consumption equivalents) for the six economies.

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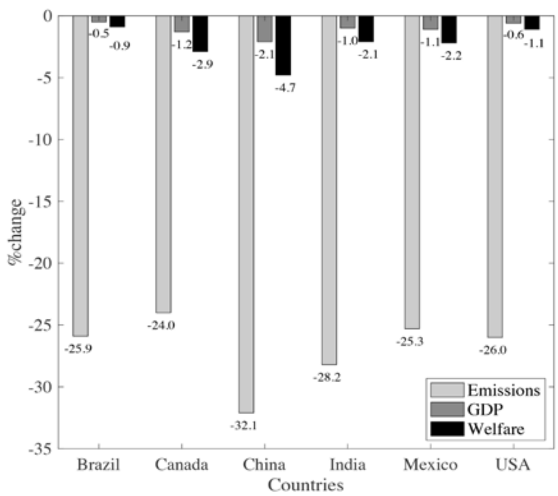
[1] The title has been later updated to "Climate Change Mitigation Policies: Aggregate and Distributional Effects".
[2] The model builds on Roy (1951), Hsieh et al. (2019), and Eaton & Kortum (2002).
[3] The "dirty energy sectors" hereafter refer to oil, coal and natural gas sectors. "Non-dirty energy sector" refers to the green sector.
[4] The model does not feature emissions as an externality. Therefore, in this quantitative exercise, we are not solving for the optimal tax. Instead, we are trying to understand the aggregate and distributional effects of imposing a carbon tax aimed at reducing emissions.

A 32.3% carbon tax can cause a GDP loss ranging from 0.5% (for Brazil) to 2.1% (for China). The differences in national responses boil down to economies' differences in energy intensity, captured by the contribution of the dirty energy sectors to value added, intermediate consumption, and/or employment.

However, despite heterogeneity in responses, the carbon tax has relatively small aggregate effects on the six economies considered. This is not surprising given the taxed sectors constitute a small fraction of gross output in each economy (at most 5.6% in our sample of countries).

Figure 1. Effects of a 32.3% carbon tax across six advanced and emerging economies.



The Importance of Revenue-Recycling

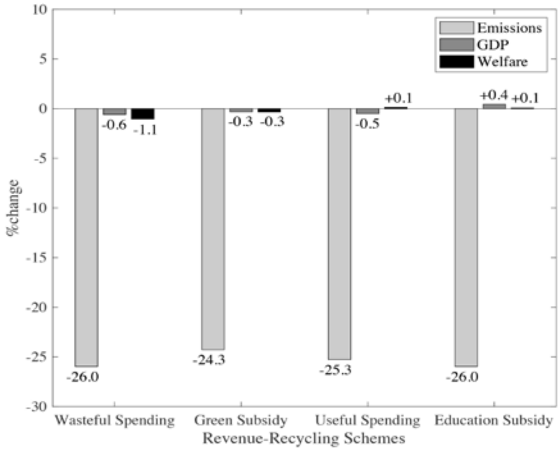
We consider three revenue-recycling schemes: (i) subsidizing green energy production, (ii) subsidizing public infrastructure, and (iii) subsidizing education.[5] Figure 2 focuses on United States and shows that the adverse effects of the carbon tax on output and welfare can be partially, or entirely, offset by implementing tax rebates.[6]

When tax revenue is used to subsidize green energy production in the United States, the drop in GDP is reduced to 0.3%. Meanwhile, when the tax revenue is used to subsidize all the non-dirty energy sectors, e.g. subsidies to public infrastructure, the drop in GDP dampens to 0.5%. Interestingly, when the tax revenue is used to subsidize education to non-dirty energy sectors, output actually improves by 0.4%. Additionally, the insurance brought by the education subsidies improves individual welfare by 1.1%.

In most cases in which tax revenue is recycled, the reduction in emissions is smaller than in the case of wasteful spending, since there is more economic activity in the former case.

Figure 2. Effects of a 32.3% carbon tax in United States across all revenue-recycling schemes.

[5] These schemes are designed such that tax revenue is neutral and government budget is balanced.
[6] The main insights across the different types of tax rebates found for the United States carry over qualitatively to the other countries.



Distributional Effects of Carbon Taxation Within Country

Underlying the minimal aggregate effects of carbon taxation are sizable distributional effects at the sectoral and individual levels.

Heterogeneity at the sectoral level

The introduction of the carbon tax on dirty energy sectors causes these sectors to downsize and witness the largest drop in wages, and consequently the largest labour outflow. By examining the skill distribution, we show that workers at the talent margin in dirty energy production choose to reallocate away from the taxed sectors to mitigate the drop in wages. Meanwhile, workers with a strong comparative advantage in the dirty energy sectors remain working in these sectors. This in turn drives up the average productivity in the dirty sectors, which captures the *selection effect*.

Heterogeneity at the individual level

In order to capture the distributional effects at the individual level more closely, we map the occupational and wage distribution of four worker categories: (i) those who remain in the non-dirty energy sectors; (ii) those who reallocate from non-dirty energy sectors; (iii) those who remain in dirty energy sectors; and (iv) those who reallocate from dirty energy sectors. Table 1 shows that workers who remain in the dirty energy sectors are the most vulnerable to the carbon tax, witnessing a welfare loss of 12.9% in the wasteful spending scenario. This is almost double the welfare loss witnessed by workers who manage to reallocate away from the taxed sectors (6.8%), and almost twelve times the welfare loss witnessed by workers in non-dirty sectors (~1.1%). However, workers who remain in dirty sectors and bear the brunt of the tax constitute a small fraction of the labour force (at most 0.6% in the United States, and 1.9% in our sample of countries). Moreover, when tax revenue is recycled, workers in non-dirty sectors might even witness a welfare gain. These workers constitute the majority of the labour force.

Table 1. Welfare Change and Labor Force Contribution by Worker Category in United States.

	Wasteful Spending		**Green Subsidy**		**Useful Spending**		**Education Subsidy**	
	CE (%)	**LFP** (%)	**CE** (%)	**LFP** (%)	**CE** (%)	**LFP** (%)	**CE** (%)	**LFP** (%)
Non-dirty sectors, stayers	-1.1	99.4	1.1	99.3	0.2	99.4	0.1	99.4
Non-dirty sectors, switchers	-1.0	0.1	9.5	0.1	0.2	0.1	0.1	0.1
Dirty sectors, stayers	-12.9	0.4	-11.5	0.4	-11.9	0.4	-11.9	0.4
Dirty sectors, switchers	-6.8	0.1	-5.7	0.1	-5.7	0.1	-5.7	0.1
Aggregate	**-1.1**	**100.0**	**-0.3**	**100.0**	**0.1**	**100.0**	**0.1**	**100.0**

Conclusion

Carbon taxes can help countries achieve their climate targets at small costs to GDP. For example, a 32.3% carbon tax will help the United States achieve its original Paris pledge of 26% reduction in emissions, and it will cost at most a 0.6% reduction in US output. However, the effects of the carbon tax mask sizable heterogeneity across and within countries.

Our analysis shows that applying the same climate policy of a 32.3% carbon tax yields a spectrum of output losses ranging from 0.5% in Brazil to 2.1% in China. The differences in the effects stem from countries' differences in production structures, labour force compositions and geophysical characteristics. Nevertheless, the adverse effects of carbon taxes on output and welfare can be partially, or even entirely, offset by rebating tax revenues back to the economy.

Looking at distributional effects within country, we find that - at the individual level - the biggest losers are workers with a comparative advantage in dirty energy production. However, these workers constitute a minor fraction of the labour force.

References

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Part 2: Internal report to the managers

There were no problems encountered with the grant or its internal processing. The objectives of the grant were mainly twofold:

(i) provide monetary compensation for the research assistant on the team (Zeina Hasna)
(ii) provide support for research trips/journal submissions

The two main objectives of the grant were successfully met.

The research assistant was compensated as agreed upon in the grant proposal and with no delays in payments whatsoever.

Support for research trips were also given to Cezar to visit Cambridge in November 2019 and for Zeina to attend an IZA workshop on climate policy and labour markets in Bonn in May 2019 and to visit Bank of Portugal in March 2020.

Overall, staff has been incredibly supportive and we have no problems to report.

Part 3: Impact and outputs

The paper addresses a very topical question on the impact of climate change mitigation policies on aggregate output and its distributional consequences within and between countries. Moreover, the paper focused on estimating the output cost for the US to meet its original Paris pledge and then applied the same climate policy to other countries to gauge the differences in output responses across countries. This application has been incredibly timely given that the US rejoined the Paris Agreement in January 2021 and is now fully invested in reinvigorating its climate action after a few years of inaction, which we elaborate on in an opinion piece for the university (more on this below).

In terms of output, the project has been released as a working paper in several outlets, has gotten various media coverage and has been presented in several conferences. All detailed below.

<u>**Paper:**</u>

- a working paper version was first available in October 2020, released as: (i) CEPR working paper, (ii) Bank of Portugal working paper, and (iii) Cambridge working paper.
- another slightly more revised version was released in February 2021 as: (i) Cambridge working paper, and (ii) Energy Policy Research Group working paper.

<u>**Media:**</u>

The paper has been featured on three outlets:

- Cambridge opinion piece: "US GDP drop following Paris Accord is at most 0.6%"
- Bank of Portugal, Economics in a picture: "Climate change mitigation policies that achieve the Paris Agreement pledge cause only small changes in GDP"
- Foco Economico: "Aggregate and distributive effects of reducing carbon dioxide emissions"

<u>**Conferences/Seminars/Workshops:**</u>

- **2019:**
  - UK Envecon conference for environmental economists in UK (London–UK)
  - American University of Beirut (Beirut-Lebanon)
  - Uppsala PhD Forum (Uppsala – Sweden (although connected virtually due to health reasons))
  - Energy Policy Research Group (Cambridge)
- **2020:**
  - Lisboa Macro Workshop (Lisbon – Portugal)

    - Faculty of Economics – PhD Macroworkshop (Cambridge)
- **2021:**
    - Bank of Portugal (Lisbon – Portugal)
    - North American Summer Meeting (expected)
    - Society for Economic Dynamics (expected)

In addition, the paper has been presented to numerous economists (outside Cambridge) who are pioneers in the field of environmental economics, and macroeconomics more broadly, in side meetings/closed group presentations. A non-exhaustive list includes: Per Krusell, John Hassler, Christina Romer, Jeffrey Sachs, Peter Klenow, Simon Dietz, Richard Tol, among others.

Part 4: Any possible future plans

This is the first paper in environmental macro for all the people on the project: Tiago, Cezar and Zeina. Having completed the first step into the field, all the three researchers agree that there are more margins to be added to the existing model as well as more topics to explore on the growing environmental-macro literature. For the purpose of our model, two natural extensions are: (i) including transitional dynamics to add a time dimension to our results (this will also include an endogenous carbon cycle), (ii) featuring heterogeneity on the demand side (right now, there is a unique consumption good).

Other topics in environmental macro that are also worth exploring and which we are interested in are:

(i) investigating the role of climate change in inducing structural change; and

(ii) estimating the returns to investments in green energy and exploring whether the prospects of a green recovery post the pandemic recession exist.