Global Economic Damages from Climate Change and the Gains from Complying with the Paris Accord

Tom Kompas

School of Biosciences
School of Ecosystem and Forest Sciences
University of Melbourne

Crawford School of Public Policy
Australian National University

(co-authors: Pham Van Ha, Tuong Nhu Che and Quentin Grafton)

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Introduction: Dimension Matters!

- It is not unusual to find numerical simulations that are dimensionally very large – and often impossible to solve – especially in studies that detail environmental impacts and climate modelling or where optimization routines are required (the so-called 'curse of dimensionality').
- Standard climate change economic models are either very small dimensionally and/or are not forward-looking or intertemporal (Nordhaus, 1991, DICE/RICE model; Roson and Mensbrugghe, 2012, EVISAGE model; Tol, 2002, 2012)
- Objective: Solve a VERY large Intertemporal GTAP Global Trade and Income Model to determine the local and global impacts of climate change at various temperature levels, along with the benefits of complying with the Paris Accord (at the 2^oC target).

The Effects of Climate Change on Growth and GDP

- Using modified Roson and Satori (2016) climate change damage (+/-) functions, we solve a large dimensional intertemporal GTAP trade global model to account for the some of the effects of global warming (e.g., loss in agricultural and labour productivity, sea level rises impact on land area, and human health effects) for 140 countries, by decade and over the long term – where producers look forward and adjust price expectations and capital stocks to account for future climate effects. (Fires, floods, drought, infrastructure damage from sea level rise, tropical storms, pollution, etc. not yet included.)
- Results are generated in terms of losses in GDP for each country and by various RCPs/SSPs, with overall results for 1-4^{o}C (SSP2 'business as usual' baseline).

GTAP Model Database/Dimension

- Example: GTAP database v7: The full database includes 112 (extendable to 139) regions (countries) and 57 commodities.

Table: GTAP model with different database/aggregation levels.

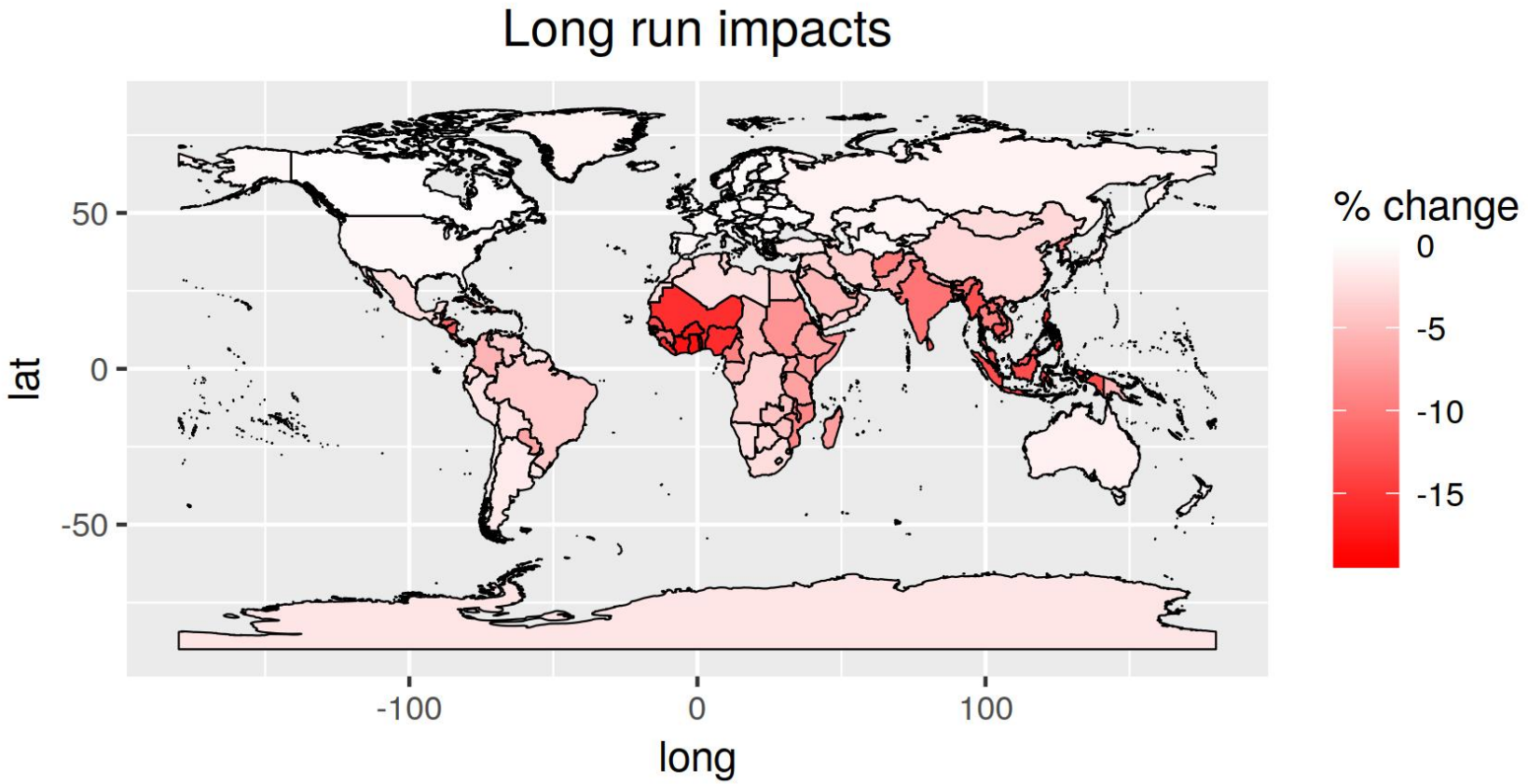
ID	Model Size	Number of endogenous variables	Number of exogenous variables	Number of non-zeros
1	112 regions, 3 commodities, 47 periods	13939336	7850081	58681307
2	112 regions, 4 commodities, 47 periods	18592712	10450826	78830677
3	112 regions, 5 commodities, 47 periods	23319784	13083155	97089894
4	112 regions, 26 commodities, 47 periods	139612072	75657968	547479803
5	112 regions, 34 commodities, 47 periods	192462632	103159736	749419439
6	112 regions, 57 commodities, 47 periods*	505112836	260697767	$1.815*10^9$

Source: Authors' calculation. Note: * Number of non-zeros is an approximation.

The Effects of Climate Change on Growth and GDP

- 57 commodity groups (with trade and spatial dimension), including paddy rice, wheat, cereal grains, vegetable, fruits and nuts, bovine cattle, sheep, goats, horses, sugar cane, milk, wool, forestry, fishing, coal, oil, gas, meat products, vegetable oils and fats, dairy products, textiles, beverages and tobacco, wood products, paper products, chemical, rubber, leather products, plastics, metal products, electronic equipment, machinery, manufactures, air transport, motor vehicles, electricity, construction, business services, defense, public administration, dwellings, communication, financial services, construction, transport, recreational and other services, etc.
- Energy and power components in the IAM/GTAP-EP Model: Coal, oil, gas, oil products, fossil fuel electricity, renewables, non-fossil electricity, etc.

Climate Change Impacts – Long Run; $3^{o}C$ Path, $\%\Delta$ GDP



Source: Authors' calculation.

Estimation of long term GDP loss per year in 2100 and forward under global warming scenarios ($US billion/year)

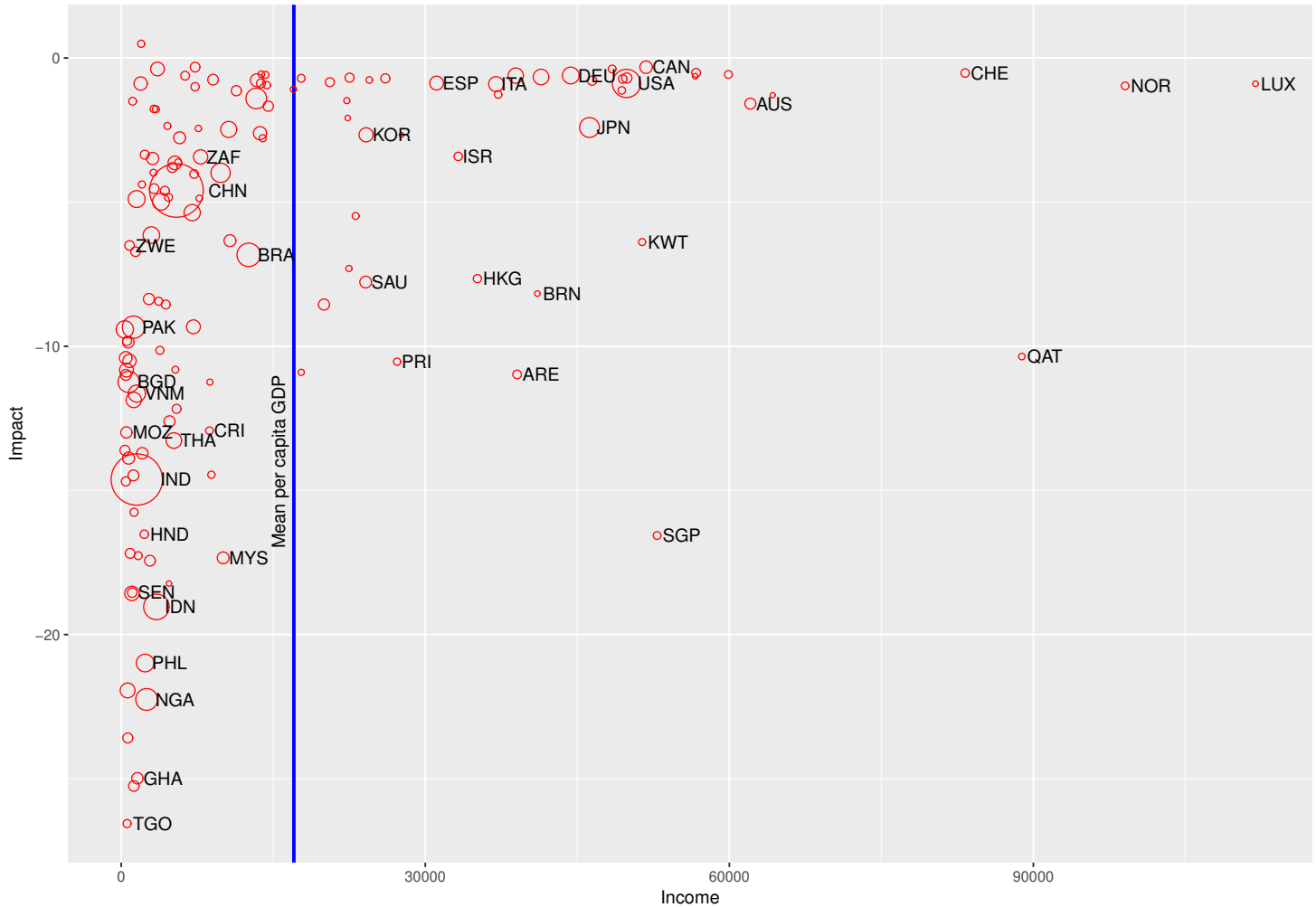
	4°C	3°C	2°C
World Total	**-23,149**	**-9,593**	**-5,659**
Sub-Saharan Africa	-8,073.68	-2,889.66	-1,927.78
India	-4,484.96	-2,070.06	-1,149.36
Southeast Asia	-4,158.88	-2,073.09	-1,166.23
China	-1,716.91	-701.75	-394.59
Latin America	-1,371.81	-576.65	-259.82
Rest of South Asia	-1,157.92	-469.98	-283.78
Middle East and North Africa	-1,032.27	-451.96	-241.12
United States of America	-697.77	-223.83	-168.48
Japan	-253.18	-54.43	-23.02
Australia	-117.42	-36.87	-23.72
South Korea	-81.44	-14.72	-7.86
Russian Federation	-24.49	-10.88	-6.53
United Kingdom	17.78	4.06	0.35
Germany	23.85	5.38	2.46
France	26.92	7.11	1.80
Vietnam	-247.09	-106.0	-63.58

What do these BIG Numbers Mean?

- Global long term economic damages in 2100 (albeit with limited damage functions) at 3^oC are \$US 9.5+ trillion per year and at 4^oC losses are \$US 23+ trillion per year.
- \$US 23+ trillion is (at least) 3 or 4 GFCs (2008) each year.
- Some country losses are especially severe. GDP losses, for example, at 4^oC, for Cambodia, Sri Lanka, and Nicaragua are over 17%, for Indonesia 19%, for India 14%, Thailand 17%, Singapore 16%, the Philippines 20%, and for much of Africa the losses range from 18 to over 26% of GDP. Global losses in GDP during the Great Depression (1930s) were 15%. (China 4.6%, USA 0.9%)
- At 4^oC, damages per person in Australia are projected to be AUD\$4,886 or roughly AUD\$13,945 per household, per year, every year, in the long run.

Distributional Effects of Climate Change at 4°C, %Δ GDP

Figure: Climate change impacts by country against income and %Δ GDP impact/damages (circle area = country population size).



Source: Authors' calculation.

Gains from Complying with the Paris Accord

- The successful achievement of the Paris Accord, which aims to keep global warming at roughly 2^oC (or RCP4.5), or less, allows us to calculate the potential benefit of the Accord as the difference in losses between various temperature changes and 2^oC scenario.
- For example, comparing the 3^oC and 2^oC scenario: The potential gains of following the Paris Climate Accord for avoided global GDP losses are $US 3,934 trillion a year in the long term.
- For the comparative case of RCP 8.5 (4^oC), the global gains from complying with the 2^oC target (RCP 4.5), are approximately $US 17,489 trillion a year over the long term.

Cumulative Losses in GDP from 2017-2100 (bill. USD)

	Impacts (GDP)		
	4°C	3°C	2°C
World Total	-604460.42	-271250.18	-171745.14
Sub-Saharan Africa	-177398.70	-67745.57	-49231.04
India	-131574.85	-65495.65	-39665.53
Southeast Asia	-118076.85	-62233.61	-37692.25
China	-64024.08	-28239.51	-16947.87
Latin America	-39444.52	-17240.66	-8529.39
Rest of South Asia	-29243.05	-11482.45	-8357.61
Middle East and North Africa	-25582.51	-12400.73	-7021.93
United States of America	-14401.80	-5699.37	-4334.33
Japan	-6625.19	-1716.01	-624.83
Mexico	-3133.90	-1289.18	-486.12
Australia	-2898.86	-1097.39	-695.97
Vietnam	-7418.66	-3369.44	-2234.69

Source: Authors' calculation.

Comparing GTAP-IAM (SSP2) model results compared to steady state GTAP-INT results

Table: Long run impact: Heavily impacted countries and AUS (%/GDP)

	Global temperature	Local temperature	GTAP 4^oC
Rest of Southeast Asia	-28.38	-22.38	-18.57
Laos	-25.37	-21.75	-15.76
Rest of Western Africa	-25.31	-23.35	-21.94
Cambodia	-24.42	-19.25	-17.18
Burkina Faso	-24.35	-23.11	-23.59
Rest of South Asia	-24.17	-23.28	-13.88
Togo	-22.16	-21.11	-26.56
Philippines	-21.54	-14.37	-20.99
Rest of Central America	-21.44	-15.82	-18.23
Cote dIvoire	-20.26	-18.35	-25.25
Australia	-1.78	-1.70	-1.58

Final Thoughts (1)

- Model dimension matters: Averaging across countries and extremes in impacts distorts overall and country-specific damages; severe damages occur even though standard damage functions are very limited in scope and impact (e.g., severe weather effects and 'natural disasters' that are climate change induced are excluded).
- The severe falls in GDP in the long term will put many governments in fiscal stress. Tax revenues will fall dramatically and increases in the frequency and severity of weather events and other natural disasters, which invoke significant emergency management responses and expenditures, indicate that pressure on government budgets will be especially severe.

Final Thoughts (2)

- 'Three Great Myths in the Economics of Climate Change':

1. Total damages, long term and cumulative, are relatively small both in income levels and as a percentage of GDP. The severe damages in the Stern Report are mainly due to the low discount rate. (In our work the discount rate is standard at 5%)
2. Poorer countries are not differentially affected, except perhaps at extreme parameter values and, in any case, they can be more than compensated by countries on high emissions pathways with BAU.
3. The costs of emissions reduction far outweigh the relative damages from climate change.

Thank you!

- Thanks for listening!
- www.tomkompas.org
- tom.kompas@unimelb.edu.au