Title: Technical comment on "Fairness considerations in global mitigation investments"

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Abstract: In otherwise excellent analysis of fair regional shares of global mitigation investments, Pachauri et al. (Policy Forum, 9 December 2022, p. 1057) dramatically overestimate developing countries' 'capability' to invest by estimating GDP using purchasing power parity exchange rates. Since internationally sourced investment goods must be paid for at market exchange rates, capability-based interregional finance flows should be vastly larger.

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Main Text: Pachauri et al. (*1*) have calculated fair regional shares of financing global climate change mitigation investments through 2030 using operational versions of 'responsibility', 'capability', and 'needs'. The authors find that these fairness considerations imply scaled up interregional investment flows. Higher capability, which is based on affluence (per capita GDP or capital stock), translates into higher fair investment shares. We show that the authors' use of exchange rates at purchasing power parity (PPP) to calculate 'capability' dramatically overestimates the capability of developing countries to finance investments.

PPPs are artificially constructed exchange rates that are supposed to reflect the ability of a currency to purchase goods and services in its country of issuance or use compared with the US-dollar in the United States. Since domestic production of goods and services in lower income countries tends to be cheaper on account of lower wages and cheaper domestically produced intermediate inputs, these goods and services' prices are lower than in a rich country, after converting currency at market exchange rates. Therefore, PPP exchange rates tend to appreciate the currency of lower income countries. As a result, GDP per capita converted to US-dollars at observed market exchange rates (MER) is vastly lower for most countries. For lower-middle income countries such as India or Indonesia MER GDP is only around one-third of that calculated at PPP; for upper-middle income countries such as China or Brazil the figure is around half. GDP per capita inflation when applying PPP exchange rates for developing countries is so pervasive that is has its own name: the Penn effect, after the university where these synthetic exchange rates were first systematically estimated (*2*, *3*).

Since the value of PPP exchange rates depends on many assumptions and changes with each new estimation exercise (the International Comparison Project), there is a substantial literature critiquing the specific values or the use of PPP exchange rates as well as adjusting the methodology in response (*4–8*). Such critiques, e.g. that PPPs tend to overestimate real incomes in lower income countries (*9*), are a serious problem for using PPP GDP to measure a capability to invest.

Our critique here is more specific. MER are simply the more appropriate indicators of purchasing power for internationally traded goods and services since these are the exchange rates at which international transactions actually occur. MER are key for financing climate change mitigation investments. Most of the essential plant and equipment for low-carbon energy supply and end-use technologies is sourced internationally and must be paid for in US-dollars obtained at MER (*10–12*). For instance, 90% of all wind turbines are manufactured in only 15 countries, 90% of silica-based solar PV modules are manufactured in East Asia, electric vehicle batteries are exclusively manufactured in East Asia, North America and Europe, and electrolyzers are manufactured exclusively in China, Europe, North America, Japan and India (*13*). This means that the capability to pay for mitigation investment through 2030 must be assessed in terms of GDP calculated at market exchange rates.

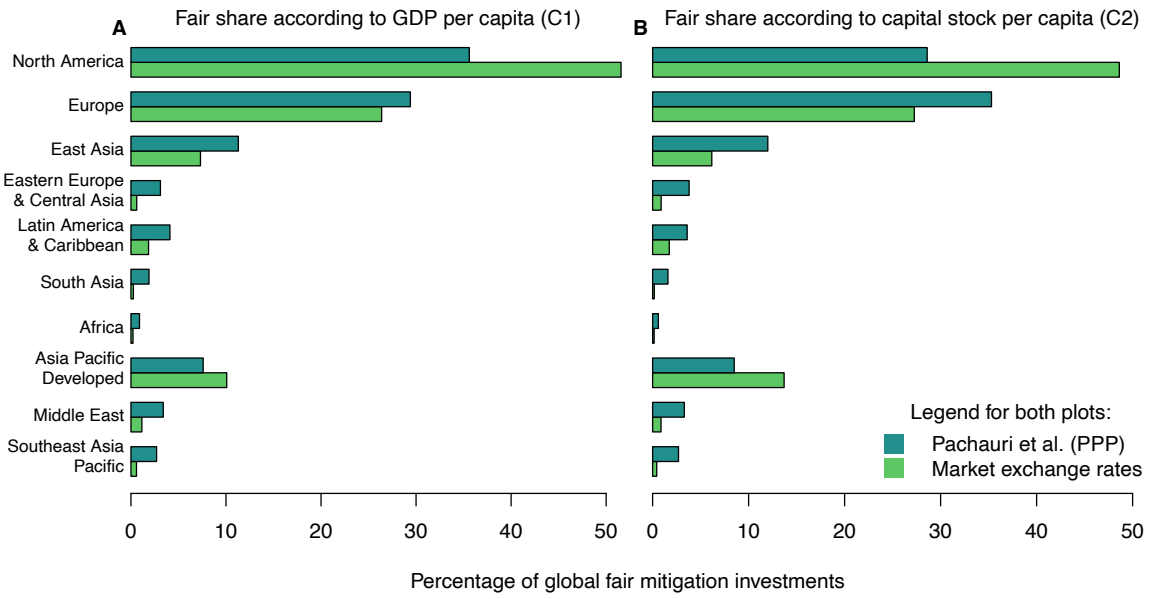

Fig. 1. Recalculated fair capability shares in context of the existing results. Fair share of investments according to PPP-based capability reported in Pachauri et al. *(1)* (dark green) and recalculated MER-based capability (light green) for each of 10 regions of the world. **(A)** shows results for capability according to GDP per capita (corresponding to C1 in Fig. 2 from *(1)*), **(B)** for capability according to capital stock per capita (corresponding to C2 in Fig. 2 from *(1)*). See *(14)* for details on data, code, and results.

Recalculating the capability to invest using GDP at market exchange rates leads to a substantial readjustment of the authors' results. We first replicated the capability results with the PPP approach of Pachauri et al. *(1)* following the instructions and results reported in their supplementary materials, and using publicly available data from the World Bank (GDP) and Penn World Tables (capital stock) (complete results, data and figure code available at (*14*)). Then we replaced all of their PPP-based conversions with a MER-based conversion from the same sources. Fig. 1 shows in dark green bars the results for capability that Pachauri et al. obtained, and in light green bars the results using the MER approach. Comparing these bars shows that in all regions but Asia Pacific Developed and North America, the fair share of investment falls when calculated at MER GDP. For instance, Southeast Asia Pacific's share drops from 2.7% to 0.6% under MER-recalculation of capability according to GDP per capita, South Asia's share from 1.9% to 0.3% and Latin America's share from 4.1% to 1.9%. In contrast, North America should pay for 52% instead of 36% of all investments. All regions outside of the three richest ones (North America, Asia Pacific Developed, and Europe) should together only pay for 12.0% instead of 27.4%. The result is analogous for the capability to invest based on capital stock per capita, whose value the authors also calculate using PPP exchange rates, and where the developing regions' joint share drops from 27.6% to 10.4% with MER recalculation.

Discussions of mitigation burden-sharing need to take seriously the major implications of the difference between PPP and MER exchange rates for trade-related considerations in climate mitigation finance modeling. In terms of market exchange rate, the capability to finance investments of the richest regions suggests nearly 90% of all investments until 2030 should be

financed by them. If done well, such cross-border investments could also vastly lower the financing costs of the global energy transition (*15*).

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