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The Distributional Impact of a Carbon Tax in Asia and the Pacific

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ABSTRACT: While a carbon tax is widely acknowledged as an efficient policy to mitigate climate change, adoption has lagged. Part of the challenge resides in the distributional implications of a carbon tax and a belief that it tends to be regressive. Even when not regressive, poor households could be hurt by a carbon tax, particularly in countries that rely heavily on carbon-intensive energy sources. Using household surveys, we study how a carbon tax may affect households in the Asia Pacific region, the main source of CO_2 emissions. We document a wide range of country-specific policies that could be implemented to compensate households, reduce inequality, and build support for adoption.

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WORKING PAPERS

The Distributional Impact of a Carbon Tax in Asia and the Pacific

Prepared by Cristian Alonso and Joey Kilpatrick[1]

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Glossary

AAY-BPL	Antyodaya Anna Yojana- Below Poverty Line
BLT/BLSM	Bantuan Langsung Tunai/Bantuan Langsung Sementara Masyarakat
BSM	Bantuan Siswa Miskin
CPAT	Carbon Pricing Assessment Tool
ETS	Emissions Trading SystemScheme
GDP	Gross Domestic Product
GHG	Green House Gas
Hong Kong SAR	Hong Kong, Special Administrative Region
IEA	International Energy Agency
IMF	International Monetary Fund
LPG	Liquefied Petroleum Gas
NDC	Nationally Determined Contributions
OECD	Organization for Economic Cooperation and Development
PKPS BBM	Dalam Pencapaian Efektivitas Dana Program Kompensasi Pengurangan Subsidi Bahan Bakar Minyak
PMT	Proxy Means Testing
USD	United States Dollar
WEO	World Economic Outlook

Introduction

While there is broad consensus on the effectiveness of a carbon tax to mitigate climate change, it has proven difficult to implement.[2] For example, many instances of fuel subsidy reform have led to social unrest.[3] Part of the challenge appears to be the belief that a carbon tax would be regressive, and so, would disproportionately hurt the poorest (Andersson and Atkinson, 2020; Dorfman, 2018).[4] While a carbon tax may be mildly regressive in some advanced economies, that is not the case everywhere and depends on country-specific characteristics (IMF, 2019a). Even if not regressive, a carbon tax would still reduce household welfare and so, could call for some compensation measures to protect the most vulnerable households, to facilitate the transition of energy workers towards greener jobs, and to build public support (IMF, 2021).[5] In this paper, we explore the impact of a carbon tax on households in Asia and the Pacific, a diverse region that holds the key to global mitigation efforts, and propose a number of country-specific compensation schemes to foster the chances of success for this reform.

We use household surveys and input-output tables to study how a carbon tax would affect households in Asia and the Pacific. First, we use input-output tables to calculate how higher energy prices induced by the carbon tax would lead to higher consumer prices in non-energy goods, assuming that the higher energy costs are fully passed-through. Second, we combine those higher consumer prices with household surveys to quantify the negative impact on welfare based on the household expenditure bundle. Third, we identify households employed in the energy sector and measure the extent of their possible labor income loss as the carbon tax leads to lower labor demand.

We find that a carbon tax would have very different implications across the region. On the basis of higher prices and lower labor income, a carbon tax of USD 50 per ton would lead to substantial losses of welfare for households amounting to around 10 percent of initial consumption in Mongolia and 7 percent in Indonesia. In China and India, the average loss would be slightly above 3 percent. It would be 2.1 percent for the Philippines and lower than 2 percent in Kiribati and Myanmar. The distributional impact would also be quite different. The carbon tax would be regressive in China, Indonesia, and Mongolia, but it would be progressive in India, Kiribati, the Philippines, and Myanmar. Across the region, small groups of households employed by the energy sector would be heavily exposed to labor income losses. However, to fully assess the impact of a carbon tax we need to account for the use of its proceeds.

The household welfare loss produced by a carbon tax can be reverted and redistributed through relatively simple and cheap compensation schemes. We document a wide range of country-specific policies that could be implemented to compensate households, reduce inequality, and build support for adoption. For that, we use

2 A carbon tax is a fee imposed on the burning of fossil fuels (e.g., natural gas, coal, oil) based on their carbon content. As such, it is an ideal tool for companies and households to internalize the externality generated by their consumption of fossil fuels in terms of CO_2 and CO_2 equivalent emissions leading to global warming. Carbon taxes are also easy to implement and administer as they can build on top of fuel excises already in existence in most countries, which makes them especially attractive for low-income countries in need of mobilizing tax revenues. In this paper, we consider a carbon tax without exemptions, so that it applies to all sectors (e.g., transport, power, manufacturing, etc.) based on their emissions from the burning of fossil fuels.

3 Haiti announced a plan to eliminate fuel subsidies in July 2018 that led to immediate protests. While the government suspended the plan the day after it was announced and the prime minister resigned a week later, social unrest persisted. The *gilets jaunes* movement in France emerged in November 2018 after the government raised fuel taxes. In October 2019, the government's attempt to reduce fuel subsidies in Ecuador led to 12 days of violent riots, after which the government was forced to backtrack. The end of fuel subsidies in Iran in November 2019 also led to widespread political unrest. A sudden increase in the price of liquefied petroleum gas in Kazakhstan in January 2022 led to riots, after which the Cabinet was dismissed. Naturally, in these cases other grievances were also at play, nevertheless the reduction in fuel subsidies may have acted as an igniter, a coordination mechanism. Of course, there have been many instances where energy price increases were accepted by the population (Guillaume and others, 2011), which highlights the importance of communication, transparency, and policy design (Rentschler and Bazilian, 2017).

4 Besides the burden on households, opposition to higher energy prices from industry and from potentially displaced workers and regions also make adoption of a carbon tax politically difficult.

5 For instance, Klenert and others (2018) emphasize the role of compensation policies on building public support for carbon pricing reforms.

both existing and new policies and we consider a range of targeting mechanisms, from no targeting in universal measures to proxy-means testing, as many countries do in practice.

We find that it would be relatively inexpensive to compensate the most vulnerable households. Using a cash transfer targeted to the poorest 40 percent of the households through realistic proxy-means testing, we find that it would cost only 16 percent of the resources raised by a carbon tax to ensure that these households are on average not worse off after the reform. It would be as cheap as 8 and 11 percent for India and Kiribati, respectively. The ratio would be around 15 percent for China and Myanmar. It would reach 17 percent for the Philippines and 23 and 24 percent for Indonesia and Mongolia, respectively. So, in all cases, the poorest 40 percent of the households can be protected while using less than a quarter of the resources raised by the carbon tax.

Ensuring that most of the households are better off is more expensive, but still affordable. Providing a universal cash transfer or "carbon dividend" to all households to ensure that more than half of the households are better off after the reform would cost only 23 percent of the resources raised by a carbon tax in India and 33 percent in Myanmar. The cost would be around 60 percent for Kiribati and the Philippines, and 80 percent for China. It would be most expensive in Indonesia and Mongolia, where it would take virtually all the resources raised by a carbon tax. Thus, even without using any form of targeting, it would be feasible to make more than half of the country better off after the reform.

We contribute to the literature studying the distributional implications of a carbon tax. The literature is very rich and covers incidence analysis on fuel subsidy reform and carbon pricing conducted directly on household surveys such as IMF (2019a), IMF (2019b), Parry and others (2018), Parry and others (2016), and Flues and Thomas (2015), or through heterogeneous agent models such as IMF (2020a), Goulder and others (2019), and Rausch and others (2011).[6] The carbon tax itself has often been found to be regressive in advanced economies, although the overall impact of the reform critically depends on the uses given to the resources raised by a carbon tax. The fact that the carbon tax can be progressive in some low-income countries was highlighted by IMF (2019a) and Coady and Hanedar (2015). We add to this literature by modeling a labor income channel, exploring a wide range of country-specific compensation schemes, and extending the analysis to countries that have not been studied in the past, such as Myanmar and Indonesia.[7] While we do not model all possible channels, our work adds to our understanding of the impact of a carbon tax in the region.

The rest of the paper is structured as follows. Section 2 discusses the importance of Asia and the Pacific for a global mitigation strategy. Section 3 describes our methodology for measuring the impact of a carbon tax on households in the region. Section 4 presents results across different economies, whereas Section 5 digs deeper into the results per country. Finally, Section 6 concludes.

The Importance of Reducing CO_2 Emissions in Asia and the Pacific

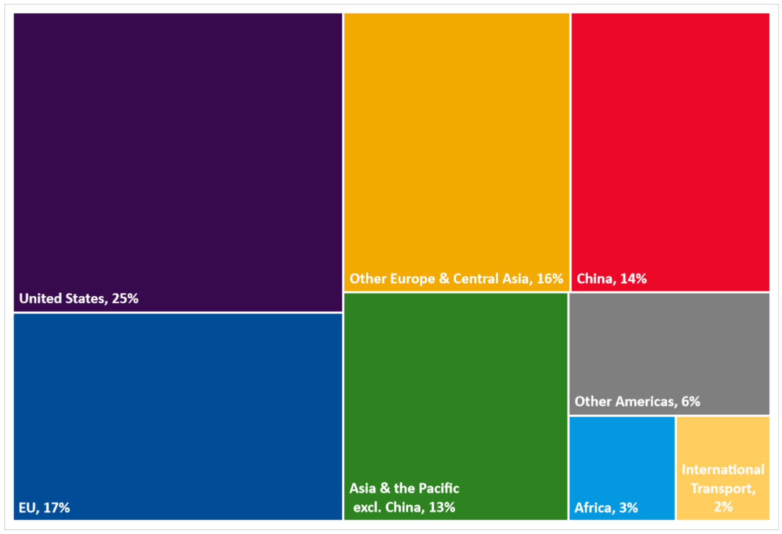
Restraining GHG emissions in the Asia and the Pacific region is essential to limit global warming to between 1.5 and 2 degrees Celsius. Cutting global emissions by between a quarter and half of today's level by 2030 will be needed to achieve this (Parry and others, 2021). As of 2020, the Asia and the Pacific region accounts for 27% of all emissions ever generated, equivalent to 452 billion tons of CO_2 (Figure 1). Further, the region's global share in fossil fuel combustion emissions has risen from 30% to 49% between 2000 and 2019, reflecting the swift economic development thanks in large part to becoming the center for much of the world's

[6] Shang (2021) provides a clear and comprehensive review of the literature and discusses the different channels at play.

[7] Dabla-Norris and others (2021) uses a previous iteration of this methodology and already covers China, India, Kiribati, Mongolia, and the Philippines.

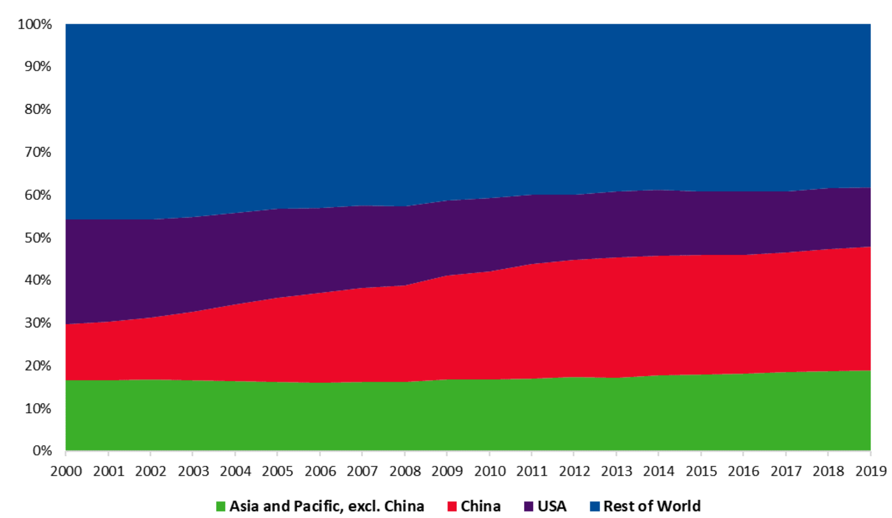
manufacturing (Figure 2). Emissions in the region are due to grow by 16% from 2019 to 2030 as economies continue to develop, having already increased by 140% from 2000 to 2019 (UNESCAP and others, 2021). If the current pace continues, meeting Paris Agreement targets to limit warming will become improbable. Currently the largest emitter in the region is China, emitting 9.9 billion tons of CO_2 in 2019, more than the United States and all the other countries in the Asia and the Pacific region combined, at 4.7 billion and 6.5 billion tons respectively. When China is excluded, emissions are shown to be relatively low compared with those of the European Union and the United States. Certainly, from a historical perspective, the United States has emitted the most of any country, at 25% of cumulative global CO_2 emissions, with the European Union accounting for the next most at 17%.

Figure 1. Cumulative CO_2 Emissions, 1750-2020



Source: Our World in Data, the Global Carbon Project.

Figure 2. Share of Annual Fuel Combustion Emissions, 2000-2019



Sources: OECD, IEA.

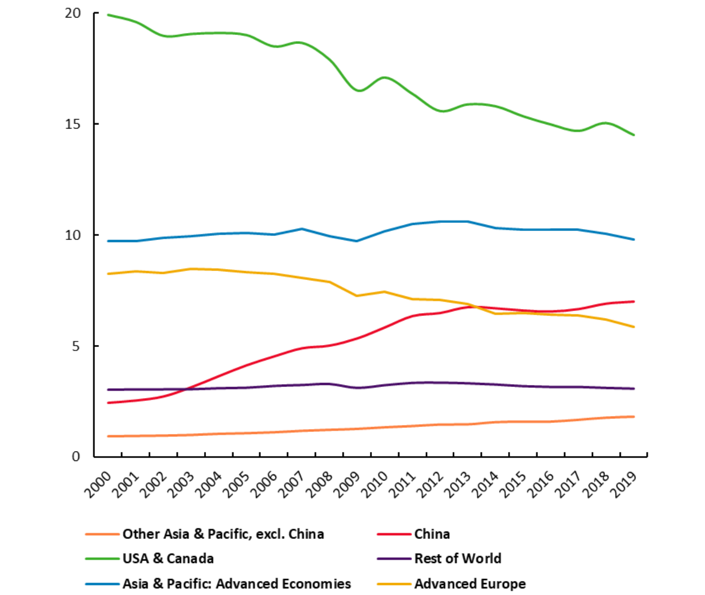
Per capita emissions in the region are growing from a low base. Excluding China, per capita emissions are very low for the low- and middle-income economies in the region, over five times less compared to the region's advanced economies. Per capita emissions of these advanced economies are double that of their counterparts in Europe and have remained flat at an average of around 10 tons of CO_2 per capita. And while the region's low- and middle-income economies' per capita emissions have increased steadily on average, China's per capita emissions have increased at a much faster pace, overtaking those of advanced economies in Europe in 2013. Per capita emissions highlight the importance of decreasing emissions that remain stubbornly elevated in the region's advanced economies as well as the importance of climate-sustainable development to curtail the potential for future emissions (Figure 3).

Carbon taxes are not a new idea for the region. There are currently carbon taxes or carbon exchange trading systems in place in China, Japan, South Korea, New Zealand, and Singapore. Brunei, Indonesia, the Philippines, Malaysia, Taiwan, Province of China, Thailand, and Vietnam are also considering such tools.

However, many of these policies do not go far enough to meet global emissions targets. Parry and others (2021) show that a price of $75 per ton for advanced economies, $50 for high-income emerging market economies, and $25 for low-income emerging market economies set in place by 2030 will be needed to achieve the Paris Agreement's target of limiting warming below 2°C. In this case, the proposal for differentiated carbon prices based on the level of development implies some loss in economic efficiency compared to a uniform carbon price around the world, but provides for more equity in the distribution of the burden across countries as it has developed countries shouldering more of the burden in line with their capacities and contribution to historical emissions.

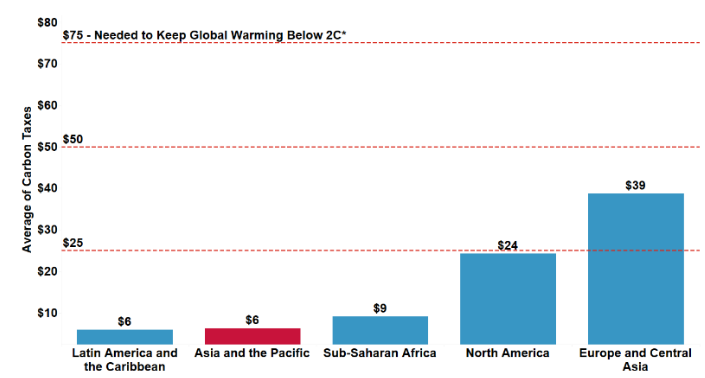
Carbon prices in the region are low based on those standards. Of the current carbon prices in place in the region, the average is around $6 per ton and only covers an average of 0.3% of yearly emissions in each country.[8] Further, carbon prices in Asia and the Pacific are low compared to other regions of the world (Figure 4). Currently Europe and Central Asia, North America, and Sub-Saharan Africa have average carbon prices above the Asia and the Pacific region, with Europe and Central Asia having an average carbon price that is six times that of the Asia and the Pacific region. While strides have been made in

Figure 3. Per Capita Emissions from Fuel Combustion, 2000-2019



Sources: OECD, IEA, WEO.

Figure 4. Average Price per Ton of Carbon by Region, 2022



Sources: World Bank's Carbon Pricing Dashboard, OECD, IEA, WEO.

[8] See the World Bank's Carbon Pricing Dashboard for data on global carbon pricing policies. Statistics do not include China's National ETS, due to be implemented sometime in 2022.

the region to adequately price emissions, it is worth exploring whether more can be done and what the effect of such policies on households would be.[9]

The importance of mitigating future carbon emissions cannot be understated, and the Asia and the Pacific region will be key to reaching global mitigation targets. However, it is also important to keep the concept of a just climate transition in mind. Of the 37 economies in the region, 7 are advanced economies, 18 are EMEs, and 12 are low-income countries. Many of these countries contributed incredibly small amounts to the world's cumulative emissions and yet, especially the small island states, are facing the brunt of the consequences. The principle of "common but differentiated responsibilities" indicates that all states have to do their part in the fight against climate change, although that part has to be commensurate to the state's means. For ease of comparison, we study the impact of a carbon tax of $50 per ton, the median recommended for the region's economies by Parry and others (2021) to achieve the goals set by the Paris Agreement. Although, as mentioned above, a carbon tax rate that varies by level of development may be preferable. Results for a carbon tax of $25 and $75 per ton are discussed in Annex II.

Methodology

We use household surveys for Australia, China, Hong Kong SAR, India, Indonesia, Japan, Kiribati, Korea, Mongolia, Myanmar, New Zealand, the Philippines, Singapore, and Taiwan, Province of China. In Australia, Hong Kong SAR, Japan, New Zealand, Singapore, and Taiwan, Province of China we use summary statistics data by income quintile, while in the rest of the countries we process household-level data. We follow five steps to trace the impact of a carbon tax on households through higher prices, lower labor income in the energy sector, and to evaluate country-specific compensatory policies.

First, we use the energy prices induced by a carbon tax of $50 per ton.[10] The impact of a carbon tax on the prices of coal, electricity, gasoline, natural gas, and other fuel products is calculated using the IMF's Carbon Pricing Assessment Tool (Parry and others, 2021).[11] The tool uses country-specific energy use matrices and projections of GDP growth, and projections on technological change and global energy prices. The tool produces energy prices in 2030, by when the carbon price is assumed to be in place after a linear rollout, and so, the composition of the energy matrix has had some time to adjust. The carbon tax that we model is in addition to existing fuel taxation (e.g., a Rs 400 per ton tax on coal in India). Our analysis considers each country separately and does not factor in spillovers from one country adopting a carbon tax into other countries in the region. For further details on the methodology, please see Parry and others (2018).[12] Additional macroeconomic variables for the survey year such as GDP, exchange rates, and inflation are retrieved from the World Economic Outlook database.

Second, we use input-output tables to track the impact of higher energy prices on the prices of other goods and services. We obtain input-output tables from national statistics agencies in the cases of Australia, China,

[9] The region's commitments to mitigating and adapting climate change is reflected in its countries' National Determined Contributions (NDC). For instance, the Philippines' NDC sets a target of 75 percent greenhouse gas (GHG) emission reduction and avoidance by 2030. Of the 75 percent target, 72.29 percent is conditional upon receiving support from developed countries, whereas the remaining 2.71 percent is unconditional and shall be implemented mainly through domestic resources.

[10] Carbon taxes of $25 and $75 per ton are covered in Annex II.

[11] The results in this paper use version 342 of the CPAT, as available at the end of February 2022.

[12] Importantly, the CPAT does not assume fuel subsidy removal for countries that currently have them as measured by a negative markup on marginal costs in the energy industries. Instead, that negative markup is preserved in the simulations. In a similar way, inefficient (or non-profit maximizing) behavior by energy state-owned companies is not required to change in the simulations, only the pass-through of the carbon tax into higher energy prices is assumed.

India, Indonesia, Japan, Korea, New Zealand, the Philippines, Singapore, and Taiwan, Province of China.[13] We identify the direct impact on energy prices through specific industries. From the input-output tables, we compute the total requirements matrix, which allows us to track the indirect effect of higher energy prices on the price of each industry's output. In this exercise, a full pass-through of higher input costs into the price of final goods is assumed.[14] A lower than full pass-through would imply weaker increases of good prices, so consumers would be less hurt by a carbon tax.[15] Instead, the burden would fall on companies whose owners may be relatively richer and so, less worrisome from a distributional perspective. The full pass-through assumption then provides an upper bound on the negative impact of a carbon tax on households via higher prices. Also, we do not adjust input-output tables for improving trends in energy efficiency over time. If we were to do so, the negative impact of a carbon tax on households would also be lower.

Third, we evaluate the impact of such higher prices on individual household's consumption using household surveys.[16] We map the goods produced by input-output tables into those reported in household expenditure surveys. We sort households in quintiles using consumption per capita (except for Australia, Hong Kong SAR, Japan, Korea, New Zealand, Singapore, and Taiwan, Province of China where we use income quintiles) because consumption tends to be measured better than income in surveys in low-income countries.[17] Consumption per capita is also used for the Gini coefficients and the references to poorer or richer households along the paper. All results are computed using sample weights. Table 1 below presents summary statistics of the household surveys, including numbers of households, individuals, percent of urban respondents, and average annual consumption expenditure per capita.

[13] For Australia, we use the 2016–17 input-output table of 114 industries. For China, we use the 2012 input-output table, which provides a breakdown for 139 industries. For Hong Kong SAR, we use the 2015 input-output table obtained from the Organization for Economic Cooperation and Development, which provides a breakdown for 43 industries. For India, we use the 130-industry input-output table for 2007–08. For Indonesia the 2010 input-output table was used, with 185 industries. For Japan, we use the 2017 input-output table that covers 107 industries. Unfortunately, there is no input-output table for Kiribati; instead, as a proxy, we use the Asian Development Bank's 35-industry 2017 input-output table for Fiji, the smallest island country in the region for which data is available. For Korea, the 2018 input-output table is used, covering 33 industries. For Mongolia, we use the 35-industry 2017 input-output table obtained from the Asian Development Bank. For Myanmar, we were unable to identify a suitable, recent input-output table so we used Bangladesh's 2017 table which provides 71 industries. For New Zealand, the 2013 input-output table is used, providing 105 industries. For the Philippines, we use the 65-industry 2012 input-output table. For Singapore, the 2017 input-output table is used, consisting of 105 industries. For Taiwan, Province of China, the input-output table from 2020 is used, covering 62 industries. Some of these input-output tables are a bit dated, so the economy may already be less carbon-intensive than what is implied by them.

[14] When the industry breakdown is not detailed enough to map each energy good directly, we gather sectoral data from other surveys (e.g., mining surveys) in the country to produce a weighted average for the industry to be traced down the input-output table and yield the indirect price effect. However, we preserve the direct price effect if that good is included in the household survey.

[15] The distributional implications of lower-than-full pass-through would not be substantially different as the direct impact of higher energy prices tend to dominate for the countries in our sample.

[16] In certain economies we were unable to obtain microdata, and instead we used average expenditure shares by income group. This is the case for Australia, where we use the average shares by income quintile for the 2015–16 Household Expenditure Survey. We use the 2018 China Family Panel Studies for China (Institute of Social Science Survey, 2021), average shares by income quartile from the 2014-15 Hong Kong Household Expenditure Survey for Hong Kong SAR (Census and Statistics Department, 2016), and the 2011-12 68th Round of the National Sample Survey for India (National Sample Survey Office, 2011). We use the 2014 Fifth Wave of the Indonesia Family Life Survey for Indonesia (Strauss, J., F. Witoelar, and B. Sikoki, 2016), average shares by income quintile from the 2019 National Survey of Family Income, Consumption, and Wealth for Japan (Statistics Bureau of Japan, 2021), and average shares by income quintile from the 2020 Household Income and Expenditure Survey for Korea (Statistics Korea, 2021). We utilize the 2006 Household Income and Expenditure Survey for Kiribati accessed through the Pacific Community's Data Hub (Kiribati National Statistics Office, 2006), the 2016 Household Socio Economic Survey for Mongolia (National Statistics Office of Mongolia, 2016), and the 2017 Myanmar Living Conditions Survey for Myanmar (Central Statistical Organization, 2018). We use the average shares by income quintile from the 2018-19 Household Economic Survey for New Zealand (Statistics New Zealand, 2020), the 2015 Family Income and Expenditure Survey for the Philippines (Philippine Statistics Authority, 2015), average shares by income quintile from the 2017-18 Household Expenditure Survey for Singapore (Singapore Department of Statistics, 2019), and average shares by income quintiles from the 2020 Survey of Family Income and Expenditure for Taiwan, Province of China (Taiwan DGBAS, 2021).

[17] Sorting households into quintiles by income per capita instead of expenditure per capita does not have a significant impact on the assessment of progressivity/regressivity of the carbon tax at the country level.

Table 1. Household Surveys' Summary Statistics

Economy	Number of Households	Number of Individuals	Average Household Size	Share of Urban Households	Consumption per Capita (2018 USD)	Survey
Australia	10,046	23,626	2.6	-	22,542	2015-16 Australia Household Expenditure Survey
China	14,218	50,602	3.3	61.2	4,730	2018 China Family Panel Studies
Hong Kong SAR	6,812	20,436	3.0	100.0	15,281	2014-15 Hong Kong Household Expenditure Survey, HKSARG
India	101,662	464,959	4.4	31.2	404	2011-12 68th Round of the National Sample Survey
Indonesia	16,931	50,148	5.1	59.9	1,446	2014 Indonesian Family Life Survey - Wave 5, RAND Corporation
Japan	34,490	78,637	2.3	-	15,288	2019 National Survey of Family Income, Consumption and Wealth
Kiribati	1,161	6,725	6.2	37.5	1,046	2006 Household Income and Expenditure Survey
Korea	7,200 (Monthly Survey)	17,280	2.4	-	14,656	2020 Korea Household Income and Expenditure Survey
Mongolia	16,441	56,525	3.5	67.0	2,577	2016 Household Socio Economic Survey
Myanmar	13,730	59,039	4.3	28.8	442	2017 Myanmar Living Conditions Survey
New Zealand	20,922	-	-	-	-	2018-19 New Zealand Household Economic Survey
Philippines	41,544	192,564	4.6	-	1,143	2015 Family Income and Expenditure Survey
Singapore	13,100	-	-	100.0	-	2017-18 Singapore Household Expenditure Survey
Taiwan, Province of China	16,528	48,262	2.9	-	8,887	2020 Taiwan Family Income/Expenditure Survey

Source: IMF staff calculations.

We follow the incidence analysis framework outlined in IMF (2019a) and measure the loss of higher prices for consumers as:

$$\sum_i \rho_i \omega_i \left(1 - \frac{\rho_i \varepsilon_i}{2}\right)$$

where i represents each consumer good, ρ_i is the percent increase in price i induced by the carbon tax, ω_i is the weight of good i on the consumer budget, and ε_i is the price elasticity of good i. For energy goods, we assume a price elasticity of -0.25 in line with empirical estimates as noted in IMF (2019a), but results are robust to assuming a zero elasticity. We do not adjust household budget shares to account for improving trends in energy efficiency over time. If we were to do so, the negative impact on households would be lower. We do not model other behavioral responses based on income levels or household characteristics.

Fourth, we use household surveys to identify households most likely to be affected through a negative labor income channel. Given that we are assuming a negative price elasticity for energy goods, we would expect lower labor demand in those sectors. Specifically, we model a negative labor income shock for workers in energy sectors assuming constant labor productivity—in other words, a 10 percent drop in consumption of output of a given sector would yield a 10 percent reduction in labor income for workers in the sector. Because each household in the survey represents many more, we do not need to take a stand on whether the reduction in labor income takes place through lower employment or earnings. We do not model the transition of energy workers to other sectors or the value of increased leisure or home production if they remain outside of the labor force. In this way, we err on the conservative side and our results constitute an upper bound on the energy-sector workers' losses.

We do not model other potential effects in the labor market. Our approach does not consider new jobs that could be created in green industries thanks to the carbon tax, nor job losses that could emerge in high-carbon non-energy sectors,[18] This is because the empirical literature has not documented a significant reduction of employment or GDP growth in the aggregate in response to carbon taxes. For example, Metcalf (2019), Bernard and others (2018), Metcalf and Stock (2020), Shapiro and Metcalf (2021), and Yamazaki (2017) use different techniques to evaluate the impact of a carbon tax on GDP growth and employment across different economies and fail to find significant negative effects. Yamazaki (2017) finds there were job losses in metal and chemical manufacturing, in addition to energy sectors, in the context of the revenue-neutral carbon tax implemented in 2008 by British Columbia, Canada. But Yamazaki also finds very substantial employment gains, specifically in retail, healthcare, education, and administrative services. Nevertheless, the employment impact could vary significantly across countries and highlights the importance of ensuring that the reallocation to greener jobs does take place, particularly in view of the urgency of job creation in many of the countries covered in this paper. In general, policies should be targeted and aim to support workers and communities, rather than jobs or sectors. They should include investments in human capital and active labor market policies to assist workers with retraining, and resources from a carbon tax could help fund such policies as outlined in IMF (2022).

We use employment and income variables on household surveys to identify energy workers. We use country-specific definitions in order to account for differences in the richness of worker's industry and occupation variables across surveys.

- In China, we identify workers employed by the mining industry and, among them, we assign coal mining jobs by using the province share on national coal production from Caldecott and others (2017). For non-coal workers, we compute their labor income shock through the average shock of Oil and Gas Extraction and Other Mining weighted by their respective share on compensation of employees as per the input output tables. Similarly, we identify workers in the utilities sector and compute their income shock as the compensation-weighted shock for Electricity, Heat Production and Supply, Gas Production and Supply, and Water Production and Supply. We identify workers involved in the refining of gasoline keeping those working in the manufacturing industry in refining occupations.
- In Indonesia, we identify workers engaged in the coal, crude oil, and natural gas extraction industries as those who identified themselves as working in the mining and quarrying industry. We categorized workers from both the electricity and the "natural and artificial gas products, providing water vapor / hot water, cold air and ice products" industries as employed in the electric, gas, and water industry.
- In India, we identify coal workers as those employed in industries 0510 and 0520, workers engaging with the extraction of crude petroleum and natural gas as those in industries 0610 and 0620, and workers involved in the refining of gasoline as those in industries 1920, 192x, and 19xx. Electricity workers are those employed in industry 3510. Natural gas workers are those employed in industries 3520 and 352x. The survey covers both formal and informal employment.
- In Kiribati, we identify electricity workers as those employed in industry 41 (Electricity supply). There are no other relevant energy sectors in the country.
- In Mongolia, we identify coal workers as those employed in industries 510, 510.1, and 520. We identify oil and gas workers as those in industries 610 and 620. Workers involved in the refining of gasoline

[18] Dabla-Norris and others (2021) explore the jobs at risk from a carbon tax in the region.

would be identified as in industry 1920, but there were none at the time of the survey.[19] Electricity workers are identified by industry 3510 and natural gas workers by industry 3520.

- In Myanmar, we identify mining and quarrying workers as those employed in industry 202; for petroleum products as those working in industry 207; and for workers in electricity, gas, and water as those working in industry 218.
- In the Philippines, coal workers are those employed in industries 510 and 520. Oil and gas workers are in industries 610 and 620. Industries 1920 and 1990 identifies workers in the refining of fuel products. Electricity workers are those employed by industry 3510. Natural gas workers are in industry 3520.

Finally, we study the impact of compensating measures through direct cash transfers. The list of measures considered in the analysis is shown in Table 2. For our main analysis, we assume that all tax revenues raised by the carbon tax are spent on each of those compensating measures. We obtain carbon tax revenues as percent of GDP from the IMF's CPAT and we apply them to GDP in local currency in the year of the survey. We divide those resources among the households or individuals eligible for each policy (and in the corresponding amounts) to ensure that all tax revenues are spent on every simulation. For example, in China, using all the carbon tax revenues to fund a universal basic income would yield a cash benefit of USD 168 per person per year. Alternatively, the carbon tax revenues could be used to fund a USD 958 annual grant for every child younger than 14 or a USD 1,293 noncontributory pension for every senior older than 65. The last two policies in each country table correspond to a cash transfer to households in the poorest two quintiles and differ on whether the targeting is perfect or, more realistically, proxy-means based. For simplicity and ease of comparison, we do not assume any administrative costs on implementing the measures, although they may be significant, especially for countries with weak social safety nets.[20]

We consider targeted cash transfers using proxy-means testing whereby we estimate household consumption per capita based on observable and easily verifiable characteristics such as type of housing and access to water and provide transfers to the households identified as poor by that estimation (Annex I describes the methodology in more detail). For the simulation of a perfect expansion of the minimum income scheme in China (Dibao), we follow the approach proposed by Ralyea (2021). In particular, given that the most common method to compute the local Dibao threshold consists of multiplying a locally determined "replacement rate" by the average consumption per capita in the region, we assume that the additional carbon tax revenues are distributed so that every region achieves the same increase in the replacement rate (in percentage points). We also consider a proxy-means tested approach to the Dibao expansion whereby only households identified as poor by the estimator benefit from higher transfers.

We do not model compensation through tax policies or enhanced public services. Countries could choose to use their carbon tax revenues to reduce distortionary taxes or strengthen public services such as the provision of health and education. The latter could be especially relevant for countries in the region with significant needs to meet their sustainable development goals and limited ability to raise other taxes due to large informal sectors. However, our framework does not lend itself to model household responses to changes in the tax system. In addition, to model the impact of higher public spending on household welfare we would need to identify how households value those services rather than how much they cost. Thus, we prefer to avoid exploring those avenues of compensation in the paper and keep the focus on direct cash transfers.

Our measure of change in welfare at the household level aggregates the three channels. That is, it includes the loss of consumer surplus due to higher prices, the loss in labor income, and the gain from

[19] The construction of the country's first oil refinery was launched in 2018. See Reuters, "Mongolia Launches Construction of First Oil Refinery with Indian Aid," published on June 22, 2018.

[20] IMF (2020b) offers advice on expanding social safety nets and implementing these types of transfers.

compensatory measures. All variables are expressed in percent of initial household consumption for ease of comparison.

We do not model co-benefits from a carbon tax. For instance, local air pollution has massive health cost in Mongolia (Warburton and others, 2018) and China (Dabla-Norris and others, 2021) and a carbon tax could mitigate pollution and improve health outcomes. It could also increase road safety. However, modeling these co-benefits for our analysis would require making assumptions of how individual households value those co-benefits, which appears challenging given the data we are using. In a similar way, we do not model the gains of avoided climate damages thanks to a carbon tax as it is hard to argue that those benefits are localized. Our not modeling of these co-benefits is then an additional source of conservative bias making our results an upper bound on household's welfare loss.

Some of the lessons from our simulations can be useful for the analysis of other mitigation tools. Carbon taxes may not be politically feasible in some countries. For instance, China has opted to implement an emissions trading scheme (ETS). In theory, the distributional implications of higher energy prices would depend on the implicit carbon price, regardless of whether that is achieved through a carbon tax or a broad based ETS. An ETS without free allowances would also raise resources to implement compensation policies as we discuss in this paper. In practice, an ETS may be more difficult and expensive to administer, and free allowances may be provided, constraining the space for compensation measures. Alternatively, excises on some energy products but not all may be appropriate when balancing other policy objectives.[21] In any case, the framework outlined in this paper could be used to explore the distributional impact of other mitigation policies and not just a carbon tax.

[21] For example, a recent tax reform in the Philippines provided for annual increases in excises taxes on coal and petroleum between 2018 and 2020.

Table 2. Compensating Measures

China

Policy	Benefit (2018 USD)
Universal basic income	168
Child grant to all children younger than 14	958
Noncontributory old age pension to everyone older than 65	1,293
Perfect expansion of Dibao with locally-determined "replacement rate" raised by 22 percentage points	-
Proxy-means tested expansion of Dibao with locally-determined "replacement rate" raised by 41 percentage points	-
Subsidy to households who live in urban communities	917
Subsidy to households who live in rural communities	1,447
Lump sum to beneficiaries of existing social protection schemes	1,683
Increase of benefit of existing social protection schemes by 89 percent	-
Subsidy to households who cook with firewood/straw or coal	2,848
Perfectly targeted transfer to the poorest 40% households	1,403
Proxy-means tested transfer to the poorest 40% households	1,403

India

Policy	Benefit (2018 USD)
Universal basic income	42
Child grant to all children younger than 14	144
Noncontributory old age pension to everyone older than 65	863
Lump sum to households with Antyodaya or BPL ration cards	532
Lump sum to all households receiving ration cards	235
Subsidy to urban households	602
Subsidy to rural households	274
Subsidy to households who cook with coke, coal, firewood and chips, dung cake, charcoal, or without cooking arrangement	302
Subsidy to households with electricity	235
Perfectly targeted transfer to the poorest 40% households	470
Proxy-means tested transfer to the poorest 40% households	470

Indonesia

Policy	Benefit (2018 USD)
Universal basic income	59
Child grant to all children younger than 18	216
Noncontributory old age pension to everyone older than 65	1,192
Lump sum to households with a female head	2,299
Subsidy to urban households	554
Subsidy to rural households	662
Subsidy to households with a health card	650
Subsidy to households with access to health fund	2,588
Subsidy to households with Letter of Poor	1,641
Subsidy to individuals with a PKPS BBM BLT/BLSM card	1,659
Subsidy to households receiving BSM (Help Poor Students)	2,582
Subsidy to those with government health insurance	1,292
Subsidy to householsd with a Kartu Keluarga (Family Card)	332
Perfectly targeted transfer to the poorest 40% households	754
Proxy-means tested transfer to the poorest 40% households	754

Kiribati

Policy	Benefit (2018 USD)
Universal basic income	11
Child grant to all children younger than 14	36
Noncontributory old age pension to everyone older than 65	357
Subsidy to urban households	176
Subsidy to rural households	106
Subsidy to households with kitchen outside or no kitchen	96
Subsidy to households who cook with wood or sawdust stoves or open fires	108
Subsidy to households with electricity	141
Perfectly targeted transfer to the poorest 40% households	165
Proxy-means tested transfer to the poorest 40% households	182

Mongolia

Policy	Benefit (2018 USD)
Universal basic income	162
Raise noncontributory old age pension to everyone older than 65	3,519
Quadruple child money	-
Subsidy to households in the 6 most severely hit aimags (Khentii, Govisumber, Govi-Altai, Bayan-Ulgii, Khovd)	4,676
Subsidy to households who own a motorcycle	4,259
Subsidy to households who own a vehicle	1,540
Subsidy to households who own a tractor	93,824
Subsidy to urban households	842
Subsidy to rural households	1,709
Perfectly targeted transfer to the poorest 40% households	1,410
Proxy-means tested transfer to the poorest 40% households	1,410

Myanmar

Policy	Benefit (2018 USD)
Universal basic income	17
Child grant to all children younger than 5	178
Child grant to all children younger than 18	50
Noncontributory old age pension to everyone older than 65	230
Lump sum to households with a female head	345
Lump sum to households with at least a member	50
Lump sum to households with disability	607
Subsidy to urban households	252
Subsidy to rural households	102
Perfectly targeted transfer to the poorest 40% households	181
Proxy-means tested transfer to the poorest 40% households	181

Philippines

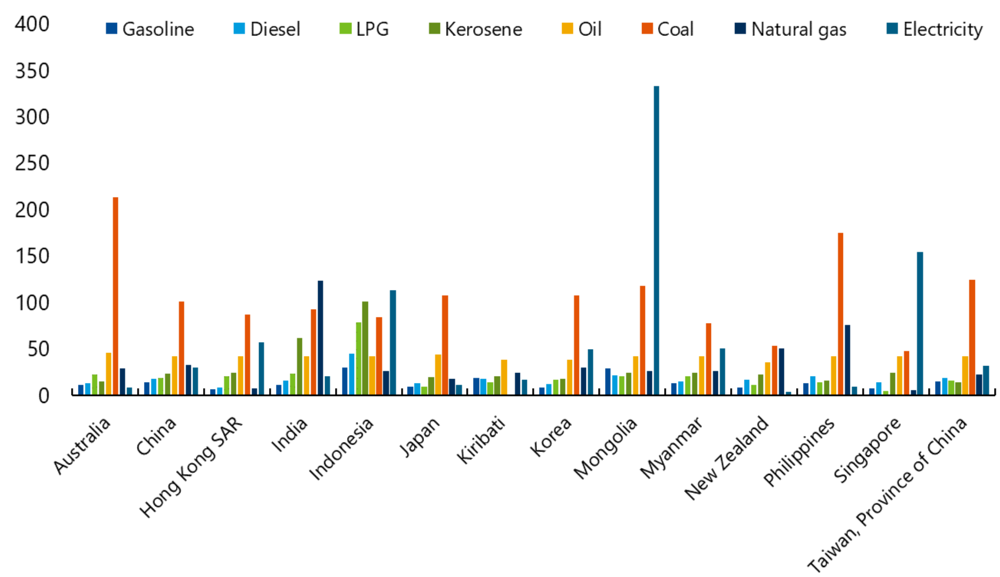
Policy	Benefit (2018 USD)
Universal basic income	24
Child grant to all children younger than 5	280
Child grant to all children aged 5-17	86
Subsidy to households who own a car	1,584
Subsidy to households who own a banca	10,282
Subsidy to households who own a motorcycle	459
Subsidy to households with electricity	124
Perfectly targeted transfer to the poorest 40% households	282
Proxy-means tested transfer to the poorest 40% households	282

Source: IMF Staff calculations.

The Impact of a Carbon Tax on Households in the Region

A carbon tax would raise energy prices in the region significantly (Figure 5). The impact would be especially large for coal, given the high level of CO_2 emitted during its combustion. The increase in the price of coal would range from 48 percent in Singapore to 214 percent in Australia. The price of electricity would rise by over 300 percent for Mongolia given its heavy dependence on coal. It would also increase substantially in Indonesia (113 percent) and Singapore (154 percent). Gasoline prices would increase by 7 to 20 percent in most economies, but by around 30 percent in Indonesia and Mongolia. The price of diesel in Indonesia would increase by 45 percent, but the change would be much smaller for the rest of the economies, ranging from 9 to 22 percent.

Figure 5. Increase in the Price of Energy Goods Induced by a Carbon Tax of $50 per Ton
(Percent)

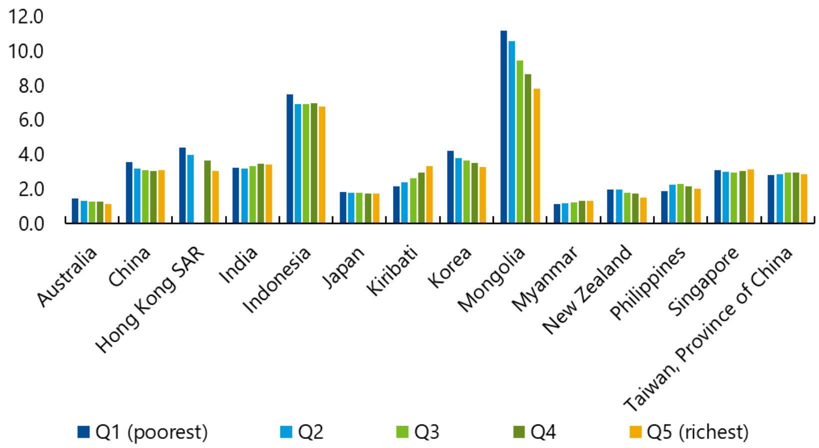


Source: CPAT.

The impact of higher energy prices on household welfare would vary widely across the region (Figure 6). On average, it would vary from around 1.2 percent of household initial consumption in Myanmar to almost 10 percent in Mongolia and 7 percent in Indonesia. Household welfare losses would amount to 3.8 percent in Hong Kong SAR and 3.7 percent in Korea. However, it is not only the average burden on households that would differ across the region, but also the distributional implications. The carbon tax would be regressive in Australia, China, Hong Kong SAR, Indonesia, Japan, Korea, Mongolia, and New Zealand because the burden would be relatively larger for the poorest households, whose consumption is more carbon intensive. But the carbon tax would be fairly proportional in Singapore and Taiwan, Province of China, with the burden being evenly distributed across quintiles. Finally, the carbon tax would be progressive in India, Kiribati, Myanmar, and the Philippines because the tax would be paid disproportionately by the richest households.

Figure 6. Burden of Higher Prices by Quintile

(Percent of household initial consumption, carbon tax $50 per ton)

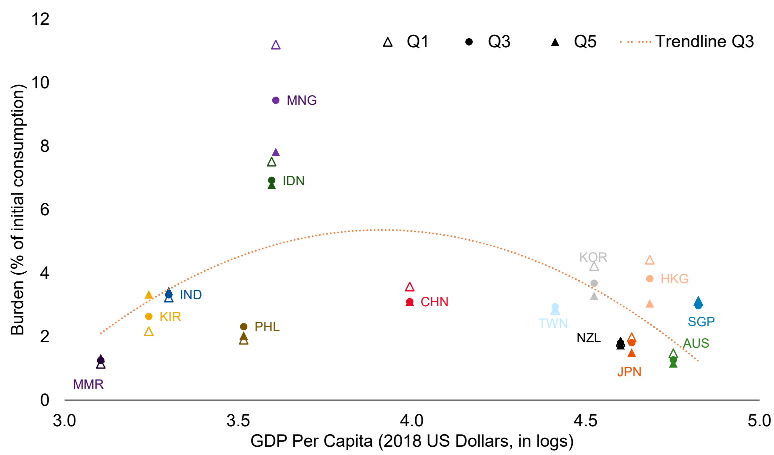


Source: IMF staff calculations based on household surveys.
Note: Quintiles determined by per capita household expenditure, except for Australia, Hong Kong SAR, Japan, Korea, New Zealand, Singapore, and Taiwan Province of China, for whom household income was used.

The burden of a carbon tax through higher prices appears to follow an inverted-U pattern on income per capita (Figure 7). There is a small impact for the poorest countries in the region (Myanmar, Kiribati, India, and the Philippines) and for the richest (Australia and Singapore). The burden is highest for middle-income countries, particularly Indonesia, and Mongolia. The inverted-U pattern reflects low access to electricity and, more broadly, utilities in low-income countries, whereas utilities have virtually universal coverage in high-income countries, but account for smaller shares of household consumption than in middle-income countries. Progressivity also appears well predicted by income per capita, with the carbon tax being progressive in the four poorest countries in our sample, and regressive or proportional in the others.

Figure 7. Burden of Higher Prices by Quintile and Income per Capita

(Percent of household initial consumption, carbon tax $50 per ton)

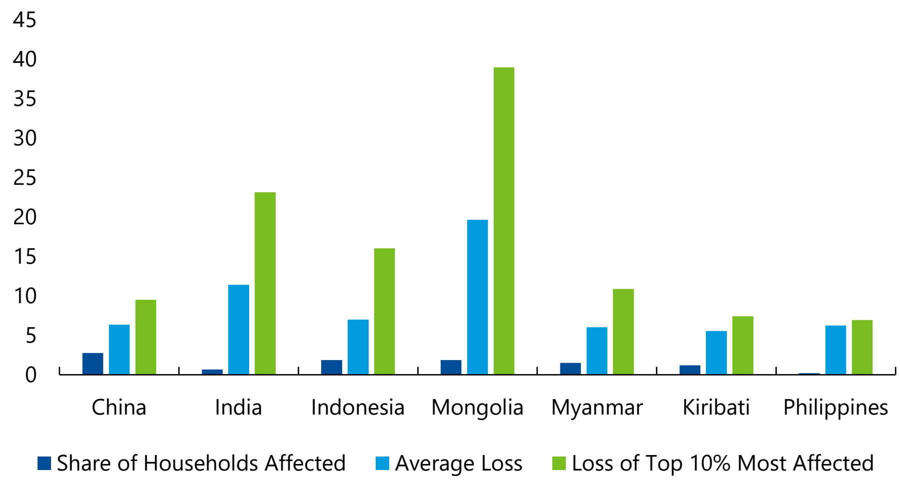


Source: IMF staff calculations based on household surveys.
Note: Quintiles determined by per capita household expenditure, except for Australia, Hong Kong SAR, Japan, Korea, New Zealand, Singapore, and Taiwan Province of China, for whom household income was used. “Trendline Q3” represents the quadratic fit of a regression of the burden for the third quintile on GDP per capita. Q1: poorest quintile. Q3: third quintile. Q5: richest quintile.
For ease of interpretation, if the filled triangle is below the hollow triangle, it means that the poorest quintile is losing more than the richest quintile, and so, the carbon tax is regressive (e.g., Hong Kong SAR). Alternatively, if the hollow triangle is above the filled triangle, the richest quintile is losing more and so, the carbon tax is progressive.

Looking at the labor channel, small groups of workers would experience very large losses (Figure 8).[22] The share of households that would experience a reduction in their labor income due to their employment in energy sectors would be small at less than 5 percent. However, their loss would be large. On average, the loss would amount to 20 percent of household initial consumption in Mongolia and 11 percent in India. In China, Indonesia, Kiribati, Myanmar, and the Philippines, their average loss would be 6-7 percent. For the top 10 percent of most affected households, the loss would reach 39 percent of household initial consumption in Mongolia and 23 percent in India. In terms of the distribution of the burden across quintiles, it would be regressive in China, Indonesia, and Myanmar, and progressive in India, Kiribati, and the Philippines. In Mongolia, the loss would disproportionately hurt the third and fourth quintile.

Figure 8. Burden of Lower Labor Income

(Percent, carbon tax $50 per ton)



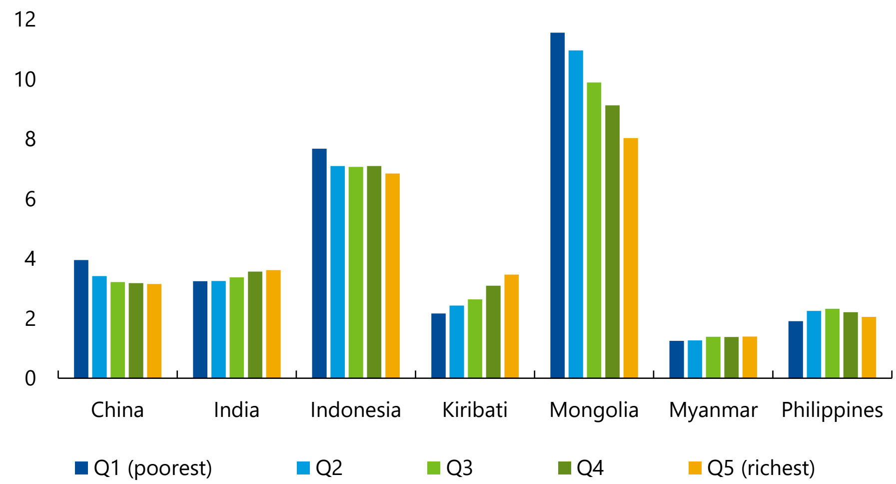
Source: IMF staff calculations based on household surveys.

Note: Both the average loss and the loss of the top 10 percent are expressed as percent of household initial consumption.

In sum, the region would see a heterogeneous reality (Figure 9). Bringing together the burden on households due to higher prices and lower labor income, we find that the carbon tax would be regressive and substantial for Indonesia and Mongolia, with an average burden of 7 and 10 percent of initial consumption, respectively. The carbon tax would be progressive in India with an average burden of 3.4 percent. The burden would be 3.4 percent for China, 2.7 percent for Kiribati, and 2.1 percent for the Philippines, regressive for the first and progressive for the other two. Finally, the burden of the tax would be 1.2 percent and progressive in Myanmar.

22 The sample for this analysis, as well as the remaining figures in the section (except Figure 10), is limited to those countries for which we were able to gather microdata.

Figure 9. Burden of Higher Prices and Lower Labor Income by Quintile (Percent of household initial consumption, carbon tax of $50 per ton)

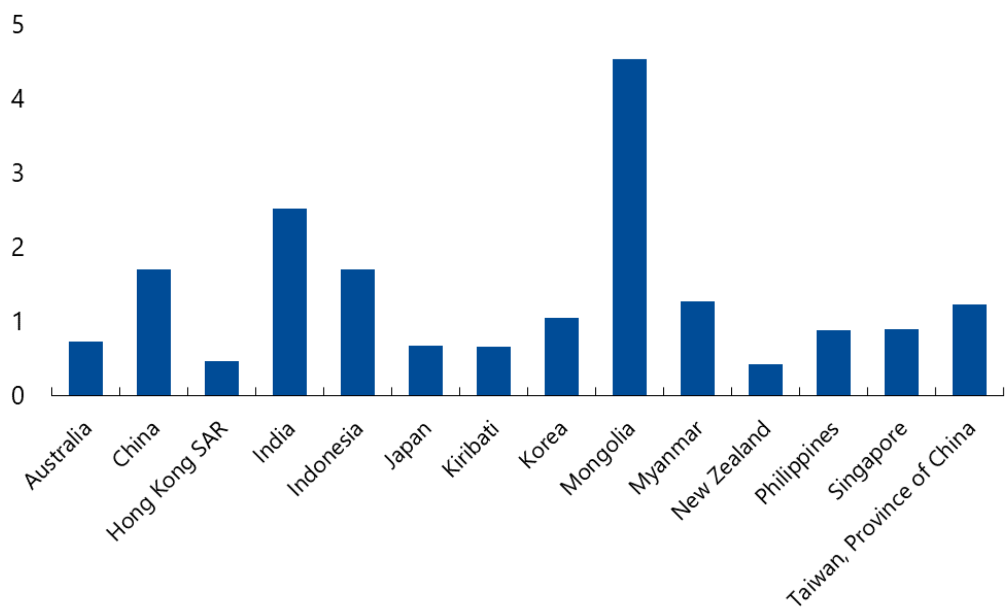


Source: IMF staff calculations based on household surveys.
Note: Quintiles determined by per capita household expenditure.

The good news is that a carbon tax would raise substantial resources (Figure 10). A carbon tax of $50 per ton would yield an average of 1.4 percent of GDP in fiscal revenues across the region. The yield would reach 4.5 percent of GDP for resource-rich Mongolia. India would collect 2.5 percent of GDP and China and Indonesia, 1.7 percent of GDP. For Korea, Myanmar, and Taiwan, Province of China the yield would be over 1 percent of GDP. Even for New Zealand that at 0.4 percent of GDP would collect the smallest amount, the yield is sizable.

Figure 10. Fiscal Revenues from a Carbon Tax

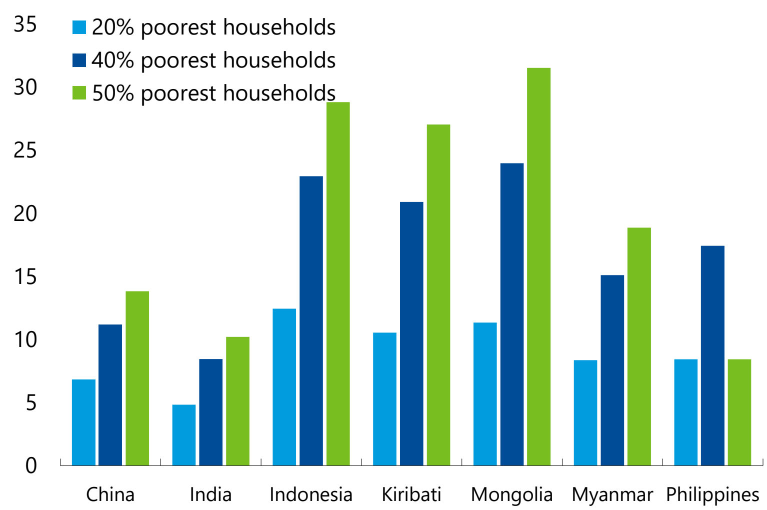
(Percent of GDP, carbon tax of $50 per ton)



Source: CPAT.

The resources raised by a carbon tax can be used to protect the most vulnerable (Figure 11). For example, we consider how much countries would need to use from the carbon tax revenues to compensate on average the poorest 20, 40, and 50 percent of households using a targeted cash transfer per household. Importantly, we do not assume perfect targeting. Instead, we use proxy-means testing based on easily verifiable characteristics, as many countries already do on the ground, and that leads to both exclusion and inclusion errors. Protecting the poorest 20 percent of households in this way could cost less than 13 percent of the revenues collected from the carbon tax, ranging from 4.8 percent in India to 12.4 percent in Indonesia. Aiming to compensate a larger share of the population requires a greater share of the carbon tax revenues. But even compensating the poorest half of the households would cost less than a third of the carbon tax revenues in Indonesia, Kiribati, and Mongolia and less than a quarter on the other countries. In addition, providing full compensation to households based on their lower labor income would cost less than 10 percent of the carbon tax revenues in all countries. Of course, for this compensation to be effective, it would need to be timely, deployed in conjunction, or maybe even in advance, to the introduction of the carbon tax.

Figure 11. Share of Carbon Tax Revenues Needed to Compensate Poorest Households on Average
(Percent, carbon tax $50 per ton)

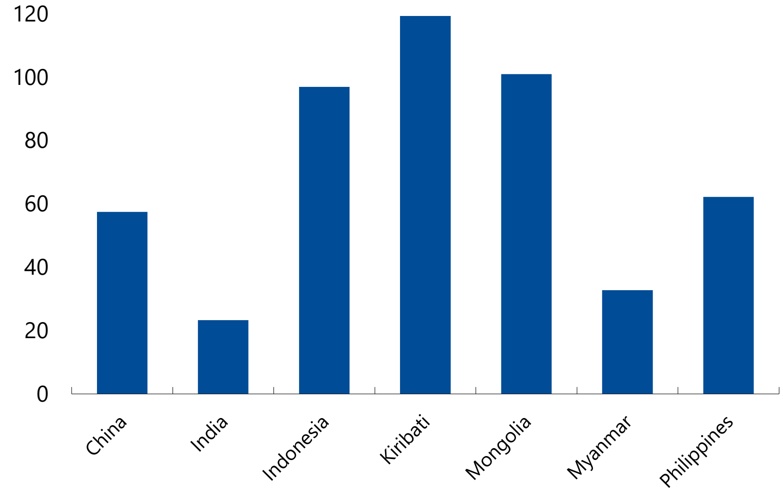


Source: IMF staff calculations based on household surveys.

Note: Compensation is assumed to take place through a targeted cash grant to the poorest 20%, 40%, and 50% using proxy-means testing (that is, using easily verifiable characteristics).

Compensation could also aim to make most of the households better off (Figure 12). To build support for the reform, governments could consider distributing the resources raised by the carbon tax in the form of a uniform carbon dividend to every household in the country. In this case, we calibrate the amount of the carbon dividend such that the median impact on households is zero, after accounting for the burden via higher prices and lower labor income, and the carbon dividend. We find that it would cost India only a quarter of its carbon revenues to make half of its households better off, and the cost would be around a third for Myanmar. For China and the Philippines, the cost would amount to around 60 percent of carbon revenues. Compensation in this way would be more expensive for Indonesia and Mongolia, who would need to spend virtually all of their carbon revenues to make half of their households better off after the reform. It would be even more expensive for Kiribati, at a cost of 119 percent of carbon tax revenues. But even then, just introducing a minimum degree of targeting into the distribution of the carbon dividend to exclude the richest quintile of households would make the reform welfare improving for more than half of the households.

Figure 12. Share of Carbon Tax Revenues Needed to Improve Welfare for 50% of Households
(Percent, carbon tax $50 per ton)



Source: IMF staff calculations based on household surveys.

Note: Compensation is assumed to take place through a universal lump sum transfer per household.

Countries can of course consider alternative uses of the carbon tax revenues (which is outside the scope of this paper). For instance, they could reduce distortionary taxation or increase spending in health, education, or other public services. A carbon tax would provide valuable resources to countries in the region with large needs to meet their sustainable development goals and limited room to mobilize revenues due to the substantial size of the informal sectors. Countries with limited fiscal space could use carbon tax revenues to reduce public debt and so, lower the burden of interest payments and build space to provide countercyclical stimulus and enhance resilience to shocks.

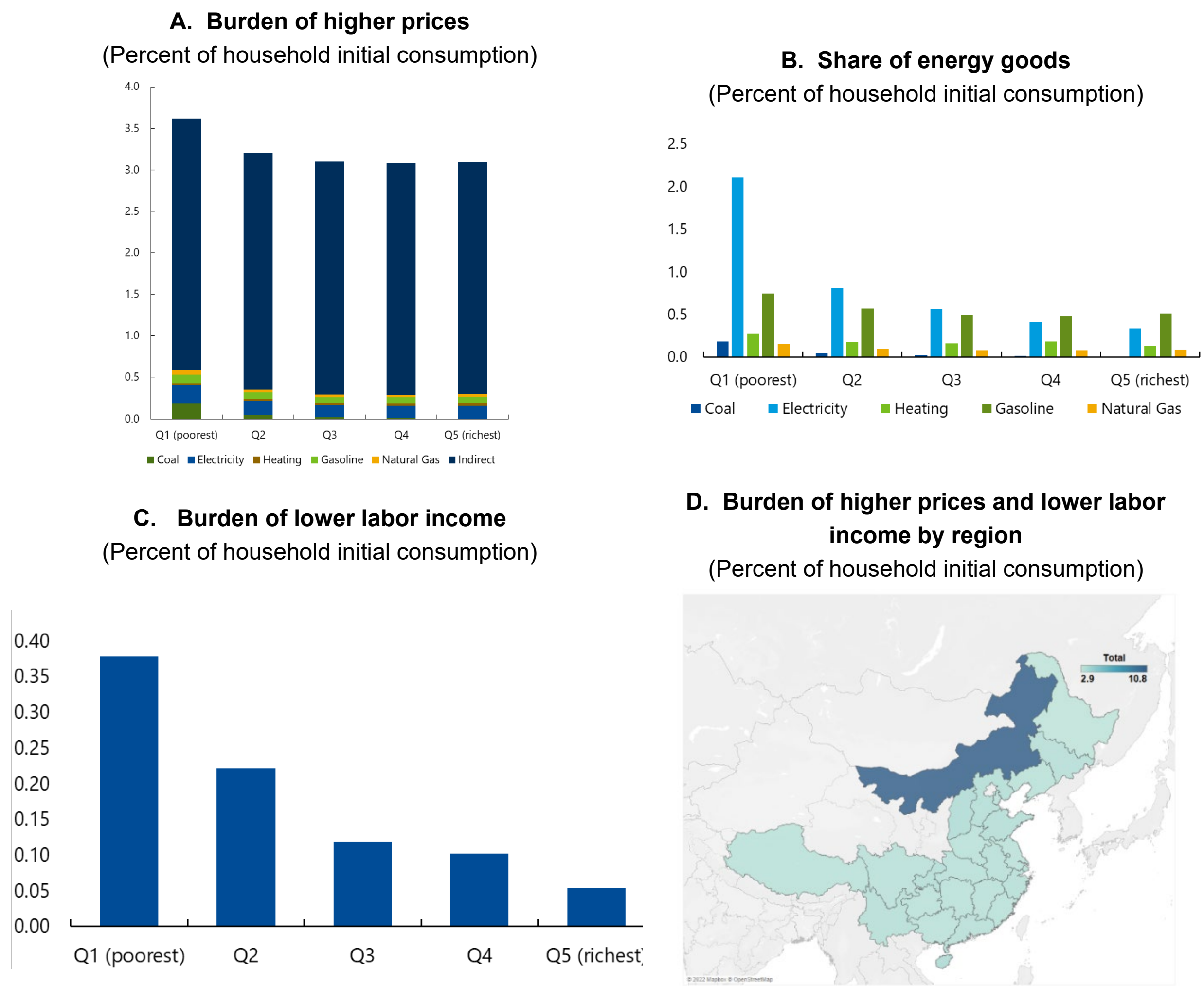
The Impact of a Carbon Tax on Households by Economy

China

A carbon tax would be regressive for consumers in China (Figure 13). Households in the richest quintile would experience a loss of welfare due to higher prices equivalent to 3.1 percent of their initial consumption compared to 3.6 percent for the poorest quintile (Panel A). This regressivity is mainly driven by coal, electricity, gasoline, and natural gas representing a larger share of consumption for the poorest (Panel B). The indirect effect of a carbon tax declines after the poorest quintile, being flat for the subsequent 4 quintiles.

The impact remains regressive after factoring in the labor income channel. For workers, the burden of the tax via lower labor income would fall on the poorest households, which make up a large proportion of laborers in the coal mining, other mining, and electricity and gas sectors (Panel C). Finally, the carbon tax would have different implications across the country (Panel D). For instance, the impact would be most severe, at 11.1% of initial consumption, in Inner Mongolia, reflecting the higher proportion of coal mining in the area, and least severe in Heilongjiang (2.8% of initial consumption).

Figure 13. Impact of a $50 per Ton Carbon Tax on Households in China

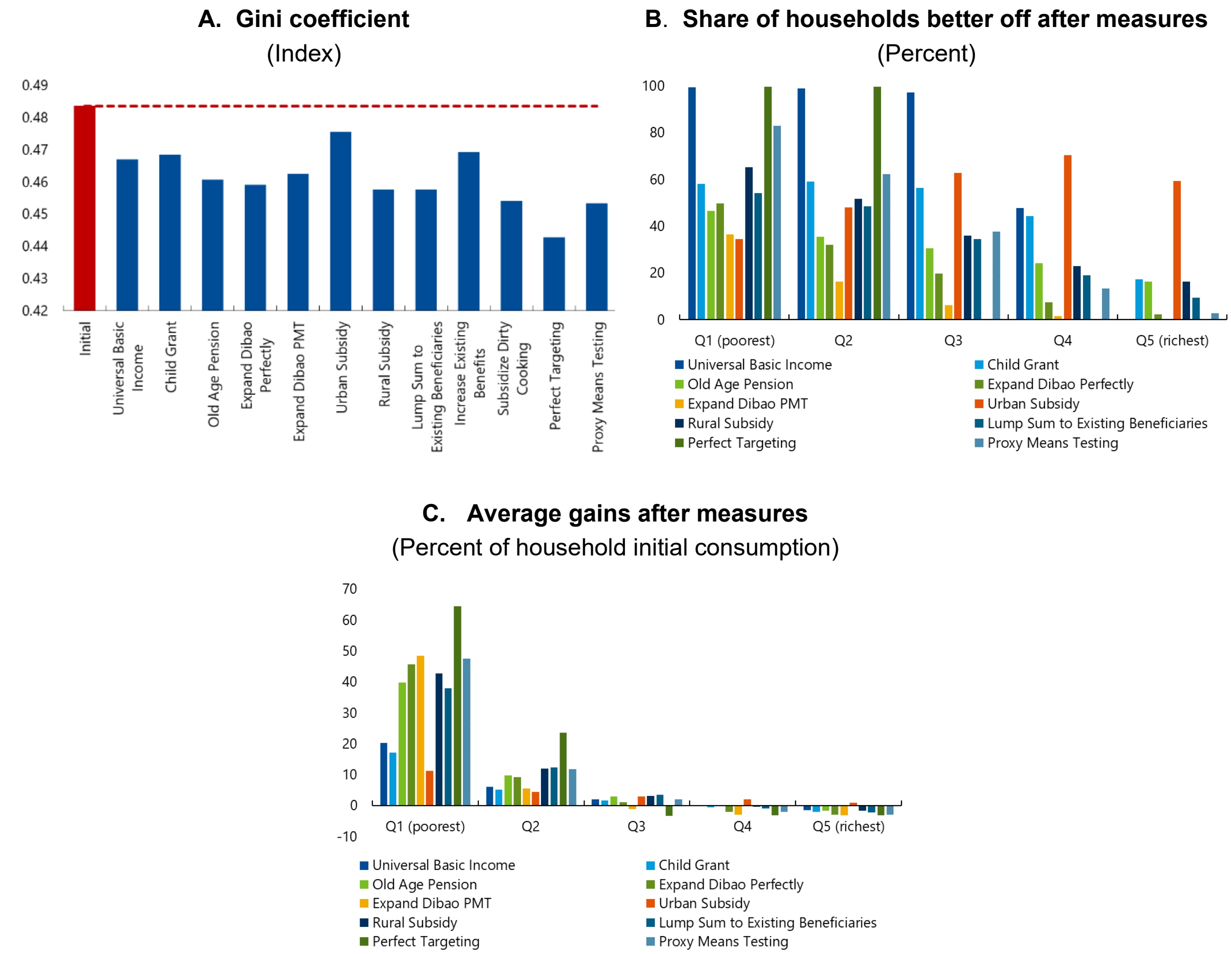


Source: IMF staff calculations based on household surveys.

The resources raised by a carbon tax could be used to compensate the most vulnerable and reduce inequality in China (Figure 14). The carbon tax would raise fiscal revenues by about 1.7 percent of GDP which, if distributed as a universal basic income (that is, a cash grant per person), would reduce inequality from 0.484 to 0.467 (Panel A). Similar reductions in inequality would be achieved if the resources were distributed as a grant for each child younger than 14 or as an increase of benefits on existing programs. Providing an old age pension (that is, a noncontributory benefit to all seniors older than 65), using a proxy-means tested expansion of the Dibao minimum income scheme, expanding Dibao perfectly, providing a rural subsidy, a lump sum to existing beneficiaries of social programs, or subsidizing households without access to clean cooking methods were more effective routes of lowering inequality. Providing a lump sum transfer to the 40 percent poorest households assuming perfect targeting would reduce inequality to 0.443, the most effective measure. However, assuming a more realistic targeting based on easily verifiable characteristics would yield a reduction to 0.453, an improvement compared with many of the other schemes and near the amount of reduction had with perfect targeting. An urban subsidy is shown to be the least effective at lowering inequality, to a level of 0.476. Alternatively, it would cost less than 6 percent of the resources raised by the carbon tax to avoid an increase in inequality after the reform using any of these cash transfers.

The provision of a universal lump sum transfer, a child grant for children younger than 14, providing a rural subsidy, perfect targeting of a lump sum transfer to the poorest 40 percent of households, and a proxy-means tested transfer would improve welfare for most of the households in the poorest two quintiles, yielding substantial average gains at the expense of mild losses for the better off (Panels B and C). Providing an urban subsidy would produce regressive results, mainly benefiting a majority of households in the 3rd, 4th, and 5th quintiles.

Figure 14. Impact of Alternative Compensation Schemes in China



Source: IMF staff calculations based on household surveys.

Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. “Perfect targeting” assumes a lump sum transfer per household to the 40% poorest households. “Proxy Means Testing” assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

India

The burden of a carbon tax due to higher prices would be mildly progressive for households in India (Figure 15). Consumers in the poorest quintile would experience a loss of around 3.2 percent compared to initial consumption, while the richest households would lose around 3.4 percent (Panel A). This outcome reflects a strongly progressive direct effect from higher energy prices, partially offset by a regressive indirect effect from higher prices on other goods.

The direct burden of higher energy prices reflects very different energy consumption patterns across households. The richest households allocate relatively more of their expenditure towards electricity, gasoline, and LPG while the bottom quintile of households consume more kerosene and to a lesser degree coal (Panel B). Electricity, gasoline, and LPG would see their prices rise by 20.5, 12, and 23.6 percent, respectively in response to the carbon tax. This would add up to a burden of 0.4 percent of initial consumption for the poorest quintile, but 1.5 percent for the richest quintile. This progressivity is mitigated by the effect of higher prices of kerosene and coal, which would lead to a burden of 1 percent of initial consumption for the poorest quintile and only 0.3 for the richest. In sum, the direct effect of higher energy prices would cost 1.4 percent of initial consumption for the poorest households and 1.8 percent for the richest.[23]

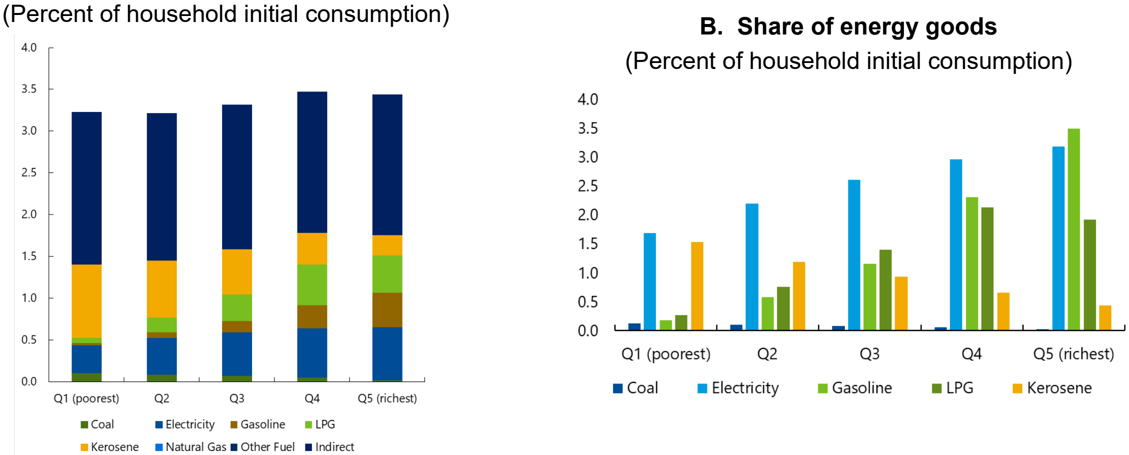
The indirect burden of higher prices of other goods would be mildly regressive. It would amount to 1.83 percent of initial consumption for households in the poorest quintile and 1.68 percent for households in the richest quintile. Food plays an important role in explaining the distribution of the burden. Cereals, whose price would increase by 2.6 percent in response to the carbon tax, represent 18 percent of the consumption bundle of households in the poorest quintile but only 5 percent of the consumption of the richest households. In a similar way, the poorest households spend 5 percent of their budget on edible oils, whereas the richest only spend 2 percent. The price of edible oils would rise by 1.9 percent after the carbon tax is implemented.

The impact proves to be more progressive after factoring in the labor income channel. For workers, the burden of the tax via lower labor income would fall mainly on the upper quintiles (Panel C). Workers in these quintiles are more likely to work in carbon intensive industries, such as the electricity, natural gas, and oil extraction sectors. It is also worth noting that the carbon tax would have different implications across the country (Panel D). Jharkhand would have the most severe welfare loss at around 5 percent of initial consumption, while at the opposite end, Tipura would see a reduction of around 2.9 percent.

Figure 15. Impact of a $50 per Ton Carbon Tax on Households in India

A. Burden of higher prices

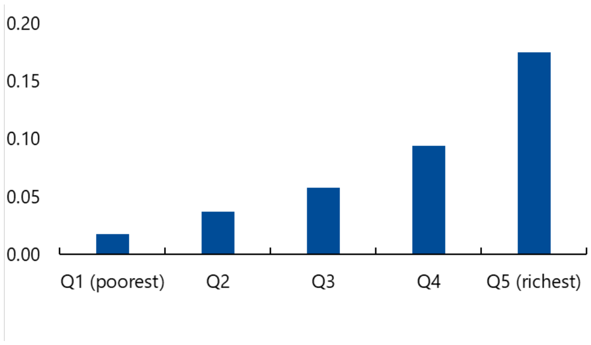
(Percent of household initial consumption)



[23] Annex IV shows that progressivity of the tax may have been reduced after accounting for the expansion in electricity access experienced in the 2010s, but the magnitude of the change would be small.

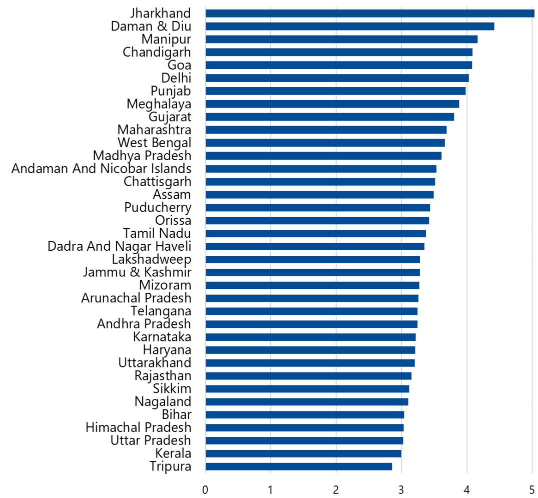
C. Burden of lower labor income

(Percent of household initial consumption)



D. Burden of higher prices and lower labor income by state

(Percent of household initial consumption)

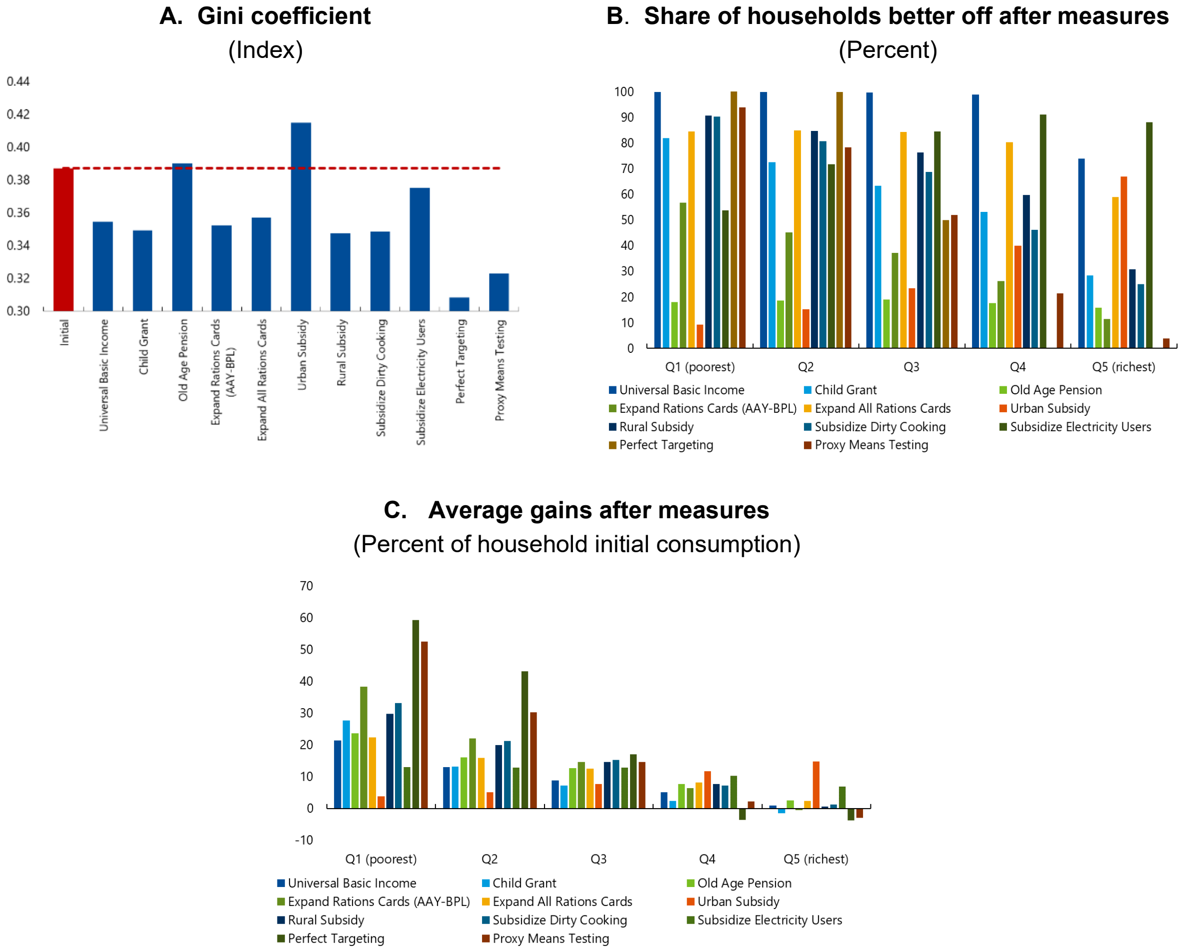


Source: IMF staff calculations based on household surveys. The list of Indian states corresponds to that applying when the 68th round of the Socio-Economic Survey was conducted (July 2011 – June 2012).

The carbon tax revenues could go a long way towards improving inequality in India (Figure 16). Our analysis shows that the implementation of a $50 carbon tax would raise fiscal revenues by about 2.5 percent of GDP. Redistributing these revenues fully as a universal lump sum per person would decrease the Gini coefficient from an initial state of 0.387 to 0.355, with similar reductions seen from establishing a grant for each child below the age of 14, expanding the existing AAY-BPL ration cards, expanding benefits to all rations cards holders, giving a subsidy to those in rural areas, or subsidizing households without access to clean cooking methods. Subsidizing electricity users would produce a smaller reduction in the Gini coefficient, due to higher-income households having greater access to electricity in India. Providing lump sum transfers to households in the bottom two quintiles, assuming perfect targeting, would reduce inequality to 0.308. This being impossible in practice, assuming a more realistic targeting based on easily verifiable characteristics would still yield a sizable reduction to 0.323. On the opposite end, implementing an old-age pension or an urban subsidy would increase inequality, to 0.39 and 0.415 respectively.

Using revenues to provide a universal lump sum, a child grant, expanding benefits for all rations cards, a rural subsidy, providing a rural subsidy, subsidizing households without access to clean cooking methods, or using a proxy means testing method would benefit more than half of all households in the bottom two quintiles. The policies would provide a large average gain to the poorest households, with only a small reduction in the consumption of those in the upper quintiles (Panels B and C). While providing an old-age pension would increase consumption flatly across quintiles, the provision of an urban subsidy is shown to benefit households in the top quintile by about 7 times as much compared to those in the poorest quintile.

Figure 16. Impact of Alternative Compensation Schemes in India



Source: IMF staff calculations based on household surveys.

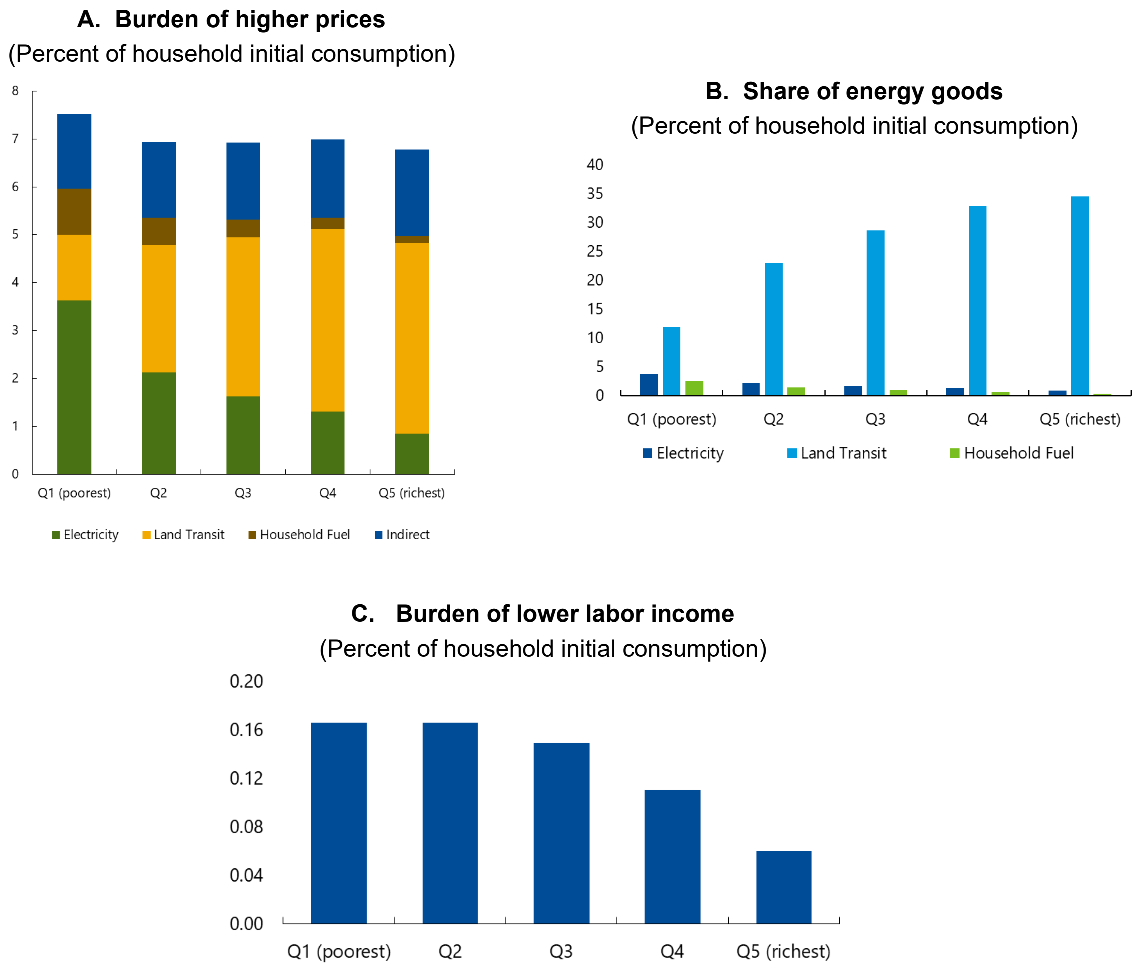
Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. “Perfect targeting” assumes a lump sum transfer per household to the 40% poorest households. “Proxy Means Testing” assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

Indonesia

Instituting a carbon tax in Indonesia would produce a regressively distributed burden via higher prices across households (Figure 17). Consumers in the poorest quintile would experience a loss of around 7.5 percent compared to their initial consumption, while the richest households would lose around 6.8 percent (Panel A). This is due to the difference in consumption between quintiles (Panel B). The poorest households have a larger proportion of their expenditure going towards electricity and household fuels, while both are shown to decrease for richer households. This reduction in relative consumption of electricity and household fuels is replaced by a larger proportion of consumption going towards land transportation and non-energy, less carbon-intensive goods for richer households.

The regressivity of the tax is reinforced when taking into account the labor income channel. For workers, the burden of the tax via lower labor income would fall mainly on the bottom 3 quintiles (Panel C). While all quintiles have around the same likelihood of working in mining industries, richer households are less likely to work in the electricity, natural gas and water industries.

Figure 17. Impact of a $50 per Ton Carbon Tax on Households in Indonesia

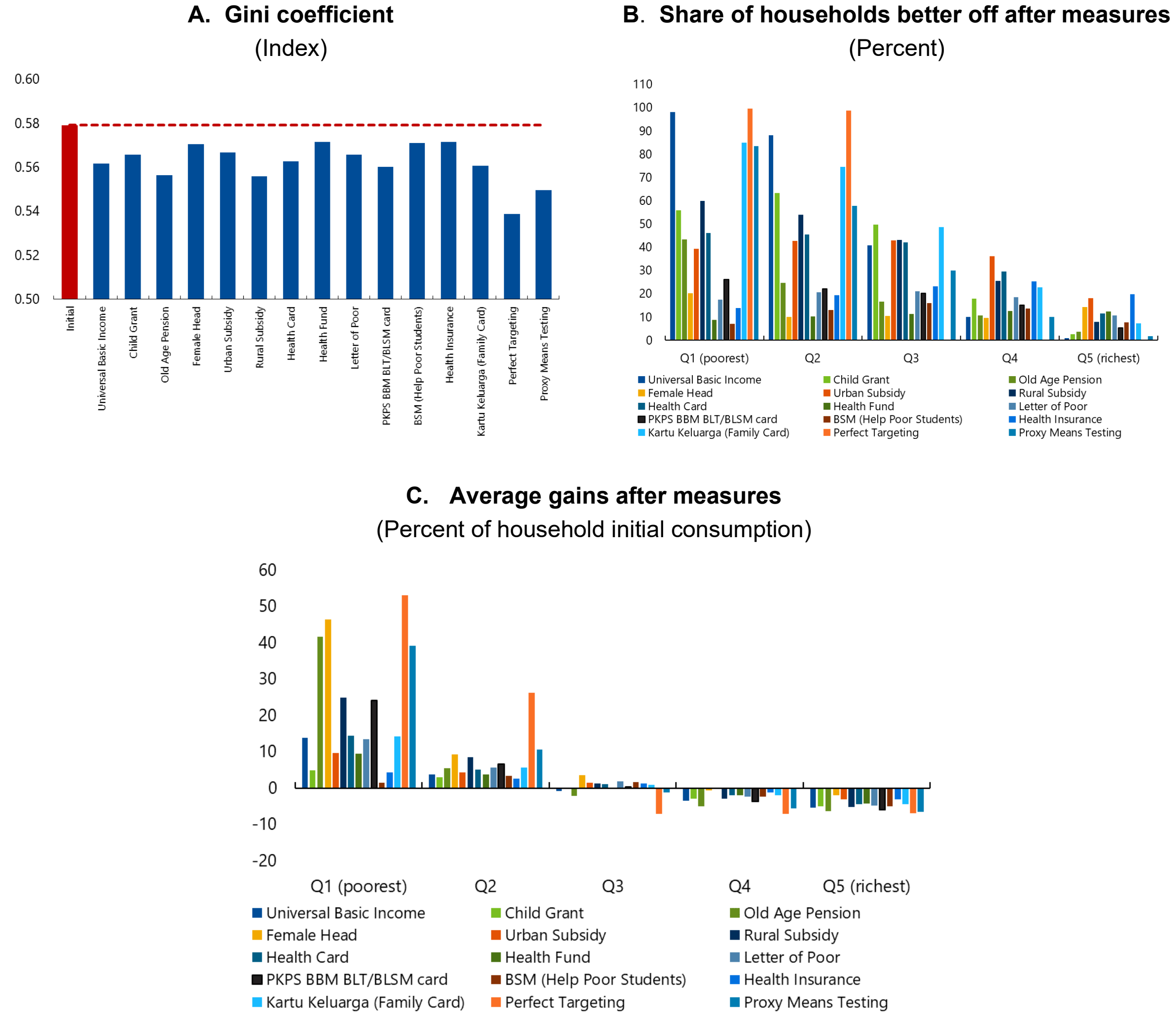


Source: IMF staff calculations based on household surveys.

While the tax is shown to be regressive for Indonesia, the revenues raised from it can be used to compensate households in the lower quintiles, reducing inequality compared to its initial level (Figure 18). The carbon tax would raise fiscal revenues by about 1.7 percent of GDP, which when distributed as any one of the 16 policy-options we have identified would serve to reduce inequality in the country (Panel A). The least effective would be expanding the health fund, decreasing the initial Gini coefficient from 0.579 to 0.572, with similar results for an urban subsidy, providing a lump sum to households with a female head, increasing benefits to households utilizing the "Letter of Poor", the BSM (help to low-income students), or subsidizing health insurance. Instituting a universal lump sum transfer to households would reduce the Gini coefficient to 0.562, with similar results for providing a child grant, an old age pension, a rural subsidy, increasing benefits to those using a Health, PKPS BBM BLT/BLSM, or Family Card. The largest decrease in inequality was seen in perfect targeting to the 40% of poorest households, at a Gini coefficient of 0.539. Using the more realistic proxy means testing showed the second largest decrease, to 0.549. While the tax is regressive, using at most 13 percent of the carbon tax revenues can avoid an increase in inequality in Indonesia with any of these policies.

A universal lump sum transfer to households, providing a child grant, implementing a rural subsidy, and expanding the family card benefit, or using proxy means testing to target transfers benefits a majority of households in the bottom two quintiles. These measures greatly increase welfare in the bottom two quintiles of households, at a small expense to households in the top three quintiles (Panel C).

Figure 18. Impact of Alternative Compensation Schemes in Indonesia



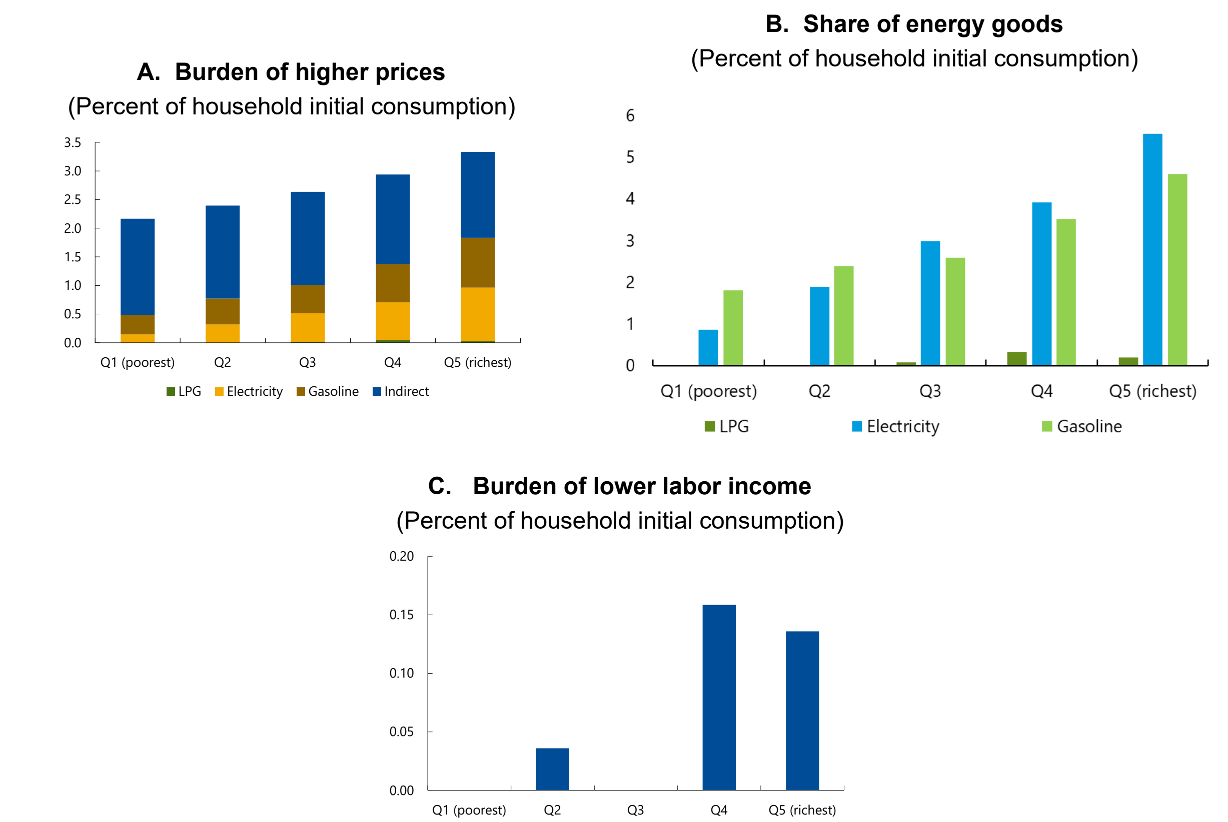
Source: IMF staff calculations based on household surveys.

Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. “Perfect targeting” assumes a lump sum transfer per household to the 40% poorest households. “Proxy Means Testing” assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

Kiribati

The higher prices from a carbon tax would prove progressive for Kiribati (Figure 19). Households in the bottom quintile would see a welfare loss due to higher prices of 2.2 percent, compared to a reduction of 3.3 percent in the top quintile (Panel A). We find that as households become richer in Kiribati, average consumption of energy-goods also increases, explaining the progressivity of the tax (Panel B). The tax continues to be progressive when taking the labor income channel into account because workers in the electricity sector tend to belong to the richest quintiles (Panel C).

Figure 19. Impact of a $50 per Ton Carbon Tax on Households in Kiribati

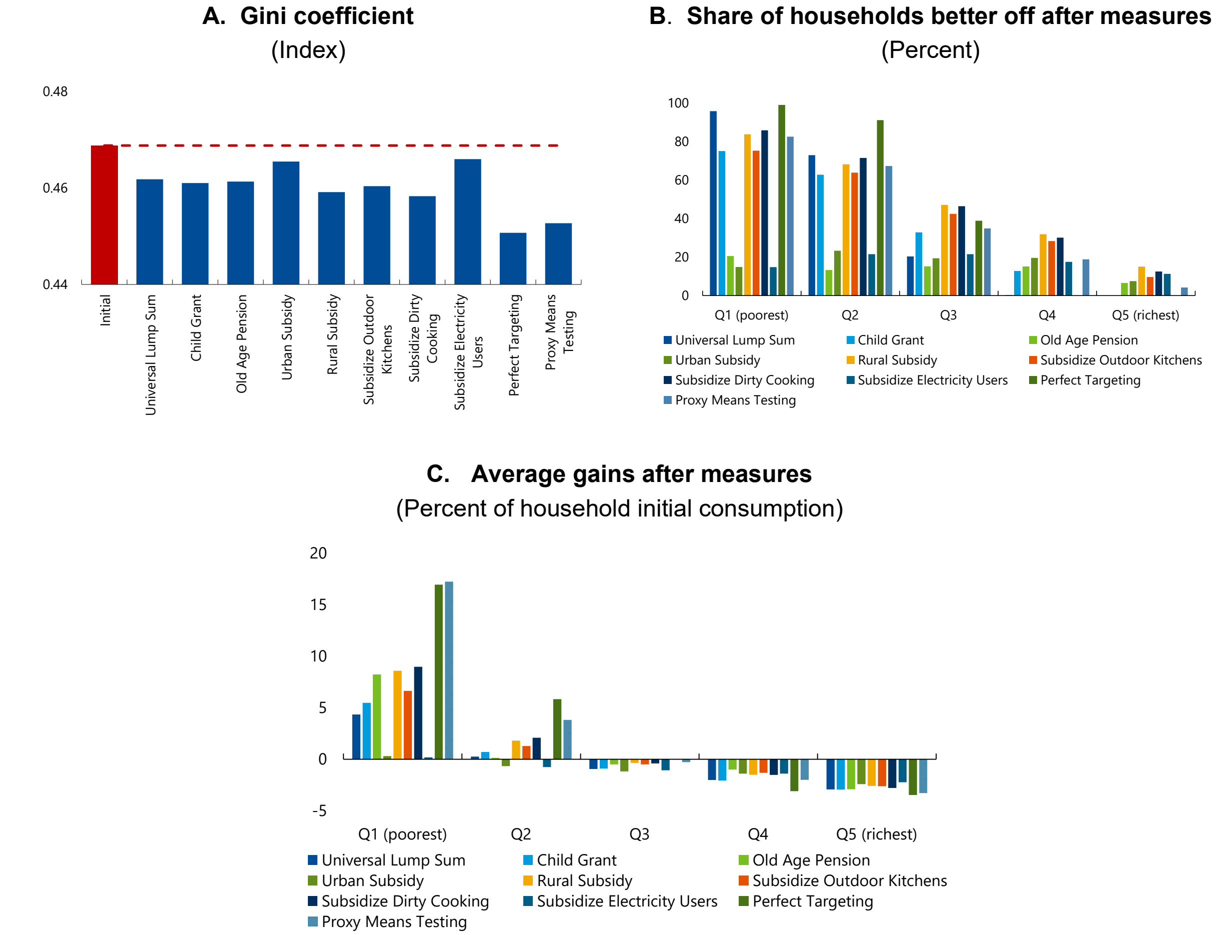


Source: IMF staff calculations based on household surveys.

Implementing a $50 carbon tax in Kiribati would raise fiscal revenues by around 0.7 percent of GDP. Using this revenue to compensate losses to poor households would prove to be an effective measure to reduce inequality (Figure 20). It is important to note that, because the carbon tax would be progressive in Kiribati, its sole implementation would reduce inequality slightly. The following policies take the reduction of inequality further. Distributing revenues as a universal lump sum would reduce the Gini from 0.469 to 0.462 (Panel A in 20). Comparable reductions would also be had from implementing a child grant for each child younger than 18, an old age pension, providing a rural subsidy, subsidizing households lacking indoor cooking areas, and subsidizing households without access to clean cooking methods. Providing a subsidy to urban households or subsidizing electricity users would also reduce inequality, but to a lesser degree compared to the previous policies. The most reduction in inequality is had from perfect targeting of cash grants, reducing inequality by 0.018 points to 0.451. However, the more realistic proxy means testing provides very close results to perfect targeting, reducing the Gini to 0.453.

A majority of households in the bottom three quintiles would benefit from the provision of a universal lump sum transfer, a child grant, a rural subsidy, subsidizing households who only have outdoor kitchens, and subsidizing households who lack access to clean cooking financed with the proceeds from the carbon tax, while proxy means testing would be an effective measure to compensate over half of households in the bottom two quintiles (Panel B). Instituting any one of these measures would yield ample gains for those in the bottom quintile at a minor cost to households in the upper three quintiles, only around 3 percent of initial consumption for the top quintile for any compensation measure (Panel C).

Figure 20. Impact of Alternative Compensation Schemes in Kiribati



Source: IMF staff calculations based on household surveys.

Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. “Perfect targeting” assumes a lump sum transfer per household to the 40% poorest households. “Proxy Means Testing” assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

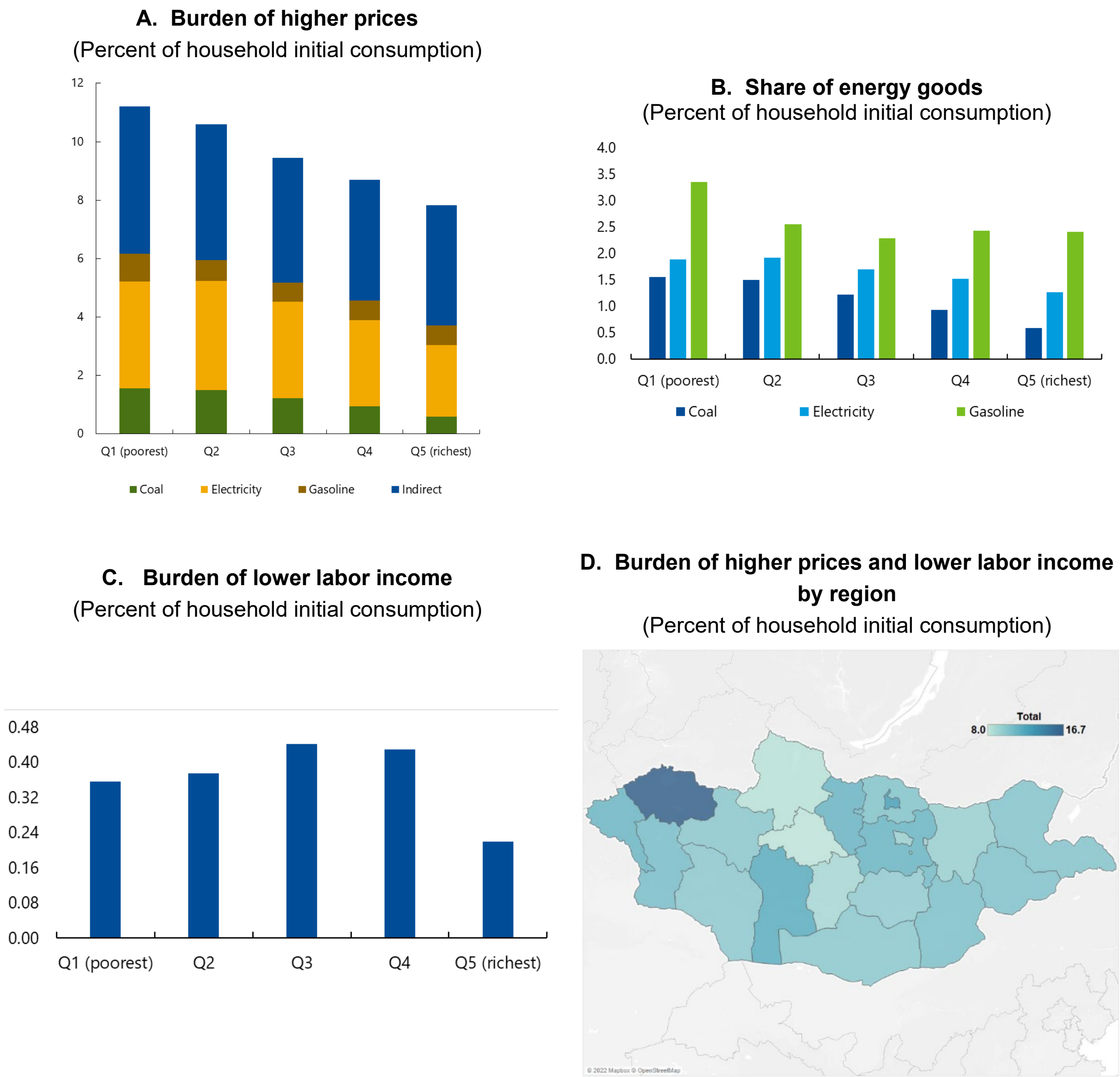
Mongolia

Applying a carbon tax to Mongolia with no compensatory schemes would prove to be a regressive measure when looking at the burden of higher prices (Figure 21). Consumers in the poorest quintile would experience a loss of around 11.2 percent compared to initial consumption, whereas households in the highest quintile would see a reduction of around 7.8 percent (Panel A). The difference between quintiles derives from the difference in consumption patterns across households (Panel B). Households in the lowest quintile have a higher portion of their expenditure going towards electricity and coal compared to households in the top quintile, consumption of gasoline is relatively flat across all quintiles.

This regressivity does not improve when taking the labor channel into account. The burden of lower income due to the carbon tax would mainly affect households in the 3rd and 4th quintile, less so in the bottom 2 quintiles, with the least effect had for those in the top quintile (Panel C). Households in the 3rd and 4th quintile are more likely to work in the electricity sector, which has a high reliance on coal-fired plants. The likelihood that a household has an individual working in other carbon intensive industries, such as mining and natural gas extraction, also decreases for richer households.

The burden of the carbon tax is also relatively heterogenous across regions (Panel D). Arkhangai Aimag would experience less than half the loss in consumption, at 8 percent, compared to Uvs, at 16.7 percent.

Figure 21. Impact of a $50 per Ton Carbon Tax on Households in Mongolia



Source: IMF staff calculations based on household surveys.

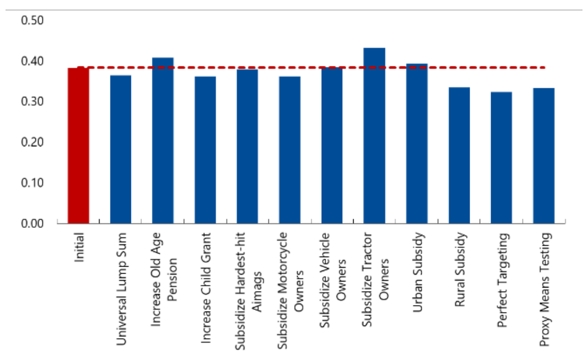
Mongolia would see fiscal revenues raised by around 4.5 percent from the introduction of a $50 carbon tax. Using these revenues fully as a universal lump sum would decrease the Gini from an initial state of 0.383 to 0.365, increasing the child grant or subsidizing motorcycle owners would produce similar reductions (Figure 22). Subsidizing the hardest-hit aimags or subsidizing vehicle owners does little to improve inequality, while increasing the old-age pension, subsidizing tractor owners or providing an urban subsidy would produce the undesired effect of raising inequality. Perfect targeting of the bottom 40 percent of households does the most to decrease inequality, to a level of 0.324. However, providing a subsidy to rural households and the use of proxy means testing for transfers produces very close results, at 0.335 and 0.334 respectively. Because a carbon tax would be strongly regressive, it would take between 10 and 30 percent of the carbon tax revenues to avoid an increase in inequality after the reform, with the cheapest way to do so being the rural subsidy and the most expensive being the universal basic income.

Using the raised revenues to provide a universal lump sum, increasing the child grant, or using proxy means testing to target households benefits a majority of households in the bottom two quintiles, providing substantial average gains to households in these quintiles at a small expense of a few percentage points of consumption for those in the upper quintiles (Panels B and C). Providing a subsidy to urban households would produce the opposite effect, benefiting a majority of households in the upper three quintiles, at the expense of households in the bottom two quintiles.

Figure 22. Impact of Alternative Compensation Schemes in Mongolia

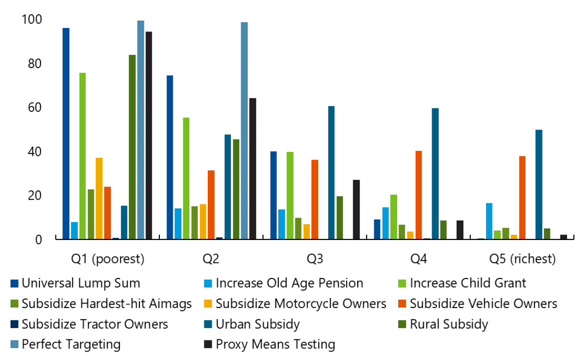
A. Gini coefficient

(Index)



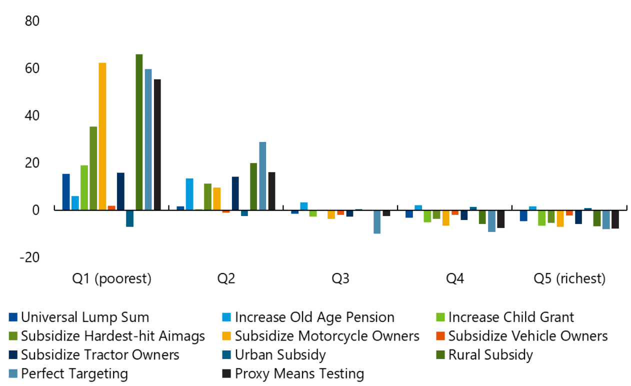
B. Share of households better off after measures

(Percent)



C. Average gains after measures

(Percent of household initial consumption)



Source: IMF staff calculations based on household surveys.

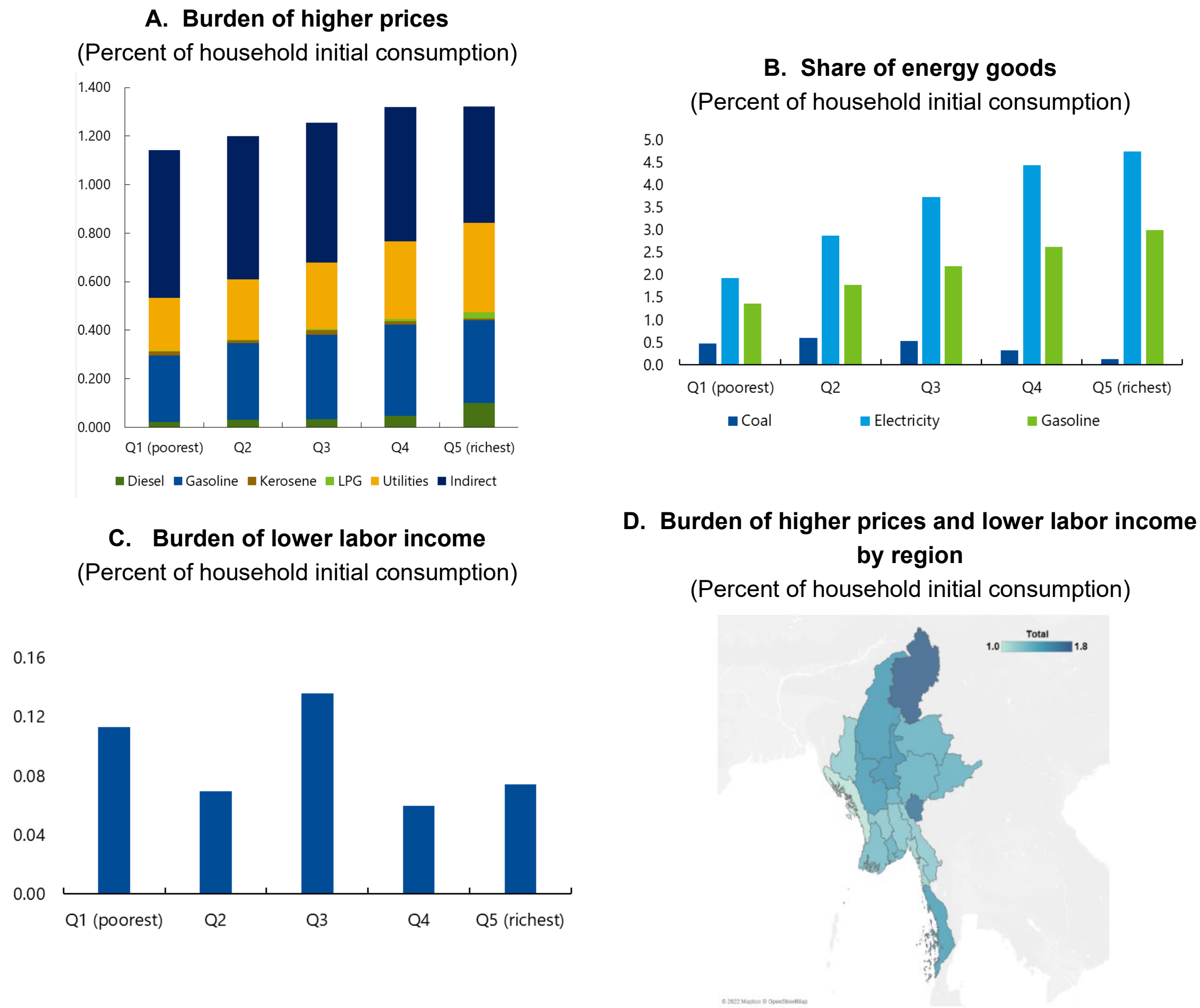
Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. "Perfect targeting" assumes a lump sum transfer per household to the 40% poorest households. "Proxy Means Testing" assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

Myanmar

A carbon tax would be mildly progressive for consumers in Myanmar (Figure 23). Households in the richest quintile would experience a loss of welfare due to higher prices equivalent to 1.3 percent of their initial consumption compared to 1.1 percent for the poorest quintile (Panel A). This progressivity is driven by diesel, gasoline, LPG, and utilities representing a larger share of consumption for the richest (Panel B). The poorest households consume relatively more kerosene, but its share is small at only 0.016 percent of consumption. The indirect effect of a carbon tax declines with expenditure as the poorest households consume relatively more carbon-intensive non-energy goods.

The impact remains progressive after factoring in the labor income channel, although less so. For workers, the burden of the tax via lower labor income would fall on the poorest households because coal workers tend to belong to the first three quintiles (Panel C). Still, adding the effect of higher prices and lower labor income results in a burden that remains mildly progressive. Finally, the carbon tax would have different implications across the country, average consumption would decrease by 1 percent in Rakhine compared to around 1.8 percent in Kachin (Panel D).

Figure 23. Impact of a $50 per Ton Carbon Tax on Households in Myanmar



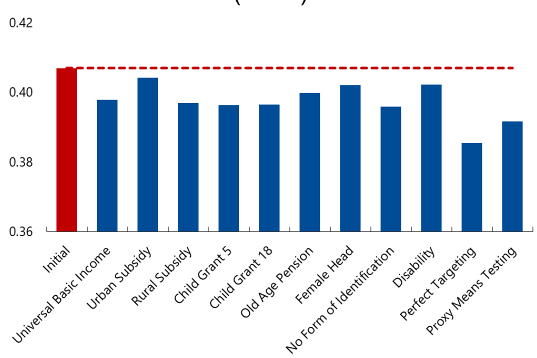
Source: IMF staff calculations based on household surveys.

The resources raised by a carbon tax could be used to compensate the most vulnerable and reduce inequality (Figure 24). The carbon tax being progressive in Myanmar would, by itself, reduce inequality marginally measured by the Gini coefficient. It would also raise fiscal revenues by about 1.3 percent of GDP which, if distributed as a universal basic income (that is, a cash grant per person), would reduce inequality from 0.407 to 0.398 (Panel A). Similar reductions in inequality would be achieved if the resources were distributed as a lump sum subsidy to rural households, a grant per child younger than 5 or 18, or a subsidy to households currently lacking identification. Urban subsidies, an old age pension, and cash transfers for female heads of households or disabled individuals would also reduce inequality, but less. Providing a lump sum transfer to the 40 percent of poorest households assuming perfect targeting would reduce inequality to 0.385, whereas assuming a more realistic targeting based on easily verifiable characteristics would yield a reduction to 0.392, an improvement compared with the other schemes. In addition, a universal basic income, a rural subsidy, a child grant for children younger than 18, a subsidy to households without identification, and a proxy-means tested transfer would improve welfare for most of the households in the poorest two quintiles, yielding substantial average gains at the expense of mild losses for the better off (Panels B and C).

Figure 24. Impact of Alternative Compensation Schemes in Myanmar

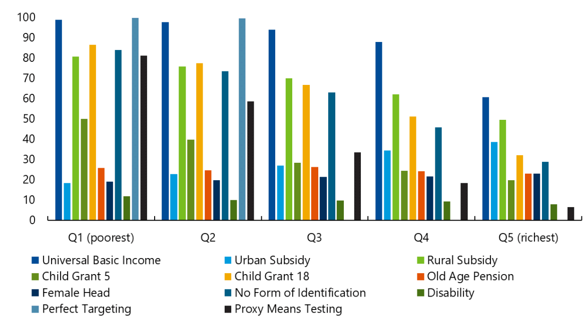
A. Gini coefficient

(Index)



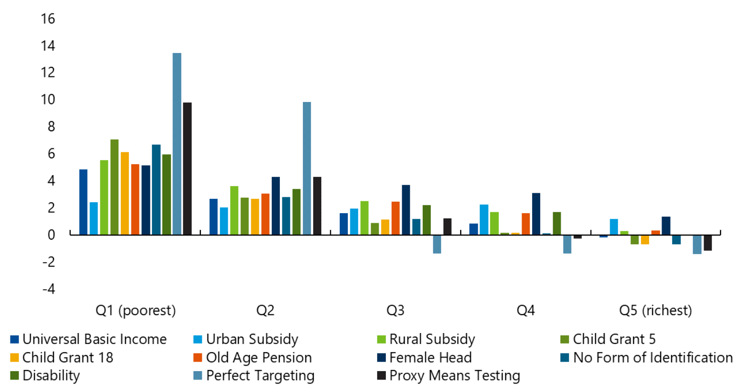
B. Share of households better off after measures

(Percent)



C. Average gains after measures

(Percent of household initial consumption)



Source: IMF staff calculations based on household surveys.

Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. "Perfect targeting" assumes a lump sum transfer per household to the 40% poorest households. "Proxy Means Testing" assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

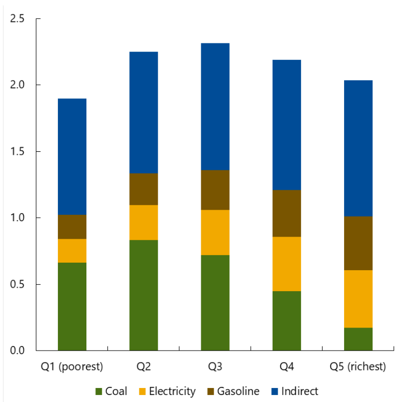
Philippines

A carbon tax would have the most effect on households in the third quintile, via higher prices, with less of an effect on the top and bottom quintiles (Figure 25). Households in the richest quintile would experience a loss of welfare equivalent to 2 percent of their initial consumption compared to 1.9 percent for the poorest quintile (Panel A). The relative expenditure on gasoline and electricity is greater for richer households, which primarily drives the progressivity for consumers (Panel B). This progressivity is partly mitigated by coal consumption being larger for poorer households, likely reflecting substitution of energy sources.

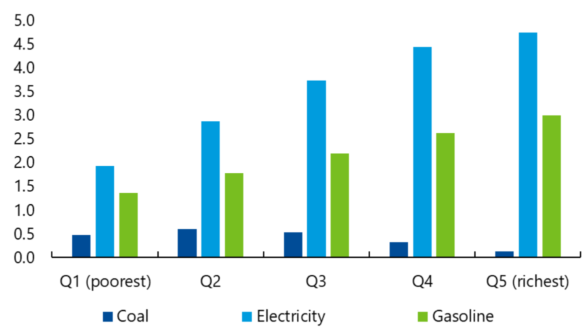
The impact becomes more progressive after factoring in the labor income channel. The burden of the tax via lower labor income falls mainly on the upper two quintiles (Panel C). Households in these quintiles are more likely to work in oil extraction, gasoline refining, the electricity sector, and the natural gas sector compared to households in the lowest quintiles. Finally, the carbon tax would have different implications across provinces (Panel D). The least affected province would be Caraga at around 1.7 percent of initial consumption, with the highest being Mimaropa with a reduction of around 2.9 percent.

Figure 25. Impact of a $50 per Ton Carbon Tax on Households in the Philippines

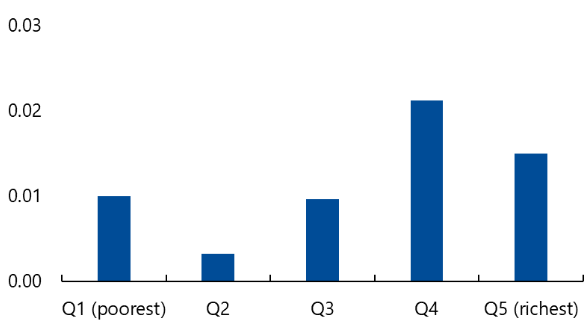
A. Burden of higher prices
(Percent of household initial consumption)



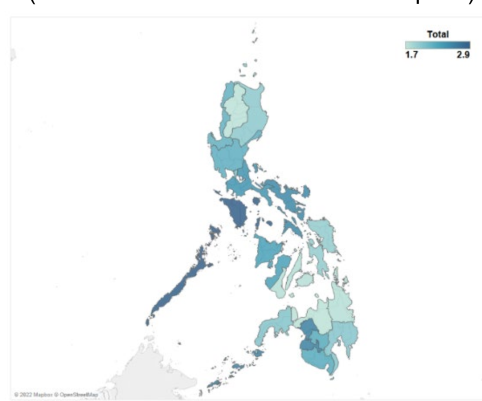
B. Share of energy goods
(Percent of household initial consumption)



C. Burden of lower labor income
(Percent of household initial consumption)



D. Burden of higher prices and lower labor income by region
(Percent of household initial consumption)

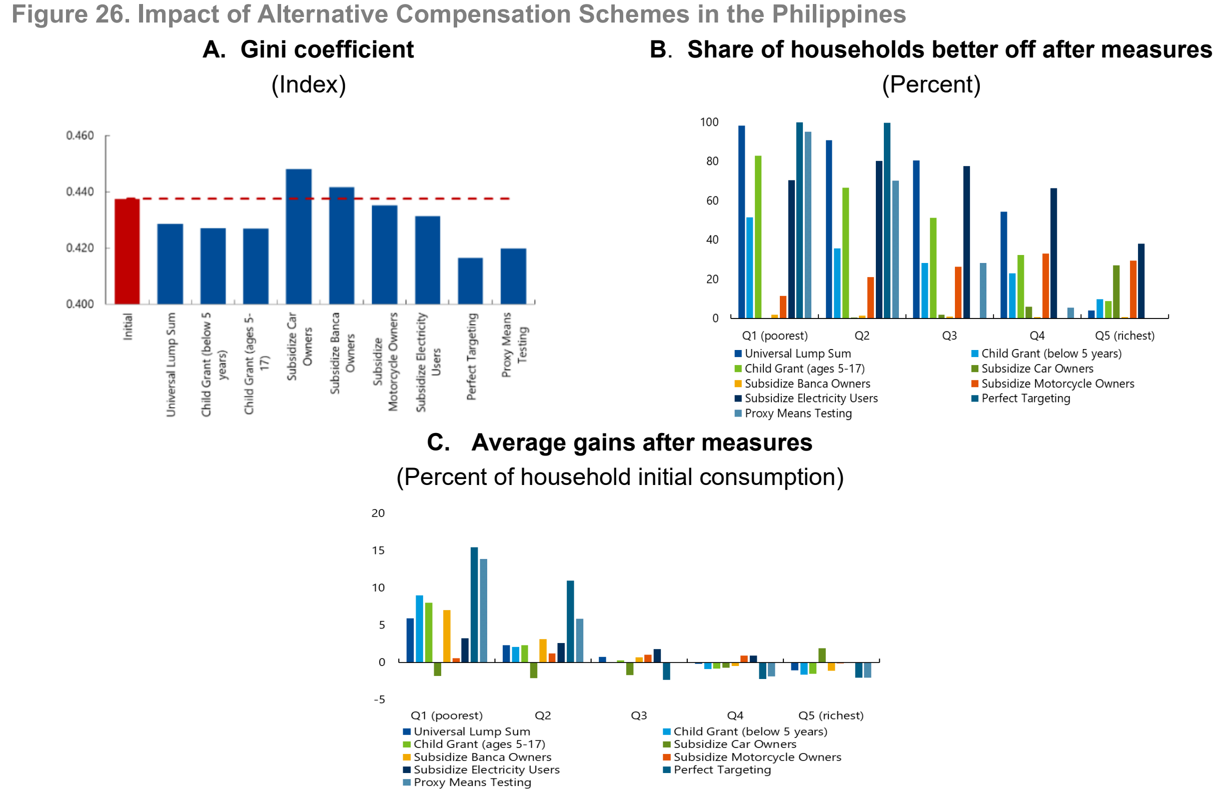


Source: IMF staff calculations based on household surveys.

Implementing a $50 carbon tax would raise revenues by 0.9 percent of GDP in the Philippines, which would be a valuable resource to reduce inequality.[24] Providing a universal basic income per person, a child grant for children below the age of five or between the ages of 5 to 17 would reduce the initial Gini from 0.44 to around 0.43 (Figure 26). Subsidizing motorcycle owners or electricity users would also lower inequality, albeit at lower amounts. Perfect targeting to the poorest 40 percent of households would reduce inequality the most, to a level of 0.416. However, using the more practical proxy means testing would produce similar results, reducing the Gini to 0.42. On the other end of the spectrum, subsidizing car or Banca (boats primarily used for transport) owners would raise inequality, reflecting the higher propensity for upper income households to own these. It would only take around 6 percent of the carbon tax revenues raised to avoid an increase in inequality using any compensation measure (aside from subsidizing car and banca owners).

While many of these measures would reduce overall inequality, it is useful to look at exactly which households benefit the most from them. Implementing a universal lump sum transfer and subsidizing electricity users would benefit the majority of households across the bottom four quintiles, a child grant for children between the ages of 5 and 17 would benefit a majority of households in the bottom three quintiles, and using proxy means testing to target benefits would benefit a majority of households in the bottom two quintiles (Panel B). Utilizing proxy means testing would increase average gains across the bottom two quintiles the most of any measure, with a relatively small cost to households in the upper two quintiles of around three percent of initial consumption (Panel C).

Figure 26. Impact of Alternative Compensation Schemes in the Philippines



Source: IMF staff calculations based on household surveys.
Note: Compensation schemes proposed assumed that all the fiscal revenues raised by a carbon tax are redistributed. Quintiles determined by per capita household expenditure. "Perfect targeting" assumes a lump sum transfer per household to the 40% poorest households. "Proxy Means Testing" assumes a lump sum transfer per household to the 40% poorest households targeted using a proxy-means testing model.

24 By 2030, when the USD 50 per ton is supposed to be in place, the carbon tax would raise USD 5.7 billion (at constant 2018 prices).

Other Economies in the Region

In this final subsection, we present some additional results for advanced economies in the region. For economies where we could not obtain household level data, we were unable to complete a detailed analysis on effects to the labor channel or how households could be compensated using revenues raised. However, we were able to explore how a carbon tax would affect prices in these economies and thus associated decreases in consumption across income groups (Figure 27). For many of the economies below a carbon tax would prove to be a regressive measure for consumers, in Australia, Hong Kong SAR, Japan, Korea, and New Zealand. But for Singapore and Taiwan, Province of China, the burden of the tax would be evenly distributed across households. These results reinforce the point that when implementing a carbon tax special consideration needs to be taken for how households will be affected, especially for households at the lowest income levels.

Figure 27. Impact of a $50 per Ton Carbon Tax via Higher Prices
(Percent of household initial consumption)

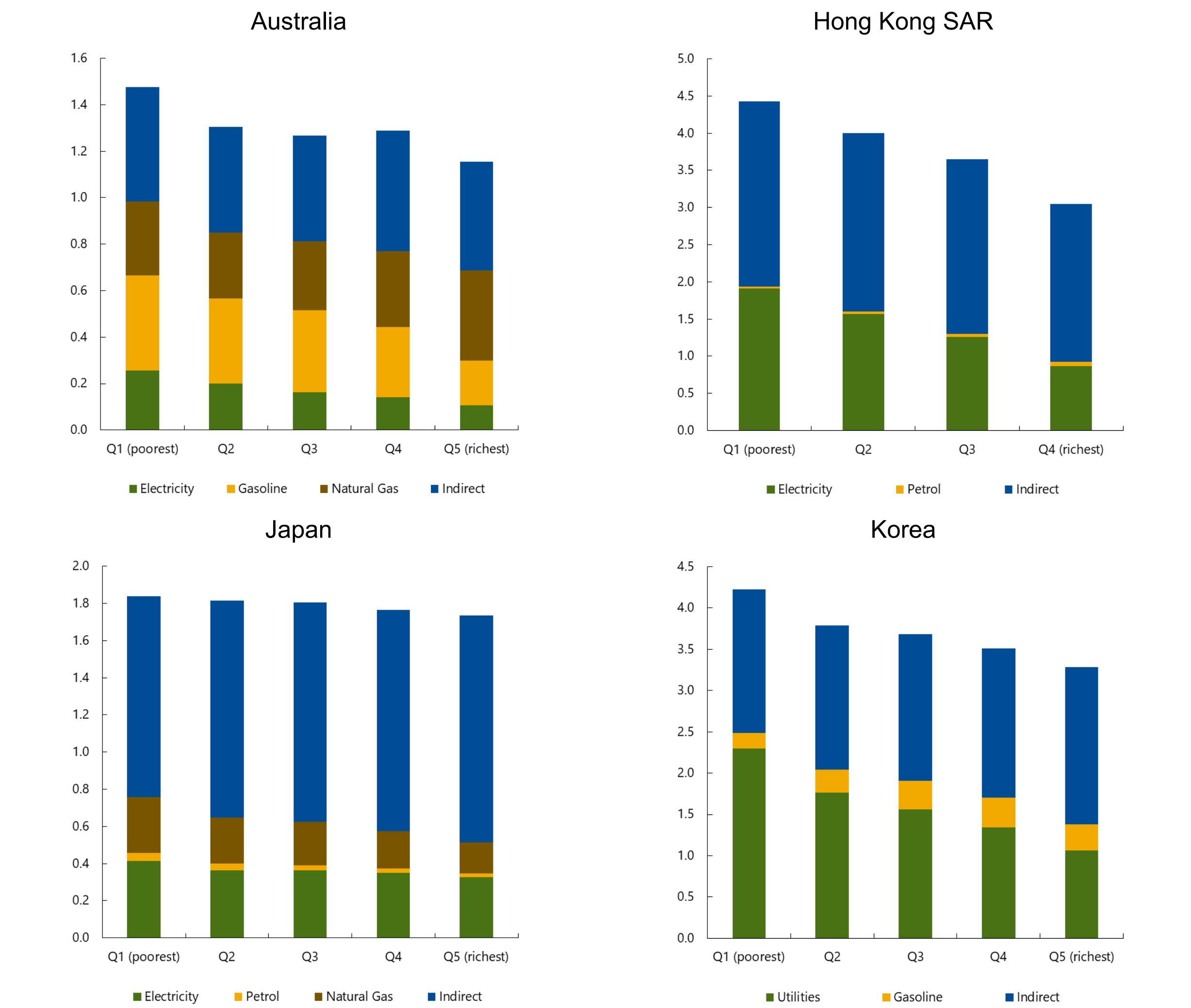
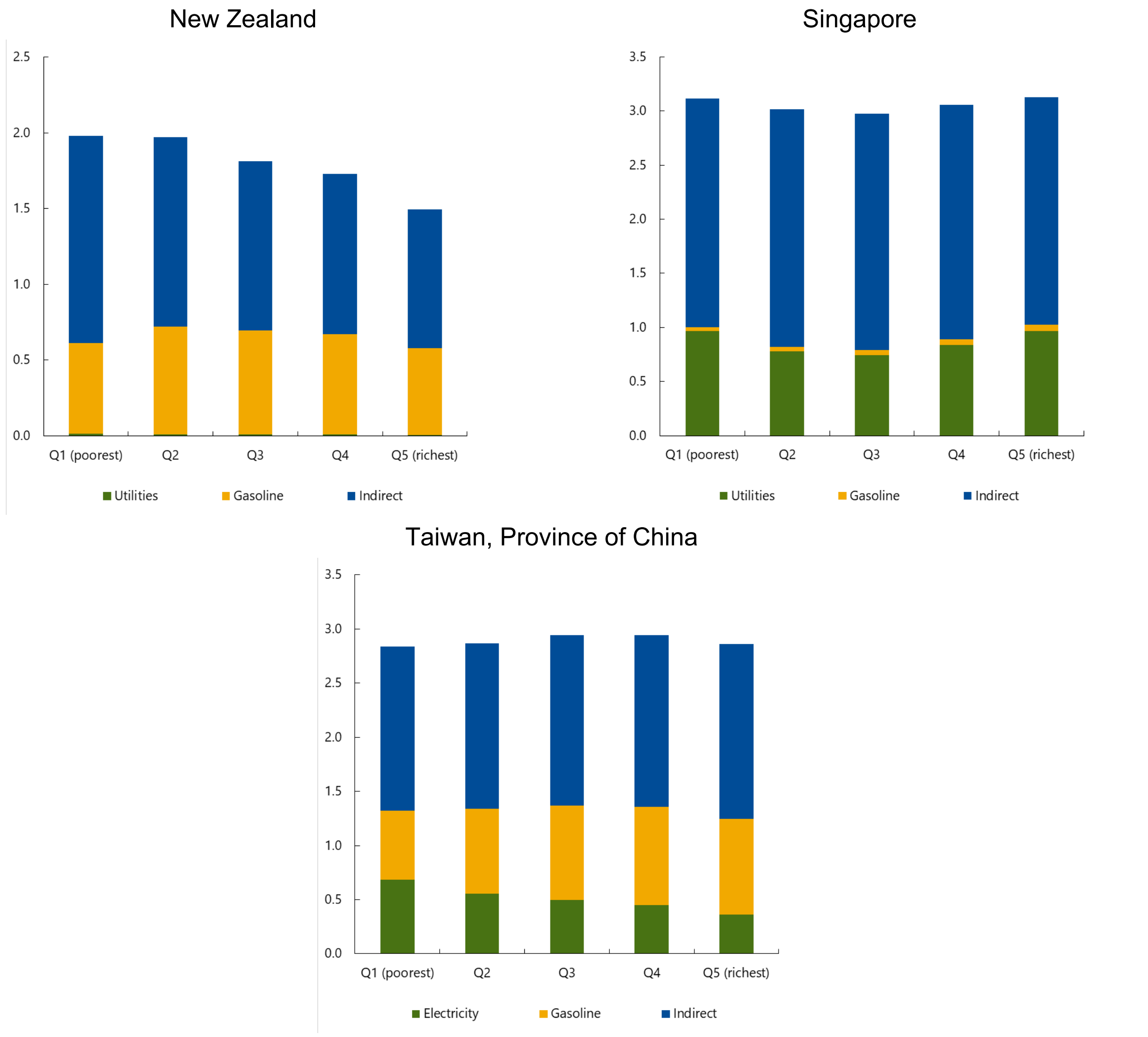


Figure 27. Impact of a $50 per Ton Carbon Tax via Higher Prices (concluded)



Source: IMF staff calculations based on household surveys.

Conclusion

Carbon taxes are unpopular and yet, they could be the most effective tool to mitigate climate change. In this paper, we have shown that the impact of a carbon tax would vary widely across Asia and the Pacific. A carbon tax of USD 50 per ton would cost households an average of around 10 percent of their initial consumption in Mongolia—due to its heavy reliance on coal—but less than 2 percent in Kiribati and Myanmar. Distributional implications would also differ. In some countries, it would be regressive, whereas in others it would be progressive or proportional. The impact would be heterogeneous within countries too, with differences across provinces and groups.

Importantly, a carbon tax can be accompanied by adequate compensation schemes that protect the most vulnerable and build public support for the measure. Using realistic cash transfers, we have shown that it takes only a fraction of the carbon tax revenues to shield the most vulnerable households from the impact of higher energy prices and to fully compensate affected energy sector workers. In several countries, the resources raised by a carbon tax are even enough to make more than half of the households better off after the reform. Incorporating these compensation schemes as part of the carbon tax design is not only feasible and affordable but could just as importantly foster public and political support for such a reform.

Annex I. Proxy Means Targeting

In this annex, we present details of our proxy means targeting (PMT) approach. In particular, Table A1 describes the variables used for PMT in each country, as well as the inclusion and exclusion errors from the approach.[25] The inclusion error or leakage rate is the share of the nonpoor who are identified as poor by the PMT estimator. The exclusion error or undercoverage rate is the share of the poor who are not identified as poor by the PMT estimator. The main takeaway from this table is that, even with the limited set of variables provided by the household surveys, the undercoverage and leakage rate of our estimations are within the range of typical PMT models, particularly for the 40 percent cutoff (World Bank, 2015).

Table A1. Details About Application of PMT for Each Country

		Undercoverage Rate			Leakage Rate		
Country	Variables Used	20%	40%	50%	20%	40%	50%
China	Family size, urban, water for cooking, fuel for cooking, air purification, ownership of other housing unit, electricity access, type of house, type of toilet, location to dump trash, province-county, ownership of automobile, bike, motorcycle, refrigerator, washing machine, TV, computer, stereo system, video camera, camera, air conditioner, mobile phone, books.[1]	46.3	28.9	20.0	46.3	28.9	20.0
India	Family size, urban, state-region-district, household type, social group, land ownership, number of children and elderly in the household, cooking mode, lighting mode.	37.5	23.7	19.1	37.5	23.7	19.1
Indonesia	Family size, number of children and elderly in the household, urban, female head, status of the house, language, electricity access, water for drinking, type of toilet, sewage, garbage disposal, ownership of refrigerator, ownership of TV, cooking mode, province-kabupaten-kecataman.	41.9	28.9	24.0	41.9	28.9	24.0
Kiribati	Family size, urban, occupation tenure status, materials of roof, walls, and floor, type of house, number of rooms, type of kitchen, cooking mode, lighting mode, drinking water, toilet facility, internet access, involved in crops or livestock, number of children and elderly in the household, island-village.	48.3	35.2	30.4	43.0	28.5	23.0
Mongolia	Family size, urban, number of children and elderly in the household, number of dwellings, type of dwellings, number of rooms, material of walls, roof, and floor, covering of the ceiling and frame, type of ownership, main source of heating, water supply, toilet, wastewater disposal, telephone, aimag-soum-bag.	26.5	19.9	17.4	26.5	20.0	17.4
Myanmar	Family size, urban, number of children and elderly in the household, female head, disabled members of the household, household members without id, zone-state-district-township-wvt, ownership of durable goods such as TV, radio, CD player, computer, car, bicycle, etc.	42.7	29.8	25.4	42.7	29.8	25.4
Philippines	Family size, urban, number of children and elderly in the household, sex of household head, type of household, type of house, roof, and walls, tenure status, number of bedroom, toilet, electricity, water supply, ownership of radios, TV, CD/VCD/DVD, stereo set, refrigerator, washing machine, air conditioner, automobile, landline phone, cellphone, PC, stove, motorized banca, and motorcycle, region.	28.2	17.3	14.0	28.3	17.3	14.0

1 Some of these variables were not available in the 2018 survey, so they were retrieved from the previous observation for each household in the 2012 survey.

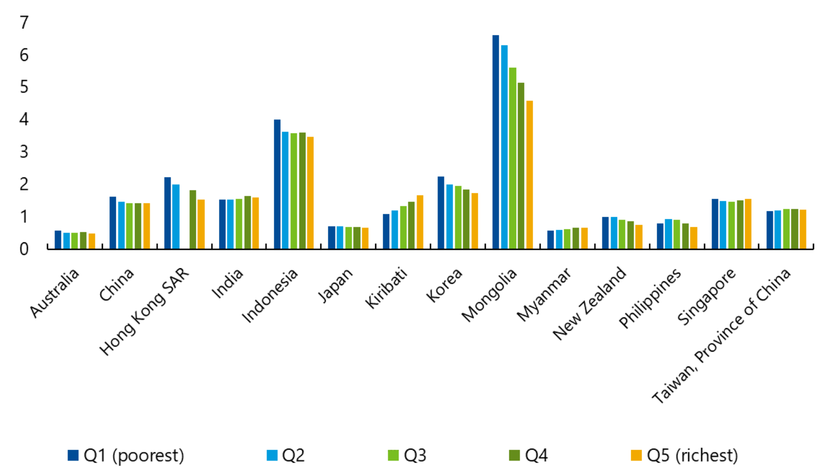
Source: IMF staff calculations based on household surveys.

25 World Bank (2015) and Sebastian and others (2018) offer good references on the proxy means targeting approach used in this paper.

Annex II. Results of a $25 and $75 Carbon Tax

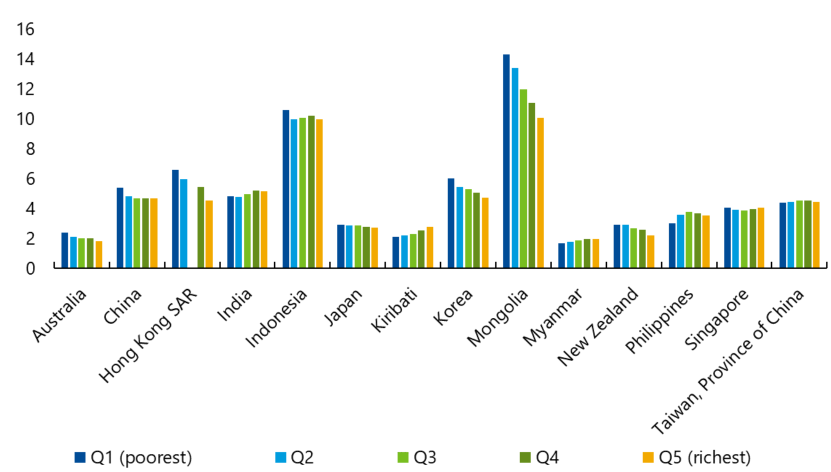
While this paper primarily focuses on the effects a $50 carbon tax would have on households, we also extend our analysis to a level of $25 and $75 per ton. The results are in line with what is seen at the $50 level, only with magnitudes changing due to relatively higher or lower prices and associated income effects. Each level of the carbon tax remains regressive for Australia, China, Hong Kong SAR, Indonesia, Korea, Mongolia, and New Zealand; relatively flat across quintiles for Japan, Singapore, and Taiwan, Province of China; and remains progressive in India, Kiribati, and Myanmar. The only exception is the Philippines, where a carbon tax of $25 would make the richest quintile shoulder less of the burden than the poorest households.

Figure A1. $25 Carbon Tax: Impact of Higher Prices on Households
(Percent of household initial consumption)



Source: IMF staff calculations based on household surveys.

Figure A2. $75 Carbon Tax: Impact of Higher Prices on Households
(Percent of household initial consumption)



Source: IMF staff calculations based on household surveys.

Annex III. Consistency of Household Surveys with Consumption in National Accounts

Consumption in household surveys tends to be significantly different from consumption estimates in national accounts. Usually, it is lower (Prydz and others, 2021). The discrepancy can be caused by a number of reasons. First, the definition of consumption may be different across these two sources of data (BLS, 2004). Second, household surveys may be affected by measurement error or inadequate sampling, with the "missing rich" being a major concern (Lustig, 2019). That is because rich households tend to be less likely to be included in the survey, less likely to respond when included, and more likely to underreport and to be affected by top coding when they do respond. Third, national accounts may rely on low-quality data sources for informality and home production (Robilliard and Robinson, 2003).

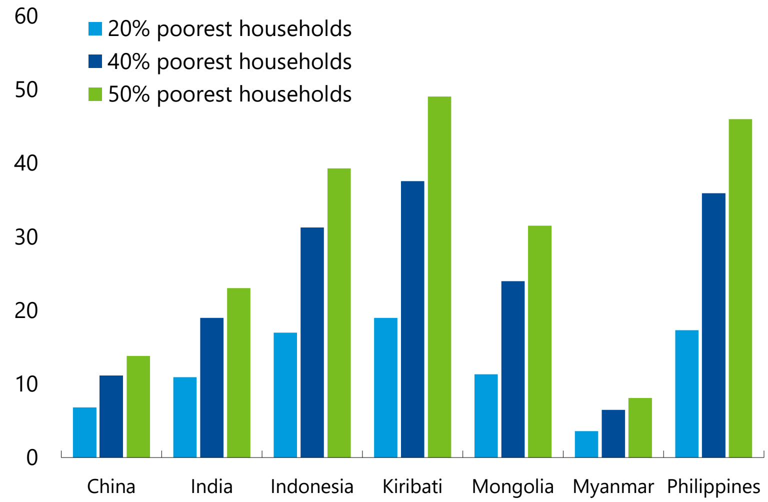
The household surveys we use in the paper are not exempt from this problem. For instance, for India, the total private consumption captured by the household survey is 44 percent of the private consumption estimates in the national accounts. The ratio is 48 percent for the Philippines.[26] The ratio is higher, but lower than 100 percent for the remaining countries, except for Mongolia and Myanmar, for whom consumption in the household survey is larger than in the national accounts.

While it is likely than the "missing rich" hypothesis is behind the discrepancy for our sample of countries (Banerjee and Piketty, 2005; Parker and others, 2009), in this annex, we consider a robustness check whereby we assume than the gap in consumption is distributed proportionally across all households and goods. In other words, we keep household survey's consumption shares of each good constant and scale up household consumption levels so that they match consumption in the national accounts when aggregated across households. This approach is probably excessively conservative because, for instance, for India, it ends up more than doubling the amount spent on energy goods for all households even when measurement error of utility and fuel bills is likely minor. In that sense, we consider these robustness results as an upper bound.

We find that protecting the most vulnerable is still affordable. For most of the countries (except for Mongolia and Myanmar), the cost of protecting the most vulnerable increases with respect to our baseline results, but it is still only a fraction of the carbon tax revenues (Figure A3). Even in Kiribati and the Philippines, it would cost less than 50 percent of the carbon tax revenues to ensure that the poorest half of households are not worse off on average. Ensuring that at least half of the households are better off after the policy reform also becomes more expensive, exceeding 100 percent of the carbon tax revenues for Indonesia, Kiribati, and the Philippines (Figure A4). But even in those countries, it remains the case that introducing some degree of targeting in the carbon dividend can ensure that more than half of the households are better off, and the burden of the reform is shouldered by the richest households.

[26] This has also been documented previously in the literature (Albert and others, 2017; Subramanian and Jayaraj, 2015).

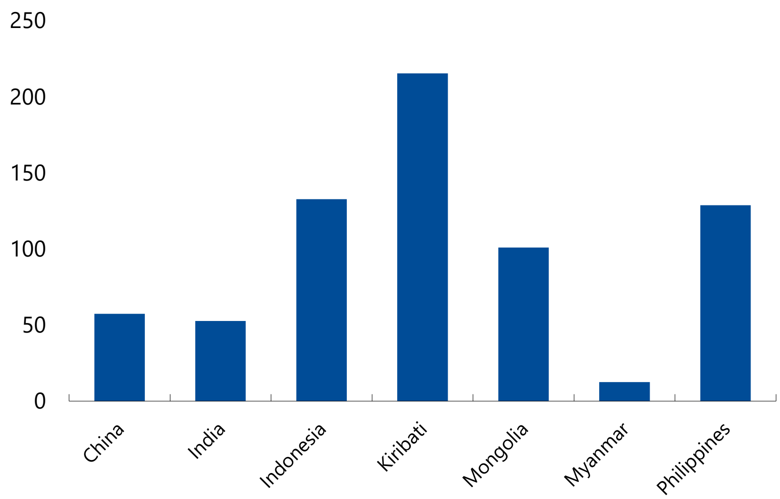
Figure A3. Share of Carbon Tax Revenues Needed to Compensate Poorest Households on Average
(Percent, carbon tax $50 per ton)



Source: IMF staff calculations based on household surveys.

Note: Compensation is assumed to take place through a targeted cash grant to the poorest 20%, 40%, and 50% using proxy-means testing (that is, using easily verifiable characteristics). Household consumption levels are scaled up (or down) proportionally to match aggregate private consumption in the national accounts.

Figure A4. Share of Carbon Tax Revenues Needed to Improve Welfare for 50% of Households
(Percent, carbon tax $50 per ton)



Source: IMF staff calculations based on household surveys.

Note: Compensation is assumed to take place through a universal lump sum transfer per household. Household consumption levels are scaled up (or down) proportionally to match aggregate private consumption in the national accounts.

Annex IV. India: Robustness Accounting for Universal Electricity Access

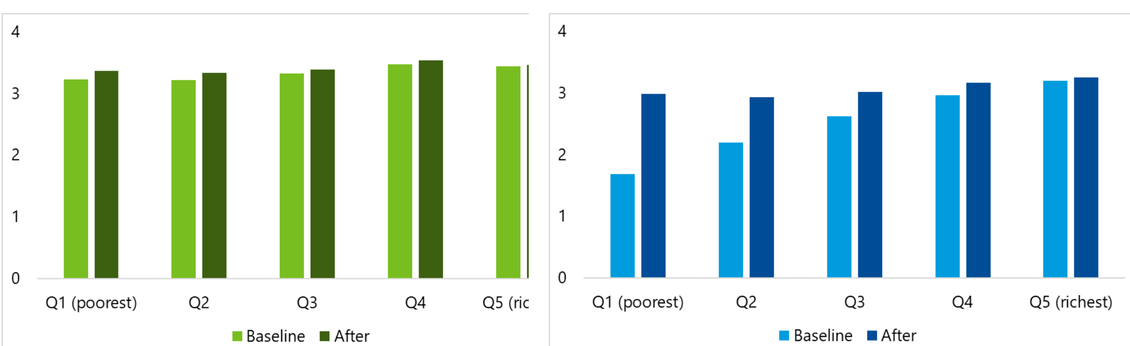
In this annex, we explore to what extent our results are robust to the significant expansion in access to electricity that took place in India in the 2010s. Between 2012 and 2020 electricity access in India has increased from 80% of the population to near universal access (World Bank, 2022). Because we use a relatively old survey from 2011/12, our baseline results miss on those developments. To have a better understanding of how a carbon tax would impact the India of today, we have extended our analysis by accounting for the increased access to electricity. In particular, we replaced the consumption shares of households that indicated no access to electricity in the household survey with the average consumption shares of similar households (that is, located in the same state, rural/urban area, and belonging to the same consumption quintile) but with electricity access. For example, the average share of consumption going towards vegetables for a household that has access to electricity in Punjab, in a rural area, in the lowest consumption quintile is about 4.4%. This share replaces the same category for similar households lacking access to electricity. Because electricity access influences other consumption choices, we assume that all consumption shares changed after getting electricity.

The tax remains progressive after accounting for wider electricity access, but to a lesser degree (Figure A5). The burden increases by about 0.14 percentage points, to 3.4 percent of consumption for the bottom quintile, compared against a rise of 0.02 percentage points, to about 3.5 percent, for the richest households. This increase is mainly due to a larger portion of consumption going towards electricity, especially for the bottom two quintiles. The share of consumption going towards electricity increases from around 1.7 percent to 3 percent for the first quintile and around 2.2 percent to 2.9 percent for the second, with the top quintile seeing a much smaller increase of about 0.06 percentage points. While adjusting for wider electricity access shows a higher burden on poorer households, the gains in revenue remain more than enough to protect the most vulnerable.

Figure A5. Impact of a $50 Carbon Tax in India, Baseline and After Imputing Wider Electricity Access

A. Total burden of the carbon tax
Percent, average by quintile)

B. Electricity share of consumption
(Percent, average by quintile)



Source: IMF staff calculations based on household surveys.

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