Carbon Taxation in Developing Countries: **Who Could and Should Raise Energy Taxes Now, and How?**

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Executive Summary

Energy has a central role in people's lives. Fossil-fuel powered electricity, heating, and transportation are ubiquitous in economies, facilitating production and trade in goods and services. However, one in five people lack access to electricity while 3 billion people rely on biomass for cooking and heating.[1] For this reason, affordable access to clean energy is one of the Sustainable Development Goals (SDGs), while most lower and middle-income countries (LMICs) subsidize fossil fuels directly or indirectly.

However, subsidizing fossil fuel-based energy is an ineffective way to help the poor or promote economic development. The wealthy capture the majority of benefits at a significant cost to government budgets, while overconsumption of fossil fuels imposes broad societal costs. Local pollution impacts human health through death and pollution-related disease. Congestion creates economic inefficiency and increases road deaths. Carbon emissions - of which energy accounts for 60% - increases the risks of dangerous climate change. Lastly, energy mispricing keeps economies energy-inefficient and vulnerable to shocks in global energy prices.[2]

By 'getting energy prices right' countries can reap health, environmental, and development benefits. This entails incorporating social costs into energy prices through carbon pricing policies. Taxes on coal, gasoline, diesel, and natural gas linked to carbon content can reduce air pollution deaths, reduce congestion, and tackle climate change while making economies more energy-efficient and resilient. They can also raise substantial government revenues, which can be used for expanding social spending, reducing fiscal deficits, investing in infrastructure, or reducing more distortionary taxes.[3]

However, there is limited experience with carbon taxation in developing countries. Only 3% of LMICs have implemented or plan to implement carbon taxation, though it is desirable for many more countries. Learning is therefore needed domestically and internationally.

Further, carbon taxation appears more desirable and feasible for some LMICs over others. Evidence suggests that their economic desirability depends on country characteristics, including the level of pre-existing fossil fuel subsidies. Carbon taxes also have particular effects and implementation practicalities which may make them politically or administratively infeasible. Though countries should seek to 'get energy prices right', some are better placed to do so now.

Assessing LMICs for suitability to carbon taxation can help governments implement corrective pricing policies effectively. It can also help partners assist these countries, allocate their scarce resources efficiently, and facilitate cross-border learning.

By ranking countries by their desirability and feasibility for carbon taxes - through the 'Carbon Taxation Suitability Index' (CTSI) - **this report finds that countries that are more suited to carbon taxation**:

[1] United Nations, "Sustainable Development Goals - United Nations," *United Nations Sustainable Development*, accessed August 11, 2017, http://www.un.org/sustainabledevelopment/sustainable-development-goals/.
[2] David Coady et al., "How Large Are Global Fossil Fuel Subsidies?," *World Development* 91 (March 1, 2017): 11–27, doi:10.1016/j.worlddev.2016.10.004.
[3] Ian Parry et al., *Getting Energy Prices Right* (IMF, 2014), http://elibrary.imf.org/view/IMF071/21171-9781484388570/21171-9781484388570/21171-9781484388570.xml.

- **account for a majority (two thirds) of all developing country greenhouse gas emissions.** This is promising from both a climate policy and economic efficiency perspective: carbon taxes are an effective and efficient instrument for mitigation.

- **appear to be better at** achieving environmental objectives and regulating the private sector, and tend to be freer and slightly wealthier.

- **may have been more ambitious** in their Paris Agreement mitigation commitments.

All countries which have implemented or are planning carbon taxes rank highly on the index (4 countries, 3 of which are ranked in the top 10 of 133 countries). This is limited evidence in support of the CTSI. Carbon taxes also appear to be more desirable in countries that are performing less well at meeting the SDGs; revenues raised could help them make progress.

This report recommends that **domestic policymakers** in LMICs where carbon taxes are:

- **both desirable and feasible** should seek to phase them in gradually. They should define national objectives, and design policies in a fair and transparent manner. This includes following recently-published guidance and investigating clues offered by CTSI scores.

- **less desirable but still feasible** should use the opportunity to investigate carbon tax implementation for specific national objectives.

- **desirable but less feasible** should seek to understand the political and administrative obstacles carbon taxes may face, engaging with the public or improving administration where necessary.

- **less desirable and less feasible** should be conscious of the numerous domestic obstacles carbon taxes may face, at least in the short-term. They should diagnose low scores and consider specific carbon taxes against well-defined objectives, e.g. coal taxes to reduce local pollution.

Recommendations for LMIC's **international partners and policymakers** are to:

- **Support LMICs that plan to implement carbon taxes, irrespective of their CTSI scores but nonetheless informed by them.** Technical support - and perhaps financial support - will be needed as countries pursue socially efficient pricing of energy.

- **Consider using the CTSI to inform the allocation of scarce technical assistance and financial resources.** This includes targeting support at countries where carbon taxes are especially desirable and feasible so that they can achieve the biggest impact.

- **Help facilitate domestic and international learning**. While the gap between current and efficient energy prices is wide, experience with corrective measures among LMICs is limited. Learning needs to be generated and shared, both within the UNFCCC process as part of countries' Paris Agreement domestic surveillance procedures, and outside through fora such as the Partnership for Market Readiness.

"We at the Fund believe that carbon pricing – essentially charging fossil fuels for their carbon content – needs to be the centerpiece of mitigation efforts… Let us price it right, tax it smart, and do it now, so we do not end up like cooked chickens!"
- Christine Lagarde, 2015[4]

"Carbon pricing can raise revenues and these added resources can be used to generate more economic and social benefits… Every country, no matter its stage of development, can strive to effectively manage its economy, and to decarbonize while also ending poverty and boosting shared prosperity."
- Jim Yong Kim, 2014[5]

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[5] Jim Yong Kim, "World Bank Group President Jim Yong Kim Remarks at a Press Conference in Ghana," *World Bank*, October 16, 2015, http://www.worldbank.org/en/news/speech/2015/10/16/world-bank-group-president-jim-yong-kim-remarks-at-a-press-conference-in-ghana.

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I. Introduction

Fossil fuel subsidies are widely disliked by economists. Studies show that they encourage overconsumption of energy, damage the environment through CO2 emissions and other pollutants, cause premature deaths through local air pollution, exacerbate congestion, impose large fiscal costs which can be a drag on economic growth, discourage investment in energy-efficiency, increase the vulnerability of countries to volatile international energy prices, and fail to cost-effectively support the poor as most of the benefits drain away to the rich.[6] "In fact it is difficult to think of products that are more harmful to subsidize than fossil fuels."[7]

Despite this disapproval, fossil fuel subsidies persist globally, albeit unevenly. This includes direct fiscal costs ('pre-tax subsidies') and plus broader societal costs (externalities). The total of these two are 'post-tax subsidies'[8]. In 2015, these amounted to an estimated $5.3 trillion, or 6.5% of global GDP.[9] While pre-tax subsidies have fallen in recent years, post-tax subsidies have grown (Figure 1). These are unevenly distributed around the world, with a larger absolute and relative share in East Asia and Eastern Europe than in Latin America and Sub-Saharan Africa, for instance (Figure 2).

Figure 1. Post-tax subsidies rose in recent years...

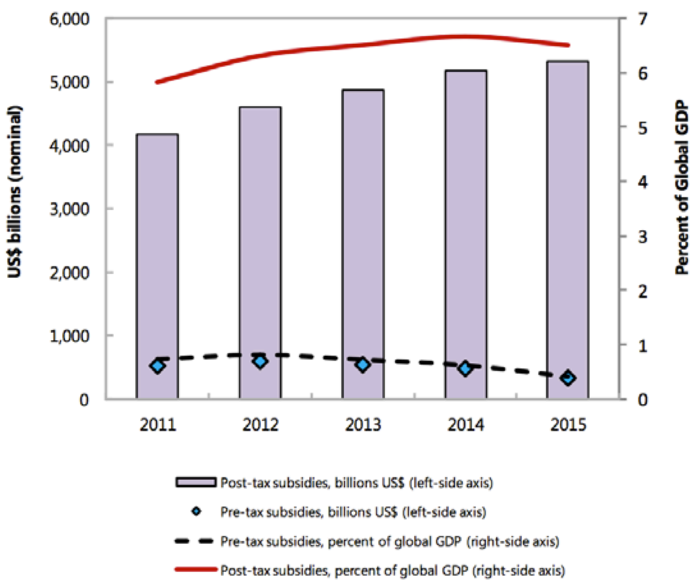
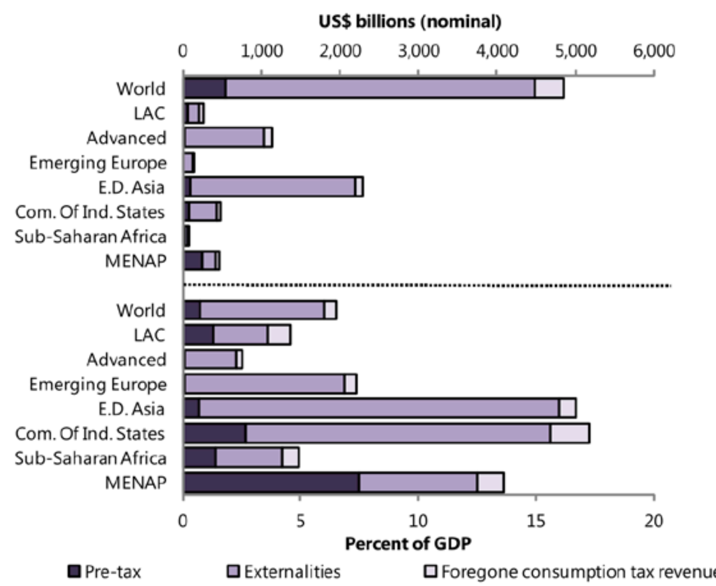


Figure 2. ...but there is large variation globally



Source: IMF, 2017[10]

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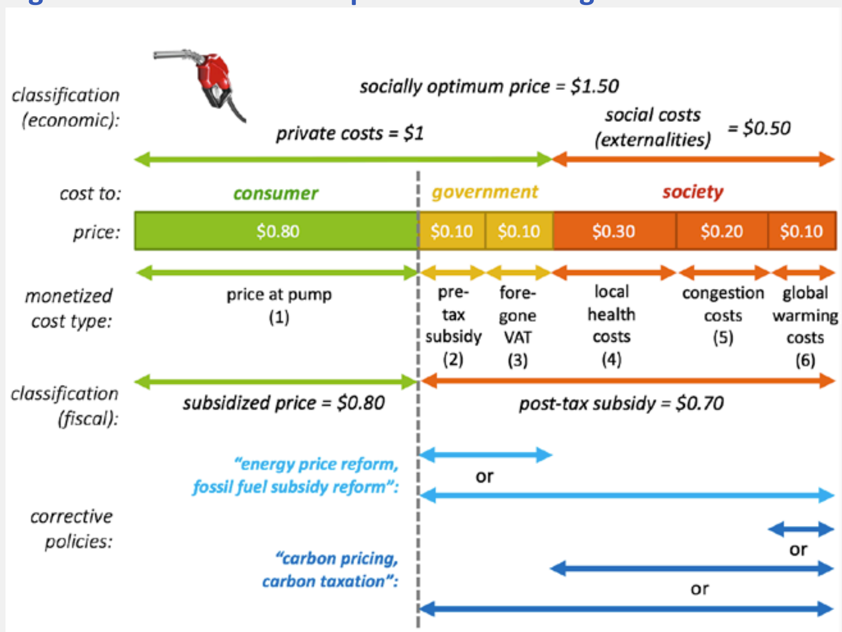
[6] Coady et al., "How Large Are Global Fossil Fuel Subsidies?"; Jennifer Ellis, "The Effects of Fossil-Fuel Subsidy Reform: A Review of Modelling and Empirical Studies," 2010, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1572397.
[7] Coady et al., "How Large Are Global Fossil Fuel Subsidies?," 11.
[8] 'Pre-tax subsidies' are the financial costs of subsidies to the government. 'Post-tax subsidies' are the combination of these financial costs and broader costs to society from overconsumption of fossil-fuel based energy. This broader definition of subsidies - the gap between consumer prices and supply costs plus societal costs - is used hereafter.
[9] Coady et al., "How Large Are Global Fossil Fuel Subsidies?". Note this estimate includes costs from global warming (22% of the total), air pollution (46%), broader vehicle externalities (13%), supply costs (11%), and the gap with other consumer taxes (8%). It excludes losses from underinvestment in energy efficiency measures and increased vulnerability to global energy prices as these are difficult to estimate.
[10] Ibid.

Box 1. Post-Tax Fossil Fuel Subsidies and Energy Price Reform

Fossil fuel subsidies arise when prices paid by consumers are below cost (defined either as private or full private and social costs). Figure 3 illustrates an example. A consumer purchases 1 liter of gasoline for $0.80 (1). The government subsidizes fuel directly through $0.10 of financial support (pre-tax subsidy, 2) and indirectly by foregoing VAT normally charged on goods (3). The total ($1) is the private cost of gasoline consumption.

But there are also social costs (externalities). Burning fossil fuels increases pollution-related deaths and health disorders, costs which can be estimated (e.g. $0.30, 4). Underpricing fuel also incentivizes inefficient car use, with welfare and efficiency costs from congestion ($0.20, 5). Lastly, there are global warming costs from emitting carbon dioxide ($0.10, 6). Total private and social costs ($1.50) equal the socially optimum price of fuel. The difference with the pump price is the effective 'post-tax subsidy' ($0.70).[11]

Figure 3. Illustrative example of subsidized gasoline



'Energy price reform' or 'fossil-fuel subsidy reform' variably refers to eliminating the pre-tax subsidies and foregone VAT, or the entire post-tax subsidy. 'Carbon pricing' can mean policies which 'internalize' the global warming externality, all externalities (a 'Pigouvian tax'), or the total post-tax subsidy. This paper uses the latter definition: eliminating the full post-tax subsidy.

In this case the government should eliminate the pre-tax subsidy ($0.10) and impose a tax on gasoline of $0.60 per liter, which would correct for the full-post tax subsidy. It could do this by taxing the extraction (upstream) or refinement (midstream), imposing a consumption charge (downstream tax) or taxing gasoline imports (excise duties). However, it is reach, policymakers should seek to 'get energy prices right' by targeting the social optimum; below this level incentivizes inefficient overconsumption of fossil fuels.

Eliminating these 'post-tax subsidies' entails ending financial support and implementing a carbon tax or tax-like instrument[12] so that the price of energy reflects the broader costs (refer to Box 1 for an illustrative example). Doing so could increase GDP, reduce CO2 emissions, improve health outcomes, encourage energy efficiency, reduce fiscal constraints, and make economies more resilient against shocks in global energy prices. The IMF estimates that eliminating subsidies in 2013 would have

[11] Note there are also other externalities from energy use whose costs are difficult to quantify and therefore have been excluded. This includes: benefits of active living, environmental impacts from fuel extraction and transportation, energy security, indoor air pollution, and terms of trade effects. Ian Parry, Chandara Veung, and Dirk Heine, "How Much Carbon Pricing Is in Countries' Own Interests? The Critical Role of Co-Benefits," 2014, https://www.imf.org/external/pubs/cat/longres.aspx?sk=41924.0.

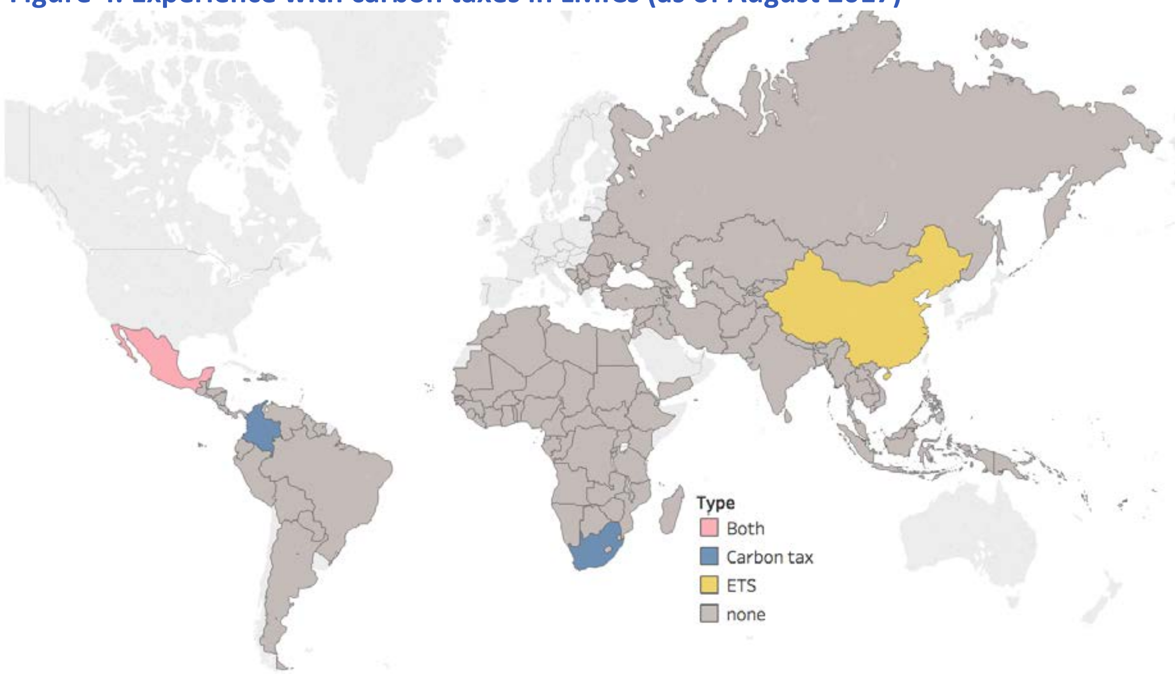
[12] Emissions trading systems can also incorporate social costs into consumer prices while raising government revenues. However, as described in Box 1, they are out of the scope of this report. Regulations can also impose costs (implicit carbon pricing), but are seen as less desirable by economists on economic efficiency grounds.

reduced carbon emissions by 21%, fossil-fuel air pollution deaths 55%, while raising revenue by 4% and social welfare by 2.2% of global GDP.[13]

Carbon taxation is a popular proposal among economists to correct the mispricing. A form of 'carbon pricing' (refer to Box 2), carbon taxes are a series of charges on fossil-fuel based energy linked to the cost of externalities. As a result, carbon taxes can shift incentives away from consumption while raising much-needed revenues. These revenues could be used to reduce fiscal deficits, invest in infrastructure, or reduce more distortionary taxes, yielding various welfare benefits. At a global level, implementing efficient energy prices could reduce carbon emissions by 23%, air pollution deaths by 63%, and raise revenues averaging 2.3% of GDP.[14] For LMICs, efficient energy pricing could increase welfare by 5.2% of GDP while raising revenues worth 7% of GDP.[15]

However, LMICs vary in their economic, political, and bureaucratic contexts. For some countries, carbon taxation may be especially desirable economically but infeasible politically or administratively.

Figure 4. Experience with carbon taxes in LMICs (as of August 2017)



Additionally, there is little research on carbon taxation in developing[16] country contexts and experience is lacking. Only four LMICs have implemented, scheduled or are actively considering carbon taxation measures (Figure 4). Meanwhile, in the academic literature, the economic and political consequences of carbon taxes developing country contexts has received little attention. In 2016, a group of academics highlighted two areas where progress is 'sorely needed' in climate economics: "the

[13] Coady et al., "How Large Are Global Fossil Fuel Subsidies?"
[14] Ian Parry et al., *Getting Energy Prices Right*.
[15] Coady et al., "How Large Are Global Fossil Fuel Subsidies?". The average revenues raised across countries is 2.7% of GDP and welfare gains of 2.1%. The higher aggregate figures are due predominately to the large revenues and welfare benefits in China (9.2% and 10.1% of GDP, respectively).
[16] 'Developing country' and 'lower and middle-income country' is used in this report interchangeably.

consequences of particular policies," and "the economic impacts and policy choices in developing economies."[17]

Box 2. Carbon Pricing and Carbon Taxation

Carbon pricing policies - types of 'market-based instruments' - include carbon taxes, emissions trading systems (ETSs, also known as 'cap-and-trade'), and hybrids. Carbon taxes are duties on the burning of carbon-based fuels (coal, oil, and gas). Charges can be levied at the point of extraction (upstream), refinement (midstream), consumption (downstream), or import (trade duties). For instance, the government could impose charges on extraction of coal at the mouth (upstream) or increase VAT on gasoline (downstream). ETSs cap emissions and allocate or auction permits to (usually large) emitters of CO_2, such as coal-fired power plants. Permits can be used for compliance or sold to other regulated entities. Hybrid policies incorporate elements of both. For instance, an ETS could include a 'safety valve', allowing entities to purchase permits at a specified fixed price, thereby acting like a tax, or a tax policy could allow trading of carbon tax credits.

There are advantages and disadvantages to each. Broadly, carbon taxation provides price certainty for energy consumers (businesses, households, and governments), but may be more politicized due to the higher salience of costs to consumers and businesses. ETSs offer more certainty over emissions levels but, as with hybrid schemes, are more difficult to set up and manage. Both can raise government revenue, though experience suggests that carbon taxes tend to raise more.[18]

These pros and cons have been analyzed extensively for developed countries.[19] However, developing countries tend to have lower levels of both state capability[20] and revenues[21], arguably tilting the balance towards carbon taxes. While there may be developing countries suitable for ETSs or hybrid schemes, this report focuses on carbon taxation.

This study seeks to identify countries which should and could raise energy taxes now and how. Using a framework which operationalizes economic and institutional variables, it pinpoints countries for whom carbon taxation is both desirable economically and feasible politically and administratively. In doing so, it aims to help close gaps in the literature on the economic and political consequences of carbon pricing in developing countries, while providing an actionable set of recommendations for both LMIC governments and their international partners.

This report has been prepared for the IMF's Fiscal Affairs Department to inform its technical assistance and thought leadership activities. However, findings may also be of interest to others at the IMF, the World Bank, and the governments of their member countries.

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[17] M. Burke et al., "Opportunities for Advances in Climate Change Economics," *Science* 352, no. 6283 (2016): 292–293 The third and final area was progress on the social cost of carbon (SCC).

[18] Carl and Fedor, for instance, find that carbon taxes raise six times as much as ETSs in revenue per capita (0.13% vs. 0.02% GDP). Jeremy Carl and David Fedor, "Tracking Global Carbon Revenues: A Survey of Carbon Taxes versus Cap-and-Trade in the Real World," *Energy Policy* 96 (September 2016): 50–77, doi:10.1016/j.enpol.2016.05.023.

[19] Joseph E. Aldy and Robert N. Stavins, "The Promise and Problems of Pricing Carbon: Theory and Experience," *The Journal of Environment & Development* 21, no. 2 (2012): 152–180.

[20] On government effectiveness, for instance, according to the World Banks's Worldwide Governance Indicators database, high-income countries are ranked in the 80th percentile on average, while middle and low-income countries are in 37th and 17th percentile respectively. World Bank, "Worldwide Governance Indicators - Aggregate | Data," October 14, 2016, http://data.worldbank.org/data-catalog/worldwide-governance-indicators.

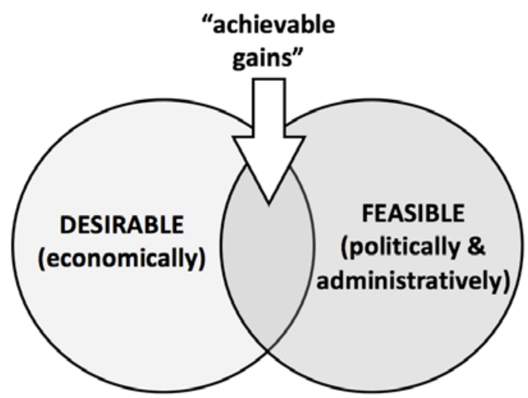
[21] For the 105 countries in the IMF's 2016 Fiscal Monitor Database, government revenues in high income countries were on average around 27.3% of GDP, and 17.5% in middle-income and 16.2% of GDP low-income countries, respectively. IMF, *Fiscal Monitor, April 2017*, 2017, 25.

I. Research methodology

In designing reforms, policymakers have increasingly looked beyond economic variables.[22] Having discarded 'one-size-fits-all' approaches, in recent years policy design has included detailed analysis of context, such as 'social institutions'[23] and political economy factors.[24] Considering political and administrative factors, alongside traditional welfare analysis such as economic appraisal, can help policymakers reach sustained, welfare-enhancing outcomes.

According to one view, 'achievable gains' (Figure 5[25]) can only be made where policies are both desirable (economically) and feasible (politically and administratively). Economically desirable policies are those where the benefits - e.g. increased economic production or broader welfare gains - are likely to outweigh costs - such as those from economic restructuring. But economically desirable policies may have effects which make them politically unsupportable, and therefore infeasible. For instance, new regulations which negatively affect firms with large lobbying power may not be sustained through subsequent electoral cycles. In addition, desirable policies may fail to be implemented effectively by the bureaucracy. This can result in undesirable, incomplete, or illusory reform.

Figure 5. Categories of achievable policy gains



Operationalizing 'desirability' and 'feasibility' can be done quantitatively (e.g. through the various 'government effectiveness' metrics) or qualitatively (e.g. via case studies). One formal approach is through constructing composite indicators. According to the OECD, composite indicators (CIs) are "increasingly recognized as a useful tool in policy analysis and public communication."[26] They provide simple comparisons of countries that can be used to illustrate complex or multi-dimensional issues like

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[22] Patricio Navia and Andrés Velasco, "The Politics of Second-Generation Reforms," *After the Washington Consensus: Restarting Growth and Reform in Latin America. Washington, DC, United States: Institute for International Economics*, 2003, http://www.piie.com/publications/chapters_preview/350/10iie3470.pdf; Lant Pritchett and Michael Woolcock, "Solutions When the Solution Is the Problem: Arraying the Disarray in Development - Working Paper 10" (Center for Global Development), accessed October 8, 2016, http://www.cgdev.org/publication/solutions-when-solution-problem-arraying-disarray-development-working-paper-10.

[23] Michael Woolcock, "Social Capital and Economic Development: Toward a Theoretical Synthesis and Policy Framework," *Theory and Society* 27, no. 2 (April 1, 1998): 151–208, doi:10.1023/A:1006884930135; Michael Woolcock, "Social Institutions and the Development Process: Historical Foundations, Contemporary Examples, Policy Applications" (World Bank, April 2017).

[24] The World Bank, "Concept Note for an IEG Category One Learning Product on the Use of Political Economy Analysis in the Design and Implementation of Development Policy Financing" (The World Bank, March 4, 2016), http://documents.worldbank.org/curated/en/152781467991009009/Concept-Note-for-an-IEG-category-one-learning-product-on-the-use-of-political-economy-analysis-in-the-design-and-implementation-of-development-policy-financing.

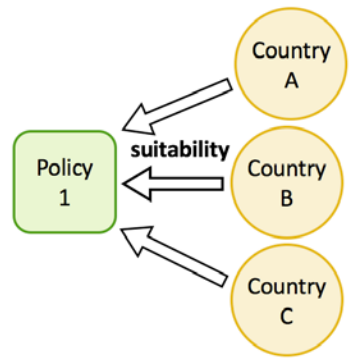
[25] Chart adapted from: Lant Pritchett, "The Political Economy of Targeted Safety Nets" (The World Bank, January 1, 2005), http://documents.worldbank.org/curated/en/283821468772779954/The-political-economy-of-targeted-safety-nets.

[26] Michela Nardo et al., "Handbook on Constructing Composite Indicators," OECD Statistics Working Papers (Paris: Organisation for Economic Co-operation and Development (OECD), August 9, 2005), http://www.oecd-ilibrary.org/content/workingpaper/533411815016.

poverty or sustainable development performance. CIs can help with setting policy priorities, summarize complex issues to support decision-makers, and can be easy to interpret. However, they can also send misleading policy messages if poorly constructed or misinterpreted, can invite simplistic policy conclusions, and can be misused if the construction process is opaque.[27]

CIs have mostly been used for benchmarking and monitoring national performance. This often has a normative objective. Transparency International's *Corruption Perceptions Index* (CPI) ranks countries by perceived corruption to 'send a powerful message" to governments, for instance.[28] The World Bank's *Doing Business Report* (DBR) ranks countries across 'ease of doing business' metrics to encourage "economies to compete towards more efficient regulation", to offer measurable benchmarks for reform, and serve as a resource for academics and others.[29]

Figure 6. Matching many countries to one policy



However, this paper proposes that composite indicators can also be used for *ex ante* policy design: specifically, using CIs to target 'achievable gains' for carbon taxation. Instead of ranking countries by performance at achieving particular outcomes (e.g. control of corruption or private sector regulation) countries can be ranked by how 'suitable' they are for a policy (Figure 6). This can be done by creating sub-indicators which proxy for 'achievable gains' criteria (Figure 5): given a country's context, whether carbon taxes are likely to be 'desirable' (economically) and 'feasible' (politically and administratively). For instance, government effectiveness can be a proxy for administrative feasibility, as governments that are more effective are more likely to implement carbon taxes effectively.

By selecting a number of indicators, countries can be scored, ranked for suitability and clustered into 'types'. This can help give a preliminary answer to the question of 'who should and could implement carbon taxes now', while offering some preliminary clues as to 'how'.

Advantages and limitations

Although the approach is cross-country and top-down, by allowing for heterogeneity and comparison across economic, political, and administrative indicators, it can be a useful tool for targeting policy gains. As with benchmarking, this too can send a powerful message to governments. Policymakers in countries 'matched' to carbon taxes may be more assured in their pursuit of efficient carbon tax policies. This can also help multilateral and national providers of aid and technical assistance better allocate scarce resources to where it is likely to have the largest impact.

However, such an approach intrinsically has its limits. Firstly, there are detractors to the creation and use of composite indicators in general. Composite indicators are mathematical combinations of a set of indicators. In aggregating metrics, there will necessarily be weighting across them (including 'zero' for excluded variables). The primary objection of 'non-aggregators' is that this process is arbitrary.[30] The selection and weighting across individual indicators to create an aggregated representation of a

[27] Ibid.
[28] Transparency International, "Corruption Perceptions Index - Overview," accessed July 29, 2017, https://www.transparency.org/research/cpi/overview.
[29] World Bank, "About the Doing Business Project," accessed July 29, 2017, http://www.doingbusiness.org/about-us.
[30] Andrew Sharpe, "Literature Review of Frameworks for Macro-Indicators" (Centre for the Study of Living Standards Ottawa, 2004), 9, http://www.csls.ca/reports/LitRevMacro-indicators.pdf.

broader concept, objective, or outcome (e.g. 'ease of business' or 'achievable gains') is inherently a matter of art rather than science. This raises doubts about the "robustness of rankings and the significance of the associated policy message."[31]

Nevertheless, much like an economic model, the justification for a particular composite indicator is whether it fits its intended purpose and is accepted by peers as doing so.[32] For the former, composite indicator quality can be defined broadly as "'fitness for use' in terms of user needs"[33]. The broader debate on the validity of forming composite indicators is unlikely to ever be settled.[34] But as long as they hold some utility for policymakers and are carefully and transparently constructed, this report proceeds from the proposition that CIs can be useful tools for policymakers in general and for policy design in particular.

For acceptance of peers, composite indicator modelers face a degree of skepticism among statisticians, economists and others, partly due to low transparency of some existing indicators.[35] In addition, while there is a burgeoning literature on carbon pricing, empirical research on their consequences is only just emerging. Creating a theoretical framework and selecting relevant sub-indicators for 'desirability' and 'feasibility' therefore entails an element of subjectivity. **The best antidote to such subjectivity is transparency in index construction but, ultimately, "the users of composite indicators should assess their quality and relevance".**[36]

Secondly, the cross-country nature of the approach means important details may be missed. While allowing for economic, political, and administrative heterogeneity across countries, the approach nonetheless relies on a uniform set of internationally measurable inputs, such as level of national debt or government effectiveness. These measures themselves may be flawed, and it is highly likely that there will be specific circumstances in countries that prevent a particular policy from being feasible or desirable which is not captured by these metrics.

Lastly, this approach differs from traditional welfare analysis. 'Economic desirability' here is not based on cost-benefit analyses or dynamic-stochastic general equilibrium models (DSGE), which have the become standard bearers for assessing the welfare effects of interventions. Instead, economic desirability indicators proxy for factors which are deemed to indicate *likelihood* of economic desirability.

As a result of the above, the proposed 'achievable gains' approach to constructing a composite indicator for policy suitability should be seen as a first pass: an initial scoping or screening exercise prior to deeper analysis. The index is not meant to replace modelling and cost-benefit-analysis, but to supplement them and other methods in the policymaker's toolkit. Nor is the index prescriptive: it does

[31] M. Saisana, A. Saltelli, and S. Tarantola, "Uncertainty and Sensitivity Analysis Techniques as Tools for the Quality Assessment of Composite Indicators," *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 168, no. 2 (March 1, 2005): 307–23, doi:10.1111/j.1467-985X.2005.00350.x.
[32] Nardo et al., "Handbook on Constructing Composite Indicators," 8.
[33] Ibid., 31.
[34] Michaela Saisana and Paris OECD, "Composite Indicators: A Review," in *Second Workshop on Composite Indicators of Country Performance, OECD, Paris*, 2004, https://www.researchgate.net/profile/Michaela_Saisana/publication/267986167_Composite_Indicators_-_A_review/links/554b77e10cf21ed213594143/Composite-Indicators-A-review.pdf.
[35] Nardo et al., "Handbook on Constructing Composite Indicators," 12.
[36] Ibid., 13.

not say which countries *should not* implement carbon taxes, for instance, but rather highlights relative variation of their desirability and feasibility across countries. **With these caveats, this report constructs a composite indicator - the 'Carbon Taxation Suitability Index' (CTSI) - as a tool to help policymakers better assess countries for suitability to carbon taxation.**

II. Constructing the Carbon Taxation Suitability Index (CTSI)

The CTSI composite indicator was built using standards established in OECD guidelines.[37] The 'ideal sequence' is: elaboration of the theoretical framework on a fitness-for-purpose basis, selection of sub-indicators, performing multivariate analysis (principal components analysis and factor analysis), imputation of missing values using Markov Chain Monte Carlo-based methods, normalization, weighting, robustness and sensitivity checks, regressing the CTSI with other indices and metrics, and visualization (**refer to Annex 1. Technical Appendix for detail on ten steps followed**). By following this standardized sequence, transparency for replicability can be maximized while minimizing potential pitfalls.

The key judgmental steps to constructing a composite index are sub-indicator selection, normalization, weighting, and aggregation. These are described briefly below (detail in Steps 2-8 of Annex 1).

Sub-indicator selection and normalization

A total of 23 sub-indicators were selected across the three 'categories of achievable gains': economic desirability, political supportability, and administrative feasibility (Table 1).

Based on a review of the literature on climate economics, fiscal policy, and political economy of reform, factors were sought which answered the following question: "what are the likely determinants of carbon taxation's desirability and feasibility?" For instance, the literature suggests that an economic efficient use of carbon revenues is to reduce government deficits, especially where fiscal constraints are strong.[38] Next, variables were selected which were believed to proxy for these factors. For example, annual fiscal deficits and government debt levels were selected as sub-indicators to proxy for the strength of fiscal constraints (full details of sub-indicator selection rationale are in Table 3-6 and complete data sources in Table 9).

Table 1. Categories, suitability factors, and sub-indicators selected

Category	*Suitability Factor*	*Sub-indicator*	*Weighting*	
			Within category	*Overall*
Economic desirability	Fiscal constraint	Government debt (%GDP)	14%	7%
		Fiscal deficit (%GDP)	14%	7%
	DRM gap	Government revenue (%GDP)	13%	6%
	Tax distortions	Tax on businesses (%commercial profits)	23%	12%

[37] Nardo et al., "Handbook on Constructing Composite Indicators."
[38] Jared Carbone, Richard D. Morgenstern, Roberton C. Williams III, Dallas Burtraw, "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts | Resources for the Future" (Resources for the Future, 2013), http://www.rff.org/research/publications/deficit-reduction-and-carbon-taxes-budgetary-economic-and-distributional; Jared Carbone, Richard D. Morgenstern, Roberton C. Williams III, Dallas Burtraw, "Getting to an Efficient Carbon Tax: How the Revenue Is Used Matters | Resources for the Future" (Resources for the Future, January 13, 2014), http://www.rff.org/research/publications/getting-efficient-carbon-tax-how-revenue-used-matters.

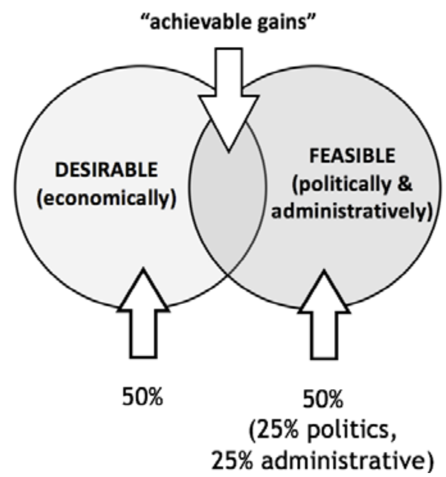
Category	Suitability Factor	Sub-indicator	Weighting	
			Within category	Overall
	Energy distortions	Fossil fuel subsidies (%GDP)	11%	6%
	Informality distortions	Shadow economy (%GDP)	14%	7%
	Investment gap	Infrastructure investment gap (rank)	11%	5%
		Total	**100%**	**50%**
Political feasibility	Fiscal reform opportunity	IMF loans outstanding (%GDP)	11%	2.8%
	Fiscal policy engagement	IMF FAD technical assistance missions	11%	2.8%
	Interest in carbon pricing	Carbon pricing mentioned in INDC	11%	2.8%
	Climate objectives	Unconditional component of INDC	11%	2.8%
	Distributional objectives	Gini index	11%	2.8%
	Constraints on pricing changes	History of protests over fuel prices	11%	2.8%
	Competitiveness concerns	Manufacturers' share of goods exports	11%	2.8%
	Energy poverty	Population without electricity access and/or relying on biomass	11%	2.8%
	Environmental effectiveness	Electricity production from coal sources	11%	2.8%
		Total	**100%**	**25%**
Administrative feasibility	Implementation effectiveness	Control of corruption (WDI score)	14%	3.6%
	Ability to use revenues effectively	Government effectiveness (WDI score)	14%	3.6%
	Existence of consumption tax system	Government charges VAT	14%	3.6%
	Ability to adjust energy prices	Government sets fuel prices	14%	3.6%
	Existence of excise system on upstream energy	Government taxes natural resources	14%	3.6%
	Risk of fuel smuggling	Anti-trafficking Policy Index score	14%	3.6%
	Ability to compensate poorest	Adequacy of benefits in poorest quintile (all Social Assistance)	14%	3.6%
		Total	**100%**	**25%**

These sub-indicators were then explored using principal component and factor analysis and had missing values imputed using Monte Carlo Markov-Chain simulation methods. They were then normalized into scores out of 5 (5 being most suitable, 1 being least suitable). For continuous variables, scoring is based on their quintile within the distribution of the values, and for dichotomous variables scores were either 1 or 5.

Scoring and aggregation

Within categories, sub-indicators were weighted using robust principal component analysis (RPCA). RPCA can be used to correct for large correlations between variables by preventing over-weighting of the same source of variation.[39] For instance, fiscal deficits and government debt are heavily correlated; giving equal weight to these indicators would overweight the same source of variation ('principal component' or 'factor'). However, sufficient correlations between indicators are required, and only the economic desirability indicators had sufficient intra-category correlations. Economic indicators were therefore weighted based on RPCA, while political and administrative indicators were weighted equally within their category (11% and 14%, respectively). Finally, robustness checks were conducted on sub-indicator selection, missing data imputation, and weighting within and across categories.

Figure 7. Weighting on categories of achievable gains



Final rankings were created by weighting scores on economic desirability at 50%, political feasibility at 25%, and administrative categories at 25%, with a final CTSI score out of 5 (5 indicating most suitable). This aggregation balances scores across the two 'achievable gains' criteria (Figure 8): whether policies are desirable and feasible. It also allows interpretation and visualization on these two dimensions (see below).

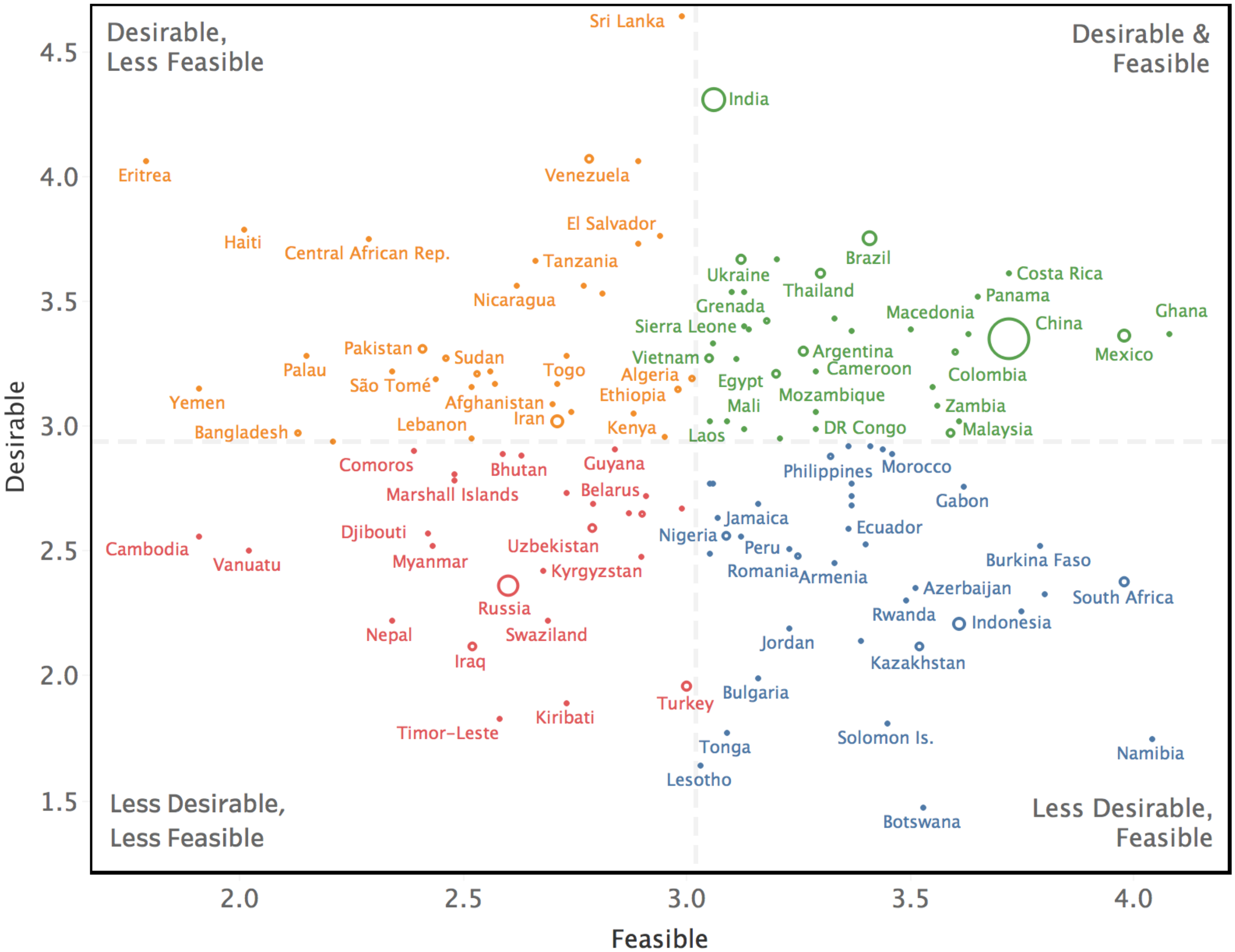
III. Results: 'Which countries should and could implement carbon taxes now?'

Overall results of the CTSI are presented below (full rankings, including scores across categories and suitability criteria, are shown in **Annex 2. CTSI - Full Rankings**). Figure 8 shows all 133 LMICs in the dataset in two-dimensional ('desirable' and 'feasible') space, with bubbles representing 2012 greenhouse gas emissions. Figure 9 shows country scores for each region. Figure 10 is a map of CTSI country 'types' and their estimated post-tax fossil fuel subsidies. Figure 11 gives a sense of the proportion of GHG emissions for country types. Figure 12 disaggregates country scores by the contribution of the three categories (economic, political, and administrative indicators) for selected countries.

LMICs varied considerably across carbon taxation suitability metrics, including across categories. Sri Lanka and India, for example, score very high overall (ranked 1st and 3rd) but have very low political feasibility scores (2.6 and 2.1 out of 5, respectively - Figure 12). The Gambia and Ukraine rank highly overall (10th and 16th) but have low administrative feasibility scores (3.0 and 2.6). Ghana and Mexico (ranked 2nd and 4th) have high administrative scores (4.7 and 4.3), but moderate political (3.4 and 3.7) and economic desirability scores (both 3.4). Even among highly ranked countries such as these there appears to be diversity across economic, political, and administrative factors.

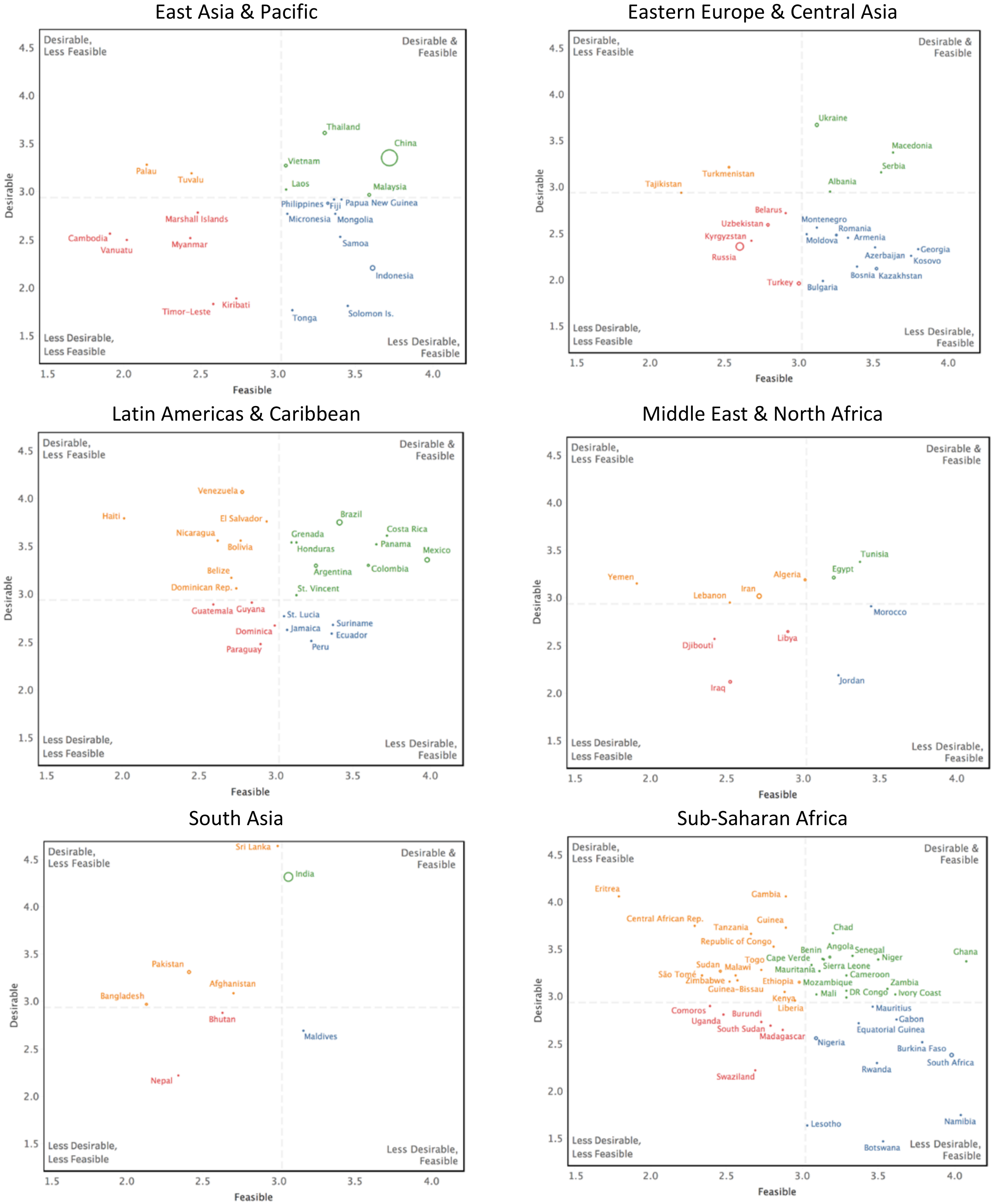
[39] Note that, with RPCA, "weighting only intervenes to correct for the overlapping information of two or more correlated indicators, and it is not a measure of theoretical importance of the associated indicator. If no correlation between indicators is found, then weights can not be obtained estimated with this method." Nardo et al., "Handbook on Constructing Composite Indicators."

Figure 8. Carbon Taxation Suitability Index (CTSI): All Lower and Middle-Income Countries



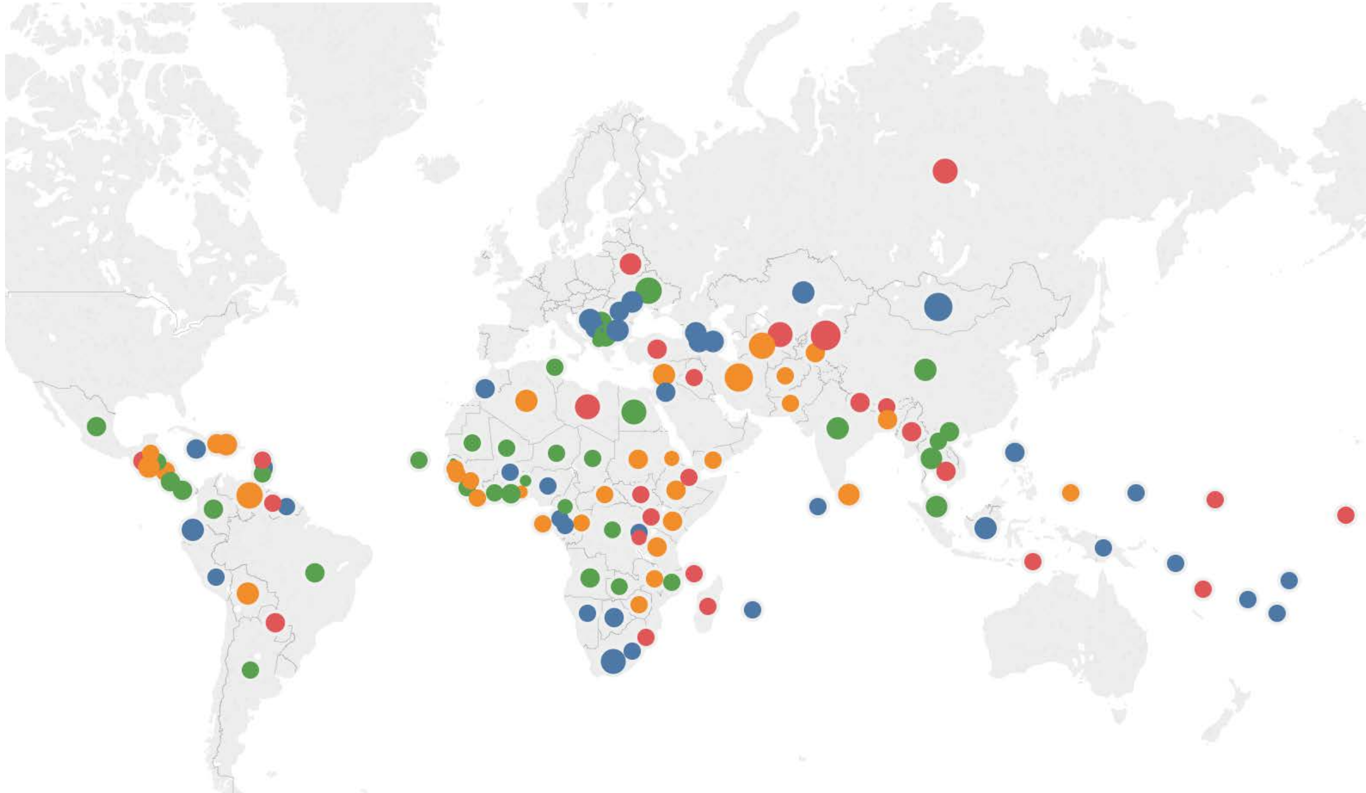
Source: author's calculations. 'Desirable' accords to the economic desirability category score (average 2.93 across all 133 lower and middle-income countries in the dataset). 'Feasible' is the average of political feasibility (average of 2.57) and administrative feasibility (3.06) scores. Bubbles represent 2012 greenhouse gas emissions (including LULUCF). Colors represent types of countries split into quadrants: green - desirable & feasible; blue - less desirable, feasible; orange - desirable, less feasible; red - less desirable, less feasible. Cutoffs for types are average of 'desirable' score (2.93) and 'feasible' score (3.02) across all countries in the dataset.

Figure 9. Carbon Taxation Suitability Index: Regional Results



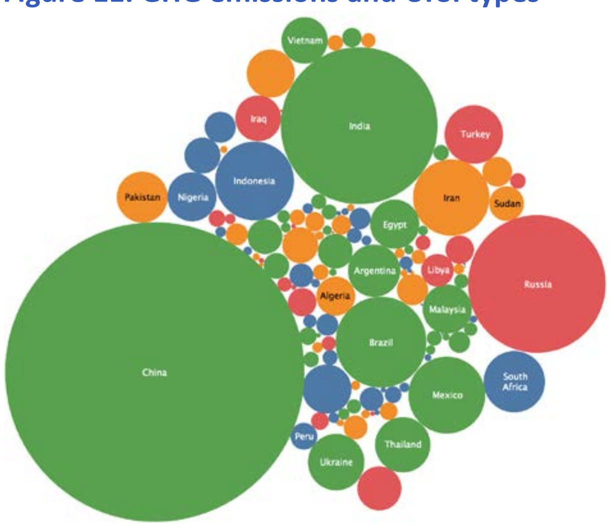
Source: author's calculations. Bubbles represent 2012 greenhouse gas emissions. Colors represent CTSI types.

Figure 10. Map - CTSI types and Post-Tax Fossil-Fuel Subsidies



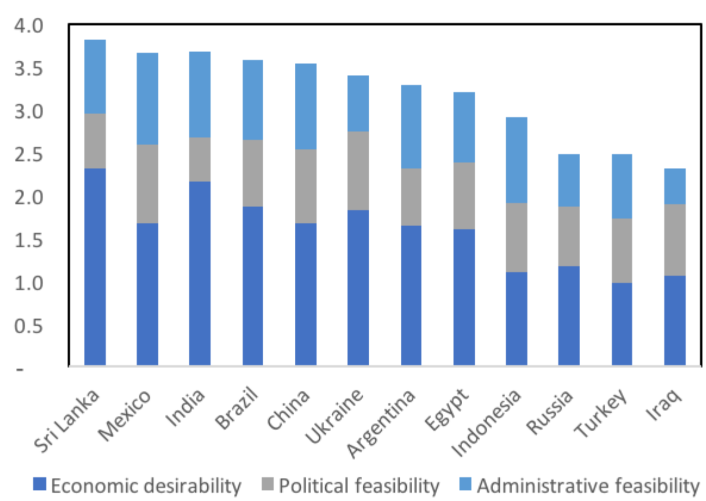
Source: author's calculations & IMF 2017[40]. Circles represent potential fiscal revenues raised (% GDP, 2015). Colors represent CTSI types of countries: green - desirable & feasible; blue - less desirable, feasible; orange - desirable, less feasible; red - less desirable, less feasible.

Figure 11. GHG emissions and CTSI types



Source: author's calculations & WRI 2017.[41] Circles represent share of 2012 global GHG emissions.

Figure 12. Decomposition of overall CTSI scores across categories, selected countries



Source: author's calculations. Bar height represents category's contribution to overall CTSI scores.

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[40] Coady et al., "How Large Are Global Fossil Fuel Subsidies?"

[41] WRI, "CAIT - CAIT Country GHG Emissions Database," February 2, 2017, http://www.wri.org/resources/data-sets/cait-historical-emissions-data-countries-us-states-unfccc.

'Types' of countries can also be identified. It is theorized that there are some threshold effects on 'desirable' and 'feasible' scores (rather than a perfect substitutability, i.e. convexity in the desirable-feasible space). For example, it could be that below a certain threshold of administrative feasibility carbon taxes are unlikely to be viable. If so, countries can be separated into 'types' using some cutoff.

Choosing the mean for 'desirable' (2.93) and 'feasible' (3.02) for this threshold creates four quadrants and types of countries: green - desirable & feasible (36 countries); blue - less desirable, feasible (37 countries); orange - desirable, less feasible (34 countries); red - less desirable, less feasible (26 countries). The number of countries seems to be balanced (if somewhat skewed towards suitable) across types. Types also do not appear to be systematically skewed across regions (Figure 9).

Lastly, the CTSI suggests that countries which account for a majority of LMIC's greenhouse gas emissions are the most suitable for carbon tax policies. Figure 11 gives a sense of emissions by country type. Countries in the 'feasible & desirable' category represent 67% of LMIC 2012 greenhouse gas, of which China and India account for 40% and 11%, respectively. Scores were not weighted by emissions and there was no *ex ante* reason to expect that two thirds of emissions would be in the 'most suitable' category. Given carbon pricing is widely regarded as the most efficient mitigation measures, this is promising from both an economic efficiency and climate mitigation 'achievable gains' perspective.

Other observations

The CTSI was also used to explore links with other variables and indices (Step 8 of Annex 1). Regression analysis suggests that countries where carbon taxes are highly desirable may have been more ambitious in their Paris Agreement mitigation commitments ('nationally-determined contributions' - NDCs) and tend to be better at meeting the SDGs. In addition, countries where carbon taxes are highly feasible also may have been more ambitious in their NDCs, tend to be better at achieving environmental objectives, are better at regulating the private sector, are slightly wealthier per capita, and slightly freer politically. Note that while income is not a strong driver of suitability, government effectiveness is.

While only four countries have implemented carbon tax policies (Mexico and India) or are scheduled to implement them (Colombia and South Africa), all of these countries score highly on the CTSI. Mexico, India, and Colombia are ranked in the top 10 of 133 ranked overall, and South Africa is in the top third (Annex 2). This is early (albeit suggestive) evidence that the theoretical framework underpinning the CTSI has validity.

However, this should not be overstated: the sample size is small, plans for carbon taxes were drawn up prior to constructing the CTSI, and one of the sub-indicators was whether the country's NDC mentioned the use of carbon pricing (all four countries did, albeit only South Africa's mentioning domestic carbon pricing). Nevertheless, while an approach like the CTSI approach is a normative one, it may hold some positivist predictive power as well.

IV. Policy Recommendations: 'How?"

Having identified countries where carbon taxes is desirable and/or feasible, the question arises: 'how?' Guidance in this area is new but growing, including the World Bank process guidelines in the *Carbon Tax Guide: A Handbook for Policymakers*.[42] This section suggests a four-step process for policymakers: adopt a normative framework; learn from the experiences of others; design, implement, and review carbon taxes, including by using the CTSI as a diagnostic tool; and, lastly, generate shared learning.

Step 1. Adopt a normative framework

It is important to set out a normative framework prior to engaging in reforms. The World Bank and the OECD has developed a set of norms for carbon pricing (refer to Box 3). While some of these norms may conflict - notably fairness and efficiency - as a set of guiding principles they can help guide policymakers towards more effective implementation of carbon taxation.

Box 3. FASTER Principles for Carbon Pricing

The OECD and World Bank jointly developed a normative framework for policymakers.[43] The 'FASTER' Principles for Carbon Pricing states that carbon tax should be designed to ensure:

- ***F****airness* - distributing costs and benefits equitably, especially avoiding a disproportionate burden on low-income groups
- ***A****lignment between objectives and policies* - ensure carbon pricing policies are a part of a package of measures which collectively align to objectives
- ***S****tability and predictability* - send consistent and credible signals to the private sector
- ***T****ransparency* - clarity in design and implementation
- ***E****fficiency and cost effectiveness* - allow private agents to adjust independently, and use raised revenues effectively
- *envi****R****onmental integrity* - aim for measurable reductions in harmful activities.

Step 2. Learn from the experience of others

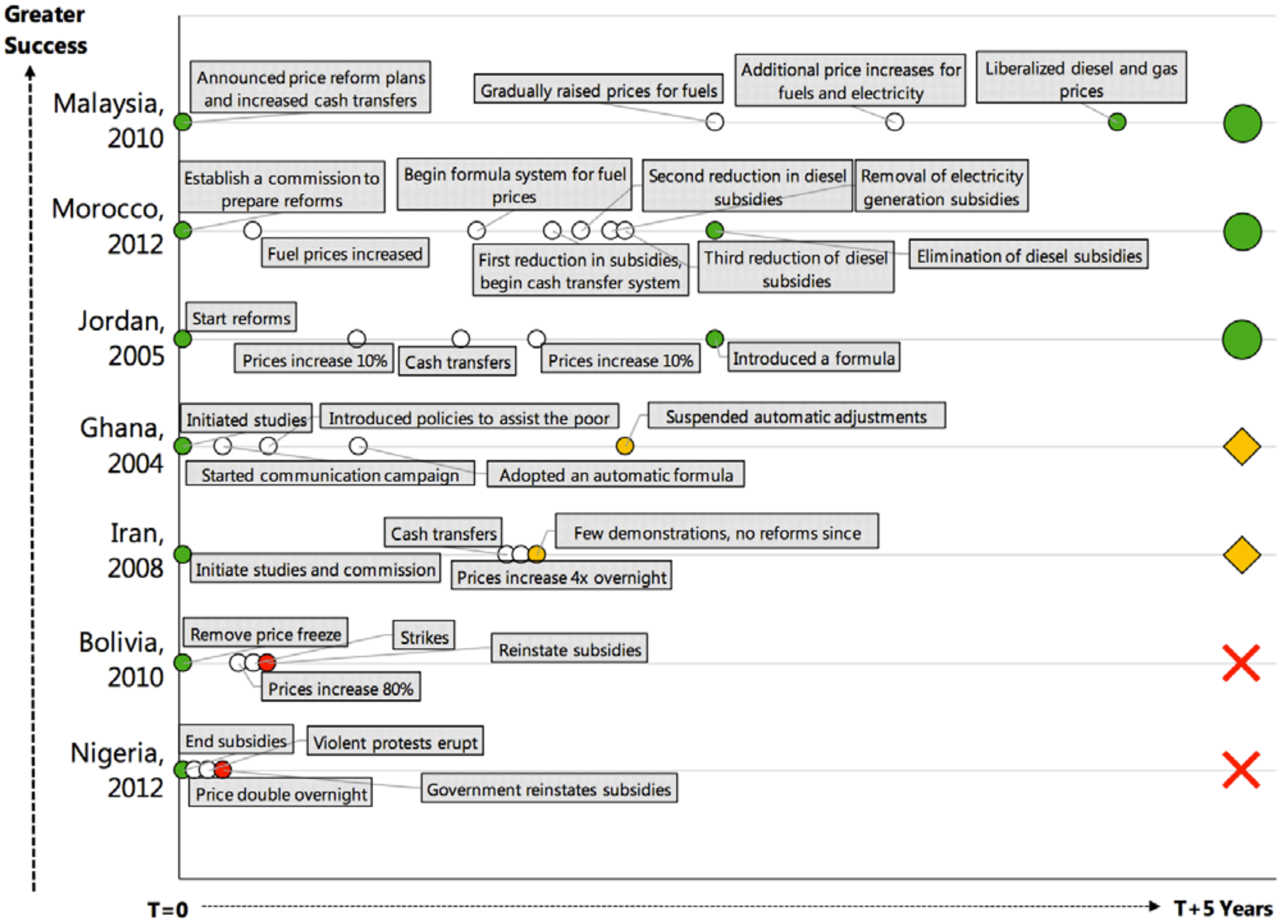
Increasing energy prices by charging a carbon tax is similar to increasing prices through reducing pre-tax fossil fuel subsidies (negative carbon taxes). A number of countries which subsidize fossil fuels financially have taken the opportunity provided by low oil prices to reduce these pre-tax subsidies. Their experiences are informative and applicable to governments seeking to raise energy taxes.

As shown in Figure 13, countries experienced varying levels of success with energy price reform.[44] **Malaysia** successfully reduced and then eliminated diesel and gas subsidies from 2010-15, assisted by numerous press statements from prime minister on the need for reform alongside and politicization that was limited to improving targeting of the poor. **Morocco** managed to eliminate subsidies on fuel between 2012-15. It established commissions to evaluate specific proposals, proceeded gradually with steady price increases, and used funds to expand spending in health, education, and transport. **Jordan** reformed

[42] Partnership for Market Readiness, "Carbon Tax Guide: A Handbook for Policy Makers" (World Bank, March 2017).
[43] OECD and World Bank, "The FASTER Principles for Successful Carbon Pricing: An Approach Based on Initial Experience," September 2015, https://www.oecd.org/env/tools-evaluation/FASTER-carbon-pricing.pdf.
[44] IMF, "If Not Now, When? Energy Price Reform in Arab Countries," April 2017.

subsidies gradually from 2005, eliminating fuel subsidies in 2012 and using measures implemented as part of its Standby Arrangement to bring its national utility back to full cost recovery. To compensate, the government increased public sector wages for low earners and put in place cash transfers if oil prices rise above $100 per barrel covering 70% of the population and a targeted food subsidy program. These measures were costly but generated public support for the program.

Figure 13. Case studies in energy price reform



Source: IMF (2017)[45] *based on World Economic Forum (2013)*[46] *and Clements et al. (2013)*[47]
Note: Green indicates success, orange indicates possible success, and red indicates lack of success.

Despite a promising start, **Ghana** had mixed success in eliminating subsidies. A campaign of engagement, buttressed by a raft of compensatory measures across transport, education, and electrification were ultimately followed by waning political support for automatic price adjustments in subsequent years. **Iran** embarked on a bold reform program, increasing fuel prices by 400-1,000 percent in a short space of time. The sharp price increases pushed inflation upwards, eventually, alongside sanctions, increasing poverty. **Bolivia** increased fuel prices sharply (by 80%) in 2010. This led to strikes in major cities by unions, and the

[45] Ibid.
[46] World Economic Forum, "Lessons Drawn from Reforms of Energy Subsidies," 2013, http://www3.weforum.org/docs/GAC13/WEF_GAC13_LessonsReformsEnergySubsidies_Report.pdf.
[47] Mr Benedict J. Clements et al., *Energy Subsidy Reform: Lessons and Implications* (International Monetary Fund, 2013), https://books.google.com/books?hl=en&lr=&id=Xvu1AwAAQBAJ&oi=fnd&pg=PP1&dq=Energy+Subsidy+Reform:+Lessons+and+Implications&ots=iZjN7WWX_f&sig=S59RbCU5luJM2kjPGl3iTtklbl8.

government quickly revoked the price hikes. **Nigeria** also increased fuel prices sharply in 2012. Facing fiscal pressure, it abruptly ended fuel subsidies, doubling gasoline prices overnight. This led to widespread protests, stoked by concerns about corruption and fears that interest groups were seizing control of natural resources.

These experiences lead to five 'rules of thumb' for reforming energy prices (refer to Box 4). By following these, policymakers can increase the chances of success in increasing energy taxes.

Box 4. Rules of Thumb for Energy Price Reform

Experience with energy price reform informs following rules of thumb:[48]

- **Formulate an integrated reform strategy** - consider all reform pieces holistically, tailored to the domestic policymaking, including: alignment and trajectory towards efficient prices, incentives, pace, support for consumers and producers which stand to lose, while maintaining appropriate monetary and fiscal policies to keep inflation expectations anchored
- **Protect the most vulnerable** - prefer cash transfers over in-kind compensation, targeted cash transfers are ideal although universal cash transfers are easier to implement
- **Build public support** - communicate costs and benefits of reform, use careful consultations and/or clear communication
- **Avoid piecemeal approaches** - depoliticized and transparent rules which lead to automatic price changes are more durable than ad hoc, one-time adjustments
- **Reform gradually** - avoid large adjustments when possible, allowing consumers and businesses to adjust to the new reality of higher prices steadily

Step 3. Design, implement, and review carbon taxes

The *Carbon Tax Guide* offers detailed guidance on designing and implementing carbon taxes (refer to Figure 14), including:

- deciding whether to adopt a carbon tax
- defining objectives, understand national circumstances
- designing carbon taxes: determine the tax base, tax rate, and use of revenues, using modelling throughout
- ensure oversight and compliance
- evaluate outcomes

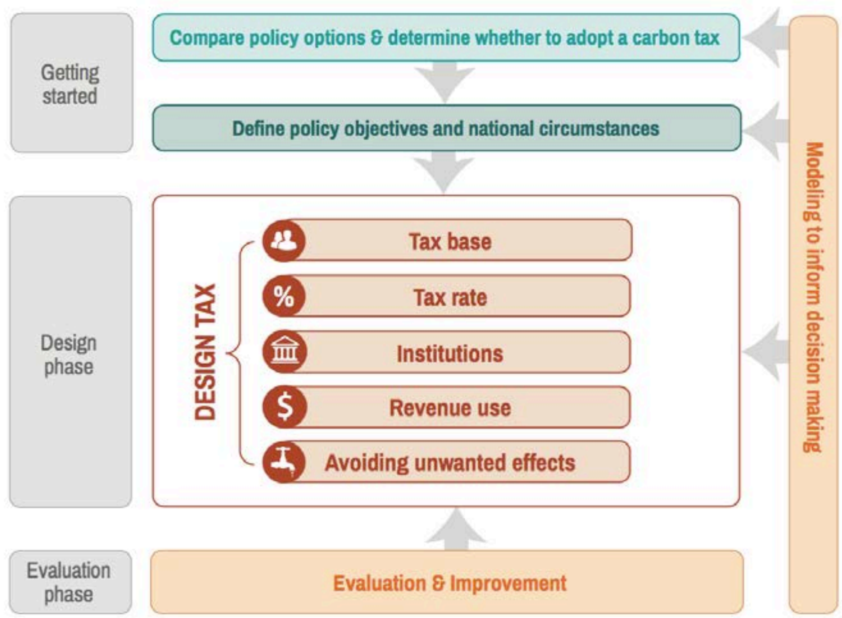
[48] IMF, "If Not Now, When? Energy Price Reform in Arab Countries."

The first two stages are crucial. As the *Carbon Tax Guide* notes, "carbon taxes can be molded to each jurisdiction's particular legal, economic, and social context, and to fulfil different roles within its overall climate, energy, and social policy mix."[49]

Given the significant heterogeneity of economic, political, and administrative structures, **the question is therefore not 'how should a country raise energy taxes?', but rather 'how should *this* country raise energy taxes?'**

The CTSI can be used as a diagnostic tool to help answer this question.

Figure 14. Stages of Carbon Tax Design



Source: World Bank/PMR, *Carbon Tax Guide*, 2017[1]

Firstly, the 'type' of country can inform first steps:

- *Desirable & feasible countries* (green) should seek to phase in carbon taxes gradually. They should define national objectives, and design policies in a fair and transparent manner. This includes following recently-published guidance, alongside investigating clues offered by detailed CTSI scores.

- *Less desirable, feasible* (blue) countries should consider using opportunity of feasibility to implement carbon taxes given specific government objectives (e.g. domestic resource mobilization or infrastructure investment)

- *Desirable, less feasible* (orange) countries should be cognizant of likely implementation issues, diagnose and proactively seek to build state capability, political support for carbon taxes, or both

- *Less desirable & less feasible* (red) should be conscious of the numerous domestic obstacles carbon taxes may face, at least in the short-term. They should seek to diagnose reasons for low scores and whether certain carbon taxes can nonetheless meet specific objectives, e.g. coal taxes for local pollution.

Secondly, detailed scores can provide more clues as to likely obstacles to implementation of carbon taxes. All scores are benchmarked against other countries, helping to identify relative weaknesses. For example, Sri Lanka was ranked in 1st place in the CTSI, but was nonetheless in the 'desirable, less feasible (orange)' category due to low political and administrative scores. Closer inspection of detailed scores (Table 2) indicates why, from which policies suggestions can be drawn. Sri Lanka:

[49] Partnership for Market Readiness, "Carbon Tax Guide: A Handbook for Policy Makers," 21.

Has a history of protests over fuel prices, low adequacy of social benefits, high inequality, and some population without energy access - in this case it may be especially important to gain popular consent for policy by linking to increase social support programs and paying for energy infrastructure to expand access

Does not have a fiscal regime over natural resources - This is needed if seeking to implement energy extraction carbon taxes. Fuel taxes may be preferable given existence of VAT regime, although import duties are also an option.

Has a large manufacturers' share of exports - the Sri Lankan government may be especially sensitive to competitiveness concerns. It should seek to identify export-competing/import-competing sectors at risk, design protections for them (e.g. tax exemptions, offset credits), balancing these protections against environmental integrity and other objectives.

Has an NDC which does not have an unconditional component or mention of carbon pricing - climate objectives may be low on the list of priorities for Sri Lanka, or it may lack information on carbon pricing. If true, Sri Lanka may be more attracted to the non-climate benefits of carbon taxation (health, congestion, and revenues).

Table 2. Detailed scores for Sri Lanka

Economically desirable	**Score**
Government debt	5
Fiscal deficit (% GDP)	5
Government revenue	5
Tax on businesses	5
Infrastructure investment gap	5
Shadow economy	4
Fossil fuel subsidies	3
Politically feasible	**Score**
IMF loans outstanding	4
IMF FAD technical assistance missions	4
Electricity production from coal sources	3
Gini index	2
Population without electricity access and/or relying on traditional use of biomass	2
Carbon pricing mentioned in INDC	1
History of protests over fuel prices	1
Manufacturers' share of exports (%)	1
INDC includes unconditional component	1
Administratively supportable	**Score**
Government sets fuel prices	5
Government charges VAT	5
Government effectiveness	4
Control of corruption	4
Anti-trafficking Policy Index score	3
Adequacy of benefits in poorest quintile (all Social Assistance)	2
Government taxes natural resources	1

Colors show score (green being highest, red lowest)

In this way, the CTSI can help policymakers deciding whether to adopt a carbon tax to define objectives and better understand national circumstances in an international context.

Step 4. Generate shared learning

Lastly, governments and partners should put in place procedures *ex ante* to maximize learning *ex post*. Given the large efficiency gains from economy-wide measures compared with other mitigation instruments, but the pervasive and limited experience with carbon taxation, there is an urgent global need for generating and sharing lessons learned.

Key questions include appropriate tax levels and pathways, appropriate charges on sources and sectors in different contexts, effective compensatory targeting methods and levels, engagement best practice, interactions with climate finance, complications for resource-rich versus import-dependent countries, interactions with the shadow economy and fuel smuggling incidence, and the changing role of external support such as technical assistance and policy crediting. The gains of improving understanding in these areas for mitigation, health, congestion, and welfare domestically and internationally are large, but so too is the gulf in current experience.

Generating the learning needed may require venturing outside of existing frameworks. The UNFCCC has a long and dismal track record on transparency efforts on domestic mitigation efforts, for instance.[50] The World Bank's Partnership for Market Readiness is a good model, but current membership is limited. What is needed are volunteer LMICs to pilot carbon taxes while putting in place rigorous *ex post* evaluation frameworks, supported by bilateral, multilateral, and academic institutions through technical and, in some cases, financial assistance. This process could form part of countries' domestic policy surveillance procedures under the Paris Agreement, while helping promote learning and building trust.[51]

By seeking to maximize these positive policy externalities, governments will be demonstrating commitment to meeting their NDCs, as well as to the health and welfare of their own citizens. By supporting these efforts, multilateral and bilateral partners will be enacting their commitment to help developing countries meet their NDCs, and accelerating countries towards implementing the most effective mitigation instrument of all: carbon pricing.

Overall, by following this four-step process, LMIC policymakers and their partners can maximize the likelihood that 'getting energy prices right' is effective, equitable, and sustainable.

I. Conclusion

This paper has attempted to answer the question: 'which countries should raise energy taxes now, and how?' This question flows from the observation that energy prices are too low worldwide. Energy prices do not incorporate the cost of externalities including human mortality, morbidity, congestion, and climate, implying substantial post-tax fossil fuel subsidies.[52] Increasing energy prices through taxation, and linking the level of taxation with carbon content, appears a desirable reform for virtually all countries.

However, such reform is more economically desirable in some countries. In addition, the ability of countries to implement such policies politically and administratively varies. This study has incorporated considerations of economics, politics, and administration using a novel application of existing frameworks.

The CTSI is a novel use of composite indices. Firstly, international composite indices have been principally used to assess international performance. A large variety of indices have been created to rank countries on the basis of political and economic performance metrics, such as human development, sustainable development, environmental performance, freedom, governance, and regulatory performance. On the one hand, such *ex post* metrics are useful benchmarking exercises, providing "qualified confirmation of the desirability"[53] of reform, for instance. On the other hand, they offer little guidance on the particular measures likely to be effective.[54] By contrast, the CTSI is explicit *ex ante* about which reforms are desirable and feasible for countries.

[50] Joseph E. Aldy, "The Crucial Role of Policy Surveillance in International Climate Policy," *Climatic Change* 126, no. 3–4 (2014): 279–292.
[51] Joseph Aldy, "The Role of Domestic Policy Surveillance in the Multilateral Climate Transparency Regime," in *The Paris Agreement and Beyond: International Climate Change Policy Post-2020* (Harvard Project on Climate Agreements, 2016), 43–47, https://www.belfercenter.org/sites/default/files/files/publication/2016-10_paris-agreement-beyond_v4.pdf.
[52] Coady et al., "How Large Are Global Fossil Fuel Subsidies?"
[53] David Parker and Colin Kirkpatrick, *Measuring Regulatory Performance* (OECD, 2012), 40.
[54] Ibid.

Secondly, economic policy design frameworks, such as growth diagnostics (GD), tend to match countries to policies. By identifying the sources of low performance ('binding constraints'), GD seeks to diagnose the malady before prescribing policies.[55] In doing so it matches one country to a plethora of possible policies. This is appropriate when considering only one country. But on the international scale, the matching logic can be reversed. Instead of matching one country to lots of policies, the CTSI matches one policy to lots of countries.

This is not a 'one-size-fits-all' approach, however. Suitability is explicitly contingent on heterogeneous national economic, political, and administrative circumstances. For reforms whose desirability is entirely context specific, such as creation of free-trade zones, indices can function as a filter: whittling down a list of countries to those where the reform is both desirable and feasible. For reforms which appear more uniformly desirable - such as correcting the near-universal mispricing of energy[56] - the index can help identify 'achievable gains': pinpointing which countries are especially suited to reform right now, and offering clues as to what the major obstacles might be.

This approach can be informative for multilateral institutions, overseas development agencies, and national governments alike. All have scarce financial, political, and human capital and varying objectives. Given these constraints, identifying and ranking countries and reforms for suitability - including matching countries to policies, as well as vice-versa - can help inform prioritization and improve resource allocation.

There is a long way to go before all countries 'get energy prices right'. But by offering more targeted and benchmarked policy advice - such as that arising from the *Carbon Taxation Suitability Index* - a world of socially optimal energy prices could be ushered in sooner.

[55] Ricardo Hausmann, Dani Rodrik, and Andrés Velasco, "Growth Diagnostics," *The Washington Consensus Reconsidered: Towards a New Global Governance*, 2008, 324–355; Dani Rodrik, "Diagnostics before Prescription," *The Journal of Economic Perspectives* 24, no. 3 (2010): 33–44.

[56] Ian Parry et al., *Getting Energy Prices Right*.

Annex 1. Technical Appendix

This technical appendix describes the process of constructing the Carbon Taxation Suitability Index, following the steps set out by OECD guidelines on creating composite indicators.[57]

Step 1 - Theoretical framework

The purpose of the Carbon Taxation Suitability Index is to provide a suggestive answer to the question: "which LMICs should and could increase energy taxes now?" It does this by scoring LMICs in relation to carbon taxation across the three elements of policy design: economically desirable, politically supportable, and bureaucratically feasible. Each of these elements are crucial for the desirability and durability of carbon taxation: without one of these elements, such policies are likely to fail.

The selection criteria for underlying sub-indicators is whether they amount to a reasonably comprehensive view of what are currently believed to be the key variables determining whether carbon tax policies are desirable, supportable, and feasible in different contexts. For desirability, there is a burgeoning literature on the contexts in which carbon taxation is particularly economically desirable or costly. The selection of these sub-indicators is based on recent advances in the climate economics literature and conforms roughly to a consensus view of the effect of different country circumstances on economic desirability of carbon taxation.

For political supportability, there is significant diversity across countries in the structures of accountability and legitimacy which help determine whether certain policies are likely to receive sustained support over time. Not all countries are democratic, for instance, and the influence of business over political priorities varies significantly. However, the author has selected variables which could reasonably be expected to correlate with political support over time in an 'average country': where the government's stated objectives (e.g. climate change mitigation) accord with its actual objectives, and where the government gains legitimacy from the citizenry by virtue of its effectiveness at addressing the concerns of a large body of citizens, whether democratic or authoritarian.

Similarly, for administrative feasibility, the author has selected sub-indicators which would reasonably be expected to predict the ability of a bureaucracy to implement carbon tax policies in an average country. As with supportability variables, these have been selected with on the basis of their "relevance, analytical soundness, timeliness, [and] accessibility"[58] However, given the high degree of subjectivity, the selection indicators for both can be reasonably challenged; there may be others that are more important in predicting support and feasibility in an 'average' country, alongside numerous country-specific characteristics not easily captured by cross-country metrics. Given the non-deterministic nature of political and bureaucratic outcomes to inputs, this is to be expected. In addition, testing of these indicators through correlation and sensitivity analysis is significantly hampered by the lack of experience and therefore data of carbon taxation success and failure among LMICs.

However, the hope is that what is missing or lost does not override the usefulness of the index itself for its purpose of giving a first-pass answer to the question of which countries should and could increase energy prices now.

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[57] Nardo et al., "Handbook on Constructing Composite Indicators."
[58] Ibid., 13.

Step 2 - Data selection

Sub-indicators were selected across the three categories of carbon taxation suitability. These variables were selected following a review of the literature in climate economics, carbon pricing, and the political economy of reform. They were also chosen on the basis of their analytical soundness, measurability, country coverage, relevance to the question of carbon taxation suitability, and relationship to each other.[59]

Is carbon taxation - the increase in energy taxes to reflect carbon content - economically desirable for a given country? Seven indicators have been selected which proxy for this (Table 3). What country characteristics are likely to make carbon taxation politically supportable? Nine sub-indicators selected to proxy (Table 4). Lastly, what characteristics determine whether carbon taxation is likely to be feasibly implemented by the bureaucracy of a country? Seven selected sub-indicators were selected (Table 5).

Table 3. Economically desirable sub-indicator selection rationale

Metric	*Description and theoretical justification*	*Impact on scores*
Government debt levels *(% GDP)* & ***Fiscal deficit*** *(% GDP)*	Indicate how constrained government finances are in the short to medium term (strength of fiscal constraint). A country with high or rapidly growing debt may seek new sources of revenues such as from carbon taxation. Evidence suggests that this use of revenues is one of the most economically desirable ways of using revenues raised from carbon taxes.[60]	Countries with higher debt levels are larger fiscal deficits have a larger opportunity to use revenues raised for paying down debt [Higher debt and wider fiscal deficit result in higher scores]
Government revenues *(% GDP)*	Indicates how able a country is to collect revenues off of its existing tax base (domestic resource mobilization). Some forms of carbon pricing - notably carbon taxation - may be more collectible than existing forms of taxation, such as income taxes which may be more easily evaded through informality. Carbon taxation is more economically desirable/less costly for countries facing large fiscal constraints.[61]	Countries with lower government revenues have a bigger opportunity to improve domestic resource mobilization through carbon taxation [Lower revenues score higher.]
Tax on businesses *(% commercial profits)*	Proxies for distortions in existing tax system. Business taxation, which is widely believed to the most distortive form of taxation policy, proxies for the level of distortions of the existing tax system. Taxing consumption - such as CO2-producing energy consumption - may be less distortionary than taxing capital. Recycling revenues to reduce distortionary taxes may result in a net positive effect on welfare (the 'double dividend'[62]	Countries with higher business taxation levels have a bigger opportunity to reduce distortions in the tax system through revenue recycling. [Higher taxation levels result in higher scores]

[59] Ibid.

[60] Jared Carbone, Richard D. Morgenstern, Roberton C. Williams III, Dallas Burtraw, "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts | Resources for the Future"; Jared Carbone, Richard D. Morgenstern, Roberton C. Williams III, Dallas Burtraw, "Getting to an Efficient Carbon Tax: How the Revenue Is Used Matters | Resources for the Future."

[61] Jared Carbone, Richard D. Morgenstern, Roberton C. Williams III, Dallas Burtraw, "Deficit Reduction and Carbon Taxes: Budgetary, Economic, and Distributional Impacts | Resources for the Future."

[62] Dale W. Jorgenson et al., *Double Dividend: Environmental Taxes and Fiscal Reform in the United States* (MIT Press, 2013); R. Carson, M. Jacobsen, and A. A. Liu, "Are Carbon Taxes More Efficient in Industrializing Countries? Comparing the Cost of a Carbon Tax in China and the United States," in *UCSD Working Paper*, 2015, https://www.aeaweb.org/conference/2015/retrieve.php?pdfid=634.

Metric	Description and theoretical justification	Impact on scores
	argument), or will at least substantially reduce the economic costs of carbon taxes.[63]	
Size of the shadow economy *(% GDP)*	Proxies for distortions from informality. Developing countries tend to have larger shadow economies. The shadow economy is a source of economic distortions, and so reducing it may increase economic growth. Reducing it may also result in more government revenue by broadening the tax base. Carbon taxes are more difficult to evade than other forms, so shifting towards them may help reduce the size of the shadow economy.[64]	Countries with larger shadow economies have a larger opportunity to reduce distortions from informality by shifting the fiscal regime towards carbon taxation. [Higher shadow economy results in higher scores]
Fossil fuel subsidies *(post-tax as % GDP)*	Proxies for distortions from existing energy prices. By incentivizing the overconsumption of CO2-emitting fossil fuels, subsidies act as an implicit negative carbon price. These policies are known for being highly distortionary, increasing externalities, and encouraging an inefficient level of energy intensity of an economy. There are significant economic benefits to phasing out fossil fuel subsidies.[65] However, even economies with no explicit financial subsidies are likely to be implicitly subsidizing fossil fuels. This is because of the various negative externalities (heath, congestion, climate, etc.) which are not incorporated into market prices.[66] Countries should seek to internalize these externalities to maximize the co-benefits of carbon taxation[67]	Countries with larger post-tax fossil fuel subsidies (whether financial or implicit subsidies) have a bigger opportunity to gain from energy price reform. [Larger fossil fuel subsidies result in higher scores]
Infrastructure investment gap *(% GDP)*	Proxies for opportunity to use revenues for development objectives. Many LMICs face large gaps in their need for infrastructure. Some economists have suggested that this would be an effective use of revenues.[68]	Countries with larger infrastructure investment gaps have a larger opportunity to plug them with revenues raised from carbon taxes [Larger gaps score higher]

[63] Lawrence H. Goulder, "Effects of Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis," *Journal of Environmental Economics and Management* 29, no. 3 (November 1, 1995): 271–97, doi:10.1006/jeem.1995.1047.

[64] Anil Markandya, Mikel González-Eguino, and Marta Escapa, "From Shadow to Green: Linking Environmental Fiscal Reforms and the Informal Economy," *Energy Economics*, Supplement Issue: Fifth Atlantic Workshop in Energy and Environmental Economics, 40 (December 1, 2013): S108–18, doi:10.1016/j.eneco.2013.09.014; Carson, Jacobsen, and Liu, "Are Carbon Taxes More Efficient in Industrializing Countries? Comparing the Cost of a Carbon Tax in China and the United States."

[65] Ellis, "The Effects of Fossil-Fuel Subsidy Reform."

[66] Note that not all countries accept this "price gap" concept of subsidies favored by economists, especially if prices charged domestically recover supply costs. Note however, that this latter definition excludes opportunity costs (from selling overseas at higher prices) and externalities. Refer to: Ian Parry, Chandara Veung, and Dirk Heine, "How Much Carbon Pricing Is in Countries' Own Interests? The Critical Role of Co-Benefits."

[67] Ian Parry et al., *Getting Energy Prices Right*; Ian Parry, "The Right Price," *Finance and Development* 52, no. 4 (December 2015): 10–13; Dirk Heine Ian Parry, "How Should Different Countries Tax Fuels to Correct Environmental Externalities?," *Economics of Energy & Environmental Policy* Volume 3, no. Number 2 (2014), https://ideas.repec.org/a/aen/eeepjl/eeep3_2_05parry.html.

[68] "Larry Summers: It's Time to Tax Carbon and Treats," *Washington Post*, accessed September 6, 2016, https://www.washingtonpost.com/blogs/she-the-people/wp/2012/11/23/larry-summers-its-time-to-tax-carbon-and-treats/.

Table 4. Politically feasible sub-indicator selection rationale

Metric	*Description and theoretical justification*	*Impact on scores*
IMF loans outstanding *(size of outstanding loans in 2016, % GDP)*	Proxies for opportunity for fiscal reform. The IMF provides loans to countries who are facing balance of payments crises. Countries tend to reform their restructure their public finances as a result. Carbon taxation can provide a large source of revenues and may therefore be more attractive.	Countries which have IMF loans outstanding are more likely to be reforming fiscally and more receptive to new sources of finance. [Higher IMF lending results in a higher score]
IMF Fiscal Affairs Department technical assistance missions *(number per year)*	Proxies for international engagement on fiscal reform. Client countries can request technical assistance from the IMF's Fiscal Affairs Department. A larger number of missions may indicate that a country is more engaged internationally on fiscal policy, including carbon taxation.	Countries which request technical assistance on fiscal issues from the IMF may be more open to international advice on fiscal reforms such as carbon taxation. [More missions per year results in a higher score]
INDC mentions carbon pricing *(categorical: no, international only, domestic only, or both)*	Proxies for climate objectives and interest in carbon pricing instruments. Many INDCs make mention of economy-wide measures including carbon pricing. Carbon pricing measures can include international carbon pricing (trading of carbon assets such as allowances, credits, or offsets) or domestic carbon pricing (carbon taxation and emissions trading schemes).	Countries which mention carbon pricing in their INDCs are likely to be more receptive to adopting carbon taxation. [Mention of carbon pricing scores higher - domestic carbon pricing scores higher than
INDC includes unconditional component *(yes/no)*	Proxies for ambitiousness of INDC. NDCs from LMICs tend to have 'conditional' components, which are subject support from developed countries for example, and 'unconditional' components, implying they will pursue those actions irrespective of support from developed countries.	Countries with an unconditional component in their INDC may be more ambitious and therefore more likely to pursue carbon taxation. [Unconditional component results in higher score]
Gini index *(Gini score)*	Proxies for strength of distributional concerns. The Gini index measures income inequality across countries. Carbon pricing is known for having a regressive distributional impact (although this varies across countries and only a small portion of raised revenues is required to offset any regressive effect[69]).	Countries with higher Gini scores (more unequal) may be less amenable to carbon taxation as it tends to be mildly regressive. [Higher Gini results in lower score]
History of protests over fuel prices *(yes/no)*	Proxies for political ability to tweak fuel prices. Many countries have histories of protests over fuel prices, which tends to be a salient cost to consumers. This salience can increase the mitigation effectiveness of carbon prices,[70] but may also increase the risk of protests.	Politicians in countries with a history of protest over fuel prices are less likely to support an increase in energy taxes. [Yes results in a lower score]

[69] Ian Parry, "Carbon Tax Burdens on Low-Income Households: A Reason for Delaying Climate Policy?," 2015, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2661433.

[70] Carl and Fedor, "Tracking Global Carbon Revenues" note a number of studies showing the increased effectiveness of salient interventions, including an apparent seven-fold increase in effectiveness of British Columbia's carbon tax to consumer response expectations.

Metric	Description and theoretical justification	Impact on scores
***Manufacturers' share of exports** (%)*	Proxies for level of competitiveness concerns. Carbon taxation can have some adverse effects on the competitiveness of exporting (or import-competing) manufacturers, which tend to be high in energy intensity.	Countries with large shares of exports accounted for by manufacturers may be less likely to support economy-wide carbon pricing measures due to competitiveness concerns. [Higher manufacturers' share scores lowers]
***Population without electricity access and/or relying on traditional use of biomass** (%)*	Proxies for energy access. Globally, 1.2 billion people do not have access to electricity[71] and 2.7 billion people rely on wood, coal, charcoal or animal waste for cooking and heating.[72] A dozen countries in Asia and Africa account for two thirds of people without access to electricity and three quarters of biomass users.[73] Increasing energy prices could further place energy access out of reach for these countries.	Countries with large numbers of people with electricity access or relying on biomass for cooking are less likely to want to increase energy prices [Higher population share scores lower]
***Electricity production from coal sources** (%)*	Proxies for the likely environmental efficacy of carbon taxes. Pricing mechanisms like carbon taxation are more effective reducing CO2 emissions from coal sources than others, e.g. natural gas and motor fuel. Charges on coal are also more likely to yield large non-CO2 co-benefits[74]	Countries with larger share of coal for electricity production have larger scope to impose carbon charges on coal and should therefore carbon taxation more attractive as it is more environmentally effective [Higher share of coal in electricity production scores higher]

Table 5. Administratively feasible sub-indicator selection rationale

Metric	Description and theoretical justification	Impact on scores
***Government effectiveness** (WGI score)*	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Countries with more government effectiveness will be better able to implement carbon tax policies [Higher government effectiveness results in a higher score]

71 International Energy Agency, "World Energy Outlook 2016 – Energy Access Database" (OECD/IEA, 2016), http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/.

72 International Energy Agency, "World Energy Outlook 2016 – Biomass Database" (OECD/IEA, 2016), http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/.

73 For people with lack of access to energy, in 2016 there were approximately 632m in Sub-Saharan Africa, mostly in: Nigeria (98m), Ethiopia (73m), Democratic Republic of Congo (62m), Tanzania (36m), Kenya (36m), and Uganda (31m); and about 512m in Asia, mostly: India (244m), Bangladesh (60m), Pakistan (51m), Indonesia (41m), and Myanmar (36m). For use of biomass, aproximately 632m people without access are in Sub-Saharan Africa, mostly in: Nigeria (134m), Ethiopia (92m), Democratic Republic of Congo (71m), Tanzania (50m), Kenya (38m), and Uganda (37m); and about 1.9bn in Asia, mostly in: India (819m), China (453m), Bangladesh (142m), Pakistan (105m), Indonesia (97m), and Myanmar (49m).

74 Ian Parry, Chandara Veung, and Dirk Heine, "How Much Carbon Pricing Is in Countries' Own Interests? The Critical Role of Co-Benefits."

Metric	Description and theoretical justification	Impact on scores
Control of corruption *(WGI score)*	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	Countries better able to control corruption will be better at allocating revenues from carbon taxation [Higher control of corruption results in a higher score]
Government charges VAT *(yes/no)*	Indirect taxation has become widespread globally, and is a common way of charging for consumption, including of energy.	Existence of a pre-existing VAT system implies that the government could impose or increase indirect taxes on energy [Yes results in a higher score]
Government sets fuel prices *(yes/no)*	For many countries fuel and power prices are set by the government. If the government has control over prices in this way it should be able to increase them to take into account a price on carbon.	If the state sets fuel and power prices, it should have the means to reset them to reflect a carbon tax [Yes results in a higher score]
Government taxes natural resources *(yes/no)*	The existence of an excise system for energy indicates that a country already has the ability to tax extracted hydrocarbons to reflect a carbon price.	Countries with pre-existing excise taxes on energy should be able to extend them to include a carbon tax [Yes results in a higher score]
Anti-trafficking Policy Index score *(out of 100)*	Proxies for risks of fuel smuggling. Imposing carbon taxes on fuels could incentivize smuggling of fuel over borders. This proxy assumes that countries that are effective at anti-trafficking measures are also effective at combatting smuggling.	Countries that are effective at combatting trafficking should also be better at combating fuel smuggling [Higher scores higher]
Adequacy of social assistance benefits for poorest quintile *(%)*	Proxies for ability to compensate the poorest from any negative effects of carbon taxation through compensation. Many countries have existing social assistance programs which target the poorest. These could be increased using a portion of the revenues from carbon taxes.	Countries with social assistance programs in place should be better able to compensate the poorest for any relative welfare losses due to carbon taxation [Higher scores higher]

Step 3 - Multivariate analysis

After creating a dataset of the above indicators, multivariate analysis is performed to assess the data's suitability given the purpose and theoretical framework and explain methodological choices. This includes analyzing the structure of data along two dimensions: sub-indicators and countries.

Analysis of sub-indicators

Principal components analysis (PCA) and factor analysis (FA) seek to reveal how different variables change in relation to each other and their association.[75] PCA and FA are very similar. Both transform a set of correlated variables into a small set of uncorrelated variables (principal components or factors). Both can be used as a method of exploration of datasets as well as reduction of dimensionality. The main difference is that while factor analysis assumes that the variability in the data is being driven by some unspecified and unobserved common variables, PCA makes no such assumption. In addition, while PCA is often the preferred approach for dimensionality reduction, factor analysis is used predominately for structure detection purposes.

[75] Nardo et al., "Handbook on Constructing Composite Indicators."

Using PCA and FA requires that a number of assumptions be met: enough cases (in this case, countries), a sufficient case-to-variable ratio, assumption of interval-level data, no bias in selecting sub-indicators, no outliers, linearity, some shared underlying dimensions in clusters, and strong intercorrelations.[76] The preliminary set of sub-indicators have sufficient observations for every case (100-134 for 134 countries) and case-to-variable ratios (>>3:1).

Out of 23 sub-indicators, six are dichotomous (non-interval) variables: whether the country has the ability to set fuel prices, has a history of protests over fuel prices, has an INDC which mentions carbon pricing, has an INDC which has an unconditional component, taxes natural resources, and charges VAT. Dichotomous variables can be used for PCA and FA as long as the underlying metric correlation between them is moderate (0.7 or lower).

Using Spearman's test for rank correlation coefficients, all pairs of variables have correlation coefficients lower than 0.7 (refer to Figure 15). These six dichotomous variables are therefore deemed suitable for PCA and FA.

Figure 15. Spearman's test for rank correlation coefficients

	fuel_s~t	tax_re~t	vat_ex~t	indc_c~g	hist_~ts	indc_u~t
fuel_setti~t	1.0000					
tax_resour~t	0.1585	1.0000				
vat_exist	0.0330	0.2775	1.0000			
indc_carbo~g	0.2014	0.2204	0.1954	1.0000		
hist_prot~ts	0.2415	0.0870	0.0607	0.1195	1.0000	
indc_uncon~t	0.1338	0.0546	0.0898	0.2078	0.0070	1.0000

Selection bias is an intrinsic issue for both PCA and FA, namely because including of all possible variables (e.g. macro-indicators for countries) is impossible, and even if it were then including all variables or deleting them for the sake of neatness of factors can result in erroneous conclusions.[77] Judgment of which variables are relevant is therefore required and assumed: in this case, that the 23 sub-indicators explain a large portion of variability between country's suitability for carbon taxation policies. Note, however, that since few countries have implemented carbon taxation policies it is currently not possible to test this statistically.

PCA is based on covariance matrices, and is therefore sensitive to outliers. Given the large variety of countries and metrics, covering economic, political, and bureaucratic phenomena, it was expected that numerous outliers would be found for the sub-indicators. OECD guidelines suggest searching for outliers using Mahalanobis distance.[78] However, since the publishing of this guidance a number of drawbacks associated with Mahalanobis distance for finding outliers have been identified.[79]

However, another robust method for finding outliers is using the minimum covariance determinant (MCD) estimator of location.[80] Using this, 33 outliers were identified.[81] One approach to dealing with these

[76] Ibid., 40–41.
[77] Jae-On Kim and Charles Mueller, *Introduction to Factor Analysis* (2455 Teller Road, Thousand Oaks California 91320 United States of America: SAGE Publications, Inc., 1978), doi:10.4135/9781412984652.
[78] Nardo et al., "Handbook on Constructing Composite Indicators," 40.
[79] Vincenzo Verardi and Catherine Dehon, "Multivariate Outlier Detection in Stata," *Stata Journal* 10, no. 2 (2010): 259–66.
[80] Ibid.
[81] Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Bosnia and Herzegovina, Brazil, Cabo Verde, Cambodia, Cameroon, Costa Rica, Ecuador, Ghana, Guyana, Haiti, Kazakhstan, Lesotho, Malawi, Malaysia, Mauritania, Mexico, Moldova, Nepal, Nigeria, Panama, Peru, Philippines, Sri Lanka, Suriname, Thailand, Uganda, and Ukraine.

outliers is to throw away cases (countries). However, this is anathema to the analysis, which is an identification exercise whereby the entire population of LMICs should be included.

An alternative approach is to use Robust Principal Component Analysis (RPCA), which is not sensitive to outliers.[82] RPCA removes the effect of outliers on PCA by relying on a robust estimation of the covariance matrix, for example using the same minimum covariance determinant (MCD) method that was used to find outliers.[83] This was the preferred approach to the PCA given the large presence of outliers.

However, for the results of RPCA to be informative, there also needs to be strong intercorrelations between sub-indicators. This can be tested using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. This compares the magnitudes of the observed correlation coefficients to the magnitudes of the partial correlation coefficients.[84] The expectation is that for distinct factors to emerge from factor analysis, the partial correlations should not be large.[85] A KMO score of at least .60 or higher is required, dropping sub-indicators until KMO rises above this level.

The results of the KMO test were disappointing (Figure 16). Only two of the sub-indicators had a KMO score of above 0.6, so eliminating of sub-indicators would eliminate virtually all others, rendering resulting factors and component uninformative for the use case of the composite indicator. The low KMO scores make principal component and factor analysis unsuitable for the 23 sub-indicators as a collective group.

Figure 16. Results of KMO measure of sampling adequacy test

Variable	kmo
gov_debt_gdp	0.4940
gov_rev_gdp	0.5236
gov_defici~p	0.3317
tax_profits	0.4720
ffs_post	0.2878
shadow_gdp	0.5356
infra_gap	0.4225
imf_loans_~p	0.1883
imf_fad	0.6303
indc_carbo~g	0.4398
gini_index	0.4166
hist_prot~ts	0.2172
corruption	0.3649
gov_effect~e	0.6422
vat_exist	0.6992
fuel_setti~t	0.6223
tax_resour~t	0.2559
manuf_exp~ts	0.6153
energy_pov~y	0.3544
coal_elec	0.2991
trafficking	0.4620
social_ass~t	0.1838
Overall	0.3948

Overall, no underlying factors could be identified across categories which would allow for a simpler (fewer dimensions) or more intuitive understanding of country characteristics. The three categories will therefore be retained, with further RPCA conducted to determine weights within categories (Step 6 from page 40).

Step 4 - Imputation of missing data

In creating a composite index, missing data must be dealt with. Among observations, there was one with a significant portion of missing data: Syria. Given the country's ongoing civil war, it has not reported numerous figures internationally such as GDP and government debt figures. Additionally, many of the remaining sub-indicators are likely to be wrong, such as shadow economy, which is an average over the 1999-2006/7 period. Syria was therefore dropped from the dataset.

[82] Vincenzo Verardi, "Robust Principal Component Analysis in Stata," United Kingdom Stata Users' Group Meetings 2009 (Stata Users Group, September 16, 2009), https://ideas.repec.org/p/boc/usug09/02.html.
[83] Ibid.
[84] Nardo et al., "Handbook on Constructing Composite Indicators," 41.
[85] Ibid.

Table 6. Sub-indicators with missing values: summary of Hotelling t-squared tests

Sub-indicator	*Obs.*	*Missing obs.*	*Hotelling F-test statistic*	*Missing-data mechanism inference*
Government debt	129	4[86]	0.9244	See above
Tax on business profits	117	16[87]	1.5198	See above
Fossil-fuel subsidies	100	33[88]	4.6120***	Unlikely MCAR
Shadow economy	110	23[89]	4.9975***	Unlikely MCAR
Gini index	115	18[90]	2.4010***	Unlikely MCAR
Manufacturing exports	118	15[91]	2.2922***	Unlikely MCAR
Anti-trafficking Policy Index	127	6[92]	3.0108***	Unlikely MCAR
Social assistance coverage in poorest quintile	87	46	1.5852***	Unlikely MCAR
Electricity production from coal sources	90	44	3.8128***	Unlikely MCAR

**** means statistically significant at the 99% level*

Among sub-indicators, after removing Syria, there were nine variables with missing values (Table 6). These variables were tested to see if observations were likely to be: missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR). MCAR is when 'missingness' does not depend on the variable of interest or other variables in the dataset. MAR is when missingness is conditional only on other observed values in the dataset, not on the unobserved value of the variable of interest. MNAR is where missingness depends on the value of the variable of interest (e.g. people with very low incomes are less likely to report them). Many of the data imputation methods assume at least MAR.

There is no universally accepted statistical test for MCAR or MAR for a variable as missingness depends on its own (unobserved) value. However, the MAR assumption needed for many imputation methods can be made more plausible through knowledge and analysis of the dataset.[93]

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[86] Mongolia, Palau, Syria, Timor-Leste, and Tonga.
[87] Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Fiji, FYR Macedonia, Islamic Republic of Iran, Lao P.D.R., Micronesia, Republic of Congo, Russia, São Tomé and Príncipe, Syria, The Gambia, Turkmenistan, Tuvalu, Venezuela, and Yemen.
[88] Burundi, Bhutan, Central African Republic, Chad, Comoros, Eritrea, Fiji, Gambia, Guinea, Guinea-Bissau, Kiribati, Kosovo, Lao P.D.R., Liberia, Maldives, Marshall Islands, Mauritius, Micronesia, Niger, Palau, Samoa, San Marino, São Tomé and Príncipe, Seychelles, Sierra Leone, Solomon Islands, South Sudan, St. Lucia, St. Vincent and the Grenadines, Swaziland, Syria, Timor-Leste, Togo, Tonga, Tuvalu, and Vanuatu.
[89] Afghanistan, Djibouti, Dominica, Grenada, Iraq, Kiribati, Kosovo, Marshall Islands, Micronesia, Montenegro, Palau, Samoa, São Tomé and Príncipe, Serbia, South Sudan, St. Lucia, St. Vincent and the Grenadines, Timor-Leste, Tonga, Turkmenistan, Tuvalu, Uzbekistan, and Vanuatu.
[90] Afghanistan, Algeria, Dominica, Egypt. Equatorial Guinea. Eritrea, Grenada, Iraq, Jordan, Kosovo, Lebanon, Libya, Marshall Islands, Myanmar, Palau, St. Vincent and the Grenadines, Swaziland, Syria, and Yemen.
[91] Chad, Democratic Republic of the Congo, Equatorial Guinea, Guinea-Bissau, Kosovo, Lao P.D.R., Liberia, Marshall Islands, Micronesia, Montenegro, Romania, South Sudan, Timor-Leste, Tuvalu, and Uzbekistan.
[92] Dominica, Grenada, Samoa, São Tomé and Príncipe, Tuvalu, and Vanuatu.
[93] Nardo et al., "Handbook on Constructing Composite Indicators," 16.

Among the six sub-indicators, none of the missing values are likely to be MCAR. The lack of collection or computation of missing values is likely to be correlated with other variables of interest. For instance, Timor-Leste has missing data for gross government debt, energy subsidy estimates, and the size of the shadow economy. This is likely to do with the lack of available data due to the small size of the country rather than random sampling error.

For three of the sub-indicators, countries which have missing values appear to be statistically different from those that do. This is shown using Hotelling's T-squared test, which checks for equality of means across groups. In this, countries with missing values had their means on other (complete) sub-indicators compared with countries that do not have missing values or that specific indicator (Table 6). For fossil fuel subsidies, shadow economy, and Gini index measures, countries with and without missing data appear to be different from each other along other measures. This could indicate that these countries are systematically different. If so, countries could have missing data because of these systematic differences, implying that MCAR is an inappropriate assumption.[94]

Table 7. Results of Markov Chained Monte Carlo multiple imputation

Sub-indicator	***Mean***	***Std. Error***	***95% confidence interval***	
Government debt	45.6	2.29	41.1	50.1
Tax on business profits	43.4	2.3	38.8	48
Fossil-fuel subisidies	3.2	.54	2.1	4.3
Shadow economy	39.5	1.12	37.3	41.8
Gini index	41.5	.81	39.9	43.1
Manufacturing exports	35.9	3.03	29.8	41.9
Anti-trafficking Policy Index	9.3	.21	8.9	9.8
Adequacy of social assistance for the poorest quintile	21.6	2.81	15.9	27.2
Electricity production from coal sources	27.6	7.4	12.2	43

However, the author believes that missing values on the five sub-indicators are still likely to be MAR. Although their tendency to be observed is likely to be related to other factors, such as country size and levels of development (not MCAR), it is not likely to be due to the value of the variable of interest itself (likely MAR). For instance, the size of the economy of Laos is likely to affect whether the shadow economy figures are computed, but the actual size of the shadow economy is not. It could plausibly be argued that countries that do not report these values are likely to fair 'worse' than the average country, therefore reducing the incentive to report such figures, and violating the MAR assumption. However, for these specific country-variable pairs, it is far from clear that any notional disincentive effect could sufficiently affect the likelihood of data being reported. It appears more likely that reporting is due to other factors, such as country size and institutional quality. Furthermore, no variables which could affect both these other factors (e.g. institutional quality) and the likelihood that the figure is reported could be identified. **Therefore, imputation methods that assume MAR can be used.**[95]

[94] Similarity across groups (with and without missing data) could not be rejected for two of the sub-indicators: government debt levels and government taxation on commercial business profits. However, this was likely due to the low sample size of missing observations on these sub-indicators (4 and 16 countries, respectively).

[95] More precisely, additional parameters ϕ and θ, which define the missing-data mechanism, are "ignorable". Refer to: Paul D. Allison, "Missing Data: Quantitative Applications in the Social Sciences," *British Journal of Mathematical and Statistical Psychology* 55, no. 1 (2002): 74.

Multiple imputation (MI) is a simulation-based approach to missing values using a random process to reflect uncertainty.[96] A popular application of MI is the Markov Chain Monte Carlo (MCMC) method. MCMC relies on Bayesian theory to create a sequence of random variables drawn from a normal distribution. Multiple random values are imputed and then combined, with between and within imputation variance reported. For cross-sectional, international data, MCMC can sometime give absurd values.[97] As a result, some favor techniques such as linear interpolation, means, or researchers' personal best guesses. However, according to King and Honaker, these techniques "routinely produce biased and inefficient inferences, standard errors, and confidence intervals, and they are almost uniformly dominated by appropriate multiple imputation-based approaches."[98] MI techniques will therefore be favored for imputation in this study, though results will be sense checked for 'absurdity'.

MCMC was used to infer missing data for the nine sub-indicators. As all missing data was within non-categorical sub-indicators, the multivariate normal model (MVN) was used.[99] There were 20 imputations run for each sub-indicator with missing data, imputed against all other sub-indicators with complete data (summary of results in Table 7).

Step 5 - Normalization

The end objective is a comparable ranking for each country across two dimensions: how much they 'desirable' and 'feasible' implement carbon taxation. An overall ranking - the simplest form of normalization - across these two dimensions will be produced for each country. This requires scoring across the sub-indicators within each dimension. However, sub-indicators are expressed in different units and normalization is therefore required prior to aggregation.

Different techniques have varying sensitivity to outliers, and therefore can produce different results.[100] For instance, standardization (z-scores) is sensitive to outliers. This rewards countries that have very high scores on a few sub-indicators, compared to countries which have a lot of average scores. For the purposes of the exercise, it is not clear that this is desirable: a country with all average scores across economic desirability indicators may be said to be more suitable by virtue of having more options (for revenue usage, for instance) than one with high score on one sub-indicator only.

As a result, this study normalizes measures using percentiles. Specifically, countries will be ranked according to which quintile of the distribution they sit in across sub-indicators, and receive a score from one to five (five indicating high suitability). This normalization process is less sensitive to outliers: a country in the top 20% would receive the same score as one in the top 1%, for instance. The use of a five-point scale also makes it easily comprehendible. It does, however, lose information on the variance of the transformed sub-indicator.

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[96] Nardo et al., "Handbook on Constructing Composite Indicators," 55.
[97] James Honaker and Gary King, "What to Do about Missing Values in Time-Series Cross-Section Data," *American Journal of Political Science* 54, no. 2 (2010): 562.
[98] Ibid.
[99] Joseph L. Schafer, *Analysis of Incomplete Multivariate Data* (CRC press, 1997), https://books.google.com/books?hl=en&lr=&id=3TFWRjn1f-oC&oi=fnd&pg=PR13&dq=(Schafer+1997)+multivariate+normal+model&ots=2qDJwHIdnc&sig=xw3SbPC9Gu21FSfj1NrfZSaGqtU.
[100] Nardo et al., "Handbook on Constructing Composite Indicators," 17.

One complication arises with categorical and dichotomous sub-indicators. A country may have a history of protests over fuel prices or not, for instance. In this case, the appropriate normalization to a five-point scale is unclear. Ultimately, as with many facets of composite indicator construction, scoring for dichotomous and categorical sub-indicators are judgment calls. However, categorical scales can be adopted which nevertheless contain information on the variance of the transformed indicators using the researcher's best judgment.[101]

The approach that has been taken for dichotomous and categorical variables is as follows. For the five dichotomous non-interval sub-indicators (Table 8), normalization will be based on scores of one or five. This is equivalent to being in the bottom or top quintile for interval sub-indicators.

For the remaining two non-interval sub-indicators, an ad hoc scoring system based on the researcher's reading of political phenomena has been adopted. For the carbon pricing sub-indicator, mention of international carbon pricing (e.g. participation in an international carbon market) scores 3, while domestic carbon pricing (emissions trading schemes or carbon taxation) will score 5. This is because mention of domestic carbon pricing (or both domestic and international carbon pricing) could be read as a strong signal of interest in instruments such as carbon taxation. For IMF FAD technical assistance missions, 1 mission scores 3, 2 missions score 4, and 3 missions score 5. The larger jump from 1 point for no mission to 3 points for 1 mission, is based on the researchers suspicion that the marginal increase in international engagement on fiscal policy this proxies for is higher for this than for subsequent increases to 2 or 3 missions.

Table 8. Scoring of non-interval categorical and dichotomous sub-indicators

Sub-indicator	***Scoring approach***
History of protests	Yes scores 1, no scores 5.
Government charges VAT	Yes scores 5, no scores 1.
Government sets fuel prices	Yes scores 5, no scores 1.
Government taxes extraction of natural resources	Yes scores 5, no scores 1.
IMF FAD technical assistance intensity	0 missions score 1, 1 mission scores 3, 2 missions scores 4, 3 missions scores 5.
INDC mentions carbon pricing	1 if no mention, 3 if international carbon pricing mention, 5 if domestic carbon pricing mention.
INDC has unconditional component	Countries with score 5, otherwise 1.

Step 6 - Weighting and aggregation

For aggregation, weighting is required both across the three categories (economics, politics, and administration) and across the sub-indicators within them. For the former, to link rankings as closely as possible to the research question, there is equal weighting between categories that address the 'desirable' (economics) and 'feasible' (politics and administration) parts of the research question. For the latter, within-category aggregation is determined using statistical analysis where possible.

Weighting across categories

Economic desirability ('desirable') is weighted higher at 50% than political and administrative feasibility (the combined 'feasible', 25% each) in the index. This is for two primary reasons. The first is that even if

[101] Ibid., 18.

a policy is both politically and administratively feasible, from a welfare-maximizing perspective if it is not economically desirable it should not be implemented. The second is that political and administrative feasibility themselves entail a certain amount of economic desirability: if the gains to be made are large, then welfare-maximizing policymakers and officials should be more willing to put those policies into place.

Economic desirability therefore contains information about political supportability and, to the extent that bureaucracies have some influence over the shape and durability of policies, bureaucratic feasibility.[102] Equalizing weighting across economic desirability, political supportability and administrative feasibility would therefore overweight the latter two factors. This paper therefore equalizes weights between the 'desirable' (economic desirability) and the 'feasible' (average of political and administrative feasibility). Although inherently contestable, this should give a reasonably defensible view of the suitability of different countries to carbon taxation.

Weighting within categories

As well as searching for common drivers of variability (refer to Step 3), RPCA and factor analysis can be used to help determine weights across sub-indicators.[103] For each category, RPCA and FA was performed on the relevant sub-indicators. While RPCA and factor analysis were unable to isolate sufficient components and factors driving the variability across all sub-indicators (refer to Step 3), some were found within one category of sub-indicators: economic desirability. This is the only category whose sub-indicators passed the KMO test, with an overall score of .6081 (Figure 17). Using the 'scree plot' stopping rule, whereby factors are retained prior to a levelling off of eigenvalues (Figure 18), three components were retained.

Figure 17. Factor Analysis scree plot for economic desirability

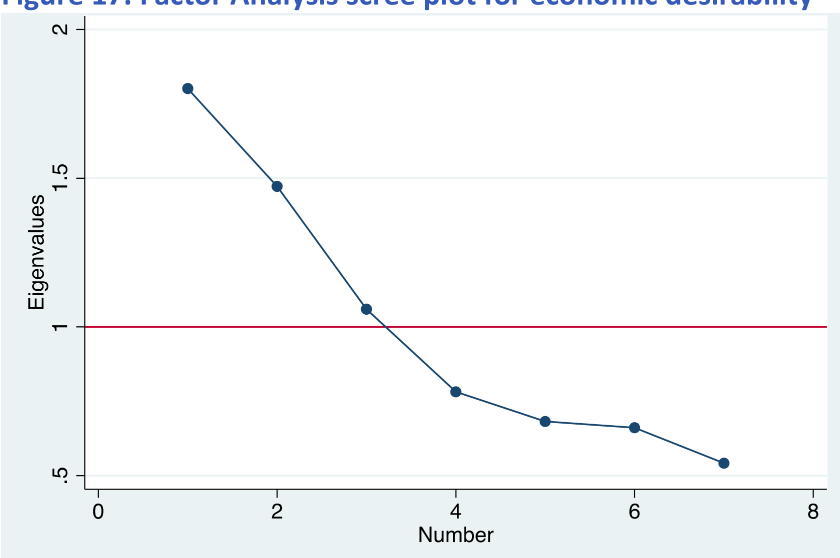

Figure 18. KMO test on economic desirability indicators

Variable	kmo
gov_debt_gdp	0.6063
gov_defici~p	0.6703
gov_rev_gdp	0.5968
tax_profits	0.5541
ffs_post	0.6372
shadow_gdp	0.6364
infra_gap	0.6315
Overall	0.6253

[102] Note that in the case of composite indicators, sub-groups do not necessarily need to be statistically independent from each other. Ibid., 13.
[103] Ibid., 64.

Two components showed large (>0.3) loadings onto three variables each (Figure 19**).**[104] Both promax and varimax rotations yielded the same broad result. The first component loads onto: government debt (% GDP), government fiscal deficit (% GDP, negative numeraire), and the size of the shadow economy (% GDP). This component could be interpreted broadly as how financially constrained the government is. A government with large debts and annual deficits, facing a high degree of informality in the economy and therefore a limited tax base, is financially constrained domestically and internationally.

The second component loads onto: government's annual revenue (% GDP), post-tax fossil-fuel subsidies (% GDP), and the infrastructure investment gap (% GDP). Components do not always accord to intuitive interpretations. However, one interpretation for factor could be: 'government's preference for fossil fuels'. A government with high revenue collection, fossil fuel subsidies, and facing a larger infrastructure investment gap can be said to have a preference for collecting revenues to subsidies fossil fuels to the detriment of infrastructure investment.

In addition to these two components, a third component loads entirely onto tax rates on commercial profits and can be interpreted (as intended for this sub-indicator) as how distortive existing tax policy is.

These three components and their respective loadings are used to determine the relative weightings on each sub-indicator for the economic desirability category. Each of the three components ('intermediate indicators') are weighted based on the proportion of the variation they explain (eigenvalues), with each sub-indicator weighted based on its loading onto the component.[105] It should be noted that weighting is not a measure of the theoretical importance of each sub-indicator: it intervenes only to correct for overlapping information across the correlated indicators.[106]

Figure 19. Component loadings on economic desirability sub-indicators

Variable	Comp1	Comp2	Comp3	Unexplained
gov_debt_gdp	-0.5504			.3396
gov_defici~p	0.5592			.4134
gov_rev_gdp		0.6301		.3728
tax_profits			0.7899	.2552
ffs_post		0.5434		.3406
shadow_gdp	0.5395			.4366
infra_gap		0.5298		.2958

For political and administrative categories, RPCA did not reveal any significant components driving variation across sub-indicators. Low KMO scores for political (0.4369) and administrative (0.4693) sub-indicators meant that it would be inappropriate to rely upon the components generated by RPCA.[107] **As a result, each of the indicators in the political and administrative categories has been given an equal weighting. Total weighting across categories and indicators can be found in** Table 9 **below.**

[104] Note that this loading onto at least three variables arguably helps address the aforementioned issue of selection bias: "Some authors (Thurstone) recommend at least three variables for each factor for a good resolution of the dimensionality issue" Kim and Mueller, *Introduction to Factor Analysis*, 22.

[105] For instance, component 2 has an Eigenvalue of 1.55323 which is 34% of the variation explain by the three components in total: 1.55323/(1.94295+1.55323+1.0499) = 34%. Within component 2, total loadings amount to 1.7033 (0.6301+0.5434+0.5298 = 1.7033), of which government revenue is 37% (0.6301/1.7033 = 37%). The economic desirability category has a weighting of 50%, so total weighting for government revenue is 6% (37% x 34% x 50%).

[106] Nardo et al., "Handbook on Constructing Composite Indicators," 64.

[107] Ibid., 41.

Table 9. Full sub-indicator details and sources

Category	*Suitability factor*	*Sub-indicator (proxy)*	*Units*	*Year*	*Source*	*Obs.* [108]	*Category weight*	*Overall weight*
Economic desirability	Fiscal constraint	Government debt[109]	% GDP	2014[110]	IMF WEO[111]	129	14%	7%
	Fiscal constraint	Fiscal deficit (% GDP)[112]	% GDP	2014	IMF WEO	133	14%	7%
	DRM gap	Government revenue[113]	% GDP	2014	IMF WEO	133	13%	6%
	Tax distortions	Tax on businesses	% profits	2016	WB WDI[114]	117	23%	12%
	Energy distortions	Post-tax fossil fuel subsidies	% GDP	2015	IMF[115]	100	11%	6%
	Informality distortions	Shadow economy	% GDP	1999-2006/7	Schneider et al.[116]	110	14%	7%
	Investment gap	Infrastructure investment gap	ordinal rank	2015	WB[117]	134	11%	5%
		Total					**100%**	**50%**
Political feasibility	Fiscal reform opportunity	IMF loans outstanding	% GDP	2016	IMF[118]	134	11%	2.8%
	International fiscal engagement	IMF FAD technical assistance missions	# per year	2015	IMF[119]	134	11%	2.8%
	Interest in carbon pricing	Carbon pricing mentioned in INDC	catego rical	2015	C2ES[120]	132	11%	2.8%
	Climate objectives	INDC includes unconditional part	binary	2015	WRI[121]	134	11%	2.8%

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108 Missing observations are detailed in 'Technical Appendix: Step 4 - Imputation of Missing Values'

109 "Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future. This includes debt liabilities in the form of SDRs, currency and deposits, debt securities, loans, insurance, pensions and standardized guarantee schemes, and other accounts payable." "World Economic Outlook Database April 2016," accessed October 25, 2016, https://www.imf.org/external/pubs/ft/weo/2016/01/weodata/index.aspx Note that the gross debt figure was used instead of net debt because it has much higher country coverage (129 vs. 55). .

110 2014 data was used in the majority of cases as this had the highest proportion of reported versus estimated observations.

111 "World Economic Outlook Database April 2016."

112 "Net lending (+)/ borrowing (?) is calculated as revenue minus total expenditure." Ibid.

113 "Revenue consists of taxes, social contributions, grants receivable, and other revenue." Ibid.

114 World Bank, "World Development Indicators," January 3, 2017, http://data.worldbank.org/data-catalog/world-development-indicators.

115 Amyra Asamoah, David Coady, and Baoping Shang, "IMF Energy Subsidies Template," December 2015, http://www.imf.org/external/np/fad/subsidies/data/subsidiestemplate.xlsx.

116 Friedrich Schneider, Andreas Buehn, and Claudio E. Montenegro, "New Estimates for the Shadow Economies All over the World," *International Economic Journal* 24, no. 4 (December 2010): 443–61, doi:10.1080/10168737.2010.525974.

117 Fernanda Ruiz-Nuñez and Zichao Wei, *Infrastructure Investment Demands in Emerging Markets and Developing Economies*, Policy Research Working Papers (The World Bank, 2015), http://elibrary.worldbank.org/doi/abs/10.1596/1813-9450-7414.

118 IMF, "IMF Lending Arrangements as of September 30, 2016," 2016, https://www.imf.org/external/np/fin/tad/extarr11.aspx?memberKey1=ZZZZ&date1key=2016-06-30&tsvflag=Y42 countries had non-zero balances as at September 2016. Countries without balances registered are assumed a zero balance.

119 IMF, "Fiscal Affairs Department - Technical Assistance," 2015, http://www.imf.org/external/np/fad/news/fadbroch.pdf.

120 C2ES - Center for Climate and Energy Solutions, "Comparison of INDCs," 2015, https://www.c2es.org/indc-comparison.

121 WRI, "CAIT - CAIT Country GHG Emissions Database."

	Distributional objectives	Gini index	index	latest [122]	WB WDI[123]	115	11%	2.8%
	Constraints on pricing changes	History of protests over fuel prices	binary	2014	GIZ [124] & author	134	11%	2.8%
	Competitiveness concerns	Manufacturers' share of exports (%)	%	latest [125]	WB WDI	119	11%	2.8%
	Energy poverty	Population lacking electricity access/using biomass	avg. % of popn.	2014	IEA[126]	134	11%	2.8%
	Environmental efficacy of carbon taxes	Electricity production from coal sources	%	2014	WB WDI	90	11%	2.8%
		Total					**100%**	**25%**
Admin-istrative feasibility	Implementation effectiveness	Government effectiveness	score	2015	WB WGI[127]	134	14%	3.6%
	Ability to use revenues effectively	Control of corruption	score	2015	WB WGI[128]	134	14%	3.6%
	Existence of excise system on energy	Government charges VAT	binary	2016-17	EY[129] & ICTD[130]	134	14%	3.6%
	Ability to manually set energy prices	Government sets fuel prices	binary	2014	GIZ [131]	134	14%	3.6%
	Existence of excise system on upstream energy	Government taxes natural resources	binary	2014	ICTD[132]	133	14%	3.6%
	Risk of fuel smuggling	Anti-trafficking Policy Index score	score (of 15)	2013	3P Index[133]	127	14%	3.6%
	Ability to compensate poorest	Adequacy of benefits in poorest quintile	%	latest [134]	WB ASPIRE[135]	90	14%	3.6%
		Total					**100%**	**25%**

[122] The latest year corresponds to the latest year data was reported within the WB's WDI database. The range of years was 1992-2014 and the median year was 2012.
[123] World Bank, "World Development Indicators."
[124] For countries without pages on GIZ's database, the author manually searched for a history of fuel prices protests (34 countries). energypedia, GIZ, "International Fuel Prices Database," accessed January 30, 2017, https://energypedia.info/index.php/International_Fuel_Prices.
[125] Latest year data was reported within the WB's WDI database. The range was 1990-2015 and median year was 2015.
[126] International Energy Agency, "World Energy Outlook," 2016; International Energy Agency, "World Energy Outlook," 2016.
[127] World Bank, "Worldwide Governance Indicators - Aggregate | Data."
[128] Ibid.
[129] EY, "Worldwide VAT, GST and Sales Tax Guide - Rates," accessed January 29, 2017, http://www.ey.com/GL/en/Services/Tax/Worldwide-VAT--GST-and-Sales-Tax-Guide---Rates.
[130] International Center for Trade and Development, "ICTD Government Revenue Dataset."
[131] For countries without pages on GIZ's database, the author manually searched for whether the government sets fuel prices (34 countries). energypedia, GIZ, "International Fuel Prices Database."
[132] International Center for Trade and Development, "ICTD Government Revenue Dataset."
[133] Cho, Seo-Young, Axel Dreher and Eric Neumayer, "The Determinants of Anti-Trafficking Policies - Evidence from a New Index," *Scandinavian Journal of Economics*, forthcoming, https://www.uni-heidelberg.de/fakultaeten/wiso/awi/professuren/intwipol/datasets.html.
[134] Latest year data was reported within the ASPIRE Database. The range was 1992-2014 and the median was 2012.
[135] World Bank, "The Atlas of Social Protection: Indicators of Resilience and Equity (ASPIRE)," May 9, 2017, http://data.worldbank.org/data-catalog/atlas_social_protection.

Aggregation into 'desirable' and 'feasible' and final rankings

Once scores have been estimated according to the above weights, the three categories can be aggregated into a more easily communicated set of suitability criteria: 'desirable' and 'feasible'. These two 'suitability criteria' accord to economic desirability ('desirable') and combined political supportability and administrative feasibility ('feasible') categories. This approach allows for a direct answer to the research question, for more easily communicated messaging, and for simple representation in the form of charts (refer to Figure 8, for example).

Lastly, the final step is to aggregate 'desirable' and 'feasible' into a final ranked score (CTSI). The simplest method of all to do this is through addition or averaging between scores.[136] This has the benefit of clear presentation and scoring out of some easily interpretable baseline (e.g. out of five, ten, or 100). Expressed algebraically, aggregating across sub-indicators i results in the following CTSI score for country m:

$$CTSI_m = \frac{econ_m + \frac{(pol_m + admin_m)}{2}}{2}$$

where:

$$econ_m = \sum_{i=1}^{n} economic\ indicator_i^m \times weight_i$$

$$pol_m = \frac{\sum_{i=1}^{n} political\ indicator_i^m}{n}$$

$$admin_m = \frac{\sum_{i=1}^{n} administrative\ indicator_i^m}{n}$$

expressed in terms of 'desirable' and 'feasible':

$$CTSI_m = \frac{desirable_m + feasible_m}{2}$$

where:

$$desirable_m = econ_m$$

$$feasible_m = \frac{pol_m + admin_m}{2}$$

and:

$$CTSI_m, econ_m, pol_m, admin_m, desirable_m, feasible_m, and\ all\ indicators_m \in \mathbb{R}, [1,5]$$

Step 7 - Robustness and sensitivity

Robustness checks were conducted on the selection of sub-indicators, the imputation of missing data, and choice of weights within and between categories.

Selection of sub-indicators

The foremost driver of the logic behind the CTSI as an answer to the research question is the policy design framework outlined in the 'Research methodology' section. This suggests that 'achievable gains' can be made only for policies which are desirable economically, supportable politically, and feasible

[136] Nardo et al., "Handbook on Constructing Composite Indicators," 75.

administratively. As a result, theses appeared to be natural overarching 'categories' for constructing a composite index of policy suitability. For each category, sub-indicators were selected on the basis of what appears to be the consensus in the climate economics literature, alongside theories of political economy and administration (refer to **Step 2**).

Some sub-indicators were not included in the index. For instance, resource dependence (proportion of energy consumed which is imported) and resource rich (rents from natural resources) indicators were excluded because it was unclear what the sign would be for political and economic categories. For politics, an import-dependent country could aim to maintain low energy prices (to compete with resource rich countries), or seek increase prices to shift the domestic economy away from reliance on imports. For economics, it is difficult to estimate the desirability of raising energy prices for resource rich countries as the terms of trade effects depend on the response of other countries.[137] More studies on the economics and politics of resource endowments and dependence to understand their effect on carbon taxation suitability.

Imputation of missing data

Imputation of missing data is a source of uncertainty in composite indices. As such, indicators with potentially implausible results were checked using sensitivity analysis. Two sub-indicators produced results which could be deemed implausible: electricity produced from coal and adequacy of social assistance. The MCMV process assumes a normal distribution and can result in negative values. The multiple imputation resulted in negative values for the proportion of electricity from coal (23 negative values) and adequacy of social assistance for the poorest quintile (3). These were the two sub-indicators with the largest amount of missing data (43 observations each).

Sensitivity analysis of country rankings on these two sub-indicators was therefore conducted. This entailed comparing rankings for the model either by excluding the sub-indicators or setting missing values equal to zero. For electricity produced from coal, exclusion shifted country rankings by an average of 3.25 places, and by 5 places by setting missing values equal to zero.

For adequacy of social assistance, exclusion resulted in an average shift of 7.9 places and zero values by 7.6 places. Although there is no standard cutoff, the rankings were not deemed significantly sensitive to these imputed values.

For other sub-indicators with missing observations, imputed values were sense-checked using local comparators. The MCMC model was not fed data on geography, but comparisons with neighboring countries could help identify any 'absurd' results. For government debt levels, Tonga's imputed value of 39.1% was not too dissimilar to neighboring Fiji (47.7%), Vanuatu (19.5%) and Tuvalu (57.4%). For taxation on commercial profits, Macedonia's imputed value 55.8% was fit within a broad range of levels charged by its neighbors: Kosovo (15.2%), Bulgaria (27%), Serbia (39.7%), and Albania (71.7%).

For post-tax fossil-fuel subsidies (FFS), the imputed value for Kosovo was 5.1% of GDP. The, but one could infer that Kosovo's policies would not be radically dissimilar to its neighbors for which FFS data is available. This includes Serbia (15.5%), Albania (0.9%), Bulgaria (14.8%) and Montenegro (8.7%); Kosovo's does not

[137] Ian Parry, Chandara Veung, and Dirk Heine, "How Much Carbon Pricing Is in Countries' Own Interests? The Critical Role of Co-Benefits," 9.

appear absurd. For Bhutan, the imputed value of FFS was 0.3%. This is below the overall mean of 3.2%, but similar to neighboring Nepal (0.6%) and Bangladesh (1.6%). Dominica's shadow economy was imputed as 34.5% of GDP. This is similar to nearby St. Lucia (32.5%), Jamaica (34.8%), Grenada (37.8%), and the Latin American average (40.6%). Palau's imputed shadow economy was 42.6% of GDP, not unlike neighboring Philippines (41.6%) but below Indonesia (18.9%).

Swaziland's imputed Gini index was 47.4, not unlike Zimbabwe (43.2), Mozambique (45.6), and Lesotho (54.2), though below South Africa (63.4) and Botswana (60.5). Eritrea's imputed Gini of 43.1 is not dissimilar to that of Ethiopia (33.2), Sudan (35.4), and Djibouti (44.1). Montenegro's imputed manufacturers' share of exports (52.1%) is not dissimilar to that of Albania (52.9%), Serbia (65.9%), and Bosnia and Herzegovina (66.8%). **Overall, these imputed values do not appear unreasonable.**

Choice of weights

For weighting within categories, only the economic ('desirable') category has its individual weights determined by statistical analysis through RPCA. As a result, the economic category "no longer depends upon the dimensionality of the dataset but it is rather based on the 'statistical' dimensions of the data."[138] Weights are therefore based on the statistical drivers of variation, reducing the risk of selection bias.

However, for the political and administrative ('feasible') categories, equal weighting has been made of each sub-indicator. As a result, this means that ranking could be subject to selection bias in the underlying sub-indicators, especially if multiple variables are explaining the same phenomena. However, low KMO scores for these categories imply that correlation in the underlying sub-indicators is limited, and so risk of overweighting should be lower. Checking through correlating of sub-indicators confirmed that this was mostly the case.

The only political or administrative sub-indicator pairs to be highly correlated (>0.5) were control of corruption and government effectiveness (.7323). This is not unsurprising: an effective government is more likely to be able to control corruption than an ineffectual one. Since there is a strong correlation between the two it could be argued that there is an underlying factor or component driving both ('state capability' or 'governance quality', for example). It could be argued that including both metrics means overweighting this underlying factor. However, the category of 'administrative feasibility' can be theorized to be highly dependent by government effectiveness, and in the case of revenue-raising measures such as carbon taxation, control of corruption. It is not possible to test this statistically, given the lack of a dependent variable. But weighting these two correlated sub-indicators at a combined 28.6% does not appear to the author to be too high given their importance to administrative feasibility.

For weighting across categories, because of the 2:1:1 scale used, each of the suitability criteria ('desirable' and 'feasible') account for equal weighting (50% each). This allows for easy interpretation of categories, suitability rankings, and charts (refer to section **III. Results**). It also implies an equal rate of substitution (convexity when represented on an x-y Cartesian plane) between 'desirable' and 'feasible'. In some ways, this is intuitive. A country may be equally as suitable for carbon taxation by having a high 'desirable' and low 'feasible' scores as one with low 'desirable' and high 'feasible' scores. In other ways, it may be less intuitive. A country with a very high 'feasible' score may be more suited to energy price reform than one

[138] Nardo et al., "Handbook on Constructing Composite Indicators," 64.

with a very low 'feasible' score, irrespective of the reform's economic desirability. Interpretation of outliers therefore needs to be made carefully.

In addition, economic and political/administrative phenomena are not as clearly separable as an equal rate of substitution between them would imply. There is a large body of literature on the relationship between economic and political-economy and administrative metrics, notably under the guise of institutional economics. However, as shown through regressions, 'desirable' on 'feasible' scores are not correlated in a statistically significant way. In this sense, we can have further confidence that changes in the two are not the result of some shared factors or components not included in the study. **The circumstances in which carbon taxation is desirable appears to be different to when it is possible.**

Separately, there is a broader question about the interpretation of suitability criteria when considering a reform which is desirable in the majority contexts, as may be the case with increasing energy prices. It could be interpreted that the reform is not suitable for a country with low desirable and feasible scores. For this reason, 'desirable' and 'feasible' need to be interpreted as continuous and relative criteria. **Low scores do not imply that carbon taxes are 'undesirable' or 'infeasible', but merely that they are is *less* preferable or possible compared with countries with higher scores.**

Robustness checks were performed on weightings across the three categories. It could be argued that economic, political, and administrative categories should be weighted equally, with a 1:1:1 rather than a 2:1:1 weighting. Equal weighting resulted in an average absolute ranking change of 11 places, with the majority of countries (87 out of 133) remaining in the same quintile and only 5 countries changing more than 1 quintiles.[139] The weighting across the categories matters, but does not appear to materially change the conclusions.

Rankings were also checked for sensitivity to weighting within the economic desirability category. This is the only category to have non-equal weighting across sub-indicators, as it was the only category which yielded principal components. Equal weighting across economic desirability sub-indicators resulted in an average ranking change of 6.2 places, with 32 countries shifting one quintile and all others remaining. This was deemed not significantly sensitive.

Overall evaluation

In creating composite indices, it is best practice for the modeler to provide an evaluation of the confidence in the model.[140] In an ideal world, the CTSI would be assessed against its predictive, as well as explanatory or prescriptive, power for determining which countries could and should raise energy prices. However, only four countries in the index have implemented carbon taxation policies: three in the ten (Mexico, Colombia, and India) and one in second quintile (South Africa). The sample size is too low to warrant statistical analysis and the timing is backwards (*ex ante* assessment of a model developed *ex post*, rather than vice-versa). Therefore, while the CTSI may have predictive as well as prescriptive power, at present this is speculative.

Ultimately, as with all data-driven composite indices, the result of the CTSI is subjective. This is because scoring is contingent upon selection of sub-indicators and weighting between them. This issue is intrinsic

[139] Botswana, Eritrea, Namibia, Nicaragua, and Venezuela.
[140] Nardo et al., "Handbook on Constructing Composite Indicators," 81.

and is unlikely to ever be resolved. **That said, despite inevitable ambiguity, the author believes the CTSI to provide a good first approximation of assessing countries based on their suitability for increasing energy prices.**

Step 8 - Links to other variables

Now that the CTSI has been constructed, links with other variables and indicators can be explored. A number of different indices were correlated with the CTSI criteria ('desirable' and 'feasible'), including those encompassing environmental, economic, political and administrative performance indicators, holding for income. These are summarized in Table 10 below.

Table 10. Summary of regressions of the CTSI on numerous indices and variables

	Environmental		***Economic***		***Administrative & political***	
Dependent variable:	**EPI Index score (out of 100, higher is better)**	**INDC emissions abatement (% 2030)**	**GDP per capita (PPP, 2015)**	**SDG Index score (out of 100, higher is more performant)**	**Freedom House Index score (out of 7, lower is freer)**	**Regulatory Effectiveness Index (higher is better)**
Independent variables:	(1)	(2)	(3)	(4)	(5)	(6)
'desirable'	-1.339 (1.278)	3.54* (1.838)	-248.42 (471.51)	-2.222* (1.251)	.181 (.236)	-.114 (.077)
'feasible'	3.671** (1.796)	5.661** (2.404)	2040.81*** (684.3)	1.026 (1.722)	-.793** (.32)	.626*** (.087)
GDP per capita US$	.002*** (.0003)	.0007** (.0003)	-	.0022*** (.00024)	-.00008 (.00005)	.000033* (.000018)
Constant	46.056	-23.108	-1468.1	47.108	6.098	-2.199
Observations	125[141]	133	133	104[142]	133	133
Adjusted R-squared	0.4575	0.1342	0.0808	0.5133	0.1033	0.3356

*Note: robust standard errors are in parentheses. * implies significant at 90% confidence level, ** at 95% level, and *** at the 99% level. GDP per capita was used in all regressions to control for income.*

Environmental performance (regression 1)

The Environmental Performance Index (EPI), produced by Yale University, assesses countries for their track record in meeting environmental objectives.[143] It includes the calculation and aggregation of 20 indicators, combined into 9 categories matched with two overarching objectives: 'environmental health' and 'ecosystem vitality'.

[141] The Environmental Performance Index is not produced for the following 8 countries in the dataset: Kosovo, Marshall Islands, Micronesia, Palau, South Sudan, St. Lucia, St. Vincent and the Grenadines, and Tuvalu.

[142] The Sustainable Development Goals Index is not produced for the following 30 countries in the dataset: Belize, Comoros, Djibouti, Dominica, Equatorial Guinea, Eritrea, Fiji, Grenada, Guinea-Bissau, Kiribati, Kosovo, Libya, Maldives, Marshall Islands, Micronesia, Palau, Papua New Guinea, Samoa, São Tomé and Príncipe, Solomon Islands, South Sudan, St. Lucia, St. Vincent and the Grenadines, Syria, Timor-Leste, Tonga, Turkmenistan, Tuvalu, Uzbekistan, and Vanuatu.

[143] Yale, "The Environmental Performance Index," 2015, http://epi.yale.edu/.

The author's prior was that the EPI would correlate positively with 'feasible'. This is because performance on the environment (EPI) should correlate somewhat with the government's willingness and ability to use economic instruments that partly address climate change (as with 'feasible' under the CTSI). It was also expected that there would be a weaker but negative correlation between EPI and 'desirable', as countries that are performing well on addressing environmental problems should presumably show less of a gap with respect to their economic policy (specifically through the negative affect of fossil-fuel subsidies on environmental quality).

A statistically significant relationship between the EPI and 'feasible' was found, but not for 'desirable'. **This suggests that countries that have good performance in environmental management are also more suitable for carbon taxation.**

Climate change mitigation ambition (2)

It was also assessed whether a country's suitability for carbon taxation suitability was associated with the ambitiousness of their INDC under the Paris Agreement. In the run-up to the 2015 Paris Agreement, countries submitted 'intended nationally-determined contributions', indicating how they would limit or reduce greenhouse gas emissions. Because they were voluntary, the INDCs vary in levels of what is termed 'domestic ambition', which can be defined as the proposed deviation from a business-as-usual scenario by a certain end date.

The author's prior was that carbon taxation suitability would be positively associated with both 'desirable' and 'feasible': countries that are more suited to economy-wide mitigation instruments like carbon taxation would be willing to submit more ambitious INDCs. Unfortunately, the INDCs are infamously diverse in terms of their construction, with no consistent base year, future year, or even unit of abatement (carbon intensity targets versus absolute or relative reductions for example). In addition, INDCs for LMICs tend to distinguish between 'unconditional' and 'conditional' components, the latter usually contingent on flows climate finance from developed countries. Therefore, in order to assess the links between carbon tax suitability and mitigation ambition, a model had to be constructed for each country which would harmonize these INDCs onto a common baseline.

Only the unconditional INDCs were used, because these were deemed to be the strongest signal of mitigation ambition. As a result, 47 countries from our dataset without unconditional INDCs were dropped. For countries which had stated an unconditional reduction against a 2030 BAU scenario, their stated contribution against that baseline was used (49 countries with an average 16.5% abatement). For the remaining 36 countries, a simple model was constructed for projecting forward business-as-usual (BAU) emissions in the dataset through to 2030.

Country's greenhouse gas emissions (excluding LULUCF) for 2012 were collected from WRI's CAIT Climate Database.[144] For each region, the IIASA Energy Program produces forecasts for greenhouse gas emissions growth rates for 2012-20 and 2020-30.[145] This is the data used in the construction of the Shared

[144] WRI, "CAIT - CAIT Country GHG Emissions Database."

[145] Regions are aggregated as follows: R5.2OECD = Includes the OECD 90 and EU member states and candidates. R5.2REF = Countries from the Reforming Economies of Eastern Europe and the Former Soviet Union. R5.2ASIA = The region includes most Asian countries with the exception of the Middle East, Japan and Former Soviet Union states. R5.2MAF = This region includes the countries of the Middle East and Africa. R5.2LAM = This region includes the countries of Latin America and the Caribbean.

Socioeconomic Pathways (SSPs) - scenarios of future emissions and warming levels used by the IPCCC - which are integrated into the various Integrated Assessment Models (IAMs) by climate economists for projecting future climate damages.

Each country's emissions were projected using the regional average growth rates, giving a rough BAU baseline through to 2030. Where possible, for each INDC that did not use a target against a 2030 BAU baseline, the effective emissions implied in 2030 by the INDC were imputed, with the difference to BAU resulting in their implied unconditional emissions abatement. For instance, Brazil's unconditional INDC is a 43% reduction compared with 2005 levels by 2030. This would imply 605.2 million tonnes of CO2e by 2030 (57% of 2005 emissions of 1061.8 MtCO2e), compared to a projection of 1,005 MtCO2e using the IIASA data. This implies a net abatement of 39.8% against BAU in 2030. Where a country the country's projected BAU emissions were below that implied by their INDC (net increase in emissions), a zero 'implied emissions abatement' value was used. In total, 54 of the 134 countries in the dataset had unconditional INDCs which implied net reductions in GHGs by 2030 against BAU.

This implied unconditional emissions abatement variable was regressed against 'desirable' and 'feasible', showing a positive and statistically significant relationship with both (Table 10). A one point increase in 'desirable' or 'feasible' ratings (out of five) is associated with a 3.5 and 5.7 percentage point increase in a country's unconditional mitigation contribution to 2030, significant at the 5% and 10% level respectively.

Note that the unconditional mitigation model is a rough approximation and cannot be relied upon in a substantive manner. It was originally intended to be a 'climate ambition' sub-indicator under the political category of the CTSI, but was rejected given large uncertainties behind the resulting figures, especially on 2012 greenhouse gas inventories, in the regional aggregation of GHG growth, and uncertainty on INDC interpretation.[146] Note also that, even if accurate, the R-squared is not especially high (0.1342). However, this is early evidence of a potential link between ambition and carbon taxation suitability: **countries more suited to carbon taxes may also be more ambitious in their mitigation objectives.**

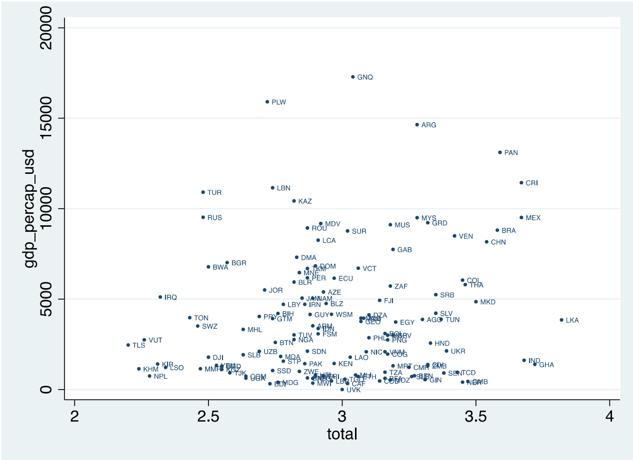
[146] This 'implied unconditional mitigation contribution' sub-indicator was dropped in favor of 'INDC includes unconditional component' as proxy for climate ambition

Links with GDP per capita (3)

The link between the CTSI and economic output per capita were explored. It could be that the factors which it is proposed are indicative of suitability for carbon taxation are simply driven by per capita income. The author's prior is that this was plausible for 'feasible': factors that should accord with an environment conducive to carbon taxation policies should be more likely in wealthy countries. For economic desirability, it was ambiguous: it could be that wealthier countries subsidize fossil fuels more, or they could be less likely to have high debt levels. But the opposite was also plausible.

As expected, 'feasible' is associated with GDP per capita, while 'desirable' is not. However, the link is weak: a one standard deviation increase in 'feasible' is associated with a 0.28 standard deviation increase in GDP per capita (US$972). In aggregate, CTSI scores do not appear to be driven by income: total CTSI score did not correlate with GDP per capita in a statistically significant way (Figure 20). **For LMICs, income is weakly correlated with suitability for carbon taxation.**

Figure 20. Weak link between CTSI and GDP per capita



Note: The correlation is not significantly different from zero at the 10% confidence level.

Link with sustainable development performance (4)

The Sustainable Development Goals Index assesses countries against the SDGs.[147] It could be that high-performing countries are particularly suited to carbon taxation policies due to the institutional environment. However, countries facing strong fiscal constraints may be less performant on the SDGI and simultaneously more suited to carbon taxation as a source of revenue. The author's prior was that there would be a positive correlation between SDG performance and 'desirable' and a negative correlation with 'feasible' under the CTSI.

A negative relationship was found between the CTSI and 'desirable' but not 'feasible'. A one point increase in 'desirable' is associated with a 3.1-point decrease in SDG performance (out of 100 with a mean of 52.2 and standard deviation of 11 for LMICs).

These results are not surprising. For 'desirable', countries that are performing badly on the SDGs may be doing so due to low domestic resource mobilization (DRM) - for whom carbon taxation may be an attractive source of revenue. According to the World Bank, improving DRM for achieving the Sustainable Development Goals (SDGs): "a country's ability to collect domestic taxes and spend those resources effectively lies at the crux of financing for development."[148] Oxfam estimates that an extra $1.5 trillion is needed each year to meet the SDGs,[149] while for LMICs, efficient energy pricing is could raise $2.2

[147] Sustainable Development Solutions Network, "Sustainable Development Goal Index," 2016, http://www.sdgindex.org/.
[148] World Bank, "Domestic Resource Mobilization," Text/HTML, *World Bank*, (March 29, 2016), http://www.worldbank.org/en/topic/governance/brief/domestic-resource-mobilization.
[149] Matthew Martin, Development Finance International and Jo Walker, Development Finance International, "Financing the Sustainable Development Goals" (Oxfam, 2015), https://www.oxfam.org/en/research/financing-sustainable-development-goals.

trillion.[150] **Carbon taxes appear to be more desirable in countries that are performing less well at meeting the SDGs, and could be a source of funds to help them make progress.**

Political freedom (5)

Are freer countries more suited to carbon taxation? On the one hand, by holding government's more accountable, democratic rights could be associated with more effective economic policymaking (lower 'desirable', higher 'feasible'). On the other, freer societies could be more fiscally constrained or have higher rates of protest (higher 'desirable', lower 'feasible').

Regressing the CTSI on Freedom House's index of 'Freedom in the World'[151] suggests freer countries are more suited to carbon taxation. A one standard deviation increase in 'feasible' is associated with a .45 standard deviation decrease (meaning freer) in the freedom index score. There was no statistically significant relationship with 'desirable', however. **Freer countries may be more able to implement carbon tax policies.**

Regulatory quality (6)

Lastly, it was expected that regulatory quality should be strongly associated with 'feasible'. Regulatory quality is defined by the World Bank's World Governance Indicator's as "the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development."[152] This was explicitly left out as a sub-indicator for administrative feasibility, as it could be argued that carbon taxation is not explicitly about permitting or promoting the private sector (unlike, for instance, emissions trading systems). However, given links with government effectiveness and control of corruption, a strong correlation with 'feasible' was expected.

As expected, there is a strong and statistically significant correlation between a country's ability to implement carbon taxation (as defined by the CTSI) and its regulatory effectiveness. A one standard deviation increase in 'feasible' is associated with a 0.5 standard deviation increase in regulatory effectiveness. **Countries that are better at permitting or promoting the private sector should also be more able to implement carbon taxes.**

Steps 9 & 10 - Deconstruction and presentation

Lastly, for deconstruction and visualizations, please refer to Results in from **page 16**.

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[150] Coady et al., "How Large Are Global Fossil Fuel Subsidies?"

[151] Freedom House, "Freedom in the World 2016," accessed November 3, 2016, https://freedomhouse.org/report/freedom-world/freedom-world-2016.

[152] World Bank, "Worldwide Governance Indicators - Aggregate | Data."

Annex 2. CTSI - Full Rankings

		Categories			Carbon Taxation Suitability Criteria		Overall score
Rank	Country	Economic-ally desirable (1)	Politically feasible (2)	Admin-istratively feasible (3)	'Desirable' =(1)	'Feasible' =(2+3)/2	CTSI score =(1+(2+3)/2)/2
1	Sri Lanka	4.64	2.56	3.43	4.64	2.99	**3.82**
2	Ghana	3.37	3.44	4.71	3.37	4.08	**3.72**
3	India	4.31	2.11	4	4.31	3.06	**3.68**
4	Mexico	3.36	3.67	4.29	3.36	3.98	**3.67**
4	Costa Rica	3.61	3.44	4	3.61	3.72	**3.67**
6	Panama	3.52	3.44	3.86	3.52	3.65	**3.59**
7	Brazil	3.75	3.11	3.71	3.75	3.41	**3.58**
8	China	3.35	3.44	4	3.35	3.72	**3.54**
9	Macedonia	3.37	3.11	4.14	3.37	3.63	**3.5**
10	Gambia	4.06	2.78	3	4.06	2.89	**3.47**
11	Thailand	3.61	2.89	3.71	3.61	3.3	**3.46**
12	Niger	3.39	3	4	3.39	3.5	**3.45**
12	Colombia	3.3	3.33	3.86	3.3	3.6	**3.45**
14	Chad	3.67	3.11	3.29	3.67	3.2	**3.43**
15	Venezuela	4.07	2.56	3	4.07	2.78	**3.42**
16	Ukraine	3.67	3.67	2.57	3.67	3.12	**3.39**
17	Senegal	3.43	3.22	3.43	3.43	3.33	**3.38**
18	Tunisia	3.38	3.44	3.29	3.38	3.37	**3.37**
19	El Salvador	3.76	2.44	3.43	3.76	2.94	**3.35**
19	Serbia	3.16	3.67	3.43	3.16	3.55	**3.35**
21	Honduras	3.54	3.11	3.14	3.54	3.13	**3.33**
22	Zambia	3.08	3.56	3.57	3.08	3.56	**3.32**
22	Ivory Coast	3.02	3.22	4	3.02	3.61	**3.32**
22	Grenada	3.54	3.33	2.86	3.54	3.1	**3.32**
25	Guinea	3.73	2.78	3	3.73	2.89	**3.31**
26	Angola	3.42	3.22	3.14	3.42	3.18	**3.3**
27	Malaysia	2.97	2.89	4.29	2.97	3.59	**3.28**
27	Argentina	3.3	2.67	3.86	3.3	3.26	**3.28**
29	Benin	3.39	3	3.29	3.39	3.14	**3.27**
30	Sierra Leone	3.4	3.11	3.14	3.4	3.13	**3.26**
31	Cameroon	3.22	3	3.57	3.22	3.29	**3.25**
32	Egypt	3.21	3.11	3.29	3.21	3.2	**3.2**
33	Gabon	2.76	3.67	3.57	2.76	3.62	**3.19**
33	Cape Verde	3.33	3.11	3	3.33	3.06	**3.19**
33	Mauritania	3.27	3.22	3	3.27	3.11	**3.19**
36	South Africa	2.38	3.67	4.29	2.38	3.98	**3.18**

		Categories			Carbon Taxation Suitability Criteria		Overall score
Rank	**Country**	**Economic-ally desirable (1)**	**Politically feasible (2)**	**Admin-istratively feasible (3)**	**'Desirable' =(1)**	**'Feasible' =(2+3)/2**	**CTSI score =(1+(2+3)/2)/2**
36	Mauritius	2.89	2.78	4.14	2.89	3.46	**3.18**
36	Mozambique	3.06	3.44	3.14	3.06	3.29	**3.18**
39	Republic of Congo	3.53	3.33	2.29	3.53	2.81	**3.17**
39	Morocco	2.91	3.44	3.43	2.91	3.44	**3.17**
39	Papua New Guinea	2.92	3.11	3.71	2.92	3.41	**3.17**
42	Vietnam	3.27	2.67	3.43	3.27	3.05	**3.16**
42	Bolivia	3.56	2.11	3.43	3.56	2.77	**3.16**
42	Tanzania	3.66	2.89	2.43	3.66	2.66	**3.16**
42	Burkina Faso	2.52	3.44	4.14	2.52	3.79	**3.16**
46	DR Congo	2.99	3.44	3.14	2.99	3.29	**3.14**
46	Fiji	2.92	3	3.71	2.92	3.36	**3.14**
48	Algeria	3.19	3.44	2.57	3.19	3.01	**3.1**
48	Philippines	2.88	2.78	3.86	2.88	3.32	**3.1**
50	Nicaragua	3.56	2.67	2.57	3.56	2.62	**3.09**
51	Albania	2.95	3.56	2.86	2.95	3.21	**3.08**
52	Georgia	2.33	3.89	3.71	2.33	3.8	**3.07**
52	Mongolia	2.77	3.44	3.29	2.77	3.37	**3.07**
54	Ethiopia	3.15	2.67	3.29	3.15	2.98	**3.06**
54	St. Vincent	2.99	2.56	3.71	2.99	3.13	**3.06**
56	Mali	3.02	2.89	3.29	3.02	3.09	**3.05**
57	Equatorial Guinea	2.72	3.44	3.29	2.72	3.37	**3.04**
58	Laos	3.02	2.67	3.43	3.02	3.05	**3.03**
59	Central African Rep.	3.75	3	1.57	3.75	2.29	**3.02**
59	Suriname	2.68	3.44	3.29	2.68	3.37	**3.02**
61	Togo	3.28	2.89	2.57	3.28	2.73	**3.01**
62	Kosovo	2.26	3.78	3.71	2.26	3.75	**3**
63	Kenya	3.05	3.33	2.43	3.05	2.88	**2.97**
63	Ecuador	2.59	3	3.71	2.59	3.36	**2.97**
65	Samoa	2.53	3.22	3.57	2.53	3.4	**2.96**
65	Liberia	2.96	3.33	2.57	2.96	2.95	**2.96**
67	Belize	3.17	3	2.43	3.17	2.71	**2.94**
68	Azerbaijan	2.35	3.44	3.57	2.35	3.51	**2.93**
68	Eritrea	4.06	2.44	1.14	4.06	1.79	**2.93**
70	Maldives	2.69	2.89	3.43	2.69	3.16	**2.92**

		Categories			Carbon Taxation Suitability Criteria		Overall score
Rank	**Country**	**Economic-ally desirable (1)**	**Politically feasible (2)**	**Admin-istratively feasible (3)**	**'Desirable' =(1)**	**'Feasible' =(2+3)/2**	**CTSI score =(1+(2+3)/2)/2**
71	Indonesia	2.21	3.22	4	2.21	3.61	**2.91**
71	St. Lucia	2.77	2.67	3.43	2.77	3.05	**2.91**
71	Micronesia	2.77	3.11	3	2.77	3.06	**2.91**
74	Rwanda	2.3	3.56	3.43	2.3	3.49	**2.9**
74	Haiti	3.79	2.44	1.57	3.79	2.01	**2.9**
74	Dominican Rep.	3.06	2.33	3.14	3.06	2.74	**2.9**
77	Afghanistan	3.09	3.11	2.29	3.09	2.7	**2.89**
77	Malawi	3.22	2.56	2.57	3.22	2.56	**2.89**
77	Armenia	2.45	3.22	3.43	2.45	3.33	**2.89**
77	Namibia	1.75	3.22	4.86	1.75	4.04	**2.89**
81	Guyana	2.91	3.11	2.57	2.91	2.84	**2.88**
82	Sudan	3.27	2.78	2.14	3.27	2.46	**2.87**
82	Guinea-Bissau	3.17	3	2.14	3.17	2.57	**2.87**
82	Peru	2.51	2.89	3.57	2.51	3.23	**2.87**
82	Romania	2.48	3.22	3.29	2.48	3.25	**2.87**
82	Turkmenistan	3.21	2.78	2.29	3.21	2.53	**2.87**
87	Iran	3.02	2.56	2.86	3.02	2.71	**2.86**
87	Pakistan	3.31	2.11	2.71	3.31	2.41	**2.86**
89	Jamaica	2.63	3	3.14	2.63	3.07	**2.85**
90	Zimbabwe	3.16	2.89	2.14	3.16	2.52	**2.84**
90	Montenegro	2.56	2.67	3.57	2.56	3.12	**2.84**
92	Dominica	2.67	2.56	3.43	2.67	2.99	**2.83**
93	Belarus	2.72	2.11	3.71	2.72	2.91	**2.82**
93	Tuvalu	3.19	2.89	2	3.19	2.44	**2.82**
93	Kazakhstan	2.12	3.33	3.71	2.12	3.52	**2.82**
93	Nigeria	2.56	2.89	3.29	2.56	3.09	**2.82**
97	Libya	2.65	3.67	2.14	2.65	2.9	**2.78**
97	São Tomé	3.22	2.11	2.57	3.22	2.34	**2.78**
99	Moldova	2.49	2.67	3.43	2.49	3.05	**2.77**
100	Bosnia	2.14	3.78	3	2.14	3.39	**2.76**
100	Madagascar	2.65	3.44	2.29	2.65	2.87	**2.76**
102	Bhutan	2.88	3.11	2.14	2.88	2.63	**2.75**
103	Lebanon	2.95	2.33	2.71	2.95	2.52	**2.74**
103	South Sudan	2.69	3.44	2.14	2.69	2.79	**2.74**
103	Guatemala	2.89	2.89	2.29	2.89	2.59	**2.74**
106	Burundi	2.73	2.89	2.57	2.73	2.73	**2.73**

		Categories			Carbon Taxation Suitability Criteria		Overall score
Rank	**Country**	**Economic-ally desirable (1)**	**Politically feasible (2)**	**Admin-istratively feasible (3)**	**'Desirable' =(1)**	**'Feasible' =(2+3)/2**	**CTSI score =(1+(2+3)/2)/2**
107	Palau	3.28	2.44	1.86	3.28	2.15	**2.72**
108	Jordan	2.19	2.89	3.57	2.19	3.23	**2.71**
109	Paraguay	2.48	3.22	2.57	2.48	2.9	**2.69**
109	Uzbekistan	2.59	3	2.57	2.59	2.79	**2.69**
111	Comoros	2.9	1.78	3	2.9	2.39	**2.64**
111	Uganda	2.81	2.67	2.29	2.81	2.48	**2.64**
113	Solomon Is.	1.81	3.33	3.57	1.81	3.45	**2.63**
113	Marshall Islands	2.78	3.11	1.86	2.78	2.48	**2.63**
115	Tajikistan	2.94	3	1.43	2.94	2.21	**2.58**
116	Bulgaria	1.99	2.89	3.43	1.99	3.16	**2.57**
117	Kyrgyzstan	2.42	3.22	2.14	2.42	2.68	**2.55**
117	Bangladesh	2.97	2.11	2.14	2.97	2.13	**2.55**
119	Yemen	3.15	2.11	1.71	3.15	1.91	**2.53**
120	Botswana	1.47	2.78	4.29	1.47	3.53	**2.5**
120	Djibouti	2.57	2.56	2.29	2.57	2.42	**2.5**
122	Russia	2.36	2.78	2.43	2.36	2.6	**2.48**
122	Turkey	1.96	3	3	1.96	3	**2.48**
124	Myanmar	2.52	2	2.86	2.52	2.43	**2.47**
125	Swaziland	2.22	2.67	2.71	2.22	2.69	**2.46**
126	Tonga	1.77	2.89	3.29	1.77	3.09	**2.43**
127	Lesotho	1.64	2.78	3.29	1.64	3.03	**2.34**
128	Iraq	2.12	3.33	1.71	2.12	2.52	**2.32**
129	Kiribati	1.89	2.89	2.57	1.89	2.73	**2.31**
130	Nepal	2.22	2.11	2.57	2.22	2.34	**2.28**
131	Vanuatu	2.5	2.33	1.71	2.5	2.02	**2.26**
132	Cambodia	2.56	2.11	1.71	2.56	1.91	**2.24**
133	Timor-Leste	1.83	2.44	2.71	1.83	2.58	**2.2**

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