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Five Myths About Carbon Pricing

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Abstract

While carbon pricing, in general, and carbon taxes, in particular, are popular with economists, they are subject to considerable misunderstanding among policy makers and the public. In this paper I consider and refute five myths about carbon taxes: 1) that a carbon price will hurt economic growth; 2) that carbon pricing will kill jobs; 3) that a carbon tax and cap and trade program have the same economic impacts; 4) that we can't achieve carbon reduction targets with a carbon tax; and 5) that carbon pricing is regressive. I then discuss implications for policy making.

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I. Introduction

While it is difficult to get economists to agree on any particular policy, there is near unanimous agreement that a necessary component of any portfolio of policies to address climate change includes carbon pricing. There is some disagreement over the desirability of a carbon tax or fee versus using a cap and trade program, but the disagreement here is more about political viability than efficacy or fairness. Much of the political opposition to carbon pricing in general and carbon taxes in particular is driven by vested interests in fossil fuel production (e.g. Wright and Nyberg, 2021) and obfuscation to scientific facts (e.g. Supran and Oreskes, 2017, 2020). But some of the opposition is driven by confusion or misunderstanding of the policy impacts. This paper addresses those misunderstandings and focuses, in particular, on five myths.

The five myths that I address in this paper are: 1) that a carbon price will hurt economic growth; 2) that carbon pricing will kill jobs; 3) that a carbon tax and cap and trade program have the same economic impacts; 4) that we can't achieve carbon reduction targets with a carbon tax; and 5) that carbon pricing is regressive. All five of these statements are false as I detail in this paper. I then discuss the implications of dispelling these myths for policy.

II. Myth 1: Carbon Pricing Will Hurt Economic Growth[1]

Any program to reduce pollution will have economic costs. After all, there is no such thing as a free lunch. A common myth about carbon pricing is that it will significantly hurt the economy. The Trump Administration's retreat from a climate policy is emblematic. In initiating a process to withdraw the United States from the global Paris Agreement, for example, the President claimed that the cost to the economy would be "close to $3 trillion in lost GDP and 6.5 million industrial jobs…" (Trump, 2017).

But how large are the costs? One way to assess that is to look at the impact of existing carbon taxes on economic growth. Until recently, there was little work in this area and most analyses relied on

[1] This section draws heavily on Metcalf and Stock (forthcoming).

the use of large-scale computable general equilibrium models such as the E3 model of Goulder and Hafstead (2017). Using their model, Goulder et al. (2019) find that a $40 per ton carbon tax with an annual rate increase of 2 percent real leads to discounted GDP costs over the 2016-2050 period of less than one-third of one percent of GDP.

Metcalf and Stock (forthcoming) summarize the empirical work. Metcalf (2019a), for example, uses a difference-in-difference analysis of the British Columbia carbon tax, comparing that province to other Canadian provinces over the 1990-2016 time period and finds, if anything, a modest impact of the tax on GDP. He argues that this is plausible once one accounts for the use of the revenue to lower existing taxes in the province, an example of a double dividend (viz Goulder, 1995). Using a vector autoregression approach, Bernard and Kichian (2021) find no impact of the BC carbon tax on provincial GDP. Turning to Europe, Metcalf and Stock (2020, forthcoming) use a variety of time series macroeconomic methods to measure the impact of carbon taxes on economic growth. Let me discuss the results of Metcalf and Stock (forthcoming) in a bit more detail as it is the more comprehensive of the two analyses.

In that paper, they examine carbon taxes employed in 15 European countries, some of which have been in place for over 30 years now. Finland was the first European country to enact a carbon tax in 1990 and was soon followed by a number of other countries, many in the Nordic region, with this idea of using carbon tax revenue to finance reductions in income tax rates. To isolate impacts of the carbon taxes, they include in their analysis so-called EU+ countries, countries that are part of the EU Emission Trading System (EU-ETS). By including these 31 countries, they can control for changes in the EU-ETS over time as it became increasingly stringent, and isolate the additional impacts of the carbon taxes themselves in the 15 countries with those taxes. Figure 2 from Metcalf and Stock (forthcoming) illustrate the variability both in rate and across time for the carbon tax rates.

They estimate the dynamic effect on GDP growth of the unexpected component of the carbon tax using the Jordà (2005) local projection (LP) method, adapted to panel data. Specifically, they use OLS to estimate a sequence of panel data regressions,

(1) $$100\Delta ln(GDP_{it+h}) = \alpha_i + \Theta_h \tau_{it} + \beta(L)\tau_{it-1} + \delta(L)\Delta X_{it-1} + \gamma_t + u_{it}$$

where τ_{it} is the coverage-weighted real carbon tax rate for country *i* at date *t*, and Θ_h is the effect of an unexpected change in the carbon tax rate at time *t* on annual GDP growth *h* periods hence. The vector X_{it-1} includes ln(GDP), ln(total employment), ln(manufacturing employment), and the GDP price deflator. Note in Equation (1) the presence of country and year fixed effects. The former control differences across countries in the propensity to adopt a carbon tax and mean growth rates that could be correlated. They include year effects for two reasons: 1) the European countries in the sample share common political pressures, which could induce common changes in carbon prices, and have common economic influences. These common influences, even if exogenous, could appear as confounders, so they identify the effect of the tax increase from country-level surprises in carbon prices after controlling for common movements (year effects); and 2) even if year effects are not needed for identification, because of common macroeconomic movements (such as the global recession of 2009), including year effects could reduce standard errors.

One concern with their approach is the possibility of simultaneity. Poor economic outcomes could lead policy makers to reduce carbon tax rates (or postpone scheduled increases). They address this issue as follows. It is useful to think of changes to a carbon tax as having two components, one responding to historical economic growth, the other being unpredicted by past growth. Changes in the latter category could include tax changes based on historically legislated schedules, changes in ambition based on the environmental preferences of the party in power, or responses to international climate policy pressure. Their identifying assumption is that this latter category of changes – those not predicted by historical own-country GDP growth and current and past international economic shocks – are exogenous. Hence, the inclusion of lags in the model. They present results by producing impulse response functions (IRF's) for a counterfactual of a one-time permanent increase in the carbon tax by $40, for a tax that covers 30% of the country's emissions, a coverage rate that is close to the sample mean. They compute this dynamic response from the LP and SVAR impulse responses using the method in Sims (1986), which entails computing the sequence of shocks necessary to yield the specified counterfactual carbon tax increase. Specifically, they model a $40 policy shock with a sequence of small adjustments. The small adjustments keep the carbon tax at $40 instead of tracking its own IRF with respect to its own shock. Figure 3 shows a representative IRF. This is from a version of the model that assumes the long run growth rate is not affected but rather only near term growth rates are affected. Theory suggests that long run GDP growth rates are driven more by fundamentals than by policy variable such as tax rates. Figure 3 shows that there is no significant impact on GDP growth, either in a positive or a negative direction. But as Figure 2 demonstrates, a number of countries have very low carbon tax rates. The pattern illustrated in Figure 3 persists when they limit the sample to countries with large carbon tax rates – countries with share weighted tax rates of at least $10 per ton (corresponding to a tax rate of $30 a ton covering one-third of emissions). See Figure 4. They get similar results when focusing on countries who explicitly use carbon tax revenues to lower existing tax rates, when they focus on Scandinavian countries only, or other cuts of the data.[2]

Why do CGE models appear to overestimate the adverse impact that carbon taxes supposedly have on GDP growth? A recent paper by Finkelstein Shapiro and Metcalf (2021) hints at an answer. In a CGE model that includes endogenous firm creation and technology adoption, they find that a carbon tax designed to reduce emissions by 35 percent – roughly the reduction called for in the Biden Administration Nationally Determined Contribution under the Paris Agreement – leads to modest

[2] The carbon tax rate data for their analysis came from the World Bank Carbon Pricing Dashboard. These are statutory rates and they use the highest rate if multiple rates are reported. Their results are unchanged if they use the bottom-up carbon tax rates constructed by Dolphin et al. (2019).

positive increases in long-run output. When the technology adoption and firm creation channels are turned off, as is the case in most CGE models used for climate policy analysis, they find the carbon tax leads to significant adverse impacts on GDP. While more work needs to be done to understand the mechanisms behind these results, they point to greater flexibility and resilience in the U.S. economy than most models predict.

Summing up, a burgeoning literature on the economic impact of carbon taxes finds no evidence for significant adverse impacts of carbon taxation on economic growth. With the expansion of carbon pricing globally, there will be more opportunities for researchers to empirically test the hypothesis that carbon pricing is bad for the economy (ignoring the benefits of reducing emissions). But so far, the evidence does not support that view.

III. Myth 2: Carbon Pricing is a Job Killer

Once one accepts the view that carbon pricing does not hurt economic growth, it is not surprising to learn that it doesn't adversely impact overall employment either. The results from Metcalf and Stock (2020, forthcoming) support this view. The impulse response functions for total employment in the latter of their papers look very similar to the IRFs in Figures 3 and 4. Their results are consistent with an analysis of the employment effects of the British Columbia carbon tax by Yamazaki (2017). Yamazaki found modest positive impacts on employment in the province. While aggregate impacts were small, he found significant job shifting from carbon intensive to non-carbon intensive sectors. Using firm level data to analyze the BC carbon tax, Azevedo et al. (2020) find similar results of a negligible aggregate employment impact but significant job shifting across sectors. Carbone et al. (2020) also find significant job shifting across sectors.

That employment in carbon intensive sectors falls is not surprising. Indeed, it would be surprising if it did not fall since the entire point of a carbon tax is to cut emissions, including by shifting economic activity away from carbon intensive sectors towards carbon light sectors. That the tax does this without affecting overall employment is encouraging though the analyses to date have not addressed the transitional costs of making the shift. This is an area where more research is needed as well as a focus on transitional assistance to workers in carbon intensive sectors.

Some hints on why carbon taxes may not affect aggregate output or employment are provided by Finkelstein Shapiro and Metcalf (2021). As noted above, they show in a general equilibrium model with labor market search frictions that accounting for firm entry and exit and technology adoption significantly ameliorate the adverse impacts of carbon pricing. By altering the incentives of new firms to enter the market, a carbon tax can speed up the adjustment to a new equilibrium with carbon pricing. Similarly allowing for new technology adoption, in part driven by carbon pricing, can lower the costs of the transition as well. Technology adoption will be critical for moving to a zero carbon economy and needs to be at the center of policy efforts (over and above carbon pricing) as shown, for example, by Acemoglu et al. (2012).

IV. Myth 3: Carbon Taxes and Cap and Trade Programs Are Equivalent

Carbon pricing entails raising the marginal cost of producing goods that burn fossil fuels in their production and so align private and social costs. Abstracting from uncertainty, cap and trade programs and carbon taxes are dual instruments. A cap and trade program targets carbon emissions and, through a trading system for allowances, sets a price on emissions through market dynamics. The policy instrument is the cap. A carbon tax, on the other hand, sets the price on emissions directly and lets the market respond to the higher price of burning fossil fuels through reduced emissions. In principle, a carbon tax and cap and trade system are identical.

In a classic paper, Weitzman (1974) set forth conditions for ranking carbon taxes and cap and trade systems when there is uncertainty over the marginal cost of abatement. Weitzman's original article focused on flow pollutants, but his model was easily extended to a stock pollutant. Most analyses that extend the Weitzman model to a stock pollutant conclude that a carbon tax is more efficient than a cap and trade program.[3] While an important paper, the reality is that either tax or cap and trade systems can be updated over time. Carbon tax rates have been adjusted, raised, or lowered as illustrated, for example, in Europe's 15 carbon tax systems (see Figure 2). The financial crisis leading to the Great Recession led to a large overhang of allowances in the EU Emission Trading System (ETS) on the order of 2 billion allowances by 2013. The European Commission responded by postponing the auction of 900 million allowances in 2014 – 2016 and by setting up a Market Stability Reserve as a way to avoid large overhangs of unsold allowances accumulating from weak economic conditions.[4] The Market Stability Reserve illustrates how carbon pricing systems can be modified to account for new information over time. Given the ability to adjust pricing systems in response to new information, differences between price and quantity based systems due to uncertainty become much less significant.

But important differences between the two carbon pricing systems remain. As discussed in Metcalf (2019a, b), the two systems differ in three important ways. First, since a cap and trade system fixes emissions, prices fluctuate with economic conditions. These fluctuations complicate business planning for investments in long-lived capital intensive projects. A carbon tax provides price certainty that provides some reassurance for project planning. Second, most countries have well-functioning tax collection systems and already impose fuel excise taxes. Thus imposing a carbon tax involves little incremental investment in administrative systems. In contrast, cap and trade systems generally requires

[3] See, for example, Hoel and Karp (2002), Newell and Pizer (2003), Karp and Zhang (2005), and Karp and Traeger (2018), among others. Excepting the last paper, the papers tend to favor a price instrument (tax) in the presence of a stock pollutant. Hepburn (2006) considers non-efficiency factors when comparing the two instruments as well as Weitzman-type efficiency factors.
[4] The EC response to the large accumulation unsold allowances is described at https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets/market-stability-reserve_en, accessed on April 1, 2022.

an entirely new administrative agency to create and track allowances, hold auctions, and develop rules to prevent fraud and abuse.

The third and by far the most important difference is in how the two carbon pricing systems interact with other carbon reduction policies. Consider a carbon pricing system that covers the transportation sector. Next assume a low carbon fuel standard (LCFS) is imposed to reduce emissions in transportation fuel. If the carbon pricing system is a carbon tax, the existence of the LCFS has no effect on the carbon tax. The carbon tax rate is set by policy makers. All the LCFS does is impose a (potentially) additional constraint to reduce emissions further in transportation through the LCFS. If the carbon pricing system is a cap and trade system, however, the LCFS reduces emissions in transportation and so relaxes the binding constraint of the cap in the cap and trade system. Every ton of emissions reduced by the LCFS means a ton of emissions can be emitted by some other binding source. In practice, this means that the LCFS drives down the allowance price in the cap and trade system. At the same time, it drives up the cost of the given emission reductions under the cap since the cap and trade system left it to firms to determine the lowest cost way to reduce emissions to meet the cap. The LCFS adds a side constraint requiring some portion of the emissions to be reduced through that program. Adding an additional constraint can never lower costs; it can only raise them. That complementary policies tend to relax binding caps and so depress allowance prices in emission trading systems may help explain why cap and trade system tend to have lower prices that the tax rates of carbon tax systems (World Bank Group, 2021).[5]

V. Myth 4: Carbon Taxes Are Incompatible with Emission Reduction Targets

Countries increasingly are setting greenhouse gas emission goals in terms of emission reduction targets. The EU, for example, has committed to reduce its emissions by at least 55 percent relative to

[5] This point has been recognized by Fankhauser et al. (2010) and Metcalf (2019b), among others.

1990 levels. The United States has committed to reducing 50 to 52 percent below 2005 levels in 2030.[6] One concern with a carbon tax is that it doesn't align well with these sorts of targets since a carbon tax simply sets a price on emissions (the tax rate) while leaving the level of emissions to the market. A comment from an environmental policy leader regarding the Climate Leadership Council's carbon tax plan illustrates the concern: "While a carbon tax can be an important part of a comprehensive program to cut our carbon footprint and to hold polluters accountable, it must be accompanied by strong limits on carbon emissions, including those under existing authority granted by the Clean Air Act and all other existing legal tools."[7] This statement reflects a broader concern about the ability of carbon taxes to reduce emissions because no explicit emissions limit is built into the tax.

Whether it is optimal to set explicit emission reduction targets or not, there is a clear political attraction to them. They are concrete, focus on the desired outcome (lower emissions), and are easily explainable to the public. It does not follow, however, that a cap and trade system is preferable to a carbon tax given the former's focus on emissions.

Economists have long understood that a cap and trade system can be made to take on properties of a carbon tax (e.g. a hybrid instrument) by adding a price ceiling or floor. The safety valve sets a maximum price for allowances and prevents the price from exceeding the price ceiling by issuing additional allowances at the ceiling price. A price floor simply dictates a minimum price for issuing new allowances. Price ceilings and floors reduce price volatility and eliminates the risk of high allowance prices and the associated cost of reducing emissions.[8] While considerable analysis has been done on

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[6] These goals come from their respective Nationally Determined Contributions submitted under the Paris Agreement. See the Registry at https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx, accessed April 1, 2022.

[7] Quotation is from a June 20, 2018 NRDC press release *NRDC: Carbon Tax Must Include Limits on Carbon Emissions* found at https://www.nrdc.org/media/2018/180620-0, accessed Sept. 6, 2018.

[8] Roberts and Spence (1976) introduced the idea of a safety valve in a cap and trade system for a flow pollutant. They found that when combined with a subsidy for emissions that fall below a firm's individual cap, the hybrid system has lower expected social costs than either a pure tax or pure cap system. Pizer (2002) was perhaps the first to describe a hybrid cap and trade instrument for controlling greenhouse gas emissions. The literature on

hybrid cap and trade system with carbon tax features (i.e. ceilings and floors), it is also the case that hybrid carbon tax systems can be constructed with cap and trade features. There are several ways to do this. Murray et al. (2017) suggest three approaches for reducing emissions uncertainty in a carbon tax: (1) tax rate adjustments, either predetermined or through future congressional action; (2) the use of regulatory authority as a backstop to the carbon tax; and (3) the use of carbon tax proceeds to finance reductions in emissions (either emissions covered by the carbon tax or emissions in sectors not subject to the carbon tax). Aldy (2017) suggests a streamlined Congressional approach to update tax schedules. Given the difficulties in getting Congress to act on *any* tax legislation, much less a carbon tax, a hybrid approach that does not require explicit Congressional action seems desirable. That is my focus here.

In Metcalf (2009), I sketched out an initial way to construct a carbon tax to achieve emission reduction goals. I followed that up in Metcalf (2020) with a more detailed proposal for a U.S. Emissions Assurance Mechanism (EAM) to include as part of carbon tax legislation. The proposal calls for a carbon tax to include language to:

- set an emissions reduction target relative to some baseline over a fifteen year control period;
- include a streamlined process for setting subsequent targets;
- set a tax rate schedule for the control period that automatically adjusts if emissions are not on target to hit the fifteen year emissions reduction target; and
- establish a clear reporting process to provide transparency to firms and individuals as to the likelihood of a change in the tax rate schedule.

The EAM proposal in Metcalf (2020) creates a target emission reduction focusing on *cumulative* emission reductions relative to the baseline over the fifteen year period. This reflects the fact that greenhouse gas emissions are a stock rather than a flow pollutant. Having a target based on a particular

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hybrid cap and trade instruments is extensive. See Hepburn (2006) for a review and Burtraw and Keyes (2018) for an argument for including price floors when price ceilings are contemplated.

future year means many different emission pathways with different cumulative emissions could be consistent with that target. An example illustrates the approach. Let's say a target of achieving a 60 percent reduction in emissions by 2040 from 2005 levels was set with the controls to begin in 2025. Target emissions along the pathway would decline annually at a constant percentage reduction from the first-year level such that emissions achieve the goal of being 60 percent below 2005 emissions in 2040.

While the emissions pathway is described in terms of annual emissions that achieve a given long-term goal (e.g., a 60 percent reduction in emissions by 2040 relative to 2005), the proposed tax rate adjustment mechanism would be triggered by comparing cumulative emissions since implementation of the tax with cumulative emissions along the emissions pathway. Basing the tax rate adjustment trigger on cumulative emissions has several advantages over a trigger based on emissions in a single year (or an average of a few years). First, as noted above, basing the trigger on cumulative emissions reflects the scientific reality that greenhouse gases accumulate in the atmosphere and persist for hundreds of years; thus, it is cumulative emissions that matter for climate damages rather than emissions in any particular year. Second, basing the trigger on cumulative emissions allows for policy flexibility. For example, if emissions fall more rapidly than expected in early years but less rapidly in later years, as long as *cumulative* emissions do not increase, the policy will not overcorrect by pushing the tax rate up. Third, a trigger based on cumulative emissions will be less sensitive to fluctuations in the business cycle, thus providing price stability, an important consideration for the business community. This also improves the ability of businesses to predict future tax rates, which helps as they plan for long-lived energy investments. Fourth, greater price stability provides a clear signal for firms engaged in the research and development of new carbon-free technologies. The more certainty there is about future carbon prices, the more likely it is for innovation to occur that will accelerate the transformation to a carbon-free economy.

If emissions along the pathway do not exceed the cumulative amount along the pathway, the carbon tax rate rises at a pre-determined annual rate (say, 3 percent real). If, however, the emission reductions lag the pathway, the tax rate automatically increments annually at a higher rate, say, 10 to 15 percent). This continues until cumulative emissions catch up with the pathway cumulative emissions at which point the tax rate annually increments at the lower, standard rate. A provision could also be added to freeze the tax rate (in real terms) if cumulative emissions fall below the pathway cumulative emissions by a given amount.

While this approach does not guarantee an emission reduction target is hit, it provides some assurance that the target will be met. It may seem that an *assurance* of emission reductions is weaker than a hard cap in a cap and trade program, but even a cap and trade program with no price ceilings is subject to the ultimate safety valve mechanism – legislative action to loosen the cap is allowance prices rise to politically unsustainable levels.

In my 2020 paper, I sketched out a framework for achieving a 45 percent reduction in emissions by 2035. Hafstead and Williams (2020) present simulations from a model that suggests that the probability of achieving the 2035 cumulative emission reduction target increases from 58 percent (assuming a five percent (real) annual carbon tax rate increment) to 69 percent when the EAM is included.

The notion of an automatic rate adjustment is not that far-fetched. Switzerland has such a mechanism. Sopher and Mansell (2013) describe the Swiss carbon tax law, which contains an automatic tax rate adjustment based on environmental factors. An emissions target provision was added in 2011, whereby if emissions in 2012 exceeded 79 percent of 1990 emissions, the tax rate would increase to sixty Swiss Francs (CHF) starting on January 1, 2014.[9] Emissions did, in fact, exceed the target and the

[9] *Ordonnance sur la Reduction des Emissions de CO_2,* Le Conseil Federal Suisse, enacted on December 23, 2011 (RS 641.71) accessed Sept. 14, 2018.

tax rate was increased. Subsequent tax rate increases in 2016 and 2018 were also based on emission targets. The Swiss law is not impervious to politics. In June 2021, voters narrowly rejected a plan to increase the tax rate from CF 120 ($134) per metric ton to CF 210 ($234) per metric ton (Bosley, 2021).

Recent U.S. legislative proposals also include automatic rate adjustment mechanisms. The American Opportunity Carbon Fee Act of 2019 (S. 1128), for example, includes a long run emissions reduction target and requires that the tax rate rise at 6 percent (over inflation) annually until emissions fall to 80 percent below 2005 levels, at which point the tax rate would remain constant in real terms. Metcalf (2020) lists other legislation that includes some form or automatic rate adjustment.

Whether it is political attractive or not, the simple point here is that just as one can add carbon tax elements to a cap and trade program to control prices, one can add cap and trade elements to a carbon tax to provide greater assurance of hitting desired emission reduction targets. That being the case, a carbon tax can be made to support political commitments to emission reduction goals that emerge from, for example, international climate negotiations.

VI. Myth 5: Carbon pricing is regressive

Carbon pricing is, to a large extent, a tax on energy consumption. It has long been understood that energy consumption is a good with an income elasticity less than one (i.e., energy is a necessity good). With an income elasticity below one, the share of expenditures on energy falls as household income rises. Thus, the logic goes, carbon pricing is regressive since it raises the cost of energy which is a higher share of household budgets for low-income households.[10] This statement by an environmental justice group in the state of Washington opposing a state-level carbon price is emblematic of this

[10] A tax is regressive if the share of the tax in household income (or some other measure of household well-being) falls with income. Conversely, it is progressive if the tax share rises with household income.

viewpoint: " Carbon taxes, like sales taxes, are regressive and require financial mitigation for people with lower incomes."[11]

What this ignores is the fact that taxes have impacts on household income sources (wages, transfers, and capital income). Economists refer to the former as “uses side impacts” and the latter as “sources side impacts.” It is well understood that that a tax reform’s burden cannot be allocated to the sources and uses side in percentage terms (e.g. one-quarter of the burden is due to source side effects) since the burden share is entirely dependent on the choice of the numeraire good. But we can decompose the distributional impacts of a tax reform into source and use side influences. For example, an energy tax might be progressive with highly regressive use side effects offset by progressive source side effects.

Rausch et al. (2011) provide an example of a decomposition by analyzing a carbon pricing policy where the revenue from the policy is distributed in a way that does not enter household utility.[12] They measure source side impacts by running counterfactual simulations where all households are assumed to have the same pattern of consumption spending regardless of income. Conversely, they measure use side impacts by running counterfactual simulations where all households are assumed to have the same shares of factor incomes regardless of the level of their income. In this section, I provide a theoretical framework to justify their approach.

A. Model Setup

Assume people (indexed by *k*) derive utility from goods (X_i) and earn income by supplying factors of production (Y_j) which, while serving as sources of income, provide disutility. They may also

[11] See https://frontandcentered.org/just-transition-not-cap-trade-will-advance-climate-justice/ accessed on Oct. 14, 2022.

[12] They do this to isolate the impacts of the carbon pricing from the use of the revenue. In what follows, I don’t restrict the use of revenue in this way.

receive some lump sum transfer (positive or negative) from the government (T). For person *k* their optimization problem is to maximize utility subject to a budget constraint:

$$\max_{X_i^k, Y_j^k} U^k\left(X_i^k, Y_j^k\right)$$

subject to

$$\sum_i p_i X_i^k \leq \sum_j w_j Y_j^k + T^k.$$

B. Tax Reform

A tax reform, such as the implementation of a carbon tax, would lead to a general equilibrium adjustment in all prices and, possibly, the level of lump-sum income. This leads to a change in utility for person *k* as follows:

$$dU^k = \sum_i \frac{\partial U^k}{\partial X_i} dX_i^k + \sum_j \frac{\partial U^k}{\partial Y_j} dY_j^k. \tag{2}$$

Let λ^k represent the marginal utility of (exogenous) income. Given individual utility maximizing behavior, I can rewrite equation (1) as

$$dW^k \equiv \frac{dU^k}{\lambda^k} = \sum_i p_i dX_i^k - \sum_j w_j dY_j^k. \tag{3}$$

Equation (3) denominates the change in utility in dollar terms and can be thought of as a measure of either equivalent or compensating variation (for small changes). While most tax reforms involve discrete rather than marginal changes, equation (3) still serves to make the conceptual point about distributional impacts on the sources versus uses side.

Assuming the individual budget constraints hold as equalities, we can totally differentiate this constraint to obtain:

$$(4) \qquad \sum_i p_i dX_i^k + \sum_i dp_i X_i^k = \sum_j w_j dY_j^k + \sum_j dw_j Y_j^k + dT^k.$$

Substituting equation (4) into equation (3) yields

$$(5) \qquad dW^k = \sum_j dw_j Y_j^k - \sum_i dp_i X_i^k + dT^k.$$

The general equilibrium model will include a government budget constraint and some characterization of production. Here I assume no change in real government demand and assume all firms operate under conditions of zero profits.

Before proceeding, I want to rewrite the change in welfare as the change per dollar of income, $M^k = \sum_j w_j Y_j^k + T^k$.

$$(6) \qquad \frac{dW^k}{M^k} = \sum_j \frac{dw_j Y_j^k}{M^k} - \sum_i \frac{dp_i X_i^k}{M^k} + \frac{dT^k}{M^k}.$$

Define $\sigma_i^k = \frac{p_i X_i^k}{M^k}$, the expenditure share for person *k* on good *i*, and $\omega_j^k = \frac{w_j Y_j^k}{M^k}$, the share of income for person *k* from factor *j*. Finally, let a hat (^) over a variable indicate a percentage change. Then equation (6) becomes

$$(7) \qquad \frac{dW^k}{M_k} = \sum_j \widehat{w}_j \omega_j^k - \sum_i \hat{p}_i \sigma_i^k + \hat{\psi}^k$$

where $\hat{\psi}^k = \frac{dT^k}{M^k}$ is the percentage change in income due to the change in lump sum transfer.

The welfare impact of the tax reform per dollar of income depends on the change in factor prices weighted by the relative importance of the various factor income sources in person *k*'s income plus any change in lump sum transfers less the change in consumer prices weighted by person *k*'s expenditure shares.

C. Distributional Impacts on the Sources and Uses Side

Rausch et al. measure the distributional impact of a cap and trade program through a two-pronged counterfactual exercise. First they isolate the sources side impact by modeling households as having equal expenditure shares for all goods. Define $\bar{\sigma}_i$ as that equal expenditure share for good *i* such that

$$\sum_k \bar{\sigma}_i M^k = \sum_k \sigma_i^k M^k, \tag{8}$$

or

$$\bar{\sigma}_i = \sum_k \mu^k \sigma_i^k \;, \qquad \mu^k = \frac{M^k}{\sum_k M^k}. \tag{9}$$

The parameter $\bar{\sigma}_i$ is defined such that total expenditures on good *i* are the same with this constant expenditure share is with observed expenditure shares. The parameter is a weighted average of individual expenditure shares with weights equal to the share of household *k*'s income in total income.

The sources side distributional impact then is

$$\left.\frac{dW^k}{M_k}\right|_S = \sum_j \omega_j^k \widehat{w}_j - \sum_i \hat{p}_i \bar{\sigma}_i + \hat{\psi}^k. \tag{10}$$

All variation across households is due to differences in factor income shares and lump sum transfers.

Similarly, they isolate uses side impacts by modeling households to have identical factor income shares for all factors. Define $\bar{\omega}_j$ such that total factor income for the j^{th} factor is the same as with observed factor income shares:

$$\bar{\omega}_j = \sum_k \mu^k \omega_j^k \tag{11}$$

and assume zero lump sum transfers. Use side income impacts are now given by:

$$\left.\frac{dW^k}{M_k}\right|_U = \sum_j \bar{\omega}_j \widehat{w}_j - \sum_i \sigma_i^k \hat{p}_i. \tag{12}$$

Now all variation across households is due to differences in expenditure shares.

While this is simply a counterfactual analysis to capture the distributional impacts arising from changes in factor prices and lump sum transfers on the one hand (sources) and from changes in consumer prices on the other hand (uses), this imaginary counterfactual can be tied directly to the overall welfare impact of the policy change which is:

$$\frac{dW^k}{M_k} = \left.\frac{dW^k}{M_k}\right|_S + \left.\frac{dW^k}{M_k}\right|_U + \sum_i \hat{p}_i \bar{\sigma}_i - \sum_j \widehat{w}_j \bar{\omega}_j \tag{13}$$

The change in welfare per dollar of income is the sum of the sources and uses side burden defined above adjusted by an overall price change. Since that is constant for all households, these latter terms can be ignored for purposes of understanding the distributional impacts of the policy change.

This welfare decomposition suggests a natural price normalization for the general equilibrium:

$$\sum_i \hat{p}_i \bar{\sigma}_i - \sum_j \widehat{w}_j \bar{\omega}_j = 0 \tag{14}$$

in which case the welfare change per dollar of income neatly and completely decomposes into sources and uses impacts. Equation (14) says that the average real price level serves as the numeraire for the general equilibrium model. To be clear, the choice of numeraire is arbitrary, but choosing the average real price level as the numeraire allows for this natural and intuitive decomposition of the welfare impact into sources and uses contributions.[13]

D. Empirical Findings

Rausch et al. (2011) combine detailed microlevel data form the Consumer Expenditure Survey with a general equilibrium model of the economy to assess the distributional impact of carbon pricing. Specifically, they consider a \$20 per ton CO_2 carbon price (either a cap and trade system with fully-auctioned allowances or a carbon tax) with carbon revenues returned through one of three approaches: 1) equal percentage decreases in marginal personal income tax rates; 2) equal per capita lump sum rebates to households; or 3) lump sum transfers to households proportional to capital income. This approach is an effort to capture the impact of free distribution of allowances to firms under the assumption that the value of the allowances accrues to shareholders.[14] For their decomposition of source and use side effects described above, they assume the carbon pricing revenue is used in ways that don't enter household utility functions. Figure 1 below from their paper illustrates the point that carbon pricing appears to be roughly proportional with source side effects offsetting use side effects.

While the regressive nature of use-side impacts has been long understood (see, for example, Bull et al. (1994)), researchers were slower to focus on the source-side impacts. The regressive nature of source-side impacts for carbon pricing in the United States are driven by two forces. First, the capital to labor factor income share falls with carbon pricing. Second, Rausch et al. assume that transfer programs are held fixed in real terms. Transfer income is a higher share of income for lower income

[13] Rausch et al. choose the overall price level as the numeraire. Goulder, et al. (2019) choose the least carbon intensive good (financial services and insurance) as the numeraire.
[14] It also assumes that ownership of firms receiving allowances follows the same distribution as the more general distribution of capital. Smale et al. (2006) present evidence that the profits of five energy intensive sectors rise following the imposition of the EU-ETS with free allowance allocation.

households. Thus, transfers relative to wage and capital income rise and so benefit lower income households disproportionately.[15]

Goulder, et al. (2019) bear out the earlier findings by Rausch, et al. Using a computable general equilibrium model (the E3 model), they consider a carbon tax starting at $40 per metric ton of CO_2 that rises in real terms at a 2 percent annual rate. They consider four scenarios for rebating the revenue: 1) lump-sum rebates; 2) payroll tax cuts; 3) individual income tax cuts; or 4) corporate income tax cuts. However the revenue is rebated, the use side impacts are regressive. Source side impacts are progressive with the exception of the scenario where revenue is returned through corporate income tax reductions. Combining the source and use side effects, they find that the carbon tax is generally progressive unless the revenue is rebated through reductions in the corporate income tax in which case the tax is essentially proportional.

This analysis has focused on the burden of a carbon tax across income groups. Other distributional framing may be relevant for the political economy of carbon pricing. The geographic burden of the tax certainly matters in the United States. Rausch et al. show that the tax disproportionally burdens the central part of the country with lower impact on the East and West Coast states. They also find slightly higher burdens on Blacks than Whites and on Hispanics relative to other groups. The differences for Blacks households are driven by differences in spending patterns while the difference for Hispanics is driven more by lower shares of transfer income.

The results in Rausch, et al. are confirmed in more recent work by García-Muros et al. (2022) who redo the Rausch, et al analysis with more recent Consumer Expenditure Survey data and an updated version of the USREP CGE model used originally by Rausch et al. The newer paper also explores

[15] Fullerton et al. (2011) assess six major U.S. cash transfer programs and conclude that transfers in the U.S. (as of 2011) are partially indexed. Based on the programs assessed in their paper, nearly 95 percent of transfers were indexed as of that date. Social Security and Supplemental Security Income (SSI) dominated transfers then and continue to dominate today. Thus the view that transfers are (nearly) fully indexed in the United States is still a reasonable view. This is also confirmed by Goulder, et al. (2019).

additional revenue rebate approaches designed to mitigate adverse distributional impacts on lower income households. Their paper makes the useful point that there are a variety of rebate programs that can be used to return carbon pricing revenue beyond the standard approaches of per capita (or per household) lump sum transfers and uniform percentage tax rate reductions.

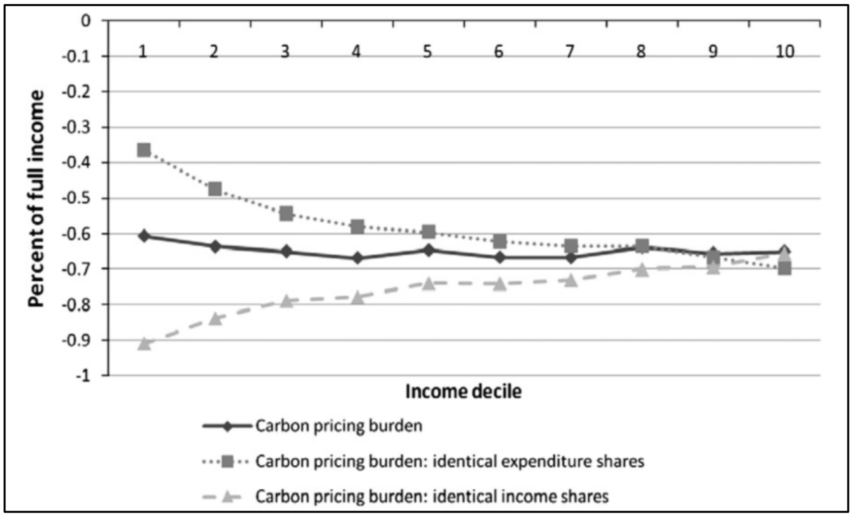
Summing up, the conventional view that a carbon tax is regressive needs to be re-examined given the importance of source-side impacts. Analyses focusing on a U.S. carbon tax suggest the tax would be progressive even before considering how to rebate the revenue. Revenue recycling through household rebates or spending that is targeted to low income and minority communities would enhance the progressivity significantly. More research is needed to understand the source-side impacts in other developed and developing countries.

VII. Conclusion

While countries and sub-national jurisdictions are increasingly turning to carbon pricing, as documented in World Bank Group (2021), it still the case that just one-fifth of global emissions are subject to carbon pricing. We have a long way to go. While the technological barriers to clean energy are falling, significant political hurdles to mitigation policies remain. This paper notes and addresses five myths about carbon taxes and provides both theoretical and empirical support for the view that carbon taxes are not growth and job killers nor need they be inherently regressive. It is important for economists to speak clearly about what we know and don't know about carbon pricing in general and carbon taxes in particular. Only then can we focus on the true political obstacles to enacting meaningful carbon pricing policies.

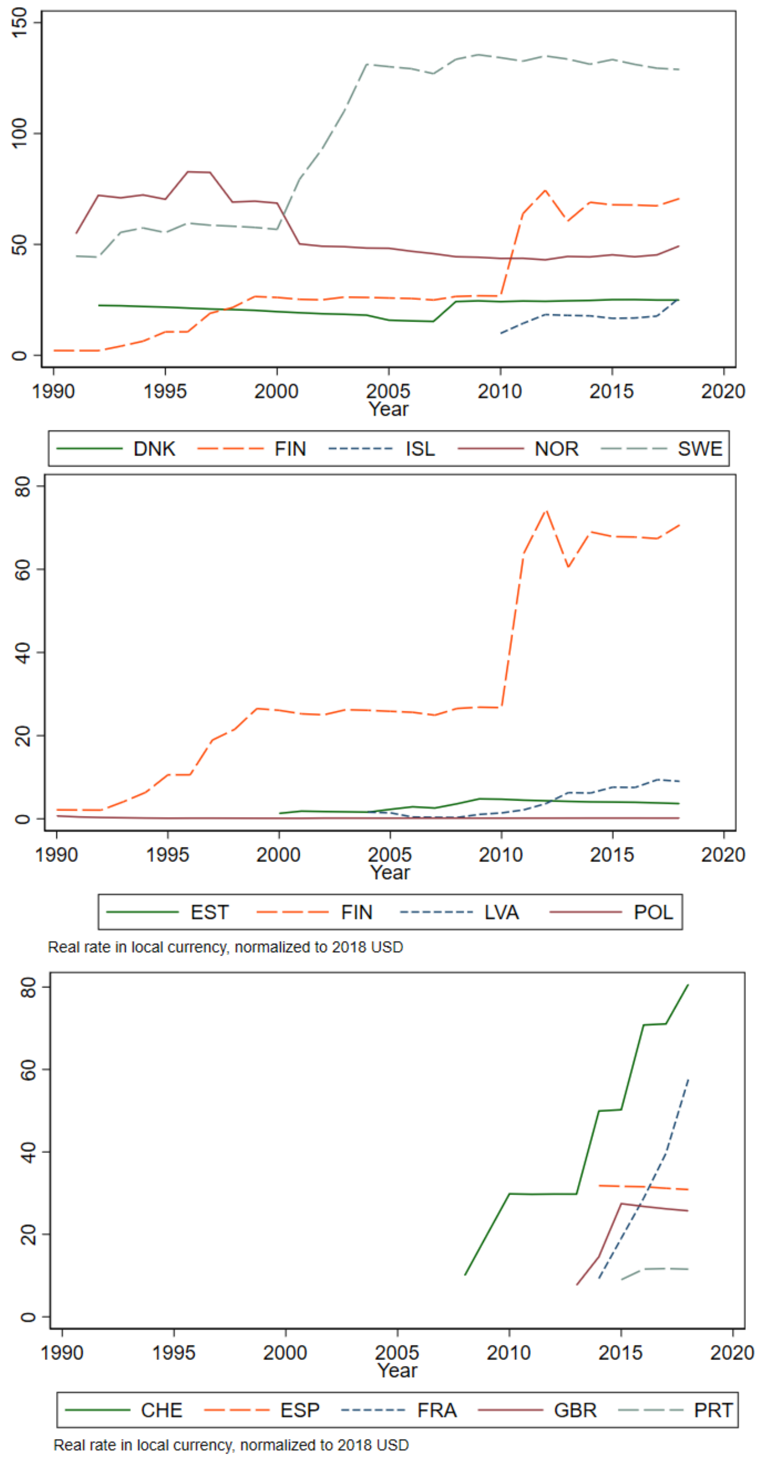
The political obstacles to carbon pricing should not be underestimated. Capital investments in fossil fuel infrastructure will become increasingly stranded assets with effective climate policy. Jobs in the coal, oil, and gas sectors will be lost. While the risk of stranded assets for capital owners is increasingly priced into those assets, suggesting little need for compensation for those assets, meaningful transition policy for workers in these sectors will be important both from a political economy perspective as well as an environmental justice perspective. By dispelling the five myths addressed in this paper, we can focus on the important work needed to decarbonize our economies.

Figure 1. Source and Use Side Effects of Carbon Pricing



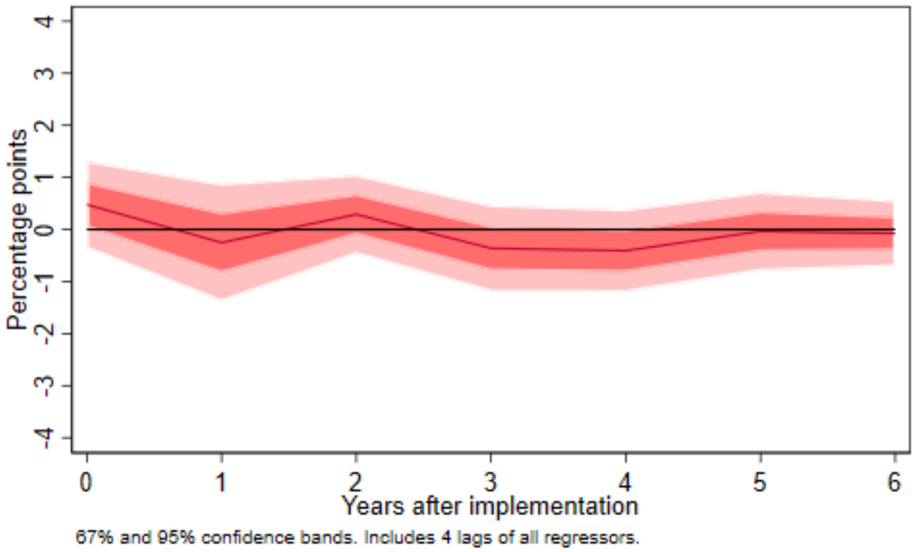
Source: Rausch, et al. (2011)

Figure 2. Real Carbon Tax Rates Over Time



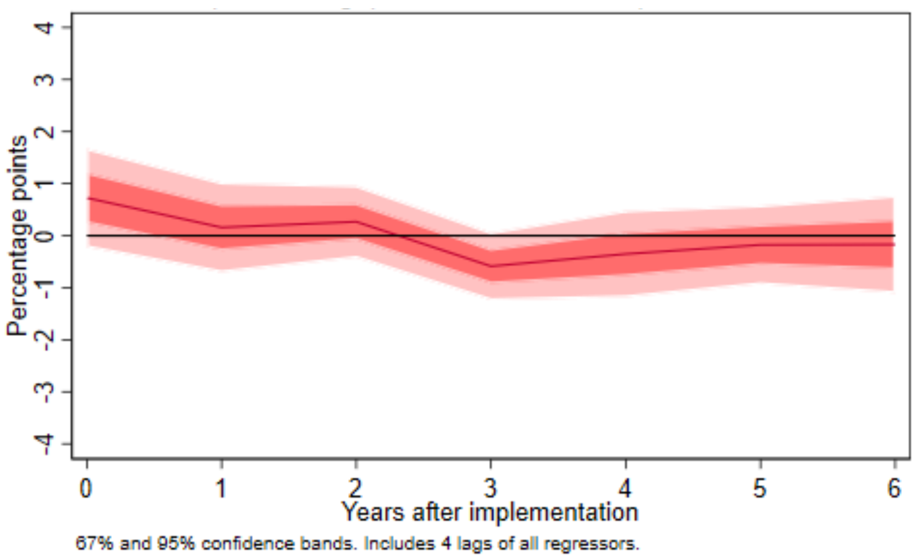
Source: Metcalf and Stock (forthcoming)

Figure 3. Carbon Tax Impact on GDP Growth



Source: Metcalf and Stock (forthcoming)

Figure 4. Carbon Tax Impact on GDP Growth for Large Carbon Tax Countries



Source: Metcalf and Stock (forthcoming)

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