INTERNAL CARBON PRICING: POLICY MAP, THEORETICAL MODELS, AND CASE STUDIES

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Executive Summary

Internal carbon pricing attempts to correct the incentive structure that underpins our consumption choices related to greenhouse gas emissions. Carbon pricing works to shift the social cost of carbon from increased health care costs and exacerbated environmental damage to the source of pollution. By doing so, it incentivizes emissions reductions and low carbon development.

Corporations can act collectively with governments towards the goal of decarbonization. Internal carbon pricing allows companies to assess the financial implications of their carbon emissions and encourage increased internal energy efficiency. To date, around 1,200 companies have reported implementing or planning to implement a carbon price to regulate their carbon emissions.

This study seeks to address the question of how an organization should design and implement an internal carbon charge. While policy guidance and tools exist for carbon pricing at the national level, it is not clear how implementation might differ for a business or other type of organization. Our project seeks to fill this gap in the carbon pricing literature, given the primacy of internal carbon charge programs in addressing the global climate externality.

To provide guidance on designing internal carbon charge programs, we provide three core contributions: (1) a policy map of key decisions; (2) a theoretical framework and putative model for evaluating a carbon charge program, and; (3) lessons learned from an examination of case studies on Yale University, Microsoft, Societe Generale, and Delta and Qantas Airlines in the context of our policy map. The latter two contributions support the operationalization of this policy map for companies, organizations, and policymakers.

Additionally, we posit that the secondary macroeconomic effects of paired taxes and investment subsidies, when considered as a single instrument, could prove cost effective for internalizing the two market failures associated with climate change: the global climate externality and the technology appropriability externality. Further work and thought, however, is necessary to properly frame this insight in the context of contemporary economic literature on this subject.

Introduction

Internal carbon pricing is a powerful tool by which the private sector can play a major role in reducing global carbon emissions. It allows companies to assess the financial implications of their carbon emissions and encourage increased internal energy efficiency.

CDP[1], formerly the "Carbon Disclosure Project," runs a global self-reported disclosure system for companies, cities, states and regions to measure their environmental impacts. Part of this disclosure includes questions regarding carbon pricing.

A recent CDP report outlines three major benefits of internal corporate carbon pricing: navigating regulation, sourcing requirements, and carbon efficiency.[2] First, companies that track their greenhouse gas emissions and implement an internal price on carbon are better prepared for a regulatory future in which carbon is priced. Second, given the global patchwork of existing carbon emissions regulations, companies that sell, source, or operate internationally are inevitably exposed to carbon pricing standards. For a company that operates or intends to operate globally, it is advantageous to start calculating, tracking, and pricing emissions to ease operation across this myriad of international pricing policies. Third, carbon pricing motivates innovation and efficiency improvements, provides a new lens for capital investment decisions, and spurs carbon-efficient technologies. Carbon pricing makes emissions-intensive business practices more costly, nudging companies to avoid them. In addition to the direct benefits from carbon pricing, investors are starting to prioritize companies that are leaders in corporate sustainability, including carbon pricing, and are increasingly investing in such companies.

To date, around 1,200 companies have reported implementing or planning to implement a carbon price to regulate their carbon emissions. Of those companies, about 520 are utilizing an internal carbon price as an accounting and risk management tool while around 150 use internal carbon pricing as a means to achieve specific climate targets.[3] Most of the current activity around internal carbon pricing occurs in Europe, Japan, Korea, Australia, and the United States. These figures indicate that research into the design of internal carbon pricing programs is currently very globally relevant, and will only continue to be more relevant in the near future.

Not all carbon pricing schemes are alike, and the implementation of a carbon pricing policy requires decisions regarding revenue neutrality, information provision, incentive structures, carbon emissions calculations, carbon price, and many others. As the first university to implement a carbon charge, Yale piloted four carbon pricing schemes, each with their own advantages and disadvantages. Yale's experimentation with carbon pricing motivated this research into the policy tradeoffs associated with the design of an internal carbon charge.

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[1] https://www.cdp.net/en
[2] https://b8f65cb373b1b7b15feb-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/comfy/cms/files/files/000/000/284/original/business-case-for-carbon-pricing.pdf
[3] http://cbey.yale.edu/programs-research/internal-carbon-pricing-practical-experiences-from-the-private-sector

Research Questions and Methodology

Our overarching research question for the project is “how should organizations design and implement an internal carbon charge?”. While existing tools from the Organization for Economic Cooperation and Development, the World Bank Group, and others give policy guidance for carbon pricing at the national level, it is not clear how implementation might differ for a business or other type of organization[4]. Our project seeks to fill this gap in the carbon pricing literature, given the primacy of internal carbon charge programs in addressing the global climate externality.

To provide guidance on designing internal carbon charge programs, we provide three core contributions: (1) a policy map of key decisions; (2) a theoretical framework and putative model for evaluating a carbon charge program, and; (3) lessons learned from an examination of several case studies through our policy map.

Our policy map captures key decisions and trade-offs that organizations must make in the design and implementation of an internal carbon pricing program. We developed decision points and a framework for thinking about tradeoffs at these decision points with the Yale Carbon Charge Program. Our map highlights the levers available to companies to design an internal carbon charge program relevant to their needs.

The framework for thinking about tradeoffs in designing a carbon pricing scheme draws on the debate in academic literature around the secondary macroeconomic effects of a carbon tax. We offer as a contribution an analysis of the use of carbon tax revenues as a subsidy to reduce the appropriability market failure that leads to underinvestment in energy efficiency technology. Accompanying the theoretical framework are equations that determine how choices in our policy map would influence the overall reduction in carbon emissions, i.e. the effectiveness of an internal carbon charge program. The equations may thus be used to examine the pros and cons of each decision on the policy map.

Third, we examine four case studies (Yale University, Microsoft, Societe Generale, and Delta and Qantas Airlines) in the context of our policy map, and provide some lessons learned that can be useful as this policy map is operationalized for companies, organizations, and policymakers.

We also aim to touch on ancillary questions that may arise in the design of an institutional carbon charge, including what the goals of the program should be, the scope of emissions that should be included, and what price should be charged.

[4]The FASTER Principles for Successful Carbon Pricing: An approach based on initial experience, *Organization for Economic Cooperation and Development (OECD) and the World Bank Group (WBG)*, September, 2015.

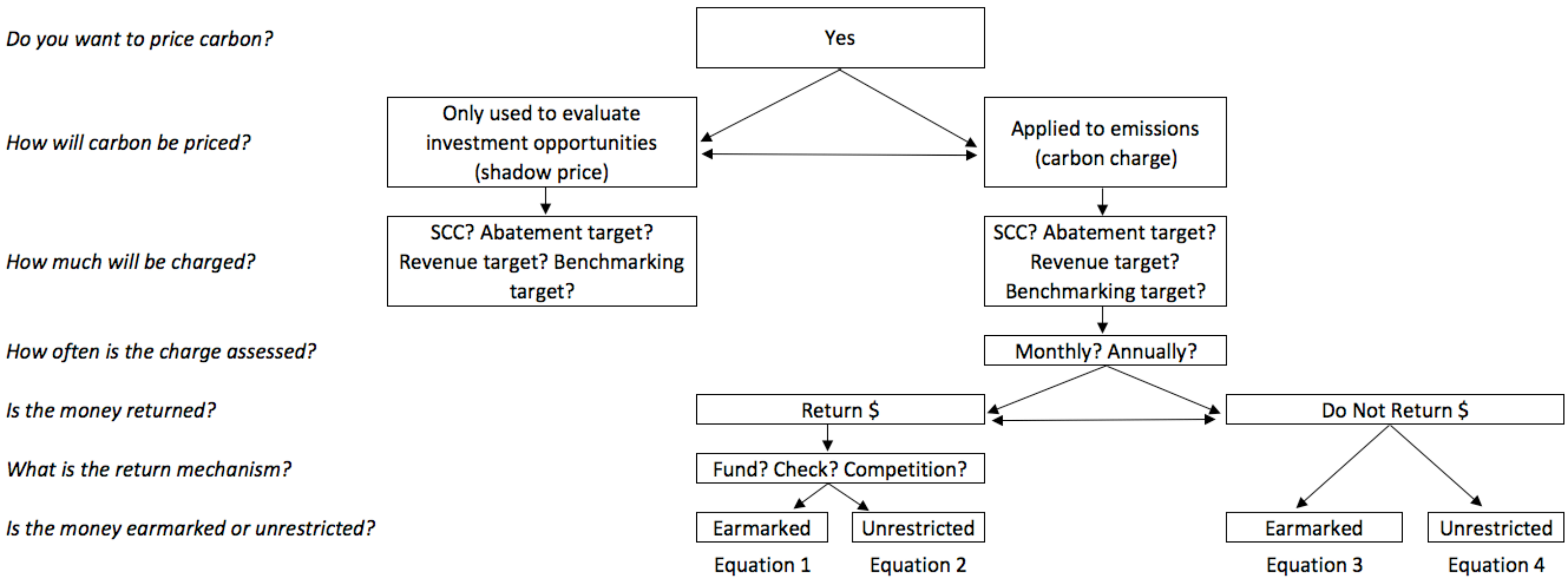

Figure 1: Internal Carbon Pricing Policy Map

Contribution 1: Policy Map

Policy maps are important tools in the iterative planning, implementation, and learning process involved in organizational decision making. Our map provides a reliable planning framework for market actors seeking to institute an internal carbon charge. For internal carbon pricing programs, a policy map presents the available questions and options a policymaker has to consider before making critical decisions on the design of the program. We designed the internal carbon pricing policy map as a set of questions ordered chronologically (Figure 1). This map lays the intellectual groundwork for other organizations and institutions to follow in Yale's footprints in designing and implementing their own carbon pricing program. The questions highlight various decisions organizations have to make, and tradeoffs associated with each decision. In this section, we provide qualitative assessments of the tradeoffs for each decision.

Should organizations price carbon internally?

Organizations are sensitive and responsive to costs and benefits, or risks and opportunities. Therefore, we have to identify the risks and opportunities of assigning an internal price for carbon within an organization to be able to answer this question.

Before we address the impacts of pricing carbon internally, it is very important to understand what an internal carbon price is. An internal carbon price is the value that an organization sets for themselves, voluntarily, to internalize the economic costs of their greenhouse gas (GHG) emissions. This value will drive the organization's plans and strategies towards low-carbon practices. In order to be effective, the objectives of the policy must be clearly defined and the price properly set. Ideally, the objective might include GHG emission mitigation, revenue generation, green development promotion or increased efficiency.

Climate change poses great challenges to businesses' activities and economic value[5]. As the world becomes increasingly concerned about impacts from climate change, companies face physical and regulatory risks which, in turn, will pose financial risks. Physical risks are the most evident as we experience floods and droughts, changes in ecosystems, changes in temperature, and climate change more broadly. Organizations can be directly affected by damages to assets, supply chains, scarcity of resources and raw materials, all of which have a direct impact on the economic and financial value of an organization. Regulatory risks, however, are highly uncertain. Although some countries have taken measures to reduce or limit GHG emissions, other countries are still debating the issue. Laws and regulations are also susceptible to change with new election cycles as we are currently witnessing in the US.

Mitigating potential impacts from climate change by instituting internal carbon pricing programs reduces or limits those risks. In addition, it can present new opportunities for organizations to potentially increase their economic value. Major benefits to a corporation of instituting an internal carbon charge include:

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[5] Internal carbon pricing: A growing corporate practice, *I4CE & EPE,* November, 2016, pp.10

- Preparing organizations for future regulatory carbon tax and new environmental laws.
- Providing competitive advantage in a low-carbon economy world.
- Reducing GHG emissions, when the price of carbon is set properly.
- Directing investment towards efficient practices and technologies.
- Incentivizing long term research and development opportunities for new cost effective and green innovations.
- Attracting environmentally aware investors and stakeholders[6].
- Positioning organizations as socially responsible.
- Contributing to long-term profits and returns by leading in environmental and social issues[7].

How will carbon be priced?

The two conventional methods of internal carbon pricing are carbon charges and shadow prices. Both options set an explicit price per ton of carbon emissions.

A carbon charge is a tax applied internally and voluntarily per ton of carbon emitted. The charge addresses short term goals and reduces emissions while also encouraging innovation for low carbon and low energy technologies in the long term. The charge, in this case, is collected by the responsible entity from all participants within an organization.

On the other hand, a shadow price internalizes the cost of carbon when making choices about capital investment and in estimating life-cycle costs. Investments include but are not limited to research and development, infrastructure, equipment, financial assets, and others. A shadow price is a theoretical value that is assigned to a targeted investment but is not actually implemented or charged to correspond to the life-cycle environmental and financial costs of the project or equipment. The goal of such a shadow price is to incorporate the impact of the cost of carbon on the organization's strategy and return on investment. The shadow price addresses long term strategies for future emissions and influences decision-maker to invest in energy efficient infrastructure and practices. However, it does not change or address current emissions.

How much will be charged?

Another key consideration for any carbon pricing program is the price at which the cost of carbon is set. An extremely high charge creates economic burdens for internal business units within an organization and makes it difficult for the program to be approved. On the other hand, a very low charge will not have as great an impact as it would be cheaper for business units to pay such a charge without changing current operations or reducing consumption. Thus, the charge needs to be high enough to be adopted by the decision-maker and also to motivate

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[6] Eccles, Robert G., George Serafeim, and Michael P. Krzus. "Market interest in nonfinancial information." *Journal of Applied Corporate Finance* 23.4 (2011): 113-127.
[7] Khan, Mozaffar, George Serafeim, and Aaron Yoon. "Corporate sustainability: First evidence on materiality." *The Accounting Review* 91.6 (2016): 1697-1724.

employees and business units to change their practices in order to reduce emissions.

One answer to this question is to use the social cost of carbon (SCC) for the country in which the organization operates. The SCC is calculated using various discount rates and is considered to be the social cost at which the externality is fully internalized.

If an organization instead elects to calculate its own price, three steps are recommended:

- Measure current and/or historical emissions and build a GHG inventory.
- Define the emissions reduction targets and time period.
- Set the price based on the GHG inventory so that it materially affects investment and practices and incentivize behavioral change to achieve the desired targets.

Once the price is set, it is recommended that it increases overtime. This is because a fixed price can potentially dull the incentives overtime. The SCC is usually revisited and adjusted as the integrated assessment models (IAMs) used are updated to more accurately estimate future damages based on increased CO_2 concentrations and resultant trend changes. For charges privately set by organizations, they should be changed as new reduction and ambitious targets are defined. This will encourage the organization to reduce emissions in the short term and incentivize energy efficiency investments and innovations for the long term to achieve sustainable practices.

Shadow prices and carbon charges may seem mutually exclusive. However, both can be employed simultaneously and, in some cases, the price of carbon for each method may differ. There are opportunities to price the carbon cost of investments differently than one would charge for carbon emissions. Perhaps this involves a graduated carbon charge for future investments that represents a different discounting scheme or risk analysis. The assumption is that these investments will be completed within a time frame in the future where the carbon prices are expected to be higher.

How often is the charge assessed?

Once the price of the internal carbon charge is set, the frequency at which the charge will be assessed and collected must be determined. The frequency of assessment and collection will depend on each organization’s structure, activity and industry. The ultimate goal is to maintain a frequency at which the incentives for behavioral change still apply. Ideally, organizations should begin with a pilot program to test and assess the responses and results of different schemes. For example, one could choose two approaches; monthly and annually assessments of the charge. The initial results from such a pilot will indicate the best practices in terms of emissions reduction and behavioral change. Initial results should also include tools and guidelines for future strategies, as well as plans and policies that would help achieve the defined targets for emission reduction.

Is the money returned?

Each organization will have to decide what to do with the fee once it is collected. The two basic options on the map are whether an organization elects to return or keep the revenue. Organizations may also choose to return only a portion of the revenue and keep the remaining portion. Ultimately, the decision should always incentivize continued abatement. From the organization's perspective, the easiest option in the short term is to keep the revenue. This will cut the administrative cost of designing a mechanism for returns. It may not, however, achieve the goal of continued abatement.

On the other hand, dividends, in terms of stocks, are fractions of profits paid back to shareholders, which exist as part of an incentive structure for investments. Similarly, dividends, or returns, from a carbon tax should be set up as an incentive for carbon emission abatement. Therefore, the decision regarding how revenue will be returned to units should be evaluated in terms of its power to incentivize emissions abatement.

What is the return mechanism?

Any level of return, whether in full or partial, should be designed in a way that best influences behavioral change and encourages emissions reduction. There are number of context-specific mechanisms that an organization can choose to implement to do this. As one example, returns could be awarded to the best and most efficient units within the organization to maintain the incentive. This particular approach introduces competition and rivalry between units and departments.

Another common example is to set a baseline to use for comparison with future improvements, or regressions. How the baseline is determined may have a heterogeneous impact on the marginal incentive for abatement by business units. The degree of memory loss built into the baseline determination impacts the timing of dividends returned to each business unit for a reduction in carbon. But a baseline with perfect memory loss makes the fee/dividend structure more volatile. It increases the risk of a fee levied after a particularly low-emission year. In deciding how to construct a baseline, organizations may consider how many years of previous emissions are used in generating the baseline. The baseline, like the charge, could continually move to push business units to perform better over time rather than allowing them to get below their baseline and become complacent there.

Is the money earmarked or unrestricted?

The collected charge has two main effects: the behavioral effect and the investment effect. The behavioral effect is the short-term impact of the charge that would encourage employees, units and the firm to reduce energy consumption and abate emissions. In contrast, the investment effect is the long-term impact and is partially dependent on the returns. Whether the revenues are returned or not, the option for the firm and the units in each case is to have an unrestricted or earmarked account.

The unrestricted account essentially grants the decision-maker the freedom to handle any revenue from the carbon pricing program. Since often only scope 1 and scope 2 emissions are included in a carbon charge program, returning revenue as unrestricted cash may be an avenue for leakage whereby the revenue collected from carbon emissions reductions is used to purchase travel or materials that are more carbon intensive and are outside of the purview of the carbon charge itself. Instead, the carbon charge program should be designed so that there remains an incentive to continue to abate.

The earmarked account, however, is dedicated towards funds or efficiency projects that would guarantee additional abatement and help units or firms adapt. These projects should be pre-evaluated to show expected performance and to demonstrate how significantly they would help achieve the defined target. Equations 1-4 depict the difference between unrestricted and earmarked accounts in terms of emissions reductions (Figure 1).

Contribution 2: Theoretical Framework and Models

The policy map provides different decision points and tradeoffs that companies face. Outcome variables, in tandem with the policy map, would help companies set targets for their internal carbon pricing schemes and align their targets with the policy decisions they make. We present the outcome variables and accompanying equations in the context of a theoretical framework that addresses the secondary macroeconomic effects of a carbon tax.

There has been much debate around whether a carbon tax nationally provides secondary benefits apart from a reduction in carbon emissions. Goulder (1995)[8] first outlined the possibility of a double dividend, where returning carbon tax revenues by lowering other distortionary taxes in the economy would increase non-environmental well-being, independent of any environmental benefits of the tax. Since then, others, including Goulder (1998)[9] and Parry and Oates (2000)[10] demonstrate the tax interaction effect, where a carbon tax is seen as effectively a tax on a factor of production and hence increases existing tax distortions in the economy. These debates have sometimes occurred in the context of comparing different policy instruments for climate change, such as the tax versus cap and trade debate (Goulder and Schein, 2013)[11]. Recent work has suggested that whether the double dividend or tax interaction dominates depends on the specific circumstances that underlie the situation in which the carbon

[8] Goulder, L. H. (1995). Environmental taxation and the double dividend: a reader's guide. *International tax and public finance*, *2*(2), 157-183.
[9] Goulder, L. H. (1998). Environmental policy making in a second-best setting. *Journal of Applied Economics*, *1*(2), 279-328.
[10] Parry, I. W., & Oates, W. E. (2000). Policy analysis in the presence of distorting taxes. *Journal of policy Analysis and Management*, 603-613.
[11] Goulder, L. H., & Schein, A. R. (2013). Carbon taxes versus cap and trade: a critical review. *Climate Change Economics*, *4*(03), 1350010.

tax is implemented Goulder (2013)[12].

Little attention has been paid to the effects of using carbon tax revenues for policies that address other environmental market failures. Examples include subsidies for the appropriability market failure in energy efficiency investments and the underinvestment in R&D for green technologies such as improved solar PV cells[13]. There is an inter-temporal feedback of such policies on the quantity of energy consumed or the amount of emissions per energy consumed respectively. Thus, it might be insightful to examine the interdependence of the carbon tax and the subsequent policy implemented, rather than treat them as two separate policy instruments. Kolstad (2011)[14] acknowledges the link between these two market failures, but in terms of incentives for induced innovation rather than through potential uses of carbon tax revenues to subsidize innovation. Figure 2 below illustrates our core theoretical idea.

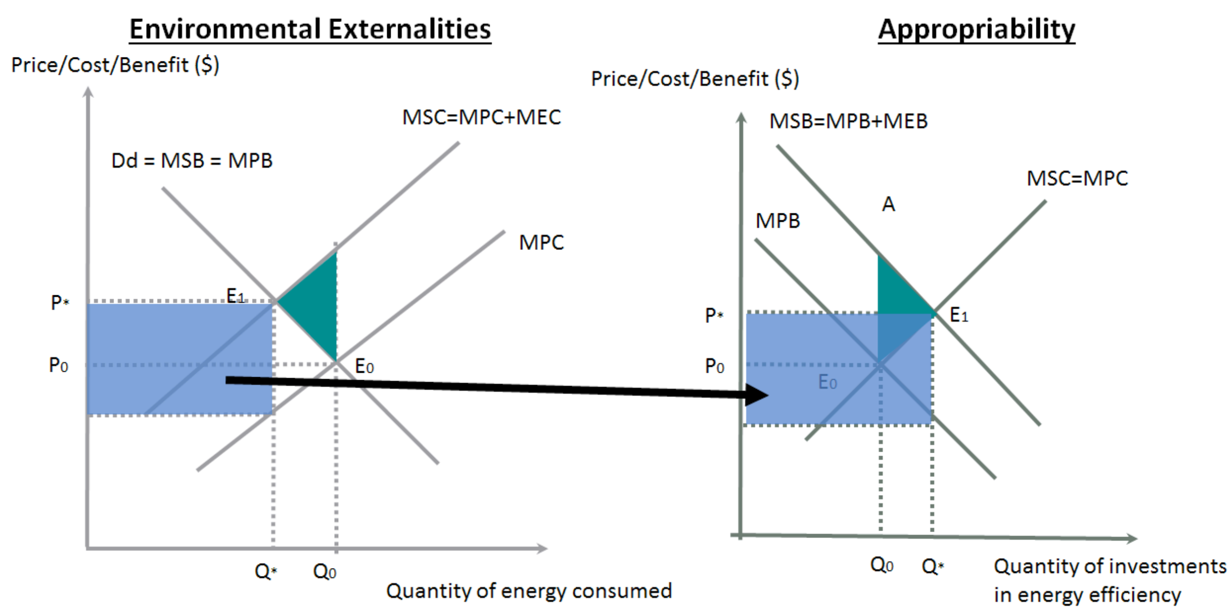

Figure 2: Using carbon tax revenues to address the appropriability market failure

The graph on the left is the classic theoretical diagram for negative externalities. Ideally, governments or companies should set a carbon tax equal to the marginal external costs of energy consumption, to force consumers or units to internalize all the external costs associated with energy consumption. Assuming this ideal scenario, quantity of energy consumed will decrease from Q_0 to Q* and the tax revenue collected would be equal to the blue box. Given that there is another externality: a positive externality in terms of appropriability of investments in energy efficiency or research and development in green technologies, these revenues may

[12] Goulder, L. H. (2013). Climate change policies interactions with the tax system. *Energy Economics*, *40*, S3-S11.
[13] Jaffe, A. B., Newell, R. G., & Stavins, R. N. (2005). A tale of two market failures: Technology and environmental policy. *Ecological economics*, *54*(2), 164-174.
[14] Kolstad, C. D. (2010). *Regulatory choice with pollution and innovation* (No. w16303). National Bureau of Economic Research.

be used as subsidies. Should the amount correspond perfectly, the subsidies would allow consumers or units to internalize the external benefits of energy efficiency investments. This causes an increase in energy efficiency investments from Q_0 to Q*. These investments low the quantity of energy consumed in future time periods, resulting in further carbon emission reductions.

Thus, using carbon tax revenues to subsidize other externalities such as appropriability would provide additional environmental and social benefits that may or may not be greater than the benefits of reducing other distortionary taxes. However, there has yet to be a comparison of the effectiveness of different uses of carbon tax revenues in the context of optimal tax theory, beyond reducing other distortionary taxes or returning the revenues lump-sum. Goulder (2013) examines whether carbon taxes are a more efficient revenue-raising mechanism for governments as compared to other revenue sources, but simply concludes that the environmental gain from green taxes is essential for green taxes to be less costly than other forms of general taxes. We think that a comparison of different uses of carbon tax revenues can provide new perspectives to the debate on double dividend versus tax interaction, as well as perhaps carbon tax versus cap-and-trade.

Relevance for internal carbon pricing

While more details are required to make the theoretical contribution outlined above, our framework is particularly relevant for internal carbon pricing. When companies set internal carbon pricing schemes, they do not face the macroeconomic effects of revenue recycling or tax interaction as discussed in the current academic literature, so the use of carbon tax revenues for other policies become a central consideration. In particular, companies can choose to earmark these revenues for green investments within the company or externally, or return them to individual units or departments earmarked, such that the units themselves engage in these green investments. These tradeoffs have captured in our policy map above, and the equations in the next section show how each decision affect total emission reductions.

Modeling Responses to Carbon Pricing Schemes through equations

To understand how different carbon pricing schemes might impact emissions reductions we explore four different schemes identified on the policy map and cast the emissions reductions, our outcome variable, as equations.

Let

$\Delta C_{i,t}$	: change in carbon emissions by unit i in period t	(tonnes CO_2e)
β_i	: carbon intensity of energy consumption for unit i	(tonnes CO_2e / mmBTU)
$\Delta Q_{i,t}$	: change in energy consumption in period t	(mmBTU)
$\psi_{i,t}$	: portion of fees collected returned to unit i	(dimensionless)
f	: carbon fee	($/ tonnes CO_2e)

$C_{i,t\text{-}1}$: carbon emissions unit i in period t-1 (tonnes CO_2e)

γ_i : carbon reduction rate per dollar invested (tonnes CO_2e / \$)

Models 1 and 2: Return, Earmarked and Return, Unrestricted

$$\Delta C_{i,t} = \beta_i \Delta Q_{i,t} + \psi_{i,t}\left(f \textstyle\sum_i C_{i,t\text{-}1}\right)\gamma_i \tag{1}$$

$$\Delta C_{i,t} = \beta_i \Delta Q_{i,t} \tag{2}$$

with dividend being zero if carbon emissions were negative; Return mechanism determines $\psi_{i,t}$

The change in carbon emissions in period t for business unit i in response to an internal carbon charge is given as the sum of the reduction in emissions due to a reduction in energy consumed and a reduction due to investment of earmarked funds collected in period t-1 and returned to the business unit.

The reduction in energy consumed, $\Delta Q_{i,t}$, is a behavioral response to the carbon price and represents the difference between energy consumed by business unit i in time t without an internal carbon charge and energy consumed by business unit i in time t with an internal carbon charge assessed. This difference could be dependent on the magnitude of the carbon price, the individual business unit's marginal abatement curve, and a number of other factors that make identification of this and other elements of these equations difficult. The translation of the reduction in energy use to a reduction in carbon emissions due to the carbon charge hinges on the parameter β, which describes the carbon intensity of the energy used. A business unit whose energy comes entirely from solar or other zero emissions energy sources will have a $\beta = 0$, whereas a business unit whose energy comes from a mix of energy sources of varying carbon intensities per mmBtu will have a βthat reflects this mix.

The revenue return equation is the product of the portion of revenue returned to unit i, $\psi_{i,t}$, the total revenue collected, $f \sum_i C_{i,t\text{-}1}$, and the carbon emissions reductions per earmarked dollar invested, γ_i . The revenue collected is the product of the carbon fee, f, and the sum of carbon emissions by all business units across which the carbon charge is applied in the previous period. The return mechanism dictates $\psi_{i,t}$ and if emissions do not decrease for a business unit relative to the baseline from one time period to the next, $\psi_{i,t}$ should be zero. In this sense, the determination of a business unit's baseline can play an important role if it is a component of the return mechanism dictating $\psi_{i,t}$.

The argument for the second term that appears in equation (1), but not in equation (2) is that earmarked funds require business units to make investment decisions they otherwise would not engage in had the funds been returned to them without restrictions. This isn't to say that business units would not invest some of the returned funds in energy efficiency; however, that is not a reduction in carbon emissions that results from the implementation of a carbon charge.

Models 3 and 4: Do Not Return, Earmarked and Do Not Return, Unrestricted

$$\Delta C_t = \beta \Delta Q_t + \gamma f\, C_{t\text{-}1} \quad (3)$$
$$\Delta C_t = \beta \Delta Q_t \quad (4)$$

The equations for “Do Not Return”, (3) and (4) are similar to the equations for “Return”, (1) and (2). Like the case for “Return”, equation (3) for earmarked revenue has an additional term since the company would make green investment decisions they otherwise would not engage in had the revenue collected not had restrictions.

The only difference from the previous case is that revenues are earmarked at a company rather than unit level, so it is the company as a whole rather the individual units that make the investment decisions based on the earmarking. From the perspective of carbon emission reductions, “Do Not Return, Unrestricted” is exactly the same as “Return, Unrestricted”, as seen from the equivalence of equations (2) and (4). Whether “Do Not Return, Earmarked” achieves more emissions reductions than “Return, Earmarked” depends on whether $\gamma f C_{t\text{-}1}$ in equation (3) is greater than $\psi_{i,t}\left(f \sum_i C_{i,t\text{-}1}\right)\gamma_i$ in equation (1). For the same tax revenue, this comparison depends on the relative efficiency of the investments between the unit and the company level. On a company level, there may be economies of scale and specialization (having a few staff focusing on green investments) which can increase efficiency of green investments in terms of carbon emission reductions. However, units may be more familiar with their own production processes and energy consumption habits, so they might be able to make more effective investments as compared to that on a company level. We expect the relative efficiency of company-level and unit-level green investments to vary by company.

Contribution 3: Case Studies

Apart from the policy map and theoretical framework with accompanying equations, we examine four case studies in the context of our policy map. This demonstrates the real-world application possibilities of our project, and also allows us to draw some lessons learnt from existing internal carbon charge programs that may offer useful guidance to other companies looking at designing their own schemes. Our four case studies are:

Case Study 1: Yale University

In 2014, Yale President Peter Salovey created a task force, chaired by Professor William Nordhaus, to examine how internal carbon pricing could be applied within the Yale context. The task force recommended[15] a pilot study, conducted in the 2015-2016 academic year, making Yale the first university to experiment with internal carbon pricing. With the pilot study complete and a report of preliminary results released[16], Yale Provost Ben Polak is expanding the initiative across campus so Yale can serve as a living laboratory for carbon pricing implementation.

The pilot aimed to determine the administrative feasibility, effectiveness, and potential impact of a carbon charge applied to energy consumption in Yale buildings. Carbon Charge managers assigned each of twenty buildings representing the diversity of Yale's building stock to one of four treatment groups, with 280 remaining campus buildings serving as a control. All four treatment groups received a new custom report summarizing building energy consumption and comparing it to past performance. One treatment group received only the energy report, while three treatment groups were given additional incentive-based carbon pricing schemes. The four treatment pricing schemes are characterized as follows:

- Information only (5 units): buildings received a monthly report with information on energy use and indicative carbon charges, but without any financial consequences.
- Target (5 units): buildings were given a reduction target 1% below their baseline; they paid for emissions above this value and received funds for emissions levels below it.
- Redistributive (5 units): a revenue-neutral scheme by which buildings were compared to the group's overall percent change in emissions from baseline, incurring charges or receiving rebates based on performance above or below baseline.
- Investment (5 units): buildings were given funds earmarked only for energy conservation investments.

Yale uses a Social Cost of Carbon of $40/MTCDE for its carbon charge. This is based on US Federal Government estimates under President Obama's Administration.[17] After completing the pilot, the Yale Carbon Charge learned five key takeaways for designing an internal carbon pricing program in a university setting. These lessons learned are:

1. Internal carbon pricing has potential for university campuses;
2. Carbon pricing scheme design is important, but many variations can work within similar contexts;
3. An effective carbon pricing scheme conveys clear information and incentives;
4. Resulting emissions reductions can be cost effective; and
5. Carbon pricing can benefit greatly from experimentation and collaboration.

Using the lessons learned from the pilot, Yale is incorporating the carbon charge into organizational budgets for 264 out of the over 400 campus buildings starting in fiscal year 2018. These buildings combined account for over 70% of Yale's carbon emissions. Administrators and operations staff will receive a monthly building energy report and will be responsible for net carbon charge payments and returns at the end of the fiscal year. In addition to implementation, the Yale Carbon Charge will continue to prioritize research and the use of campus assets for experiential learning.

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[15] http://carbon.yale.edu/sites/default/files/files/Carbon-charge-report-041015.pdf
[16] http://carbon.yale.edu/sites/default/files/files/Carbon_Charge_Pilot_Report_20161010.pdf
[17] https://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf

Case Study 2: Microsoft

Implemented in 2013, the internal carbon pricing scheme in Microsoft is an innovative quantity-based approach (Figure 3). Instead of pricing carbon at the social cost of carbon (SCC), Microsoft determines its current level of emissions and then calculates the required internal carbon price to make its operations carbon-neutral. Specifically, Microsoft relies on two core formulae in its approach:

Cost of environmental initiatives portfolio ($) = Cost of internal initiatives ($) + Cost of green power purchases ($) + Cost of carbon offsets ($)

Internal carbon price (per mtCO_2e) = Cost of environmental initiatives portfolio ($; from above) / Total emissions (mtCO_2e).

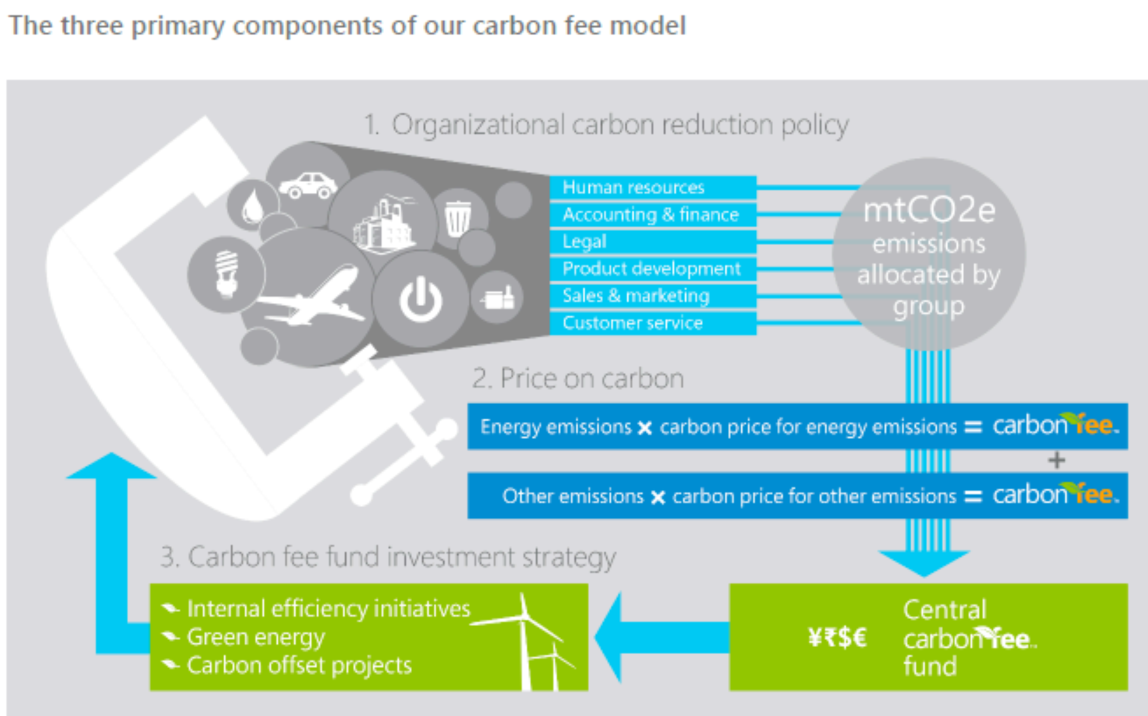

Figure 3: Microsoft's internal pricing scheme[18]

Thus, the emphasis of Microsoft's program is on how tax revenues are spent, rather the amount of the carbon price or how revenue is collected from different internal departments. Drawing on our theoretical framework, this means Microsoft focuses on the "secondary" benefits of a carbon tax, rather than the behavioral response of emissions reductions within individual subunits.

[18] The Microsoft carbon fee: theory and practice (p.6), Dec 2013

This program is innovative and would still reap the double effect of emissions reductions should the carbon price be sufficiently high. Because, the price on carbon is determined by the total cost of the carbon fee fund investment strategy, it can change from year to year, although Microsoft has thus far kept its internal carbon price constant. Unfortunately, Microsoft's current internal carbon price, while not released in official reports, has been mentioned to be between US$4-5[19]. Hence, we expect minimal reductions in energy consumption and carbon emissions internally. Microsoft's approach to carbon neutrality is to simply buy up carbon credits and reduce carbon emissions elsewhere where it is cheaper to do so.

Thus, while Microsoft has often been lauded as a leading example of internal carbon pricing, they may not be the best example to model after for companies seeking significant reduction in carbon emissions, particularly those looking to make those reductions within their own company.

Case Study 3: SOCIÉTÉ GÉNÉRALE

Societe Generale Bank Group has always been proactive and committed to reducing its carbon emissions. Since 2005, Societe Generale has performed an inventory of greenhouse gas (GHG) emissions according to the GHG Protocol[20]. The data collected from this inventory was used as the basis for calculating the internal carbon tax, €10/tCO_2 ($10.8/t$CO_2$). Societe Generale was one of the first banks to introduce such a tax in 2011.

The Bank developed a Carbon Reduction Program (CRP) based on this tax to achieve its reduction targets. The mechanism is that each entity, *core business* and *corporate division,* pays the internal carbon tax according to their carbon footprint. The revenue from tax is allocated to internal environmental efficiency initiatives via the CRP Environmental Efficiency Awards. One of the goals is to promote awareness and show that environmental efficiency initiatives are also opportunities for innovation. The program is designed to incentivize each entity to:

- Reduce the CO_2 emissions to reduce the amount of the tax levied
- Implement environmental efficiency initiatives for which funding will be available by winning an award

The entities are responsible for setting their own action plan guided by the Group's target and incentivized by the tax. The competition for awards provides additional motivation and fun internally. Each award can cover up to 100% of implementation cost with a maximum limit of €200,000 ($182,000) per initiative. Gradually, the group can transition from energy intensive products and services to become energy efficient.

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[19] According to Casey Pickett, Director of Yale Carbon Charge Program. The figures were mentioned in passing by Microsoft staff during green business events where the Yale Carbon Charge Program was also present.

[20] GHG Protocol is an international standard for how to measure, manage, and report greenhouse gas emissions developed by the World Bank.

The 2012-2015 CRP ended by the end of 2015 for which the \$10.8/tCO_2 was implemented. The result was a reduction in GHG emissions per occupant of 11.4% compared to 2012, exceeding the initial target of 11%. The program also reduced energy consumption by 11.3% compared to 2012[21]. In 2015 alone, 56 initiatives won awards worth a total of €3.4M (\$3M). Over the three-year period, 119 winning initiatives yielded annual savings of an average of €13M (\$11.8M) on overheads, an average of 4,700 tCO_2/year savings and an average of 30 GWh of energy savings[22]. Those initiatives involved buildings, IT, papers and transport. Recently, the Group set up a new and more ambitious CRP which intends to reduce emissions per occupant by 20% compared to 2014 levels by 2020[23].

Case Study 4: Delta and Qantas Airlines

The airline industry is responsible for 2% of global annual emissions, emitting a larger share of global carbon dioxide than many countries[24]. If the airline industry were a country, it would be the 21st most economically productive nation and the 6th largest emitting nation in the world[25].However, the airline industry was left out of the 2015 United Nations Climate Change Conference in Paris, despite its carbon intensity. Curbing airline emissions was instead left to the International Civil Aviation Organization (ICAO) and individual countries.

In 2012, the European Union Emissions Trading System (EU ETS) required all airlines operating in Europe to report carbon dioxide emissions and purchase compliance offsets if they exceed their tradeable allowances. A similar program was established under the Australian Emissions Trading System (AU ETS). The International Civil Aviation Organization (ICAO), seeking to harmonize regional policies for emissions reduction and mitigate the global climate damages attributable to the aviation industry, established a global market based measure (MBM) to control future carbon dioxide emissions from aviation.

Delta and QANTAS airlines have reported the use of an internal carbon pricing scheme. While both airlines are committed to using internal carbon pricing, neither is transparent about its application or level. Instead, an internal carbon pricing mechanisms seem to be voluntarily applied either as a direct pass-through of carbon pricing regimes established in various jurisdictions to the airlines' applicable business units, or in anticipation of future carbon pricing or emissions regulations. For many companies in the industry, the aim of carbon pricing now is to prepare themselves for future environmental legislation.

Forthcoming regulations are anticipated to be introduced to help the industry meet the ambitious target set out in the 2016 ICAO General Assembly: to make all aviation growth after

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[21] Corporate and Social Responsibility Report, *SOCIÉTÉ GÉNÉRALE*, 2016 pp.45
[22] Ibid pp.46
[23] Internal carbon pricing: A growing corporate practice, *I4CE & EPE,* November, 2016, pp.19
[24] U.N. sets limits on global airline emissions amid dissent, *Reuters*, 6 October 2016.
[25] http://www.atag.org/facts-and-figures.html,
http://www.ucsusa.org/global_warming/science_and_impacts/science/each-countrys-share-of-co2.html#.WQ4AoOUrKUk

2020 carbon neutral. Implementation of policies to meet this goal will include a voluntary pilot phase from 2021 to 2026 and then a mandatory second phase from 2027 to 2035 for countries with a 2018 revenue tonne-kilometre of over 0.5%.[26]Policies employed in the pilot program will either involve global emissions trading; global mandatory offsetting; and global mandatory offsetting with revenue.

Delta and QANTAS, the third and thirteenth largest voluntary carbon offset buyers globally, along with 9 other airlines currently offset carbon emissions in some form in anticipation of industry-wide regulation from the International Civil Aviation Organization (ICAO) and in compliance with the EU ETS and AU ETS requirements.

Delta also uses a shadow price of carbon to evaluate future routes, schedules, and investment opportunities. This also is done in anticipation of compliance requirements for regional or global operation of airlines.

QANTAS imposed an Australian carbon tax-linked surcharge on fares, however, removed this ahead of the repeal of the carbon tax. "Our all-inclusive fares have not risen, though we have kept a small carbon surcharge on domestic fares so that we can keep track internally of the cost of the tax...This has now been removed, but there won't be any change to the prices that customers pay"[27]. In that way, the carbon charge applied to air-travel by QANTAS was a direct pass-through to consumers of a carbon tax. The removal of the surcharge did not see a reduction in fares due to increasing market competition on the Australian domestic aviation market.

Lessons Learned from Four Case Studies

These different case studies shed several broad lessons learnt that may be useful as new companies design and implement their own internal carbon pricing scheme. Firstly, the Yale case study shows that **carbon pricing scheme design is important, but many different variations can work within similar contexts**. In testing four different carbon pricing schemes, Yale University's pilot found that all business units that participated in any pricing scheme during the pilot significantly reduced their carbon emissions relative to the business units that did not participate in the pilot. Specifically, the "investment" pricing scheme, in which buildings were given funds earmarked for energy conservation investments, experienced the greatest reduction in emissions. However, due to the small sample size of the pilot, the explanatory power of these findings is limited.

The airline industry case study clearly demonstrates the first benefit of an internal carbon pricing scheme outlined by CDP. Delta and QANTAS employ carbon pricing strategies as a **form of regulatory preparedness, or advanced/anticipated compliance**. In a similar vein,

[26]http://www.mondaq.com/x/577730/Aviation/Aviation+Emissions+The+Scheme+Agreed+At+The+2016+ICAO+General+Assembly
[27]http://www.news.com.au/finance/money/costs/qantas-scraps-carbon-tax-surcharge/news-story/aad2d2b4c7a7256a3b5e6143b7c16ad6

Societe Generale's decision to implement a carbon charge was in preparation for the upcoming Emissions Trading System (ETU) in the European Union, while Microsoft, another multinational, may also be considered as reaping the **benefits of monitoring and evaluation of carbon emissions as a means of navigating various global standards, commitments, and challenges**.

Yet, these two case studies also shed other insights. Societe Generale benefited significantly from its early performance of GHG inventory in 2005 to set an effective internal carbon charge, suggesting that **design elements from its program could be used effectively for other internal carbon pricing schemes**. In addition to the charge, **competition between units** encouraged the employees to engage and be creative to propose various internal environmental efficiency initiatives. The initial CRP in the Group achieved the defined emission reduction and energy consumption targets, and resulted in annual expenses savings of $11.8M. Such design elements

The Microsoft case study shows us that while focusing on the uses of revenue for an internal carbon charge is an innovative approach in carbon pricing, **the carbon price must be sufficiently high to reap the double reduction in emissions** as highlighted by our theoretical model. While often cited as the leading example for internal carbon pricing schemes, Microsoft's program may not be the best example to model after for companies seeking significant reduction in carbon emissions, particularly those looking to make those reductions within their own company.

Conclusion

As we surpass 400 ppm atmospheric carbon dioxide, the responsibilities for carbon emissions reduction and mitigation fall to governments at all levels as well as the private sector. While there are resources for price instruments to address damages from carbon emissions at the national level, there are limited resources available to companies and other institutions.

Our policy map captures key decisions and trade-offs that organizations will face in the design and implementation of an internal carbon pricing program, highlighting the levers available for companies to design an internal carbon charge program that meets their needs. We find that current implementation of internal carbon pricing schemes by companies generally serve as preparation for certain or anticipated future regulations. Less common, but still relevant, are positive returns to revenue neutral internal carbon charge programs like the Yale Carbon Charge. New incentives for investing in carbon efficiency technology can potentially address the behavioral failures that lead to underinvestment.

Lastly, we posit that the secondary macroeconomic effects of paired taxes and investment subsidies, when considered as a single instrument, could prove cost effective for internalizing the two market failures associated with climate change: the global climate externality and the technology appropriability externality. Further work and thought, however, is necessary to properly frame this insight in the context of contemporary economic literature.