Carbon Beta: A Framework for Determining Carbon Price Impacts on Valuation

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Abstract

Greenhouse gas (GHG) emissions create a cost liability for firms exposed to the implementation of carbon pricing. We propose a framework for public equities that links Scope 1 and Scope 2 emissions[2] with changes in firm valuation. This framework considers both 1) larger operating costs that lead to a decrease in value as well as 2) new revenues generated by "green" sales that increase the value of firms. From an initial carbon tax "shock", we distribute the tax costs across market sectors based on Scope 1 emissions and estimate higher electricity costs based on Scope 2 emissions. In addition, we consider an increase in revenues for companies generating solutions for mitigation of GHG emissions. The framework relies on a host of assumptions that we outline and test through sensitivity analysis. We find negative price responses in four sectors: Energy, Utilities, Materials and Transportation, while we find positive price responses in several sectors including Automobiles, Software and Capital Goods.

Introduction

Increasing awareness of climate change has prompted regulators to apply financial penalties on companies that contribute to greenhouse gas (GHG) emissions. The goal of these penalties is to use an economic framework to shift energy consumption away from carbon-emitting fossil fuels and towards renewable and zero-emission sources. There is growing trend for countries to coordinate policies using either new carbon taxes or emission trading schemes, as shown in Figure 1. For example, the World Bank is tracking 57 carbon pricing initiatives in 2019 that are either implemented or scheduled for implementation around the globe, covering about 20% of global GHG emissions (The World Bank, 2019).

[1] BlackRock Sustainable Investing, 55E 52nd Street, New York, NY 10055
[2] Definitions consistent with GHGprotocol.org standards for corporate emissions. Scope 1 refers to direct emissions produced by owned or operated assets of a company. Scope 2 emissions refer to indirect emissions resulting from electricity purchased.

Share of Global Emissions Covered by Regional, National, Sub-National Carbon Pricing Initiatives

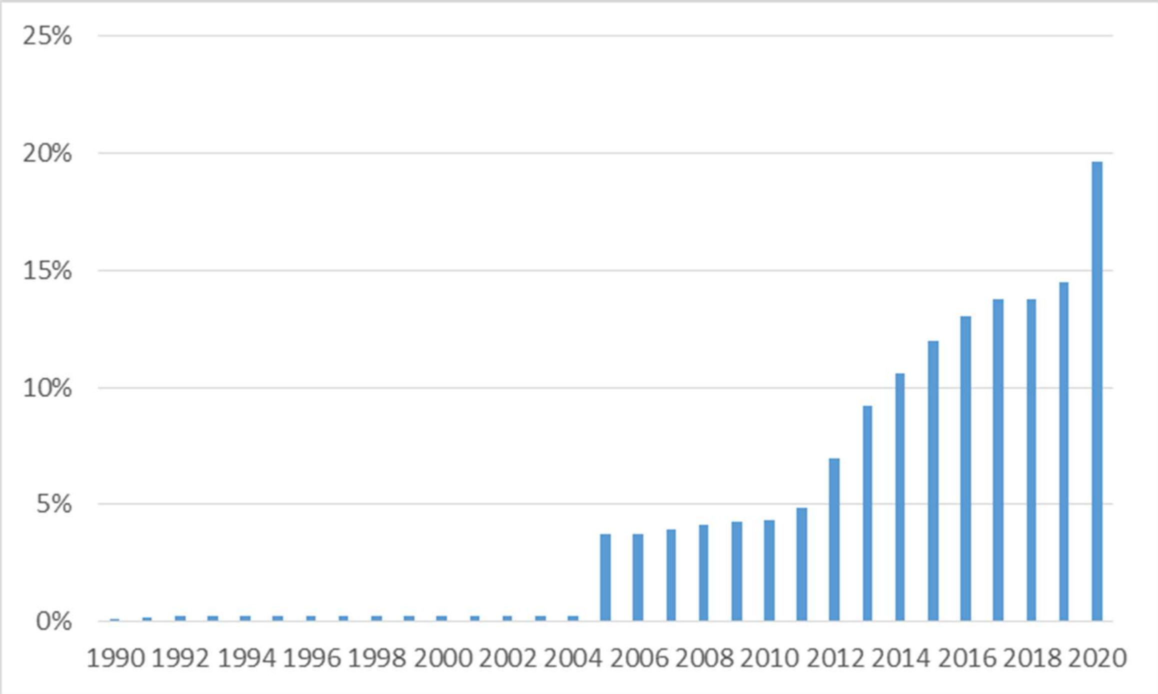


Figure 1 Global GHG Emissions Regulated Source: World Bank, BlackRock

In this paper, we propose a framework for assessing the sensitivity of company valuations to carbon pricing schemes. This sensitivity, which we term Carbon Beta, is a measure of the impact that a carbon pricing scheme will have on a company. As such, it is not a traditional measure of Beta which connects market moves with stock moves. Instead, it is a measure of sensitivity to carbon emissions which is only materialized in the presence of carbon pricing schemes. Without a carbon scheme, there will be no emission costs and the Carbon Beta measure will only represent a latent exposure. As the costs of emissions increase above zero, the Carbon Beta effect will come into play.

The concept of a Carbon Beta can be used to address the impacts from scenario analysis, such as 2 degrees or Business-as-Usual, because it is connected to the outcomes of Carbon Pricing schemes. For example, estimates of the carbon price required to comply with a 2 degree temperature scenario vary between USD $50 - 150 per metric ton of GHG (IPCC, 2018) and (World Bank, 2019). By calculating exposure to a $1 increase in carbon price, we maintain flexibility to analyze the impact of a range of carbon prices – including those in alignment with temperature scenarios – as well as understanding the relative exposure to any pricing scheme at the security level.

We define Carbon Beta as:

$$Carbon\ Beta = \frac{\Delta\ Firm\ Value}{\$1\ Carbon\ Tax}$$

Where the Δ Firm Value is the percent change in the overall firm valuation resulting from the implementation of $1 in Carbon Tax.

Our motivation in developing a Carbon Beta is to gain a deeper understanding of potential financial impacts of imposed prices on carbon – both at the individual company level and extrapolated to sectors and the broader equity investment universe.

Prior Literature

The impacts of regulations setting carbon prices or limiting carbon emissions have been investigated in several studies of the European Union Emissions Trading Scheme (EU_ETS). For example, Smale et alii (Smale, 2006) studied the impacts of the EU_ETS on five sectors and found wide variations across market share and profitability based on a sector's ability to pass on the added costs of carbon emissions. In another study, Clarkson et al (Clarkson, 2015) found that the value of firms under the EU-ETS are related to excess emissions beyond free allowances and that a firm's ability to pass on the cost of the tax varies across market sectors. These results were echoed in a study by Oestreich and Tsiakas (Oestreich, 2015) who found similar benefits to free carbon allowances. In a focused study of the European electric utility sector, Tian et al (Tian, 2019) investigated the impacts of carbon pricing on the cost of electricity and stock price of electric utilities and found a positive and symmetric relationship between carbon prices and electricity prices while the effect on firm valuation diminished over time after implementation of carbon pricing.

Carbon taxes and regulations in Australia and South Africa also provided environments for investigating impacts on firm valuations. Luo and Tang (Luo, 2014) looked at market reactions to carbon legislature events in Australia during 2011 and concluded that carbon taxes had a negative impact on shareholder returns that varied across sectors. Carbon price impacts in the South African market were analyzed by Ganda and Milondzo (Ganda, 2018) who found a negative relationship between carbon emissions and corporate financial performance.

Outside of carbon tax regulations, Garvey et alii (Garvey, 2018) investigated the relationship between carbon emissions and firm profitability. They found that firms which reduced the carbon ratio, or carbon emission per unit of sales, had stronger future profitability and positive stock returns.

In this paper, we extend the approach of Clarkson et alii (Clarkson, 2015) to include 1) positive effects of carbon pricing, 2) cost effects of scope 2 emissions and an 3) explicit connection to firm valuation. We start with a description of the Carbon Beta framework in the next section and then discuss the sensitivity of results to key inputs for the framework. In the final sections, we discuss the results across various levels of carbon pricing and present our conclusions.

Outline of Carbon Beta Framework

We define Carbon Beta as a company's sensitivity to a price of $1 / metric ton of GHG expressed as potential gain or loss of firm value. The framework consists of five steps that originate with the explicit pricing of a ton of Scope 1 emissions and concludes with an impact on the valuation of a firm.

The steps of the framework are as follows:

1. Carbon tax implementation
2. Cost elasticity and pass through
3. Scope 2 emissions as proxy for electric energy usage
4. New green revenue capture
5. Impacts on Valuation

1. <u>Carbon Tax Implementation</u>

Greenhouse gas emissions are a byproduct of a company's operations that are currently not considered in GAAP reporting. Regulatory efforts to limit GHG emissions, however, are a method for explicitly including GHG emissions as a business cost. Regulations in terms of a direct tax on GHG emissions or Emission Trading Schemes impose a price on each ton of GHG emitted and thus give companies a measure of the liability created by emitting GHG.

In our framework, we assume that the cost of Scope 1 emissions can be materialized by a global carbon tax that impacts all companies equally. The cost to each business for GHG emissions will be the carbon tax, in units of dollars per ton of carbon emitted, multiplied by the total amount of Scope 1 emissions.

2. <u>Cost Elasticity and Pass through</u>

The added cost of a carbon tax can be either absorbed by a company, and thus reduce margins, or it can be passed through to customers in the form of higher prices for products and services. Using an industry concentration approach based on the Herfindahl-Hirschman Index (HHI), we posit that in more competitive markets, firms will compete on price and hence are incentivized to minimize the cost-pass-troughs. The less competitive the market becomes, the greater ability a firm will have to increase prices and pass on costs to its customers.

We make this calculation at the industry level but are aware that differences in operational efficiencies across companies will create different abilities to pass on carbon tax costs. Also, the definition of a "market" is important for defining the HHI because a global market will result in more competition than a smaller country or regional market. Here, we assume a global market as a simplification but acknowledge that regional trade barriers will impact pricing power by limiting competition.

We propose the following approach to estimate costs pass through:

1. A carbon tax on Scope 1 emissions raises the operating costs of a firm
2. Based on its pricing power, a company will seek to pass costs on to customers in order to maintain profit margins
3. The amount of costs that cannot be passed through will result in lower profits
4. With time, a firm will rebalance its production and energy mix to maximize profits.

In this study, we adopt the first three steps above since we only consider the period immediately following the implementation of a carbon tax. Over time, however, we are aware that there can be shifts and adjustments that will create a new equilibrium. For example, we exclude the effects of step 4 given the complexity of modeling firm-level cost pass through in the period after the implementation of a carbon tax. We are also aware that higher cost of goods will result in demand shifts as substitution effects develop from customers seeking to minimize their operating costs.

We make an exception for the Utilities sector since these companies are operating in a regulated market. Our assumption that Utilities will be able to pass 75% of a carbon tax cost is consistent with analysis of the European Emission Trading Scheme environment in which utilities were able to pass between 60% and 100% of the carbon tax costs (Sijm, 2006).

3. Scope 2 emissions as proxy for electric energy usage

The cost pass-through from electric utilities will result in higher electricity prices, which in turn will result in higher operating costs and lower margins for electricity users. To estimate the cost impact at company level, we use Scope 2 emissions reported by each company as a proxy for the amount of electricity used. We then distribute the total cost of electricity passed through in proportion to each company's Scope 2 emissions. This process also generates an implied cost per ton for Scope 2 emissions, although this specific figure does not enter in the Carbon Beta framework.

4. New green revenue capture

The added cost of a carbon tax on Scope 1 emissions creates a demand for products and solutions that can reduce GHG emission in a cost competitive way. We assume in our framework that if a company is faced with a carbon tax cost of $100 but can buy a green technology solution for $99 that eliminates its GHG emissions, the company will opt to purchase the technology since it is cheaper than paying the tax.

For companies providing green solutions, we estimate the increase in revenues as a percentage of the total cost of the carbon tax which we then distribute in the market in proportion to the share of green revenues.

5. Impacts on Valuation

A carbon tax will impact the profitability of a company. Costs will increase from the payment of the tax while revenues will increase from additional sales of green technology. The net effect between costs and revenues will change earnings, with decreasing earnings coming from heavy Scope 1 emitters while higher earnings coming from companies capturing the green technology opportunity.

We estimate the change in company valuation through its Price/Earnings multiple. By assuming that a long-term P/E ratio remains constant through the impact of a carbon tax, a change in earnings will translate into a change in price, and hence a change in company valuation.

Sensitivity Analysis

To assess the robustness of our framework and its dependency on any one variable, we examine the sensitivity of Carbon Beta to two key model inputs. First, we explore the impact of adjusting the Utilities pass through ratio for publicly listed companies, or the proportion of costs we expect Utilities companies to pass through to publically-listed purchasers of electricity. Second, we examine the sensitivity of Carbon Beta to the amount of total upside capture available to producers of clean technology. We have selected these variables because they are both based on broader market assumptions and represent downside and upside inputs in our Carbon Beta model. In each case, we review the rationale for our initial assumptions and the impact of adjusting these thresholds on Carbon Beta.

1. *Sensitivity of Utilities Pass-Through Costs to the Public Market*

The Carbon Beta model assumes that in the event of a carbon price, Utilities companies will pass through costs to their consumers, or purchasers of electricity. As noted above, we expect Utilities companies to pass through approximately 75% of their direct costs to the market. However, because purchasers of electricity are not all publically-listed companies (they also include private industry and residential buyers), we must adjust the total pass through costs when reallocating these costs to listed equities. We allocate 33% of total pass-through costs to the public market, based on our understanding on electricity usage by sector. Before reviewing the sensitivity analysis around this 33% ratio, we review our methodology and estimates of electricity consumption by sector.

To estimate the amount of electricity consumed by economic sector, we reference the U.S. Energy Information Administration (EIA) total electric power by industry summary data.[3] We find that approximately two-thirds of annual electricity consumed in the United States can be attributed to commercial and industrial use, separate from transportation and residential consumption. See table below:

Total U.S. Electric Power Industry		
Sales of Electricity to Ultimate Customers		
Sector	*(million kWh)*	*% of total*
Residential	1,378,648	37.0%
Commercial	1,352,888	36.3%
Industrial	984,298	26.4%
Transportation	7,523	0.2%
All Sectors	*3,723,356*	*100%*

We note that publically-listed companies may be categorized within the commercial and industrial sectors as defined by the EIA. Because consumption in these industries may also include private companies, we must estimate the total power consumed by publically-listed companies specifically. To do this, we reference an academic study that compares the investment behavior between public and private firms. Asker, Farre-

[3] See https://www.eia.gov/electricity/annual/ "Total electric power industry summary statistics"

Mensa and Ljungqvist find that approximately 57.6% of sales and 54.5% of spending on plants and equipment can be attributed to private firms in the US.[4] From this, we assume that approximately 50% of electricity consumption from commercial and industrial sectors can be attributed to public companies. This leads us to multiply the total Utilities pass through costs by .33 (.66 of energy consumption to commercial and industrial * .50 publically listed vs. private companies) before allocating costs by companies' Scope 2 emissions. That is, we distribute a third of total pass through costs to publically listed issuers.

We turn now to examine how sensitive Carbon Beta is to this specific assumption. We do this by increasing the pass through rate – or assuming that public companies account for a greater share of electricity consumption than we initially assume. Hence, instead of allocating one-third of pass through costs to public companies, we allocate one-half and two-thirds. Below we examine the return implications specific to the materials sector (as it represents the largest consumer of energy or producer or Scope 2 carbon emissions). We find that by increasing the pass-through to 0.50 and 0.66, or by 1.5x and 2x, we observe approximately -8.3% and -16.2% difference in the estimated return of the Materials sector based on underlying Carbon Beta figures (see table below). In other sectors less reliant on purchased electricity, such as Banking, we find this assumption does not meaningfully impact outcomes.

	Scope 2 Pass Through Assumption		
	33%	**50%**	**66%**
Materials Sector Return	-0.09%	-0.10%	-0.11%
Sensitivity to Model Assumption		-8.30%	-16.20%

Our sensitivity analysis shows that while the pass-through ratio is an important component in our model, variations in its range have a modest impact on Carbon Beta. Put differently, a 2x increase in our assumption does not equal to 2x difference in valuations. Based on our underlying market research and sensitivity analysis, we believe that a 0.33 percent electricity consumption allocation to the public market is reasonable.

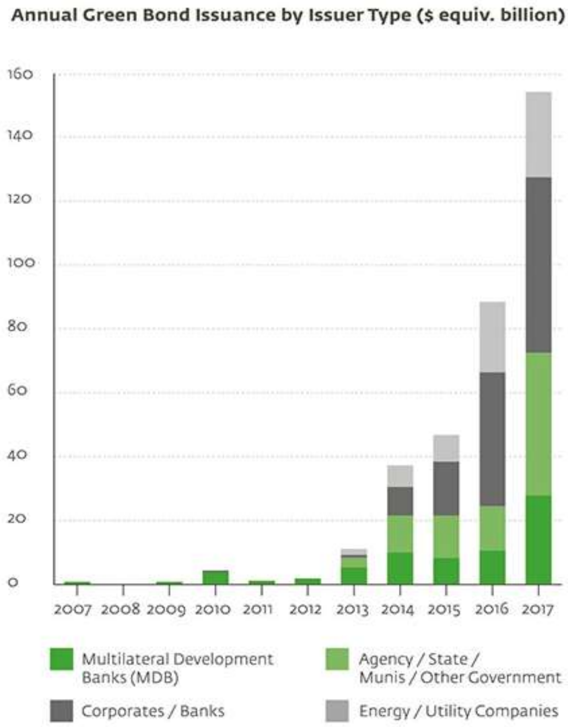
2. *Sensitivity to Clean Technology Capture Ratio*

In our second analysis, we explore our model's sensitivity to the clean technology capture ratio. Under a carbon pricing scenario, we expect companies producing low- or zero-carbon substitute products to experience an increase in earnings, and hence valuation, all-else-equal. To capture this, the Carbon Beta model incorporates an upside capture based on the 1) the total adjusted cost of direct emissions tax and 2) a company's revenue from clean technology. We assume the total clean technology upside opportunity will be equal to, but no greater than, the total direct costs of a carbon tax.

To distribute the potential revenue gains to suppliers of clean technologies, we assume 100% of the direct costs will be redistributed to these companies. We base this assumption on the rationale that green companies can increase output to meet the new

[4] "Comparing the Investment Behavior of Public and Private Firms" https://pdfs.semanticscholar.org/4728/c9bb32491dff154796eafce0e6962009202a.pdf

demand. To calibrate this assumption, we use comparisons between total costs from the carbon tax and the size of the green bond market. For background, Green Bonds are debt issued by companies, municipalities, and sovereigns for developments ring-fenced for environmental improvement, such as emissions reduction, energy efficiency or other qualifying projects. According to the International Finance Corporation (IFC), annual green bond issuance has grown from zero to nearly $170bn in little more than a decade and in 2019 global issuance is expected to reach a record $200bn.[5]



In view of the growth in green bond issuance, we considered whether the market could absorb the entire new clean technology opportunity created by the carbon tax. That is, in the case of a $25 per metric ton tax on carbon emissions, would the clean technology market be able to supply low- or zero-carbon technologies to meet the new demand? Based on our analysis, we project a $25 tax would create approximately $125B in new clean technology revenue opportunity. Given the current size and trajectory of the green bonds market, we assumed that the 100% of the direct costs could be translated into clean technology revenue. We recognize that this assumption may not hold under higher tax scenarios. For example, an initial tax of $100 per metric ton can produce direct costs of $500B for publically listed companies, more than twice last year's green bond issuance. However, for simplicity we assume that an imposed price on carbon would be initially less than $50 per metric ton and therefore the upside opportunity can be fully absorbed by clean-technology producers.

[5] International Finance Corporation, World Bank Group. Green Bonds. https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/perspectives/perspectives-i1c2

To meausure the impact of this assumption on Carbon Beta, we test the impact of a 25%, 50% and 75% capture ratio, compared to the full 100%. We examine the impact on the capital goods sector specifically, in which companies are positioned to benefit for clean technology opportunities through the sale of energy production, efficiency, and storage technologies. Below we show that the industry return expectations move linearly with our capture ratio assumption. That is, the capture ratio moves in-line with expected industry returns. Note that this is applied to the Capital Goods Sector which has the most exposure to the upside potential, whereas sectors without clean opportunity will not be similarly impacted.

	Clean Technology Capture Ratio			
	25%	**50%**	**75%**	**100%**
Capital Goods Sector Return	0.04%	0.15%	0.26%	0.36%
Sensitivity to Model Assumption	-88%	-58%	-28%	

While there is high sensitivity to this particular assumption in our Carbon Beta model, we believe that the full capture ratio is a reasonable assumption given the recent growth in environmentally-linked debt and clean technology revenue. We propose that this upside potential needs to be included in a carbon prince framework to fully capture the impacts of a carbon tax.

Results

We examine the model's sensibility and results across three levels of interest: across tax levels, across sectors, and within sectors. Carbon Beta is calculated at the security or issuer-level but, for simplicity, we aggregate Carbon Beta up to the industry and sector level and also evaluate industry-level returns rather than providing issuer-specific Carbon Beta figures. We do however examine the distribution of Carbon Beta within sectors, as noted in final section of the results.

First, we examine whether Carbon Beta reflects our intuitions with respect to increasing carbon tax and impacts on industry return. We find that as we apply Carbon Beta framework at increasing tax levels, from $25 to $40 and $80 per metric ton of carbon dioxide, we find that a global equity market performance worsens as expected, and individual industry performance diverges by wider margins, both in positive and negative returns. For example, our Carbon Beta assessments predicts that the Software and Services industry will benefit from a price on carbon – for example through increasing sales of energy efficiency and automation software – and is expected to increase from 4.4% industry return in a $25 tax scenario to a 14.1% return in a $80 tax scenario. Conversely, we find the Energy industry is expected to lose value across tax scenarios, with greater severity as the tax price increases. See table below.

Carbon Tax Impact Across Tax Levels by Industry

	$25 tax / metric ton	$40 tax/ metric ton	$80 tax / metric ton
Automobiles & Components	3.7%	7.2%	17.9%
Banks	-0.1%	-0.1%	-0.2%
Capital Goods	4.6%	6.0%	10.6%
Commercial and Professional Services	-1.4%	-2.3%	-3.7%
Consumer Durables & Apparel	1.3%	2.1%	4.3%
Consumer Services	-1.1%	-1.8%	-3.6%
Diversified Financials	-0.8%	-1.3%	-2.4%
Energy	-14.1%	-20.8%	-32.0%
Food & Staples Retailing	-1.7%	-2.7%	-5.2%
Food, Beverage & Tobacco	-1.4%	-2.0%	-3.6%
Health Care Equipment & Services	-0.2%	-0.4%	-0.7%
Household & Personal Products	-0.6%	-1.0%	-2.0%
Insurance	-0.1%	-0.1%	-0.3%
Materials	-18.4%	-23.5%	-33.3%
Media & Entertainment	0.5%	0.7%	2.0%
Pharmaceuticals, Biotechnology & Life Sciences	-0.3%	-0.5%	-0.9%
Real Estate	2.0%	2.6%	4.6%
Retailing	-0.2%	-0.3%	-0.6%
Semiconductors & Semiconductor Equipment	1.9%	3.0%	8.0%
Software & Services	4.4%	6.6%	14.1%
Technology Hardware & Equipment	1.9%	2.6%	4.7%
Telecommunication Services	-0.4%	-0.6%	1.5%
Transportation	-5.4%	-8.9%	-15.4%
Utilities	-13.4%	-18.2%	-24.3%
Market Total:	**-1.6%**	**-2.2%**	**-2.5%**

Next, our results show that carbon taxes will be heterogeneous across sectors. Below we show the expected sector return of a $25 per metric ton tax for a global equity benchmark. Again these results align with our intuition that not all sectors will be impacted uniformly by a carbon tax. In fact, some sectors stand to benefit through increase opportunity to clean and renewable technologies. The sectors hardest hit are those with greatest exposure to both Scope 1 and Scope 2 emissions, without significant clean technology opportunities to offset the potential costs. For example, we see a potential 18.4% loss in Materials, and 14.1% drop in Energy following a $25 tax, while the Information technology Sector may see a potential increase by 11.3%.

$25 Carbon Price Impact Across Sectors

Sector	Return	Sector	Return
Materials	-18.4%	Health Care	-0.5%
Energy	-14.1%	Communication Services	0.1%
Utilities	-13.4%	Real Estate	2.0%
Consumer Staples	-3.7%	Consumer Discretionary	9.1%
Industrials	-1.5%	Information Technology	11.3%
Financials	-1.0%		

Finally, we examine results within sector to explore the Carbon Beta prediction for intra-sector variation. Here we find that a carbon price impact will again be heterogeneous within sector, meaning there will be winners and losers irrespective of the sector in focus. This highlights the potential value of the framework in both security selection within sector and in company engagement initiatives: it identifies companies that are better positioned for a potential change in carbon pricing schemes versus peers that have not taken proactive measures.

Below we highlight the distribution of impact of a $25 tax on the Materials and Information Technology sectors. Both sectors have varying degrees of implications for companies within the sector, including companies the model predicts may lose 100% of market value following the introduction of a carbon price.

Companies with	Materials Sector	Technology Sector
Positive Values	20	140
Negative Values	180	120
100% Loss in Value	31	0

These initial results confirm our baseline sensibilities across different carbon prices and impacts across and within sectors. We believe the results can be used to enhance potential security selection investment processes and decision making, or serve as a starting point for further exploration. In the next section, we examine known assumptions and limitations of the Carbon Beta model, and avenues for future enhancements.

Assumptions and Limitations of Analysis

The initial Carbon Beta model includes a set of underlying assumptions and limitations, which lead us to a set of potential future enhancements to our approach. The table below summaries our 5 key methodological assumptions, ordered by what we consider to have potentially the greatest impact on the outcome of our model:

Key assumptions	Known limitations	Future enhancements
A carbon tax is enacted globally in a coordinated fashion.	This is a simplification to the current regulatory landscape.	Country specific shocks with supply chain linkages.
Reserve and potential "stranded" assets are not considered.	Reserve types and locations will be factored into new prices.	Map reserve assets by GHG intensity and cost of extraction.
Pass through costs are calculated at the industry level.	There may be heterogeneous pricing power within industry.	Develop security level view of pricing power within industry.
Carbon tax benefits are relative to last year's green revenues.	Current market shares may not scale to future benefits.	Consider supplier-consumer interactions to refine opportunity.
Valuations are consistent with historical averages.	P/E multiples may change under new market environment.	P/E variation based on natural experiments.

Conclusion

Companies that emit greenhouse gases, whether in the form of carbon dioxide or other gases, own a latent liability that is materialized in the presence of carbon pricing. While there is no single carbon price globally, regulators across countries have increased their interest in applying carbon pricing and today about 20% of global GHG emissions are covered.

We showed how a Carbon Beta framework considers the initial onset of a carbon tax and then distributes these impacts downstream through the application of price elasticity, impacts on electricity prices, gains for providers of green solutions and, finally, to impacts on the valuation of companies. Valuation outcomes vary across sectors, with the Energy, Utilities, Materials and Transportation having the most negative valuation impacts, while the Automobiles, Software and Capital Goods sectors show the most positive outcomes. We also find that within sector there is a wide variation in how carbon pricing affects companies, with some companies faring better that others.

Including an upside valuation potential for suppliers of carbon reduction technologies brings into the framework a component of positive impacts from carbon taxes. While we found that carbon taxes pose an initial loss of value in aggregate across the market, green technology companies provide some mitigation to those impacts.

The Carbon Beta model does not incorporate scenario analysis directly. Instead, through the selection of a carbon price, say $50 or $100/ton of CO_2 emitted, it can model the regulatory environment that targets a specific scenario such as 2 deg C or 1.5 deg C. Given the flexibility of selecting a particular carbon price, a variety of other scenarios can be considered.

We tested the assumptions made to arrive at a final Carbon Beta model and found some sensitivity around those assumptions, but we believe the approach yields valuable insights into the impacts of carbon pricing. There are opportunities to improve on the framework and we outlined several that are interesting areas for future research.