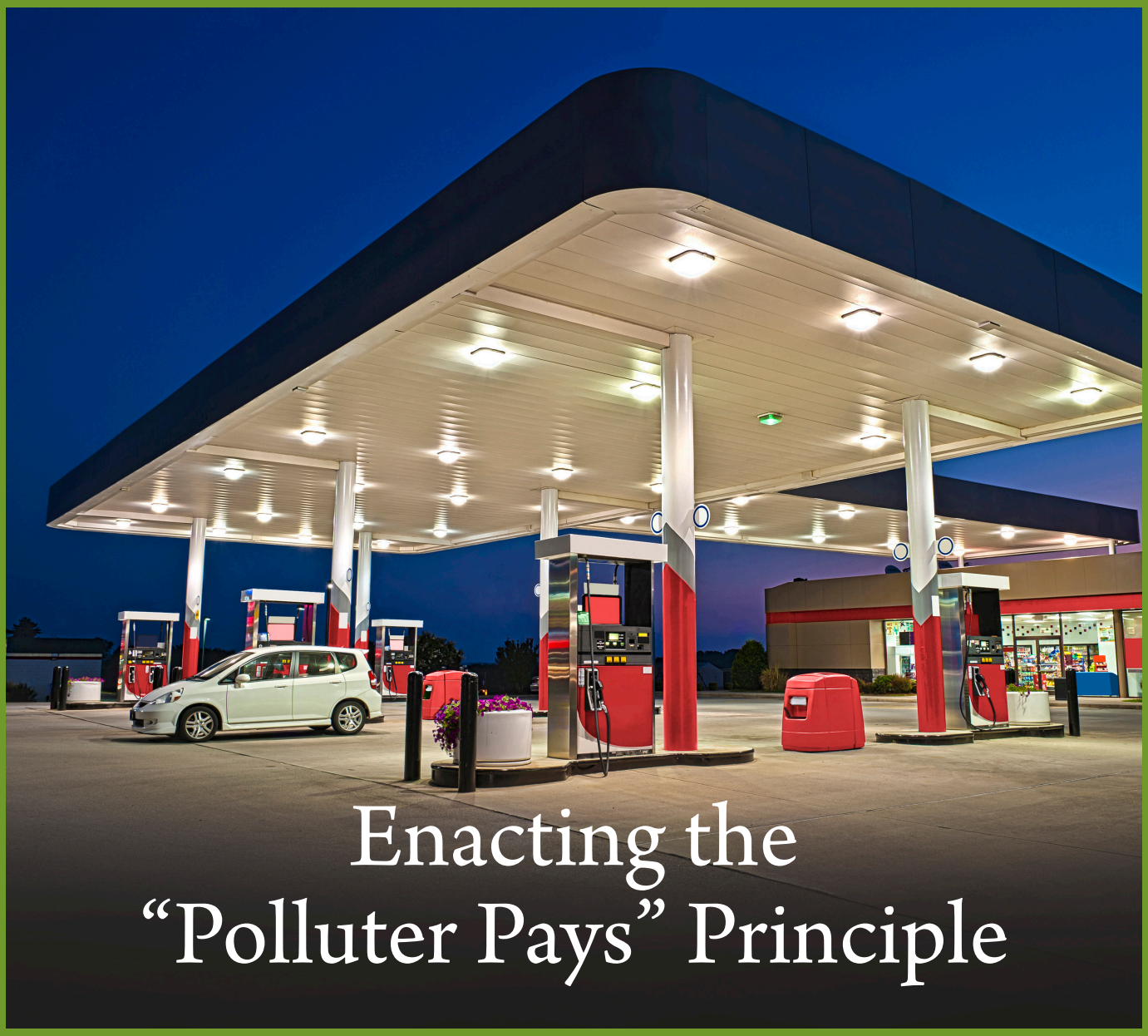
POLICY BRIEF



Enacting the "Polluter Pays" Principle

New York's Climate Change Superfund Act and Its Impact on Gasoline Prices

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Executive Summary

This policy brief analyzes how New York State's recently proposed Climate Change Superfund Act (the Act) is most likely to affect consumer gasoline prices. The Act establishes compensatory payments that would apply to fossil-fuel companies, including natural gas and coal companies, based on their historical contributions to the existing stock of greenhouse gases in the atmosphere (New York State Senate, 2022). The Act requires the state to place these payments in an adaptation fund to pay for green infrastructure that will help the state prepare for climate change.

The Act is unlikely to alter the price of gasoline at the pump in New York or the price of crude oil more generally. The Act's compensatory payments would be based on companies' historical contributions to the existing stock of greenhouse gas emissions such that these payments would reflect past sales of petroleum, and not current or future sales. Oil companies would therefore treat these payments as one-time fixed costs. Regardless of market structures, oil companies are unable to pass on increases in fixed costs to consumers due to economic incentives and competition (Nicholson, 2004, p. 205; Ritz, 2015).[1] Due to profit motivations, oil companies have significant incentives to leave their production levels and retail gasoline prices unchanged, even if firms may make operational changes in response to the Act.

The structure of the oil market in New York and globally is also unlikely to change in response to the Act. The Act applies only to large companies with significant operating revenue and large market capitalizations. Oil company profits will likely remain positive, particularly given their recent record profits, and thus widespread bankruptcies and consolidation are unlikely. Beyond the design of the Act, oil companies would also be unable to retaliate against New York by raising retail gasoline prices in the state due to the interconnectedness of the national and global energy markets and existing U.S. antitrust laws.

The Act could have a minor effect on retail gasoline prices by changing expectations about future liability, but even the direction of this effect is unclear. On the one hand, if the passage of the Act causes firms to increasingly anticipate future compensatory payments in New York based on current production decisions, the resulting expectations of increased marginal production costs could affect consumer prices in the state. On the other hand, firms may already anticipate that they will face liability for their contributions to climate change, such that failure to impose such charges may increase expectations of future policies that impose compensatory payments. Thus, it is unclear how actions taken now by New York State will impact perceptions of the likelihood of future policies. The recent rise in climate lawsuits nationally and globally combined with oil companies' internal carbon prices strongly suggest that oil companies already anticipate financial liability for their contribution to climate change and that New York's Act represents only a tiny portion of their overall liability risk.

Finally, as climate change is likely to disrupt energy markets (Clarke et al., 2018; Howard and Livermore, 2021; Rode et al., 2021), revenue generated by the Act will likely temper future energy cost impacts in the state. The Act's compensatory payments will be placed into a climate change adaptation fund for green infrastructure. Infrastructure projects launched as a result of this fund will likely lower energy companies' future expected costs in New York, including for the distribution of petroleum and the production and distribution of future oil substitutes. Thus, future energy prices related to transportation will likely be lower in the state as a result of the Act's ability to stimulate adaptation to future impacts of climate change.

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[1] Nicholson (2009. P. 205) states that "fixed costs play an important role in determining the firm's profitability in the short run, but … they play no role in determining how firms will react to changing prices because they must pay the same amount in capital costs no matter what they do." Ritz (2015) states that "From a theory viewpoint, this does not matter since changes in fixed costs do not affect prices, so any evidence for asymmetric pass-through must be due to changes in marginal costs."

Overall, the Act is likely to have a negligible impact on current and near-term oil prices, while potentially lowering future energy prices in New York, including for transportation.

1. Introduction

There is a longstanding scientific consensus that carbon dioxide and other greenhouse gas emissions contribute to climate change, which imposes considerable risk on societies around the world (New York State Department of Environmental Conservation, 2022; United States Global Change Research Program, 2018; Pörtner et al., 2022; Howard and Sterner, 2017). According to the U.S. government's National Climate Assessment (United States Global Change Research Program, 2018), climate change has already caused a wide range of damages for the Northeastern United States, including New York, and additional damages will continue for generations. Since 1900, the average surface temperature in New York has increased by 2.4°F, sea levels around the New York coastline and water levels in the Hudson River have risen by one foot, and precipitation has increased in the state, while snow cover in the wintertime is declining. Scientists expect these trends to persist, along with more frequent extreme weather events and a continued shift in native and invasive animal and plant species (New York State Department of Environmental Conservation, 2022).

Climate change will impact human and ecosystem health as well as many economic sectors, including the energy sector (Howard, 2014; Howard and Livermore, 2021; Pörtner et al., 2022). Substantial adaptation expenditures will be required to reduce exposure to these harms.

The Act aims to collect adaptation funds for New York from large fossil-fuel companies that are historically responsible for greenhouse gas emissions and sufficiently connected to the state of New York. This is consistent with the "polluter pays" principle that the polluter should bear the cost of their pollution. Often this comes in the form of the polluter compensating those impacted by the pollution or paying to prevent damages from the pollution. The principle is both an economic concept, which improves market efficiency, and a legal principle. A U.S. legal example is federal "Superfund" Law upon which the Act is based, which holds companies financially liable for the cleanup of their hazardous waste (Schwartz, 2010; Ambec and Ehlers, 2016).

New York's Climate Change Superfund Act

In May of 2022, New York State Assemblyman Jeffrey Dinowitz and New York State Senator Liz Krueger introduced the Climate Change Superfund Act to the state legislature. At the time of this policy brief's publication, the Act, also known as Senate Bill S9417, was in the Environmental Conservation Committee of the New York State Senate.

New York's recently proposed Act would require compensatory payments, assessed on firms that engaged in the extraction, production, refinement, and/or sale of petroleum from 2000 to 2018. Firms would be charged a share of $30 billion based on their proportional responsibility for global emissions of greenhouse gases emitted during this period. The Act measures greenhouse gas emissions in carbon dioxide equivalence, using emission factors based on fossil fuel type (i.e., coal, natural gas, or oil). Firms that emitted less than one billion metric tons during the covered period would be exempt from the payments. The Act imposes this liability on domestic and foreign responsible parties that are sufficiently connected to the state of New York. Firms subject to the fees could elect to pay over a nine-year period.

Currently, it is not entirely clear which oil companies will be covered by the Act. Firms will be assessed compensatory payments if they have "sufficient connection with the state to satisfy the nexus requirements of the United States Con-

stitution" (New York State Senate, 2022).[2] Companies that sell oil in New York are sufficiently connected to the state, while the designation is less clear for companies operating in parts of New York's oil supply chain outside the state both domestically and internationally (Rothschild, 2022).

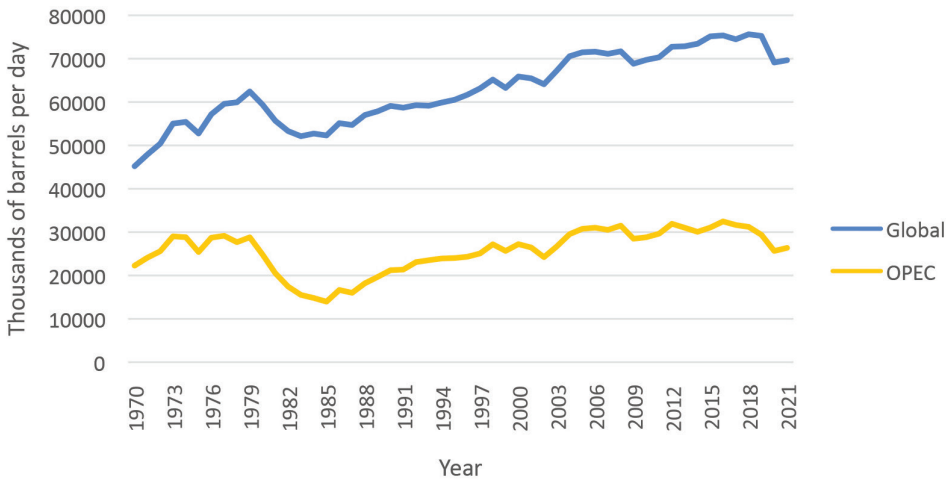
The Oil Industry

Based on the Act's coverage, the analysis in this brief focuses on the current structure of two related oil markets: the global crude oil market and the New York State retail gasoline market.[3] This subsection provides a brief overview of these two markets.

Global average annual petroleum production was 26.6 billion barrels from 2017 to 2021 (see Figure 1). The dominant players in the global crude oil market have traditionally been two overlapping organizations: the Organization of Petroleum Exporting Countries (OPEC), an intergovernmental organization of the 13 largest oil-producing and exporting countries; and OPEC+, a more loosely affiliated set of 24 countries. The former is responsible for 40% of global oil production and controls 80% of proven petroleum reserves, while the latter represents 61% of global oil production and 90% of global proven reserves (OPEC, 2022a; OPEC, 2022b); see Figure 2. Historically, OPEC countries have acted as a cartel to restrict supply and keep prices high (Tietenberg and Lewis, 2018, pp. 148-152). The combination of OPEC's supply restrictions and the fracking boom led the United States to become the world's largest oil producer starting in 2018, as it retook that mantel from Russia and Saudi Arabia (see Figure 3). The United States has approximately 2.3% to 2.5% of global oil reserves (US EIA, 2022b; OPEC, 2022a).

Figure 1. Global and OPEC Oil Production.

Source: OPEC (2022b).



[2] Under Supreme Court precedent, parties must have "certain minimum contacts" with a forum state that wishes to exert jurisdiction over them. International Shoe Co. v. State of Washington, 326 U.S. 310, 316–17 (1945). To satisfy this standard, the party must have engaged in some act by which it "purposefully avails itself of the privilege of conducting activities within the forum State." J. McIntyre Mach., Ltd. v. Nicastro, 564 U.S. 873, 877 (2011). For specific jurisdiction, the harm at issue must be connected to these activities and contacts within the state. Goodyear Dunlop Tires Operations, S.A. v. Brown, 564 U.S. 915, 919 (2011).

[3] This brief does not address the impact of this Act on natural gas or coal prices. The electricity sector predominantly uses coal and natural gas for generation, while the transportation sector uses gasoline. Hence, the impacts of the Act on these other energy sources are unlikely to interact with its impacts on the oil industry, as these markets have little overlap in New York. At the national and global scales, there is some overlap between crude oil and natural gas on the production side, as wells frequently jointly produce them (US EIA, 2013).

Figure 2. Share of Global Oil Production.

Source: OPEC. (2022b)

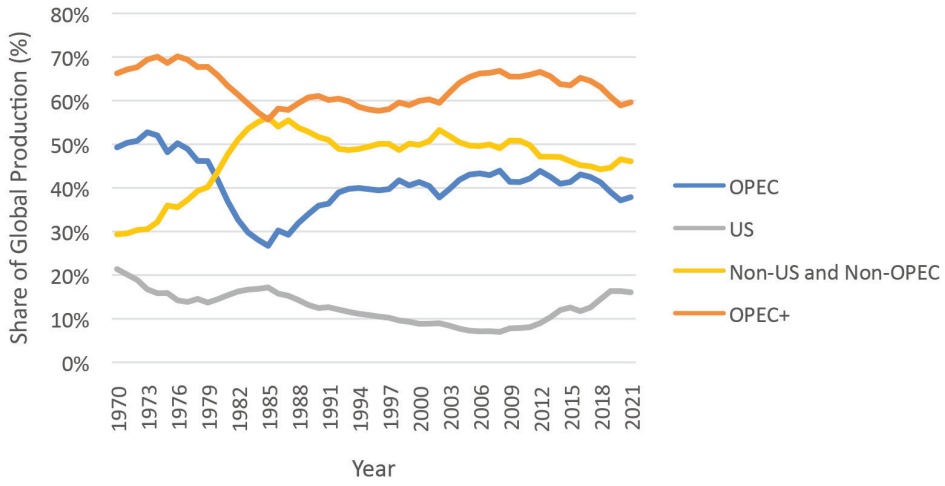
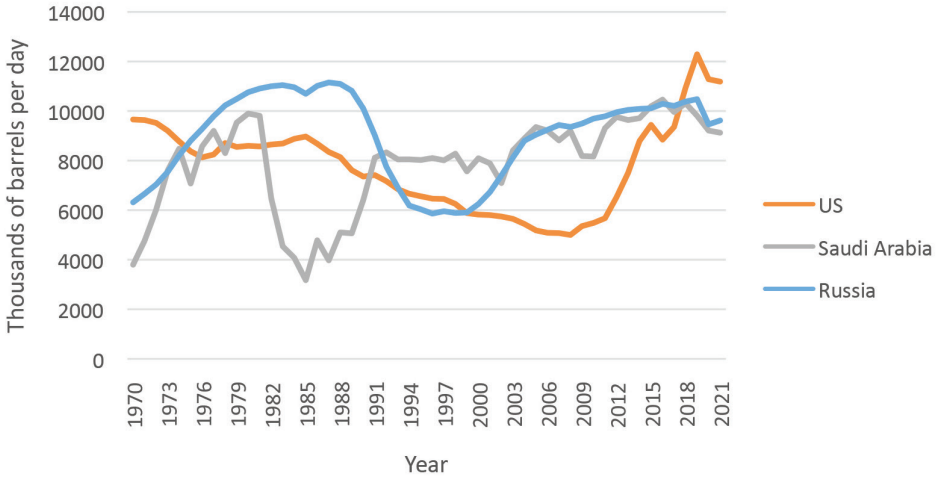


Figure 3. Oil Production of the Three Largest Oil Producing Countries.

Source: OPEC. (2022b)



In 2020, the United States accounted for 20% of total global oil consumption. The next two largest consumers are China (14%) and India (5%) (US EIA, 2022c).

New York consumes a significant share of retail gasoline in the United States, while producing virtually none. Of the 50 states, New York is ranked fifth in petroleum consumption, equivalent to 3.2% of national consumption and less than 1% of global consumption. New York ranked fourth in motor gasoline and jet fuel consumption. Most of the state's petroleum consumption comes in the form of retail gasoline (77%), though residential and commercial heating (16%) and industrial uses (7%) also represent significant shares (US EIA, 2022a).

In contrast, New York only produces 0.01% of U.S. crude oil and has no oil refineries, importing all of its petroleum from refineries in the Eastern United States (e.g., New Jersey and Pennsylvania), the Gulf Coast, the Midwest, and Canada. Thus, oil companies operating in New York State focus primarily on importing and selling fuel. In 2020, there were 4,959 gas stations in the state (US EIA, 2022a). Suppliers comprise many large U.S. and European oil companies, including ExxonMobil, British Petroleum (BP), Citgo, Shell, ConocoPhillips, and Phillips 66.[4]

2. Economic Theory of Prices in the Short Run to Medium Run

According to economic theory, firms set production quantities (and prices) to maximize their profits, subject to market demand. Regardless of the market structure, the profit-maximizing quantity and price of any good are a function of demand and the variable cost of production. As compensatory payments would not vary with firms' current production decisions, these payments would be considered fixed costs for oil firms. The proposed payments thus will not affect the equilibrium price or quantity of retail gasoline in the short run to medium run when firms are unable to exit or enter the industry, such that market structure is held constant (Nicholson, 2004, p. 205; Ritz, 2015).

General Theory

Economic theory indicates that an oil firm selects a production level to maximize its profits (total revenues minus total costs). Total costs are the sum of variable costs and fixed costs (Perloff, 2008, p. 205). Regardless of market structures, profit maximization for a firm occurs at a production level that equates the marginal revenue with the marginal cost, which are the revenue and cost of producing one additional barrel of oil, respectively (Nicholson, 2004, p. 251; Perloff, 2008, p. 458; Pindyck and Rubinfeld, 2013, p. 285, 288; Nicholson and Snyder, 2008, p. 543).[5] As the marginal revenue of a firm depends on the production decisions of other firms, the exact solution varies with the market structure, which is characterized by the number of firms and their total cost functions. However, in any market structure, fixed costs do not affect the equilibrium quantity, as they are not part of marginal revenues or marginal costs. Similarly, fixed costs do not determine the equilibrium price, as they are not part of the equilibrium quantity when market structure is constant in the short-run to medium-run or the demand curve upon which the market clearing price is determined. As the existing stock of greenhouse gases in the atmosphere form the basis of the proposed compensatory payments, these payments are part of the fixed costs of production and thus will not affect current or future variable production costs. See Appendix A for mathematical derivations discussed in this subsection.

Applying Theory to the Oil Industry

Empirical research can help characterize the structures of the two oil markets of interest – the global crude oil market and the New York retail gasoline market. In the global crude market, researchers traditionally classified OPEC as a monopolist (Li, 2010). However, recent empirical evidence points to a Stackelberg oligopoly model holding historically, where OPEC is the dominant firm that leads with its production decisions and non-OPEC producers are a competitive fringe that follow its lead (Li, 2010; Huppmann and Holz, 2010; Golombek et al., 2018). More recent evidence proposes a more competitive global market since the mid-2000s, in which the fracking boom led the United States to be the largest global energy producer and the 2008 financial crisis reduced global oil demand (Huppmann and Holz, 2010; Frondel

[4] In 2012, ConocoPhillips spun off its midstream and downstream operations into Phillips 66. However, as the Act applies to fossil fuels sold between 2000 to 2018, both companies are likely responsible for emissions during the covered period (ConocoPhillips, 2012). Of the remaining major United States' oil producers, Chevron does not appear to have retail operations in New York (ScrapHero, 2022).

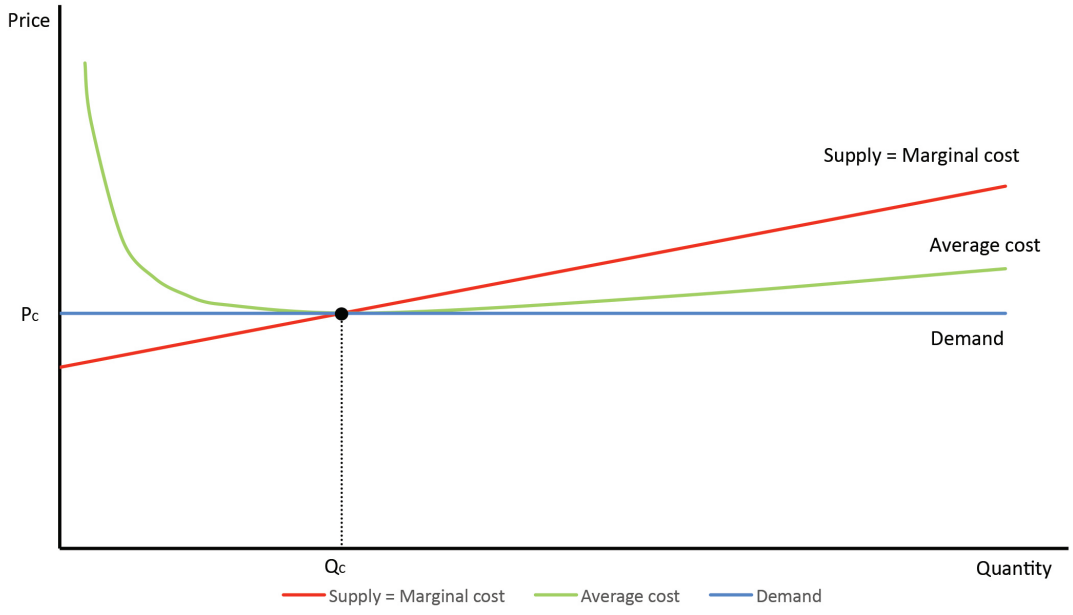
[5] Specifically, each oil firm increases its quantity produced until the marginal decrease in profits from the resulting price decline is offset by the increase in profits due to a growth in the quantity of the goods demanded.

and Horvath. 2019; Berk and Cam, 2020; Balke et al. 2020). Even then, OPEC still influences prices while non-OPEC producers act as an increasingly important competitive fringe (Frondel and Horvath. 2019). Meanwhile, mixed evidence exists about regional market power at the retail level for gasoline in the United States with only some studies supporting competitive markets (Deltas, 2008; Houde, 2010; Bumpass et al., 2015; Eleftheriou et al., 2019).

Given the wide range of possibilities, this analysis considers several market structures starting from two market structure extremes – a perfectly competitive market and a monopoly. Firms treat the price as given in a perfectly competitive market, such that individual firm's production decisions do not affect it (Nicholson, 2004, p. 312). In equilibrium, prices equal marginal production costs (see Figure 4). In the case of a monopoly, there is only one firm, which recognizes that it alone influences prices, such that it determines the equilibrium quantity by equating marginal revenue with marginal cost (see Figure 5). As fixed costs, compensatory payments do not influence the equilibrium quantity decision or the corresponding equilibrium price in either of these extreme cases.[6]

Figure 4. Equilibrium Price and Quantity in a Perfectly Competitive Industry.

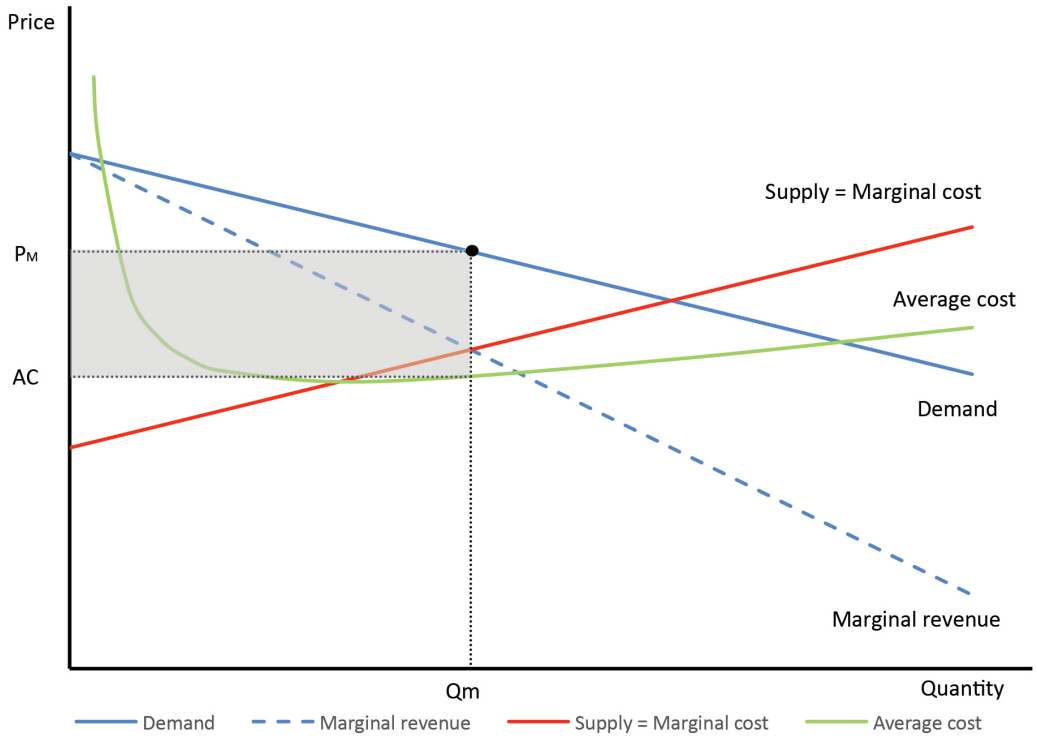
The demand curve in a perfectly competitive industry is horizontal at the market price, P_c, indicating perfectly elastic demand. All firms can sell any quantity at the market price but not at a higher price because of an infinite number of firms in the market. In this figure, total cost is quadratic, such that marginal cost is linear. Total quantity produced in the industry, Q_C, occurs where price equals marginal cost. In a perfectly competitive industry, price also equals average cost in equilibrium, such that there are zero economic profits and firms have no incentive to enter or exit the industry.



[6] The demand curve is not a function of fixed costs, which are paid by producers.

Figure 5. Equilibrium Price and Quantity for a Monopoly.

A monopoly firm produces at a quantity Q_m that equates marginal revenue and marginal cost to maximize profits. The downward sloping linear demand curve (with half the slope of the linear marginal revenue curve) determines the equilibrium market clearing price P_m. In this figure, total cost is quadratic, such that marginal cost is linear. The firm's profit is represented by the light grey area in the figure.



Unlike these extremes, the New York retail gasoline and global crude oil markets may be more characteristic of oligopoly models, where a limited number of firms with some market power produce an outcome somewhere between the monopoly and perfect-competition equilibriums (Nicholson and Snyder, 2008, p. 523). In the New York retail gasoline market, there are several large retail gasoline companies with market power and no clear market leader, such that all gasoline distributors and retailers in the state make production decisions simultaneously.[7] Assuming a Nash equilibrium (Perloff, 2008, p, 454),[8] no firm has an incentive to change its quantities, holding all other firms' decisions constant. Again, compensatory payments do not impact the equilibrium quantities and price as part of fixed costs.

[7] Companies may exhibit power at a sub-state level in New York, as ExxonMobil does appear to have more gas stations in cities and towns across the state, though any definitive statement is difficult given the incomplete nature of the data available (ScrapHero, 2022). Furthermore, gas stations may have spatial market power due to their strategic geographic location

[8] In a Nash equilibrium, no firm has the incentive to adjust its quantity produced, as each firm cannot increase its profits if other firms hold their quantities fixed.

In the global crude oil market, empirical evidence supports an oligopoly model where firms make production decisions sequentially instead of simultaneously. Specifically, OPEC is the dominant firm making production decisions prior to other producers and to which non-OPEC firms simultaneously respond by choosing their production quantities following the leader's announcement of a decision (Nicholson and Snyder, 2008, p. 543).[9] In this sequential decisionmaking framework, compensatory payments still do not impact the equilibrium quantities and prices, given that they are fixed costs. Although it is unclear whether compensatory payments would apply to all or some oil companies in OPEC nations, as discussed in Section 1, the above result applies to the full range of scenarios.

See Appendix B for mathematical derivations discussed in this subsection.[10]

3. Oil Industry Consolidation in the Long Run

In the long run, oil firms may enter and exit the industry. Thus, contemplated compensatory payments can potentially affect consumer prices through anticompetitive behavior, as additional consolidation in the market may allow firms to charge excess prices or further increase existing price premiums (Nicholson, 2004, pp. 269-269). However, this kind of consolidation is unlikely empirically given the relatively small size of the payments relative to oil firms' revenue, market capitalization, and profits.

Economic Theory on Exiting the Industry

In the above section, we held constant market structures. In theory, the introduction of compensatory payments and the corresponding increase in fixed costs can decrease firm profits and result in smaller positive profits (see Figure 6) or negative profits (see Figure 7) for assessed firms over the nine-year assessment period. In this latter case, firms may leave the industry in the long run (Nicholson, 2004, p. 205; Perloff, 2008, p. 268-2070; Pindyck and Rubinfeld, 2013, p. 233, 288-290, pp. 293). If an oligopoly holds, the exiting of firms can lead to less oil production and higher oil prices, as the number of firms declines and the remaining firms obtain a higher degree of market power (Nicholson and Snyder, 2008, p. 523). In the extreme case where the oil industry initially consists of only two firms and one goes bankrupt or the other firm purchases it, the consolidation shifts the market equilibrium from a duopoly to a monopoly (see Figure 8). As discussed below, however, this theoretical possibility is highly unlikely in reality.

[9] It is easy to observe this dominance in the real world where OPEC and OPEC+ meet and announce their production decisions and set production targets (Northam, 2022).

[10] There is an alternative type of oligopoly model in which firms compete by setting prices instead of quantities. We do not discuss this option here, as there is no evidence that it applies to oil companies. Furthermore, the results are comparable to the perfectly competitive case as the firms compete and drive the price down until price equals marginal cost, regardless of the number of firms (Nicholson, 2004, p. 398). Again, compensatory payments as part of fixed costs do not impact equilibrium price or quantity.

Figure 6. Impact of Compensatory Payments on Monopoly Equilibrium with Positive Profits After Shift.

Given the same monopoly firm in Figure 5, the average cost curve shifts up to with the introduction of compensatory payments, as fixed costs increase. Given the unchanged marginal cost despite an increased fixed cost, the equilibrium quantity quantity (Qm') and price (Pm') remains the same as Figure 5 under the equilibrium condition that marginal revenue equals marginal cost. The dark grey area represents the firm's profit in the figure, which remain positive, but smaller than the profits prior to the compensatory payments (the light grey area).

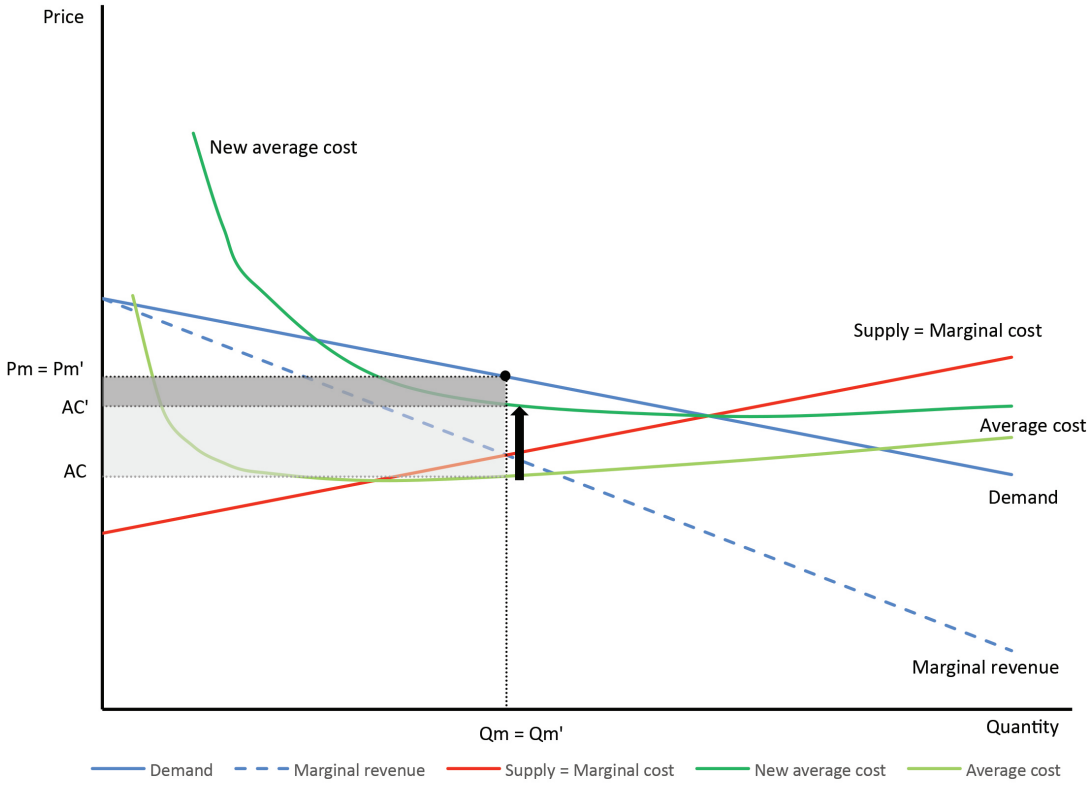


Figure 7. Impact of Compensatory Payments on Monopoly Equilibrium with Negative Profits After Shift.

Given the same monopoly firm in Figure 5, the average cost curve shifts up to with the introduction of compensatory payments, as fixed costs increase. Given the unchanged marginal cost despite an increased fixed cost, the equilibrium quantity quantity (Qm'') and price (Pm'') remains the same as Figure 5 under the equilibrium condition that marginal revenue equals marginal cost. The dark grey area represents the firm's profit in the figure, which become negative, in contrast to the positive profits prior to the introduction of the compensatory payments (the light grey area).

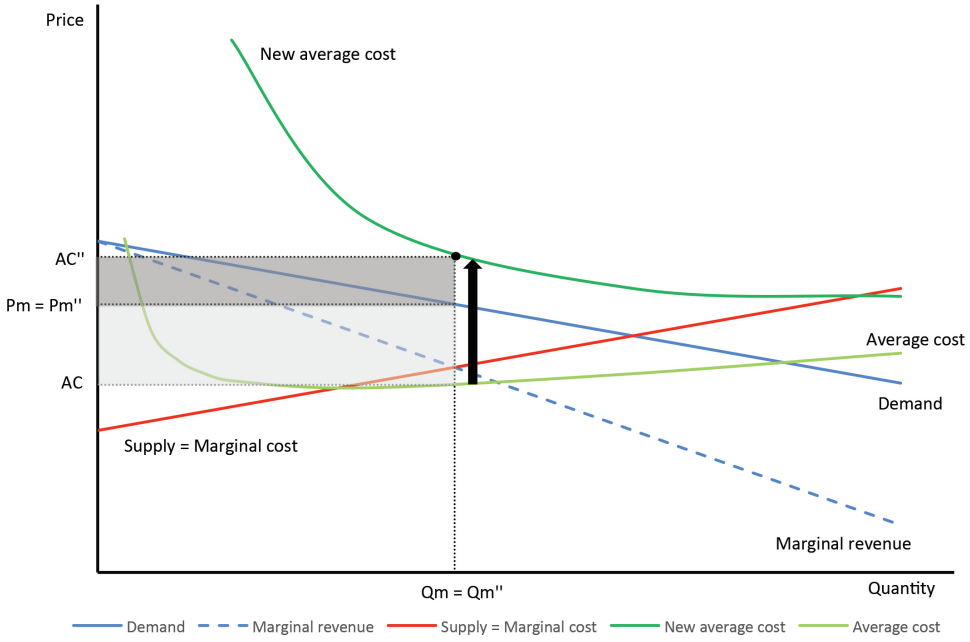
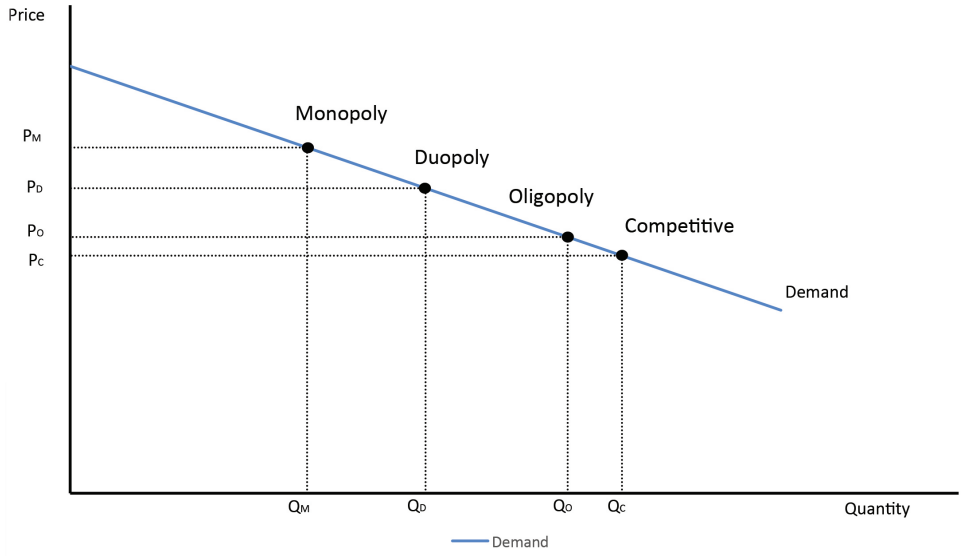


Figure 8. Equilibria by Number of Firms in the Industry.

This figure displays multiple equilibria under different market structures, where the number of firms in the industry is 1 (monopoly), 2 (duopoly), n>2 (oligopoly), and infinite (perfectly competitive), respectively. As the number of firms increases, the remaining firms obtain a lower degree of market power, leading to more oil production and lower oil prices.



Empirical Evaluation of Consolidation Incentives in the Oil Industry

In reality, the proposed compensatory payments are unlikely to lead to any consolidation in the oil industry, regardless of which firms the state assesses.

It is unclear which firms New York will assess the compensatory payments, though the impact on business operations and sector profitability will be minimal given the sector's relative size. Assessed firms' annual operating revenue and profits are likely to be vastly larger than the annual compensatory payments of $3.3 billion for nine years, regardless of whether the state assesses only U.S. firms or all large oil firms worldwide; see Table 1. For companies operating in New York, which will clearly be assessed, annual compensatory payments represent an upper bound of 5.6% of their average annual profits of $59 billion from 2010 to 2021 (Sönnichsen, 2022e – 2002i).[11] Furthermore, none of these companies' profits would shift from positive to negative, assuming a division of the $3.3 billion between these companies based on their relative greenhouse gas emissions in 2017 (see Figure 9).[12]

Like revenue, the total compensatory payments of $30 billion also make up a relatively small share of domestic and international oil firms' market capitalization; see Table 1. The largest American and European oil companies operating in New York have a market capitalization of approximately $1 trillion; total compensatory payments represent 3.1% of this value. These small shares indicate that the compensation payments will have a negligible effect on firms' major decisions, such as exit or entry, or even smaller decisions, such as operational changes.

Table 1. Relative Size of Compensatory Payments to Oil Firms' Revenues, Profits and Market Capitalization

Economic Indicator		U.S. Oil Firms	Largest U.S. and European Oil firms Operating in NY[a]	All Large Oil Firms Globally
Average Annual Revenue	2022 USD	$158 billion	*Not Available*	$2.6 trillion
	% of annual payments	2.1%		0.1%
	Relevant time-period	2016-2020		2020-2021
Average Annual Profits	2022 USD	$55 billion	$59 billion	$300 billion
	% of annual payments	6.1%	5.6%	1%
	Relevant time-period	2010 to 2021	2010 to 2021	2021 – 2022[b]
Total Market Capitalization	2022 USD	$1.3 trillion	$1 trillion	$3.8 trillion
	% of total payments	2.4%	3.1%	0.8%
	Relevant time-period	October of 2022	October of 2022	October of 2022

[a] *Excludes Citgo and 7-Eleven due to lack of data*
[b] *Only first two quarters of fiscal year 2022*
Source: Sönnichsen (2021; 2022a – 2002l); Puri-Mirza (2022); Statista Research Department (2022)

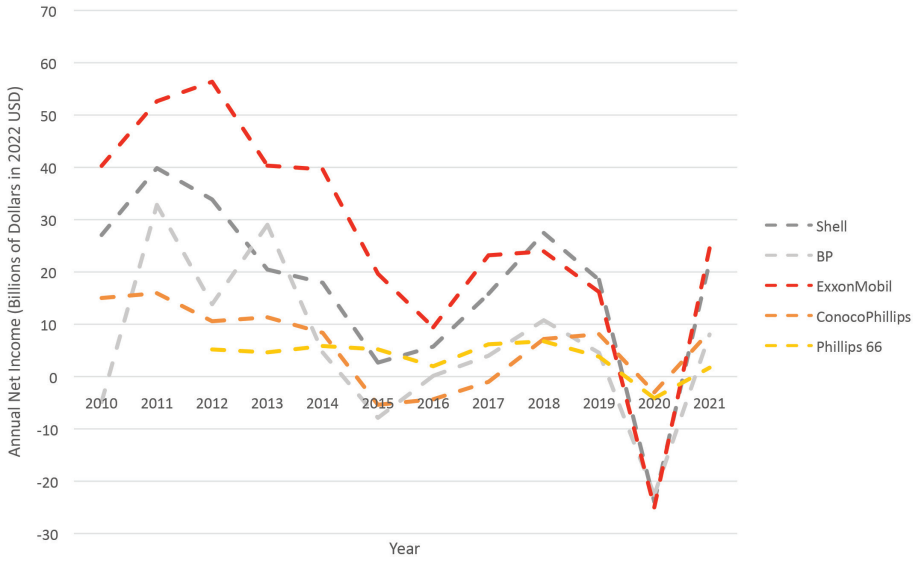
[11] Due to lack of data, these calculations excludes Citgo and 7-Eleven.

[12] If we divide annual compensatory payments using relative shares of total greenhouse emissions in 2017, each firm's annual compensatory payments equal between 3.6% and 10.3% of annual average profits between 2010 and 2021. Ideally, this analysis would use greenhouse gas emissions data for each company in every relevant year, but this data is not easily available. To check our results, we redo the calculation using net profits in 2017, which matches the year of our greenhouse gas emissions data. In this case, we find that oil company's annual compensatory payments equal between 5.5% and 15.5% of profits in 2017, except for ConocoPhillips, which earned negative profits in 2017 prior to the implementation of the compensatory payments.

A similar type of analysis can be done using total revenue as a proxy for greenhouse emissions, as long as oil prices and the emission concentrations per barrel of oil are similar across companies. If we divide annual compensatory payments using relative shares of total revenue in 2022, each firm's annual compensatory payments equal between 3.3% and 14.6% of annual average profits between 2010 and 2021. We redo the calculation using net profits in 2021, which matches the year of our total revenue data. In this case, we find that oil company's annual compensatory payments equal between 3.1% and 18.5% of profits in 2021.

Figure 9. Net Income of Largest Oil Companies Operating in New York.

Grey lines represent the profits of the largest foreign oil companies operating in New York, while the red, orange, and yellow lines represent the largest American companies operating in New York. Source: Sönnichsen (2022e – 2002i)



The analysis above almost certainly overestimates oil companies' liability. Critically, the Act's assessments applies to natural gas and coal companies in addition to oil companies, contrary to the assumptions in the calculations above, implying a far smaller assessment on the oil industry. Furthermore, the oil industry recently received record revenues and profits in 2022, exceeding the averages used in the calculations above (Carrington, 2022). Moreover, ongoing rapid inflation will likely lead to further price increases for oil, further eroding the relative share of compensatory payments to the above key indicators.[13] Finally, the Act further mitigates the likelihood of firms leaving the industry due to negative profits by exempting from compensatory payments those that emitted less than one billion metric tons. Thus, the Act excludes the oil companies operating in New York with the smallest profits margins from payments.[14]

Even if a qualifying firm did face net financial losses (i.e., negative profits), that firm would not necessarily be forced out of the market. As seen in Figure 9, individual firms have experienced negative profits in some years, such as 2015 and 2020, though these firms did not leave the market and often earned positive profits in the following years.[15] If firms expect losses to be short lived, as is the case with the proposed compensatory payments that would stretch out to a maximum of nine years, they do not necessarily exit the industry.[16]

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[13] General inflation is at 8.2% in the first quarter of 2022, which is its highest rate since the 1970s (US Bureau of Labor Statistics, 2022a). However, energy inflation is much higher at around 20% to 30% depending on the source (United States Bureau of Labor Statistics, 2022a-c).

[14] Using a subset of oil companies operating in New York (Shell, BP, ExxonMobil, Phillips 66, and ConocoPhillips) and the United States (plus, Chevron and Marathon), we find a strong correlation between greenhouse gas emissions (Fletcher et al., 2018) and profits (Sönnichsen, 2022g – 2022l) in 2017. Similarly, we find a positive correlation between profits and revenues for the subset of companies in New York (Shell, BP, ExxonMobil, Phillips 66, and ConocoPhillips) in 2021. As companies face relatively the same oil prices and emission factors, revenue should be a good approximation of emissions. Thus, profits and emissions appear positively correlated for oil companies operating in the United States.

[15] A compensatory payment can only be responsible for negative profits, and thus a firm exiting the industry, if the firm's profits are positive without the payments and negative with them.

[16] "A firm need not always earn a profit in the short-run…Note that the firm is losing money when its price is less than average total cost at the profit-maximizing output…In that case, if there is little chance that conditions will improve, it should shut down and leave the industry…Will shutting down always be the sensible strategy? Not necessarily. The firm might operate at a loss in the short-run because it expect to become profitable again in the future, when the price of its product increases or the cost of production falls." (Pindyck and Rubinfeld, 2013, p. 288-290).

Even if firms did seek to consolidate or exit the industry because of the compensatory payments, their ability may be limited. With respect to consolidation, any attempt to increase market power and force up prices would be regulated by antitrust laws,[17] though the overall incentives for companies to consolidate as a result of the Act are small to non-existent, as discussed above. Furthermore, while firms can avoid certain types of fixed costs in the long run by exiting the market (i.e., unsunk costs), exiting is not a means to avoid compensatory payments according to the current text of the proposed law. Specifically, the law has no bankruptcy or insolvency clause, such that New York will likely collect as a creditor the assessed amount to the greatest extent possible under the law following the example of the EPA (United States Environmental Protection Agency, 2022).[18]

Though firms are unlikely to consolidate or exit the industry due to the compensatory payments, some firms may sell assets or take other steps as a reaction to the proposed fees. Firms can accomplish these types of ownership-related transactions without disrupting operations. Indeed, even when they make operational changes, owners of these revenue-generating assets have strong incentives to continue their operations at their profit-maximizing levels.

4. Retaliation

Oil companies assessed compensatory payments may wish to retaliate by raising oil prices in New York State. However, they would be limited in their ability to do so by the interconnectedness of national and global energy markets. First, if oil companies ever retaliated, global oil prices would rise along with New York oil prices as the global marketplace determines wholesale crude oil price. The ability to retaliate would also be limited by competition, as New York is less likely to assess some or all foreign oil firms in the global petroleum market. Moreover, the relatively free movement of oil and other forms of energy implies arbitrage opportunities if oil companies attempt to manipulate regional retail oil prices. Again, if such retaliation occurred, nonlocal oil retailers would likely enter the New York retail market lured by above-average returns created by higher prices pushing New York retail oil prices back towards the existing equilibrium (Perloff, 2008, p. 268-2070; Pindyck and Rubinfeld, 2013, 302-304). Finally, coordinated anti-competitive behavior where multiple firms collude to punish a regulator and its constituents is illegal under New York and federal antitrust laws.[19]

5. Expectations

A fourth pathway for compensatory payments to affect prices involves expectations. The imposition of compensatory payments may lead firms to adjust their expectations about future liabilities based on their production in the future.

As the future is uncertain, oil companies make production decisions to maximize expected profits accounting for future company liability (Nicholson, 2004; Perloff, 2008; Pindyck and Rubinfeld, 2013). In this case, an increase in the probability of future liability will decrease the equilibrium quantity produced and vice versa (see Appendix C for mathematical derivations). However, it is unclear how the passage of the proposed Act would affect expectations, and thus, crude oil and retail gasoline prices. If the imposition of these compensatory payments leads firms to anticipate other, future compensatory payments based on their current and future production, the equilibrium quantity will decline as firms expect higher marginal production costs. However, it is unclear how the current action will affect future actions by New

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[17] Federal law "prohibits any agreement among competitors to fix prices, rig bids, or engage in other anticompetitive activity." (United States Department of Justice, 2005). New York State law contains a similar prohibition (New York State Attorney General).

[18] The sufficient connection requirement applies to the covered period of greenhouse gas emissions, i.e., to the 2000 to 2018 period. Therefore, if a large oil company declares bankruptcy in 2023, it would still be sufficiently connected to the state after bankruptcy if it sold gasoline in New York during the covered period.

[19] See footnote 17.

York State (or other entities). Given the ambiguous direction of the signal, there is no strong reason to believe that any anticipation effect would lead to an equilibrium increase in prices.

Reasons for Firms to Expect Liability for Greenhouse Gas Emissions

In fact, oil firms may already have strong reasons to expect liability or regulation beyond New York's regulatory decisions. In particular, the Paris Agreement, existing domestic climate policies, state and local greenhouse gas emission targets, and energy and environmental regulations, provide strong signals that the United States and other nations are taking action on climate change. Economists predict that more aggressive, additional action will be taken relative to current policy (Rennert et al., 2022).

Beyond regulation, many entities have been seeking to hold fossil fuel companies liable for climate impacts (Zhongming et al., 2021), as the public increasingly believes that energy companies are responsible for climate change (Gorbach et al., 2022). The United Nations identified 864 cases of climate litigation across 24 countries in 2017, which increased to 1,550 across 38 countries plus the European Union in 2020. Historically, most cases are in the United States with only a small portion of these cases against corporations, focusing on such topics as corporate liability, disclosure, and greenwashing. As of 2020, more than a dozen corporate liability cases were still active in the United States with no such case yet decided on its merits at that time (Zhongming et al., 2021).

In addition, the United Nations and Organisation for Economic Co-operation and Development (OECD) recognize that climate impacts may represent human rights violations. Likewise, the Philippines Human Rights Commission finds that companies are morally responsible for climate change and legally liable; even if international legal liability does not apply, countries can pass laws and hold entities liable in their domestic legal systems (Benjamin, 2021; Zhongming et al., 2021). These liability lawsuits and other climate litigation may result in additional regulations, delays, bans, and financial costs, including compensation or adaptation requirements (Zhongming et al., 2021). Thus, regardless of whether New York passes the Act, oil companies will rationally assume the possibility of future legal liability for past, current, and future emissions.

Evidence Oil Firms Already Internalizing Liability Risks

Many oil companies, along with an increasing number of firms in the energy sector and beyond, have used "internal carbon prices," assigning either a real or theoretical monetary penalty for emissions in internal processes such as cost-benefit analyses of investment decisions (Harpankar, 2019; Bartlett et al., 2021). The largest oil companies operating in New York all have internal carbon prices: BP uses $50/metric ton, increasing to $100, $200, and $250 in 2030, 2040, and 2050, respectively (CDP, 2021a); Shell uses $125/metric ton with the value increasing as high as $200 by 2050 depending on the origin country of the project (CDP, 2022); ConocoPhillips uses $40/metric ton with no variation by geography unless the origin country has a higher price (CDP, 2021b); ExxonMobil reportedly used $60/metric in the past and planned to increase this amount to $80/ton, though the company stopped reporting its internal carbon price after being sued for using lower internal carbon prices than reported to shareholders (Schapiro, 2014; Brown, 2018).[20] Beyond these New York-based oil companies, many other major oil companies have an internal carbon price, including Chevron, Devon, Total, Ameren, and Excel (Davis, 2013).

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[20] This lawsuit points to the fact that companies may report these internal prices and not use them. Even then, oil companies never set older carbon prices at levels that would be transformational (Chang, 2017), which may explain why some feel that the values are insufficient (Li et al, 2022).

While companies often have legal, normative, and competitive reasons to adopt internal carbon prices, empirical evidence and company statements indicate that regulatory risk and liability concerns frequently motivate these decisions (Chang, 2017; Harpankar, 2019; Bento and Gianfrate, 2020; Bartlett, 2021; Gorbach et al., 2022; Schapiro, 2014; CDP, 2021a; CDP, 2021b; CDP, 2022).[21] Often, companies' internal carbon prices are higher than the carbon tax or price used by jurisdictions or countries, as these companies factor in expectations about future regulatory risk (Trinks et al., 2022; Schapiro, 2014). Consequently, internal carbon prices tend to be higher in high-emitting industries with long-run investment cycles, such as the oil, gas, and utilities sectors (Ahluwalia, 2017; Chang, 2017; Bento and Gianfrate, 2020; Bartlett, 2021; Fan et al., 2021; Trinks and Scholtens, 2022).[22] In the last five years, the internal carbon prices of oil companies, e.g., BP and Shell, have rapidly increased along with regulatory risks (Schapiro, 2014; Parnell, 2020; Bartlett et al., 2021; Bento and Gianfrate, 2022; Li et al., 2022), which is unsurprising as fossil-fuel companies and utilities are the most regulated sectors of the economy and have strong expectations of future regulation (Bartlett et al., 2021).

Regardless of New York's decision, other entities are likely to ramp up climate regulations and lawsuits. As these pressures continue, oil companies will face higher costs and expected costs, which will potentially reduce the quantity of oil supplied and increase corresponding prices. Given the global nature of this marketplace, the potential for New York to impose a second round of compensatory payments in the future will have little overall impact on the current and future production decisions of oil companies. In fact, many multi-national energy and utility companies likely have already adopted internal carbon pricing assumptions for their New York operations due to regulations in other jurisdictions (Harpankar, 2019; Trinks and Scholtens, 2022), which far exceed the current market price in the New York power sector.[23] Therefore, it appears that the Act will have at most a very limited effect on industry expectations and prices.

6. Impacts of Spending the Revenue

The foregoing analysis focuses on the incidence of compensatory payments and does not account for how the state spends any resulting revenue. The New York State government could spend this revenue in ways that indirectly affect demand or production costs of retail gasoline in New York, which would in turn affect prices. Moreover, if New York legislature does not pass the Act to establish the adaptation fund, taxpayers may need to pay for necessary updates of New York's climate-vulnerable infrastructure (despite their lack of direct responsibility). This in turn has general equilibrium effects by impacting consumer spending, including gasoline demand, as well as consumer welfare implications. We set aside these general equilibrium effects, as the direction of the impact is unclear, except to note that these are secondary in nature.

In addition to general equilibrium effects, the Act places the funds from these proposed compensatory payments into a climate change adaptation fund for green infrastructure (New York State Senate, 2022; Lisa, 2022), which would aid New York in adapting to climate change. To the extent that these funds address the impacts of climate change on the energy sector of New York, energy producers and distributors will have lower marginal costs in the future due to a more

[21] In addition to the risk of changing regulations and policy, there are also risks of changing social norms and technology (Fan et al., 2021).

[22] According to this same research, oil companies and others in high-emitting industries are more likely to adopt internal carbon prices relative to companies in low-emitting industries.

[23] In the power sectors of New York and eleven other Northeastern and Mid-Atlantic states, the Regional Greenhouse Gas Initiative (RGGI) operates and manages a market that sets the market price for carbon dioxide. Specifically, RGGI is a multi-state cap-and-trade program for carbon dioxide emissions from the power sector. The current market price is $13.45 (RGGI, 2022a; 2022b).

resilient production and distribution system (Howard and Livermore, 2021).[24] This translates into lower future energy prices for consumers, including in the transportation sector.

Conclusion

In summary, this analysis finds that the Climate Change Superfund Act will have little to no impact on retail gasoline prices in New York. Economic theory shows that holding oil companies liable for past emissions will not lead to production or price changes in the local, national, or international energy markets, holding the structure of these markets constant. Empirical evidence shows that total compensatory payments for emissions from 2000 to 2018 are relatively small compared to oil company revenue, market capitalization, and profits. Therefore, the Act is unlikely to result in consolidation or bankruptcy within the industry. Expanding beyond market incentives in a static environment to consider dynamic issues, such as leadership and retaliation, the analysis finds that competitive pressures greatly restrict the ability of firms to manipulate prices. Furthermore, while expectations about future liability could impact current oil production and its corresponding price regionally and globally, there is no clear reason to suspect that passing the Act will lead to higher oil prices in the near term.

Finally, it is important to note that levying compensatory payments on companies is not a substitute for policies to reduce future emissions (like carbon pricing or regulations). State and national policies to reduce emissions remain an essential response to the many grave risks associated with climate change. Such policies will lead to higher fossil-fuel prices, though this is necessary to lower demand for pollution-intensive fuels and incentivize the transition away from these fuels.[25]

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[24] Economists expect climate change to significantly impact both demand and supply of energy (Howard, 2014). On the demand side, economists expect climate change to decrease energy demand in the winter for heating, while increasing electricity demand in the summer for air conditioning, though studies differ on the estimated net impact for the United States (Clarke et al., 2018; Rennert et al., 2020). In New York, the net impact on oil demand is likely negative from decreased heating (Rode et al., 2021), as New York uses a significant portion of its oil for heating, though the net impact of climate change on oil demand is uncertain due to unobserved feedbacks, behavior changes, and future regulations (Howard and Livermore, 2021). On the supply side, climate change will impact the costs of renewables and fossil fuels, including energy infrastructure used for production, distribution, and generation (Howard and Livermore, 2021). It is difficult to determine the net effects of climate change on the cost of supplying energy, including oil extraction, processing, and distribution, such that the magnitude of the impact is unclear (Howard, 2014). Regardless, adapting to this future will lead to lower marginal costs and prices in the future energy market.

[25] If policymakers have concerns about the impact of such policies on citizen welfare, particularly for low-income groups, they can adopt a revenue-neutral, carbon tax. The use of climate dividends can greatly benefit the most disadvantaged groups in society, as they consume the least amount of energy per capita and are the most vulnerable to climate impacts (Carattini et al., 2017).

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Appendices

Appendix A

Economic theory indicates that each oil firm selects their oil production level (q_i) to maximize their profits (Π_i). Profits equal total revenue (TR_i) minus total costs (TC_i), such that firm *i*'s profit is

$$\Pi_i = TR_i - TC_i = q_i P(Q) - C_i(q_i)$$

where the market price $P(Q)$ is a function of the aggregate quantity of oil produced by all firms *Q*, total revenue for firm *i* equals the product of this market price and its quantity produced, i.e., $TR_i = q_i P(Q)$, and total production costs for firm *i* is a function of firm *i*'s quantity produced $C_i(q_i)$. The total quantify of oil produced equals the sum of oil produced by all *N* firms in the oil industry, such that $Q = \sum_{j=1}^{N} q_j$. Total costs of firm *i* equal the sum of variable productions costs $V_i(q_i)$ and fixed production costs F_i, which are costs that vary and do not vary with firm *i*'s quantity produced, respectively (Perloff, 2008, p. 205). Therefore, firm *i*'s profit is:

$$\Pi_i = q_i P\left(\sum_{j=1}^{N} q_j\right) - V_i(q_i) - F_i.$$

In this static model of firm profits, the Act's proposed compensatory payments would be part of the fixed costs of production, F_i. Because existing stock of greenhouse gases in the atmosphere form the basis of these payments, these payments would not affect current or future variable production costs.

Profit maximization for each firm occurs when the derivative of its profit function with respect to its quantity produced equals zero (Nicholson, 2004, p. 249). Therefore,

$$\frac{\partial \Pi_i}{\partial q_i} = P(Q) + q_i \frac{\partial P}{\partial Q} \sum_{j=1}^{N} \frac{\partial Q}{\partial q_j} \frac{\partial q_j}{\partial q_i} - \frac{\partial V_i(q_i)}{\partial q_i} = 0$$

where $\frac{\partial V_i(q_i)}{\partial q_i} = MC_i(q_i)$ is the marginal production cost of *firm i*, i.e., the cost of firm *i* producing one additional barrel of oil, and $\frac{\partial q_j}{\partial q_i}$ is how firm i perceives the response of firm *j* to firm *i*'s quantity decision. With some simplifying assumptions, we can rearrange this expression to the following form:

(1) $$P(Q) + q_i \frac{\partial P}{\partial Q}\left[1 + \sum_{i \neq j} \frac{\partial q_j}{\partial q_i}\right] = MC_i(q_i)$$

where this expression equates the marginal revenue (the left side of the equation and depicted as $MR_i(q_i, Q)$) with the marginal cost of the firm producing one additional unit of quantity (Nicholson, 2004, p. 251; Perloff, 2008, p. 458; Pindyck and Rubinfeld, 2013, p. 285, 288; Nicholson and Snyder, 2008, p. 543). The exact solution depends on the structure of the market, which is characterized by the number of firms and their total cost functions. Even so, fixed costs clearly do not impact the equilibrium quantity, as F_i is missing from the above expression that determines the equilibrium quantity and its corresponding equilibrium price determined on the demand curve.

Appendix B

Firms treat the price as given in a fully competitive market, such that individual firms' production decisions do not affect it (Nicholson, 2004, p. 312). When $\frac{\partial P}{\partial Q} = 0$ in equation (1), $MC_i(q_i) = P(Q)$ determines the equilibrium quantity, where marginal production costs equals the price (Pindyck and Rubinfeld, 2013, pp. 285-287). See Figure 4.

In the case of a monopoly, there is only one firm that recognizes that it can alone influence prices. In this case, the following equation determines the equilibrium quantity:

$$P(Q) + Q\frac{\partial P(Q)}{\partial Q} = MC(Q)$$

where the left-hand side is the marginal revenue change from producing one additional barrel of oil accounting for the additional revenue from one more barrel of oil sold and the resulting decline in price for all other barrels of oil sold. See Figure 5.

Thus, as part of fixed costs, compensatory payments do not influence the equilibrium quantity decision or the corresponding equilibrium price in both extreme cases.

In a Cournot oligopoly model that best represents the New York retail gasoline market, we assume simultaneous decision making and a Nash equilibrium (Perloff, 2008, p, 454). Thus, no firm has an incentive to adjust their production quantity, as each firm cannot increase its profits if other firms hold their quantities fixed. Equivalently, $\frac{\partial q_j}{\partial q_i} = 0$, such that

$$P(Q) + q_i\frac{\partial P}{\partial Q} = MC_i(q_i),$$

Solving for q_i, we derive each firm's optimal response function to other firms' quantity decisions, and then solve for a steady state in which all firms have no incentive to change their quantities holding all other firms' decisions constant. Again, it is clear from the lack of fixed costs that charging oil firms the compensatory payments does not impact the equilibrium quantities and prices assuming that the number of firms is fixed and unaffected by the payments.

In the global crude oil market, empirical evidence supports a Stackelberg oligopoly model, in which OPEC is the dominant firm that moves before the other firms know how to respond. The equilibrium condition for the Stackelberg leader, which we label firm *k*, is

$$P(Q) + q_i \frac{\partial P}{\partial Q}\left[1 + \sum_{i \neq k} \frac{\partial q_j}{\partial q_k}\right] = MC_i(q_i)$$

where $\frac{\partial q_j}{\partial q_k}$ is firm *j*'s best response function to firm *k*'s quantity decision. The equilibrium condition for the non-dominant firms matches the Cournot equilibrium in the previous paragraph (Nicholson and Snyder, 2008, p. 543). Again, fixed costs do not enter the optimization decision. Given the dynamic nature of Stackelberg equilibriums, this also points to the generality of these results moving from static to dynamic equilibria holding the market structure constant over time (Perloff, 2008, pp. 506-507).

Above all, compensatory payments and fixed costs do not determine equilibrium quantities of firms or the equilibrium price in the short-run to medium run when market structure is constant, regardless of this structure. As these oil companies engaged in a past course of conduct that contributed to current harm, the compensatory payments act as a levy based on that ongoing harm, whereas the historical nature of the conduct eliminates any forward-looking incentive for companies to change their behavior. Thus, the profit-maximizing quantities and prices of retail gasoline would remain unchanged by the Act.

Appendix C

As the imposition of compensatory payments may lead firms to adjust their expectations about future payments, firm *i* maximizes their expected profits as follows:

$$\max_{q_i} \mathbf{E}(\Pi_i) = \max_{q_i} \sum_{m=1}^{2} \rho_m \left[q_i P\left(\sum_{j=1}^{N} q_j \right) - V_i(q_i) - F_{i,m} \right]$$

where $F_{i,m}$ is the fixed cost conditional on future company liability and ρ_m is the probability of event *m* occurring where there are only two possible states: no future liability (*m=1*) and future liability (*m=2)*. Specifically, fixed costs are a function of two terms

$$F_{i,m} = F_i + \vartheta_m \frac{q_i}{Q}$$

where ϑ_m is oil company's future climate liability that equals zero in the first state and some positive amount in the second state. Note that this latter term is not really fixed any longer, and instead varies with quantity.

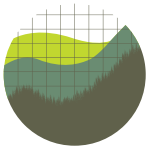
The following equation shows that a change in expectations, as reflected in a change in the probability of future liability, can impact the current optimal production decision under uncertainty. The first order condition for profit maximization equals

$$\frac{\partial \mathbf{E}(\Pi_i)}{\partial q_i} = \sum_{m=1}^{2} \rho_m \left[P(Q) + q_i \frac{\partial P}{\partial Q} \sum_{j=1}^{N} \frac{\partial Q}{\partial q_j} \frac{\partial q_j}{\partial q_i} - \frac{\partial V_i(q_i)}{\partial q_i} - F_i - \vartheta_m \left[\frac{Q - q_i}{Q^2} \right] \right] = 0$$

where $\vartheta_1 = 0$ and $\vartheta_2 > 0$. If the Act affects oil company's expectations about the probability of the future likelihood of climate liability, then

$$\frac{\partial \mathbf{E}(\Pi_i)}{\partial q_i \partial \rho_2} = -\vartheta_2 \left[\frac{Q - q_i}{Q^2} \right] < 0$$

Thus, actions that increase in the probability of future liability will decrease the equilibrium quantity produced. Vice versa, actions that decrease the probability of future liability will increase the equilibrium quantity produced. The latter appears more likely, though a more conservative assumption would be that the probability is constant and unaffected by New York's decision to pass the Act.



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