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).

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

[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).

[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).

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

7. 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

[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.

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]

[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:

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

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 influences 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 quantity produce, 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.