Establishing the Relationship Between Sewer Surcharge Fees and Pollutant Discharges by Industrial Users

By

Daniel Hicks

Applied Research Project

dkh91@txstate.edu

Submitted to the Department of Political Science

Texas State University-San Marcos

In Partial Fulfillment of the Requirements for the Degree of

Master of Public Administration

Summer 2022

About the Author

Daniel Hicks is pursuing a Master of Public Administration degree from Texas State University, San Marcos. He has worked for local governments since finding his passion in public service with the City of Kerrville in 2016. He is currently a Management Fellow with the City of San Antonio. He can be reached by email at dkh91@txstate.edu.

This ARP is proof of my wonderful wife's inexhaustible patience with me.

Abstract

Sewer surcharge fees are often implemented by utilities in the United States as part of a larger pretreatment program under the Clean Water Act's (CWA) regulatory framework. The fees are generally intended to either recoup the cost of treating wastewater with excessive pollution, or to encourage customers to discharge smaller quantities of pollutants. Currently there is no existing research that quantifies the effect of sewer surcharge fees on pollutant discharges, depriving regulators of the ability to design evidence-based sewer surcharge programs. The purpose of this research is to establish the relationship between sewer surcharge fees and pollutant discharges. Specifically, this study examines a secondary dataset with chemical oxygen demand (COD) discharges by 52 industrial users permitted by a large Tennessee utility over a four-year period from 2018-2021. A conceptual framework of formal hypotheses was used to direct a quasi-experimental study of the data. The study uses an interrupted time-series approach for regression analysis to quantify the change in COD discharges between 2018-2019 when there was no fee in place, and 2020-2021 after the fee was implemented. This analysis found no significant relationship between COD discharges and the presence of a sewer surcharge fee. The Conclusion chapter discusses the findings and suggests areas for future research.

Table of Contents

ABOUT THE AUTHOR **2**

ABSTRACT **4**

CHAPTER 1:INTRODUCTION **6**

Research Purpose 8

CHAPTER 2:LITERATURE REVIEW **9**

Purpose 9

Externalities, Pigou, and Revenue 9

Fines and Fees as a Behavior Modifier 13

The Efficacy of The U.S. Clean Water Act vis-à-vis Financial Incentives 18

Implementation of a “Polluter-Pays” or Pigouvian Method to Control Pollution 21

Summary 26

CHAPTER 3:METHODS **28**

Purpose 28

Operationalization of Conceptual Framework 28

Data Collection 29

Data Analysis 30

Strengths and Weaknesses 32

Summary 33

CHAPTER 4:RESULTS **35**

Purpose 35

Findings 35

Summary 37

CHAPTER 5:CONCLUSION **39**

Purpose 39

Discussion 39

Summary 41

REFERENCES **42**

Chapter 1: Introduction

Do financial incentives like fines and fees contribute to reducing pollution? The system of environmental enforcement in the United States relies heavily on the imposition of fines and fees in its mandate to meet environmental goals and finance regulatory activities, and it would raise many eyebrows if they did not affect behavior. Entities at all levels of government, federal to local, have the power to compel actions under the threat of financial penalties to meet environmental goals. As one example, the 1972 Federal Water Pollution Control Act, better known as the Clean Water Act or CWA, provides for a financial enforcement mechanism through civil penalties for violations. A civil violation of the CWA could garner a $56,460 per day, per violation maximum penalty because of the Environmental Protection Agency's (EPA) 2022 Penalty Rule ("Adjustment of Civil", 2022), though most enforcement actions levy penalties far lower than that amount. After these penalties are levied, do they carry any incentive to pollute less?

On their face, it is clear that financial incentives are a strong motivator for action (see: capitalism), but there are many factors that modulate their effects (Sowell, 2015). Most readers would be familiar with the concepts of substitute goods, and consumer expectations and preferences. Generally, market mechanisms tend to find efficient solutions for the economic problems created by the interplay of these factors. However, governments often provide services as a monopoly where there are no substitute choices, and there is no alternative when governments exercise their power to levy fines. Logically, this might enhance the incentive power of government fines and fees since the only way to avoid them is a behavioral change.

If this incentive effect exists, is there the potential for a more efficient system that leverages market mechanisms to meet regulatory goals? Are there examples of policymakers harnessing this effect in an impactful way? This paper seeks to answer these questions through examining the existing academic literature on fines and fees, and then testing a hypothesis on the relationship between user fees and pollution. The fee studied is called a "sewer surcharge fee," or a fee imposed by utilities on customers who discharge large or excessive quantities of pollutants into the sewer collection system. These quantities of pollutants cost large amounts of money to treat and remove, and many utilities have chosen to implement sewer surcharge fees as a cost recapture tool. Some also explicitly implement the fees as an incentive tool to discourage pollution (City of San Marcos).

Past research on other uses of fees and fines by governments suggests that customers and regulated entities are sensitive to them and choose their actions in a way that minimizes their financial impact. Chapter 2 discusses the effectiveness of environmental policies like the CWA through the lens of microeconomics, with special attention to how financial incentives affect compliance. Additionally, the chapter examines the broader body of research on policies such as toll roads and garbage collection to characterize the conditions under which financial incentives seem to work best.

Still, sewer surcharge fees are a unique implementation of environmental regulation, and the conclusions derived from existing research may have limited applicability when considering their effects. Sewer surcharge programs are individually designed and implemented at the local level, and are applied in a way that is wholly different than the CWA. Instead of facing steep fines for noncompliance or violation of a permit under the authority of the CWA, sewer surcharge fees are implemented as "polluter-pays" policies. These set a price for pollution on per-unit basis, rather than having a binary condition of "Compliant" or "Non-compliant" to determine charges like the CWA. It could be the case that sewer surcharge fees have a very different effect on customers and regulated entities than do CWA penalties. As it stands, policymakers and sewer surcharge program designers have no empirical basis on which to base their programs or make changes.

Research Purpose

This paper is the first examination of how sewer surcharge fees function, and is undertaken with the hope of providing policymakers with more complete information for program design. Specifically, the purpose of this research is to examine the relationship between sewer surcharge fees and pollutant discharges by industrial users. It analyzes a secondary, longitudinal dataset from a large utility in Tennessee containing pollutant discharge data from both before and after a surcharge fee was implemented. The research utilizes an explanatory conceptual framework to test a hypothesis on the relationship between the fees and pollutant discharges. Readers can find more information on this study's data and methods in Chapter 3. The study's results and policy implications, discussed in Chapters 4 and 5, respectively, might prompt policymakers to create new, or update existing programs. Chapter 5 also discusses further areas for future researchers, with suggestions for measures that would make the research findings more robust.

Chapter 2: Literature Review

Purpose

One could spend hours listing all of a government's goals- security, medical care, traffic reduction, economic opportunity, environmental protection, to name a few- and still find there is often little overlap between the policies used to accomplish them. But there is one broad commonality that stands out between the many policies: the use of financial incentives and market mechanisms to drive an efficient solution. This chapter will examine the existing literature on financial incentives in government policies and how they are used to accomplish various goals.

Externalities, Pigou, and Revenue

One form of financial incentive comes in the form of fines; fines are generally employed as a punitive measure after a prohibited action occurs, like a civil violation of laws like the CWA. They might be levied for the purposes of compensation after a criminal violation, as a deterrent for minor acts like moving violations, or recapturing the cost of negative externalities like pollution (Restitution and Restoration, 2015). An externality, as defined by Davidson, Martin, & Wilson (2012, p. 1), is an occurrence "whenever the social cost of an activity differs from the private cost." Although there can be positive externalities resulting from activities like research and development, or schooling, regulators, of course, normally focus their efforts on controlling negative externalities. This idea that regulators and governments should seek to internalize the *full* costs of an activity, both social and private, stems from the original writings of Arthur Pigou in *The Economics of Welfare* (1920), and 100 years later is manifested in many regulatory schemes that utilize fines. Efforts by governments to recapture the full negative externalities through fines can be considered “Pigouvian taxes.” For example, the Texas Commission on Environmental Quality, or TCEQ, takes into account the economic benefit gained and costs avoided by an entity when they pollute. The TCEQ will then either adjust the fine upwards, or include “All avoided cost returns… in the total assessed penalty (TCEQ, 2021, p. 21).”

The revenue generated from fines can be earmarked for a variety of purposes like remediation projects (TCEQ 2015), contributing to funds like the Crime Victims Fund (Victim Rights, Compensation, and Assistance), or recapturing the cost of resulting negative externalities like pollution (Restitution and Restoration, 2015). In other cases, the funds can be directed into a government’s general fund, and applied to any variety of expenditures. Fines can generate significant sums of money; so much so that discretionary fines like traffic citations increase in years following budget cuts (Su, 2020)**.** This indicates that governments, at least implicitly, rely on the revenues from fines as a reliable source of income.

Similarly, user fees are increasingly depended upon within governments’ budgets. A user fee is a price set for an elective, government-provided service that is paid when a citizen or entity enjoys its benefit. User fees are becoming an attractive and common method to fund goods and benefits provided by the government, and have steadily grown to be a significant portion of revenue in a tax-constrained environment (Jung & Bae, 2011; Zhang & Hu, 2019). As public sentiment sours on new or higher taxes, the horizontal equity of user fees is a more attractive way to fund government services. In contrast to taxes, user fees shift the expenses of providing a service from the general public, who may or may not derive any benefit, to those who directly utilize it. This idea, sometimes called the “benefit-payer principle,” creates a more equitable condition for funding special government services where only beneficiaries pay for a good, and is aligned with the concept of Pigouvian taxation. Ideally, user fees would be set at a point where the fee covers the full cost of providing a public service, precluding non-beneficiaries from having to subsidize it through other payments (Baker, 2010). In a suboptimal scenario where the fee does not cover the full cost, revenues would have to be diverted from elsewhere, begging the questions of why there were excess revenues to begin with, and whether the same quality of service can be maintained.

They are most useful for goods and services that are considered "chargeable-" divisible and exclusive in nature (Shields, 1984). An example of a chargeable good would be a paid parking lot- the benefits of the lot can be assigned to an individual, and that individual could be barred from its use for nonpayment. In this instance, parking would be a good candidate for implementation of user fees.

Furthermore, user fees carry the advantage of sending an immediate price signal to consumers, and they work along supply/demand curves. When a price is set for a user fee, it immediately creates a dynamic relationship between price and demand- the consumer's willingness to pay changes with prices. In a hypothetical supermarket, shoppers who wanted to purchase a premium steak for a weekend dinner treat likely found themselves in disbelief at the rise in prices during the COVID-19 pandemic. If prices are too high, consumers will look elsewhere for substitutes and alternatives in an attempt to save money**.** Because steaks are not a necessity or a staple, economists would expect at least some proportion of shoppers to seek out lower priced alternatives, or choose to skip the savory treat entirely. Maybe they instead selected pork chops, or went without meat entirely to save money; in either case, the rise in prices prompted a change in behavior by the consumer. In this way, setting a user fee can be an important way to regulate the usage and distribution of chargeable public goods. We can see this effect leveraged in the case of road pricing, where regulators can predictably affect the demand for roads by setting a price for their use (Walker, 2018).

The conditions used to set a fee's price can be static and simple, or highly dynamic. On the simple end of the spectrum, a fee for a permit application could be exactly equal to the compensation of the reviewing employee, divided by the expected number of yearly applications. An employee who reviews 12,000 permit applications in a year, and whose compensation package costs $60,000 per year, would have an expense of $50 per permit. If their employer wanted to recoup the costs of their employment, a permit fee of $50 would just meet that goal without accounting for additional overhead. On the more dynamic side, one can examine road and parking fees that update rapidly in response to surges in demand, or by the day of the week and city location (Kelly & Clinch, 2009).

Despite efforts to set and design fees in a Pigouvian manner, and their horizontal equity, user fees aren't inherently equitable in all cases. Dynamically-set road prices, for example, can lead to outcomes where fees become regressive because of a lack of alternatives (Suman, Charles, & Harrison, 2022). One cannot operate under the assumption that because the beneficiary is paying for a service it is always equitable; the U.S. uses a scaling, marginal income tax for just this reason. Fees can be designed in such a way as to alleviate some of the burden, with exemptions for groups of consumers like commuters, but there can be an additional administrative cost incurred to accommodate additional rules and exceptions. With future advances in technology there is great potential for dynamic fees that quickly take into account factors like a customer's socioeconomic status, location, current demand, and more, but this may not be currently feasible for financial or privacy reasons.

So, it seems clear that fines and fees can be considered useful in two primary cases: Generating revenue, and recouping the costs of actions with negative externalities. Additionally, it seems intuitive to wonder whether these fines and fees alter the behavior of the regulatee. If so, there could be a third primary use: Encouraging behavioral changes. The next section of this paper will explore how this has been used, and whether fines and fees yield a predictable effect on those who have to pay them.

Fines and Fees as a Behavior Modifier

Encouraging behavioral changes can be considered a parallel goal to the goal of recouping the costs of negative externalities. If an action produces negative externalities, and a financial cost would reduce that action's incidence, it would be logical to use that cost to both deter and recapture that action's externalities. When a discharger commits an offense that kills fish in a river, for example, the fine not only recoups the costs of environmental remediation, but serves as a deterrent for future offenses- at least regulators hope so. This approach makes intuitive sense as it mirrors common-sense, culturally-prominent approaches to punishment in the United States. In the wildly different domains of parenting, criminal law, and religion, to mention a few, punishment is uniformly presumed to be a motivator for better behavior; the threat of time-outs, prison sentences, and eternal damnation might even be equally motivating depending on a person's age. It would logically follow, then, that imposing a financial cost on activities would reduce their frequency, and most of the academic literature supports this conclusion.

First, one can look at a topic that most U.S. drivers will be familiar with: toll roads. What purpose do they serve, and what effects do they have on traffic? The first question is simple to explain with a quick consideration of the cost of infrastructure in the U.S; roads, depending on their complexity, cost millions of dollars per mile for initial construction. In an environment where their primary funding mechanism, taxes, is an unpopular notion, new projects to accommodate increasing demand can be a hard sell for administrators to make to their constituents. Toll roads offer a way for DOTs to fund these important infrastructure projects by shifting the costs onto only the drivers who use the road segment. This follows the benefit-payer principle, and allows DOTs to somewhat sidestep criticisms of funding by utilizing user fees. Utilizing dynamic congestion-based pricing on a toll road, according to a comprehensive overview by the Congressional Budget Office, "results in more efficient use of highway capacity. By decreasing the number of vehicles at times… allows existing highway capacity to carry more traffic at the same or better level of performance (2009, p. IX)." User fees, in this case, drastically change the choices of drivers through the addition of a financial barrier. Furthermore, another motivator for governments to use road pricing to reduce traffic can be seen when examining the negative externalities associated with congestion. Delays not only lengthen commutes and irritate drivers, but also increase air pollution and negatively affect an area's economic competitiveness (CBO, 2009; Sweet, 2014)**.** These externalities are not internalized into the cost of public highways, but toll roads would take this into account and cause each driver to pay their share of them.

There is also evidence that municipal solid waste programs which charge residents a fee based on the quantity of trash generated by each residence, rather than a flat service fee, reduces the trash hauled to landfills (Miranda, et al., 1994). In this case, the fee is not adjusted by total aggregate demand or changed dynamically like congestion charges, but it is a fee that residents clearly know is connected to their own actions- "a systematic reminder of their individual contributions to the local flow of solid waste (Miranda, et al., 1994, p. 696)." Therein lies an important factor when considering financial penalties to incentivize behavior changes; the action which is prompting the fee must be clear, and it must be an elective behavior that a citizen opts for. The clearer the connection between fee and action, the more robust the effect will be.

On the topic of environmental policy, the writings of Bressers & Lulofs (2015) examining, reproducing, and contemplating their own work over the role of fees in Dutch environmental policy is very insightful. The Netherlands implemented a new national environmental policy aimed at reducing pollution, and one facet of that law was to charge industries a fee proportional to the amount of pollution discharged. Called "polluter-pays" by Bresser, this Pigouvian-aligned policy yielded a substantial improvement in water quality in the country in the short term. Bresser's own work had previously shown that this fee could explain most of the decrease in pollution seen after the introduction of national water quality law (Bressers & Lulofs, 2002), a remarkable result. The fee was intended to cover the cost to treat excessive strength wastewater, and pay for the investment into additional treatment infrastructure as that was a necessary action to accomplish environmental goals. However, it was not done with the expectation that there would be an incentive effect to reduce pollution, as the assumption was that other enforcement mechanisms like permits and limits would make the greatest impact. Surprisingly, the incentive effects of fees were responsible for the majority of pollution reduction over the first years, especially once the fees exceeded the marginal cost of additional treatment for the industry. The marginal cost of additional treatment might be best thought of as the additional cost of improved production, treatment technologies, or strategies. For a business that discharges large quantities of water with high concentrations of pollutants, this marginal cost might come in the form of new, water-efficient production processes, or energy-intensive aeration tanks to reduce the concentration of pollutants. When a business acts purely by economic rationale, the fee exceeding the marginal costs of additional treatment should prompt it to invest in the more cost-efficient technology instead. Bressers & Lulofs (2002) discuss this, and caution that a consultative relationship between industry and regulators is also important to this success since the reality of business decision-making is that this economic balance must first make its way up the chain of leadership and be explicitly considered. When making predictions about whether the effect would hold over time, some four decades after the initial legislation was passed, it was unclear whether the effect would hold in a "mature" policy environment- one where the relevant programs have had years to bring regulated entities into compliance. Examining the year-over-year reductions in pollution, it does appear that the magnitude of change shrinks over time, and that fees play less of a role in driving improvements. However, it should be noted that backsliding was generally not an issue, and that the program maintained the significant improvements it created during its initial implementation. Altogether, this makes a strong case for the potential of user fees as a behavioral tool for environmental policy.

One other item that Bressers & Lulofs address is that "Scholars and politicians that assumed that incentives just tend to provide the excuse to polluters not to reduce pollution, since 'they paid in order to pollute', proved wrong (2015, p. 2)." This assumption, although not borne out in the Netherlands' water pollution policy, does have some empirical basis. The seminal study by Gneezy & Rustichini, *A Fine is a Price*, gives some indication that under the right conditions, a fine can become a price paid to continue doing an activity (2000).

In some sense, fines and fees are just prices. For user fees, they are the price charged that covers the cost of program administration or providing a service. For fines, it is the price to continue doing a prohibited activity. If a regulatory framework does not carry any additional consequences besides a financial penalty, citizens can break the law as long as they can afford it. In their study, Gneezy & Rustichini measured the incidence of tardiness for parents picking up their children from daycare in Haifa, Israel, before and after the introduction of a late fee. In accordance with the belief that fines serve as a deterrent for behaviors, one might expect the incidence of tardiness to decrease after the fee was implemented. However, the opposite was true! In the experimental group, parents became *more* tardy after being charged a fine. How could this be the case? The authors note that in the absence of additional enforcement, the addition of a fine makes a prohibited action into a transaction. "The teacher is taking care of the child in much the same way as she did earlier in the day. In fact this activity has a price (which is called a 'fine'). Therefore, I can buy this service as much as needed (2000, p. 14)." Instead of relying on social norms to act as some sort of soft coercion for on-time pickups, the addition of a price signals to parents that the daycare center is *willing* to tolerate this behavior for a price.

Indeed, there are many cases where it can be advantageous if the time or financial benefit gained exceeds the cost of the fine. a rational economic actor would continue participating in an activity as long as it was the smart choice (i.e. economic benefit exceeds fine). This is why the TCEQ penalty policy accounts for and includes economic benefits gained in the total fine. A polluter who stands to save several hundred thousand dollars by not implementing additional treatment technologies, would continue to do so if the fine were only a tenth of that cost. With that insight, one could explain Gneezy's & Rustichini's findings as an example of what can happen when the marginal cost of an action is not exceeded by the fee or fine. The late fee in this case was NIS 10, a small amount compared to the average gross salary at the time of NIS 5,595. It is conceivable that the benefits of tardiness for parents, maybe less psychological stress, or being able to work longer, exceeded the small NIS 10 price. The authors even acknowledge that

"It is true that a 'large enough' fee would eventually reduce the behavior (2000, p. 15)" So, the literature begins to show that fees and fines are most effective in a regulatory scheme where the costs are set at a level that takes into account the costs of alternatives.

There are other examples, too, of regulatory programs that don't always spur action. Parikh, et al., (2005), and Doll, Scodari, & Lindsey (1998) describe issues with stormwater user fee implementation, meant to account for the costs of treating runoff from a parcel of property. With Stavins (2003) providing supporting evidence, they together point out that much of the failure to incentivize action results from fees that are too low. When too low, they do not carry enough of an incentive to spur action on the part of a property owner. However, that does not mean that user fees are not an effective way to fund government services, as shown by Tasca, Finotti, & Goerl (2019).

After considering the evidence for the incentive effects of fees and fines, it seems reasonable to conclude that, when large enough to exceed the marginal cost of action, they can be an effective driver of behavioral change. The next section will explore the goals and accomplishments of U.S. water pollution regulation with special attention to the financial incentives used to achieve compliance.

The Efficacy of The U.S. Clean Water Act vis-à-vis Financial Incentives

In order to understand how the U.S. regulates pollution in its waters using fines and fees, it would be helpful to describe the general regulatory structure, then examine the historical literature on its effectiveness. Waterways and bodies of water in the U.S. are regulated at the federal level by the EPA, which has a mandate to implement and enforce regulations such as the landmark CWA, mentioned earlier. Although some state environmental agencies, like the Texas

Commission on Environmental Quality, have assumed primacy over this implementation, the general framework for permitting and enforcement remains generally the same and may not be any more lenient than the CWA and EPA set forth. The legislation was passed in order to restore the environmental quality of our national waterways, many in dismal shape from pollution following industrialization. Despite the risk of making water policy wonks roll their eyes at yet another mention of the Cuyahoga River in Cleveland, it is important to mention it here because of its role in shaping public opinion and driving congressional action on the CWA. There was a minor fire on the river in 1969- minor relative to the *several* other times it burned- and although the initial response was muted, the story morphed into a symbol for the growing national interest in environmental policy (Stradling & Stradling, 2008). The 1972 CWA includes the congressional declaration of goals and policy for the Act with this clear statement: "The objective of this chapter is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (Congressional Declaration of Goals and Policy)." The Act then details a framework for accomplishing this goal through the funding of publicly owned treatment works (POTW) to treat waste, and then creating a system to permit and regulate discharges to waterways. The first point lays the necessary groundwork for the infrastructure to adequately treat pollution before it is released into the environment, while the second is a continuing process that involves the use of fines as an enforcement tool.

An entity permitted under the CWA that commits a violation can be fined extreme amounts, like the $56,460 per day per violation fine allowed under the EPA penalty rule. Such fines are normally not the first tool that regulators reach for when trying to enforce compliance; fines are normally only utilized in the later stages of an "enforcement response plan" which normally begins with the regulatory equivalent of a strongly-worded letter. According to FY21 data on the EPA's Enforcement and Compliance History Online dashboard, roughly 10% of violations issued by the TCEQ were accompanied by a fine (EPA, 2022). Considering, too, that the TCEQ and other environmental agencies have deliberately designed their fees to capture and exceed the marginal cost of additional treatment by the offender, it appears that the fees should be both frequent enough and of a large enough magnitude to spur behavioral change by polluters. They may not be the first option used by regulators, but the threat of a penalty is always behind every enforcement action. Glicksman and Earnhart categorize this deterrent effect as a "general deterrence," and found robust evidence for their efficacy (2007).

Unfortunately, there is little other existing academic research into the effect of fines on U.S. polluters. Whereas Bressers & Lulofs analyzed compliance data for The Netherlands and were able to isolate the effect of fees on pollution, it would appear that this same information is lacking for the U.S. There is, however, information on the general accomplishments of U.S. water policy, and it can be inferred that the use of fines as an enforcement mechanism is responsible for some degree of those accomplishments.

The clearest evidence for the efficacy of the Clean Water Act on reducing pollution comes from Keiser & Shapiro (2019) who show that post-CWA passage there was a substantial decrease in the quantity of pollutants, as well as a simultaneous improvement in the number of "fishable" and "swimmable" streams. Although they do acknowledge that these trends were already taking shape before the CWA's passage, one point brought up by Stradling & Stradling (2008) is that such a trend could be from the beginnings of state-level action before the federal Act's passage, emphasizing the positive impact of regulation on pollution. One other interesting note is that traditional cost-benefit analyses of the CWA have found that it yields a slightly negative return on investment, although this may be underestimated (Keiser, Kling, & Shapiro, 2019).

Implementation of a "Polluter-Pays" or Pigouvian Method to Control Pollution

In order to meet the standards for wastewater discharges set by the CWA, POTWs often have to implement pretreatment programs that regulate entities which discharge wastewater to sewer collection systems. The necessity for this becomes apparent when one considers that a POTW might not otherwise be able to meet its own permit limits if it has to treat toxic wastes discharged by its customers. For example, a customer who accidentally (or intentionally) discharges several thousand gallons of sulfuric acid into the wastewater collection system has the potential to cause damage to equipment, and disrupt the POTW's entire treatment process. The resulting treatment upset would have the potential to kill aquatic life and harm downstream users, and the POTW would be subject to CWA enforcement procedures even though it was not directly responsible for the failure.

This regulation is done under the framework of the Federal General Pretreatment Regulations ("General Pretreatment Regulations"), which details how to issue discharge permits, inspect facilities, and ensure compliance in order to protect the POTW. POTWs will typically calculate the total maximum daily loading and technically-based local limits, or the maximum amount that can be effectively treated while still meeting permit limits, and then allocate that loading to their major contributing dischargers through permits. These permits are enforced by the POTW in much the same way that the CWA is enforced nationally, with inspection and sampling requirements, backed by the possibility of monetary penalties for noncompliance. Pretreatment programs have been largely successful in reducing the loadings of pollutants like metals at POTWs (Association of Metropolitan Sewerage Agencies (1994), thereby contributing to the success of the CWA.

While pretreatment programs normally focus their efforts on severe and toxic pollutants like metals and toxic organic compounds, there can be issues that stem from the typical pollutants that POTWs are designed to treat and remove from the waste stream. So-called "conventional pollutants" include biochemical oxygen demand (BOD), total suspended solids (TSS), oil and grease (O&G), as well as pH and fecal coliforms (Conventional Pollutants). There are other pollutants, too, that aren't legally defined as conventional pollutants, but that can also be treated and removed by POTWs; the most relevant of these include ammonia and phosphorous. The pollutants described here might not immediately cause interference and pass-through with the treatment process, but they still cost money to treat and contribute to additional wear and tear on equipment. O&G, for example, is famous for contributing to massive "fatbergs" in the sewer collection systems of many cities ("Belgravia Fatberg," 2020). Total suspended solids contribute to the total mass of biosolids that must be hauled away at the end of treatment, and BOD can require treatment modifications and increased electricity use to power aerators for its removal.

As such, POTWs have an economic incentive to reduce their concentrations in incoming wastewater, or at least recoup the cost of treatment as a negative externality. However, these pollutants are discharged by nearly every customer connected to a collection system; from homes and offices to restaurants and manufacturing facilities, every customer contributes to some degree. It would be impractical to issue a discharge permit to all minor dischargers like homes since the administrative and monitoring costs would far exceed the benefit, though a concentration of efforts around the largest dischargers could yield a neutral or positive return on investment.

Some POTWs have chosen to pursue this approach in the form of cost-recapture programs. Commonly referred to as "sewer surcharge" or "excess strength" programs, these are created as part of a pretreatment program, and generally monitor the largest contributors of BOD, TSS, O&G, and other pollutants to the POTW with the intention of recouping the cost to treat their waste. Sewer surcharge programs typically analyze the wastewater discharges of a customer, then apply a fee based on the concentration of pollutants, the water usage, and the cost to treat that wastewater. By design, surcharge fees are a horizontally-equitable method of charging for the use of services; they are proportional to the burden that each user places on the POTW.

However, one factor that distinguishes sewer surcharge fees from fines under the CWA, et al., is that, in most states, fees levied by a municipality or utility must be proportional to the cost of administering the fee. Whereas fines are explicitly used to recoup the full cost of an action's externalities, the avoided costs of compliance, and deter repeat offenses, municipal fees must be proportional to the cost of providing a service. *Vance v. Town of Pleasanton* (1924) litigated this issue for General Law cities in Texas on the basis of unjustified fees exceeding a city's taxing authority, and *Memphis Nat. Gas Co. v.* McCanless (1946) came to a similar conclusion for Tennessee. With these in mind, one should implement fees as if they have an upper limit before they are challenged as unlawful taxes.

There is no consensus for which customers should be subject to a surcharge fee, or which pollutants should be charged for under a sewer surcharge program. Some programs charge for an individual pollutant like chemical oxygen demand (COD), a similar pollutant to BOD that is more cost-effective to sample and measure, while others charge based on two or more (City of Webster). The lack of a consensus likely comes from the unique conditions in which individual POTWs operate, with varying treatment capacities, wastewater characteristics, and permit limits. Though there is significant variability in implementation, queries on search engines for "sewer surcharge program" return results that would indicate most mid-to-large size cities utilize some form of this program. An example surcharge calculation can be found below in Figure 1.

Figure 1. Example Surcharge Calculation

Monthly Surcharge = Volume of water * 8.34 *([C(COD-350)] + [B(BOD-200)] + [T(TSS-200)])

Where:

Volume is expressed in millions of gallons
8.34 is the weight of one gallon of water in lbs
COD, BOD, and TSS are concentrations minus the typical domestic wastewater concentration
C, B, & T are constant rates representing the cost of treatment per pound of each pollutant

A business with a water usage of 30,000 gal per month, and a COD concentration of 400, BOD of 250, and TSS of 250 would then calculate their surcharge as follows. The rates are assumed to be $0.25 per pound.

$9.38 = .03 * 8.34 * ([0.25(50)] + [0.25(50)] + [0.25(50)])

Figure 1 depicts a relatively small fee per month with conservative estimates for pollutants and water usage. However, considering that wastewater discharges from restaurants and other commercial businesses can contain pollutants well beyond 1000 mg/L for each parameter (Lesikar, et al., 2006), fees may exceed several hundred dollars per month. It is also important to note that the calculated fee only considers "excess" quantities of pollutants, or above the normal concentrations assumed to be 350 mg/L, 200 mg/L, and 200 mg/L for COD, BOD, & TSS in this calculation, respectively.

Though sewer surcharge fees serve a clear role to recoup the cost of treatment, one can also hypothesize that they will carry some degree of incentive effect to the customers on which they are levied. As with other programs, it is clear that fines and fees can spur a behavioral change, and this expected effect underpins most of the U.S.'s environmental policy. In fact, at least one city has explicitly endorsed this idea in its code of ordinances relating to its sewer surcharge program. The relevant text is below:

> "Purpose. Nonresidential users of the city sanitary sewer system are subject to surcharge fees under this section. The purpose of surcharge fees is to encourage users who have higher levels of pollutants in their sewage waste than those contained in normal domestic waste to install or modify their pretreatment facilities, or to modify their process operations in order to reduce the pollutant levels in their sewage waste. (City of San Marcos)"

With this idea in mind, it would be a valuable contribution to the academic body of knowledge to analyze the effects of sewer surcharge fees on the discharges of customers over time.

Sewer surcharges are normally calculated based on two factors within the customer's control, water usage and pollutant discharges, customers can change the one that they feel is most within their control to reduce their fees. One business might find it easier to decrease their water usage, while another could more easily change their cleaning products or process, for example. However, the dataset used in this research only contains a value derived from both the usage and pollutant concentration- pounds of COD discharged. A hypothesis for testing the relationship between surcharge fees and the pounds of COD discharged was formulated and is seen below in Table 2.1. Based on the existing research on the incentive effects of fees and fines, one can hypothesize that surcharge fees will impose a downward pressure on pounds of COD discharged.

Table 2.1 Conceptual Framework Table

Title: Establishing a Relationship Between Sewer Surcharge Fees and Pollutant Discharge by Commercial Users **Purpose: The purpose of this research is to examine the relationship between sewer surcharge fees and pollutant discharges by commercial customers**	
Formal Hypothesis	**Supporting Literature**
H1: After sewer surcharge fees are implemented, the total pounds of COD discharged will decrease.	Bressers & Lulofs (2002), Congressional Budget Office (2009), Glicksman & Earnhart (2007), Keiser, Kling, & Shapiro (2019)

Summary

This chapter examined a broad collection of research on the use of financial incentives like Pigouvian fees and fines in contemporary policies. Pigouvian fees have shown to have consistent and predictable effects in parking and environmental policy, and fines were used to great effect in the U.S.'s CWA implementation. Altogether, this provides a strong indication that imposing an additional financial cost or burden on customers and regulatees spurs a change in behavior.

However, it would be erroneous to assume that these same effects apply in the case of sewer surcharge fees without further research. Sewer surcharge programs are affected by unique effects like the marginal cost of treatment, and these have not been adequately characterized in the previous research. Additionally, because sewer surcharge fees are limited, unlike fines, there is the possibility that they are not large enough to spur a behavioral change. Thus, although the existing research provides strong support for financial penalties as a regulatory tool, research on sewer surcharge programs specifically is still necessary. The next chapter will describe the methods of this study on the relationship between sewer surcharge fees and pollutant discharges.

Chapter 3: Methods

Purpose

This chapter describes the data collection and analysis procedures used in this study. It discusses the operationalization of variables, their application to the hypothesis proposed in Chapter 2, and the strengths and weaknesses of the analysis. Furthermore, it contains a detailed description of how the study controlled for the COVID-19 pandemic as a confounding variable because it likely affected the COD discharge of industrial users.

Operationalization of Conceptual Framework

This study evaluates a single hypothesis which is stated below:

H1: After sewer surcharge fees are implemented, the total pounds of COD discharged will decrease.

The dependent variable was the average pounds of COD (Chemical Oxygen Demand) discharged each month from January 2018 to December 2021, and three independent variables were used for an interrupted time-series analysis in SPSS. The three variables were called "Month," "DUMMY," and "Fee." The Month variable was coded as 1-48 for each of the months included in the data, and was used to test for significant changes in discharge before a fee was implemented. The DUMMY variable was a dichotomous variable, coded 0 for months with no fee, and 1 for months where the fee was in effect, and tested for a significant immediate change resulting from the fee's imposition. Finally, the Fee variable was coded as 0 for months with no fee, and then 1 through 24 for the post-fee months. This variable tested for a significant difference between the pre- and post-fee discharge trends.

Table 3.1 Operationalization Table

H1: After sewer surcharge fees are implemented, the average pounds of COD discharged will decrease.			
Dependent Variable	**Hypothesis (Direction)**	**Variable Measure**	**Data Source**
Quantity of COD Discharged		Average pounds of COD discharged	Wastewater utility records
Independent Variable			
Sewer surcharge fee	H1 (-)	Presence of fee (0 = No, 1 = Yes)	Wastewater utility records

Data Collection

The data for this analysis were acquired through a request for data sharing posted on a Groups.io listserv for pretreatment industry professionals. The listserv was identified as a source of information and consultation during in-person conversations with utility workers in the Central Texas area. A consultant working with a wastewater utility in Tennessee voluntarily contacted the researcher in response to that posting, and voluntarily shared the dataset after obtaining the consent of the utility. The data were shared under the condition that the utility's identity remained confidential. The dataset contains sampling results for pounds of COD discharged by 83 individual permitted industrial users across a four-year period from 2018 – 2021. 31 of these industrial users had insufficient data for analysis and were excluded, leaving a remaining sample size of 52 (n = 52). The products and services provided by these industrial users were widely varying, spanning numerous economic sectors. The implementation of a surcharge fee program as a cost recapture method is especially important for this utility as the cost and effectiveness of their wastewater disinfection varies inversely with the COD concentration in wastewater effluent.

The utility implemented a sewer surcharge fee for these industrial users at the beginning of 2020, so the dataset contained information for the two years prior to the fee's implementation, 2018-2019, and two years after the fee's implementation, 2020-2021. This allows for a quasi-experimental study design to generally establish a cause-and-effect relationship between the presence of a sewer surcharge fee and COD discharges.

Data Analysis

The data were analyzed using an interrupted time-series approach which allowed for inference and comparison of trendlines in COD discharge before and after the implementation of a sewer surcharge fee. However, the following two challenges with the dataset had to be accounted for in the analysis:

1. Data were not continuous and complete for all 83 dischargers. Some were missing one or more months of data, while some appeared to start or cease operations entirely during the four-year period.
2. The emergence of the COVID-19 global pandemic had disastrous, but uncertain effects on our economy, and nearly coincided with the implementation of the sewer surcharge fee.

Altogether in the dataset, there were only five dischargers that had a continuous, complete 48 months of sampling data, which would be insufficient for a statistically significant finding. Instead, the selection criteria were broadened to include dischargers that had valid sampling events in each of the four years to exclude those that went out of business or started operations too late to have a sufficient sampling history. After this process, 52 individual dischargers remained. Of these 52, some were missing one or more months in each year of data, so a process of imputation was used where the mean discharge for all months was substituted for those missing months. After this, the monthly average discharge for each discharger was summed, yielding 48 months of averaged data for all 52 dischargers.

To control for the effect of the pandemic, the GDP of Tennessee from 2018 – 2021 was used to adjust these monthly averaged data. The Federal Reserve publishes quarterly GDP data, and each quarter's GDP was divided by the first quarter's GDP to create a ratio of economic growth over time. Then, each month's sum of averages was divided by its quarterly GDP ratio (Jan, Feb, Mar = Q1, so on) to isolate the effect of the sewer surcharge fee from general economic trends. Whether the state's GDP improved or worsened, this would provide a stable basis for comparison over time. The quarterly GDP data used to adjust the discharges is seen below in Table 3.2, and the ratios are seen in Table 3.3. Of particular interest is the large drop in GDP in 2020 Q2 due to the onset of the COVID-19 pandemic, but also the quick return and exceeding of normal trends by 2021 Q1. The resulting 48 months of GDP-adjusted data were analyzed by linear regression in SPSS.

Table 3.2: Quarterly Real GDP Data in Millions of Chained 2012 Dollars (U.S. Bureau of Economic Analysis, 2022).

2018 Q1	**2018 Q2**	**2018 Q3**	**2018 Q4**	**2019 Q1**	**2019 Q2**	**2019 Q3**	**2019 Q4**
321019.1	322690.0	323882.4	323002.4	326274.8	327901.4	330819.9	331450.5
2020 Q1	**2020 Q2**	**2020 Q3**	**2020 Q4**	**2021 Q1**	**2021 Q2**	**2021 Q3**	**2021 Q4**
329142.7	288729.6	320474.8	326954.3	337611.0	340933.2	343539.9	351709.5

Table 3.3: GDP ratios used to adjust COD discharges (truncated to 5 decimal points).

2018 Q1	**2018 Q2**	**2018 Q3**	**2018 Q4**	**2019 Q1**	**2019 Q2**	**2019 Q3**	**2019 Q4**
1.00000	1.00520	1.00892	1.00618	1.01637	1.02144	1.03053	1.03249
2020 Q1	**2020 Q2**	**2020 Q3**	**2020 Q4**	**2021 Q1**	**2021 Q2**	**2021 Q3**	**2021 Q4**
1.02531	0.89942	0.99830	1.01849	1.05169	1.06203	1.07015	1.09560

Strengths and Weaknesses

The greatest strength of this dataset is that it is a quasi-experimental dataset which demonstrates the immediate effect of surcharge fee implementation. A dataset like this is likely rare because of the labor and costs required to sample dozens of industrial users for two years before a surcharge fee was even implemented. It would be hard to demonstrate the same relationship with data that analyzed discharges under an already-established fee structure.

This analysis is not without its weaknesses, however. Estimates and assumptions were made through imputation to substitute for missing months of data, as well as correct for the effect of the pandemic. Time-series analysis has a limited ability to control for confounding variables, and the effect of the pandemic is the most prominent confounding variable because the burden was not evenly distributed across all sectors of the economy. Some industries faced shortages of critical components like semiconductors, while others faced unprecedented demand in response to shifting consumer behaviors (U.S. Government, 2022). To best mitigate these effects it was considered most appropriate to analyze the industrial users in the aggregate, rather than individually.

Furthermore, it should be noted that this analysis was performed on secondary data collected by a third party. Secondary data inherently present some challenges to researchers, such as the inability to control for sample selection and data accuracy. Researchers using secondary data must ensure that the data were collected accurately and appropriately, and that the variables are suitable for use for the study's purpose (Vartanian, 2011). In this case, the data are likely to be accurate because it was collected for use by a public utility. Normally, the suitability of data and measures for analysis are established in existing literature on the same or a similar topic. However, this research and its measures are novel, with there being no existing literature that examines the same relationship between sewer surcharge fees and COD discharge. To account for this, the "Data Analysis" section above transparently describes the steps and logic for preparing the secondary dataset for this study.

Additionally, the use of secondary data affords the researcher several advantages in time and expense. These data, being longitudinal and spanning 2018-2021, allows the researcher to perform a quasi-experimental, longitudinal analysis without the cost and investment necessary to collect the same information individually.

Summary

In summary, this chapter describes the operationalization of this study's conceptual framework, data collection and analysis, and the strengths and weaknesses of the research. Because this research was novel and not preceded by any studies that established the validity of its measures and methods, this chapter contains a detailed description of how the variables were identified and measured. The dataset was adapted and made suitable for analysis through imputation, and by correcting the data for changes in Tennessee's GDP. The chapter also discusses the advantages and disadvantages of using secondary data obtained from another party. Chapter 4 will detail the quantitative results of the regression analysis.

Chapter 4: Results

Purpose

The purpose of this chapter is to present and discuss the results of analyzing the relationship between sewer surcharge fees and the COD discharge quantities for the Tennessee utility. The chapter includes tables and graphs detailing the results of the regression analysis, as well as an explanation of the observed effects of sewer surcharge fees on COD discharges.

Findings

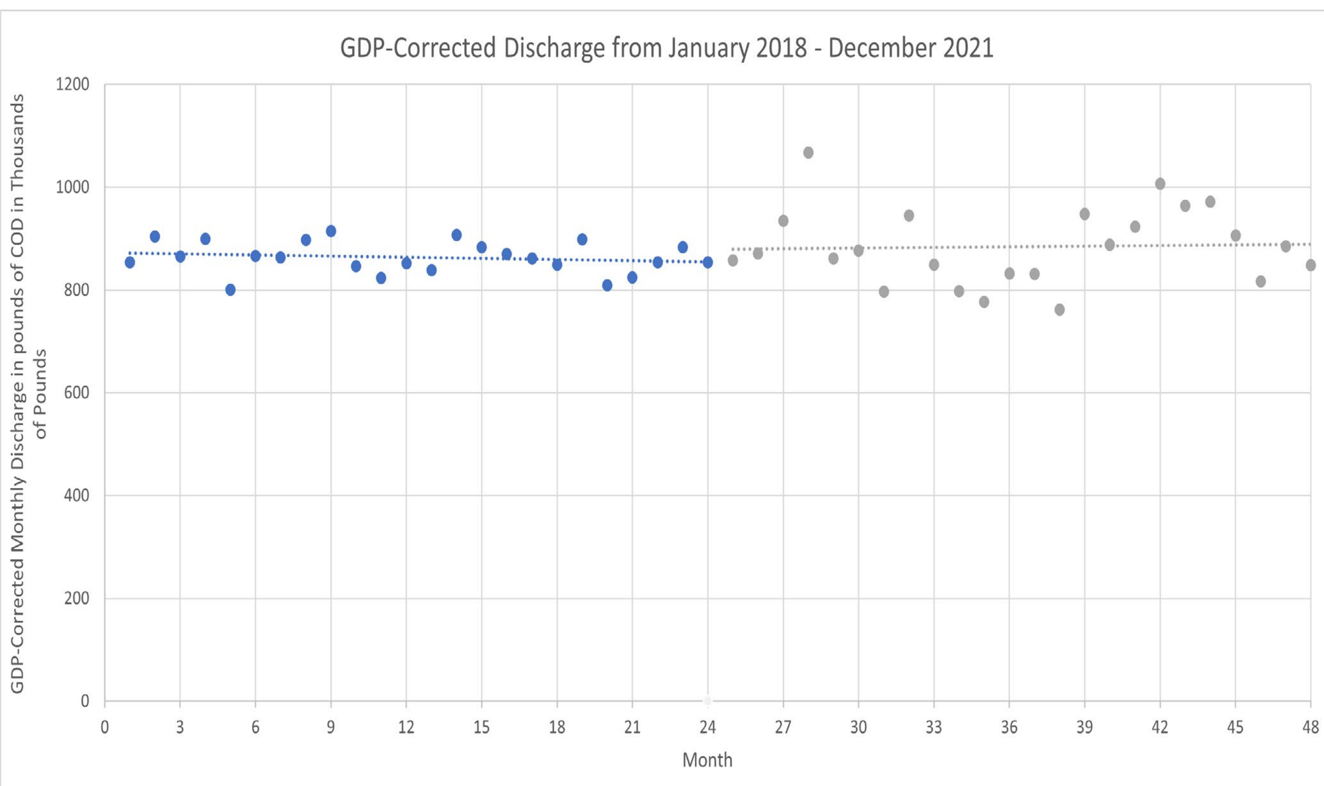
After the data were prepared according to the procedure described in Chapter 3, they were analyzed as an interrupted time-series by linear regression in SPSS. The results table is seen below in Table 4.1.

Table 4.1: Regression Results. The relationship between the presence of a surcharge fee and pounds of COD discharged by industrial users

Variables	**Unstandardized Coefficient**		**Standardized Coefficient**	**t-test**	**Significance Level**
	B	**Std Error**	**Beta**		
Constant	873026.982	24747.570		35.277	<.001
Month	-772.622	1731.969	-.187	-.446	.658
DUMMY	24491.490	33954.253	.214	.721	.475
Fee	1185.304	2449.374	.164	.484	.631
Adj. R squared	-0.027				
F- statistic	0.585				0.628

The coefficient for the "Month" variable shows the trend in COD discharges prior to the implementation of a sewer surcharge fee. The trendline points slightly downward, with the discharges decreasing by around 772 pounds of COD per month (B = -772.622). Counter to the hypothesis, the expected monthly discharge rose by around 24,000 pounds of COD per month when the fee was implemented, represented by the DUMMY variable (B = 24491.490). Following the implementation of the sewer surcharge fee, the trendline for COD discharges pointed slightly upward, with discharges increasing by around 1200 pounds per month (B = 1185.304). However, none of these results are significant, with p values far exceeding the $p \leq 0.05$ threshold that is generally accepted for a result to be statistically significant. Additionally, the R^2 value of -0.027 indicates that the implementation of a fee has virtually no explanatory value for the variation in COD discharges in this dataset. Each month's datapoints and the resulting trendlines are shown below in Graph 4.1.

Graph 4.1: Comparison of trendlines before and after the implementation of the fee



The X-axis of this graph is the month counted sequentially from the beginning of the dataset, with 1 being January of 2018, 2 being February of 2018, so on and so forth. The Y-axis is the GDP-corrected COD discharge in thousands of pounds. The sewer surcharge fee was implemented in month 25, or January of 2020, and the grey values to the right of month 24 denote that change. The values before that, shown in blue, are discharges without a sewer surcharge fee in place. The trendlines for each condition, blue for no fee, and grey for a fee, are demonstrate how discharges are expected to change in each condition. Readers should note that there is greater variation in the datapoints for months 25-48, and this is reflected in the results table, Table 4.1. The COD discharges following the implementation of a sewer surcharge fee showed a greater standard variation (std. error = 2449.374) than those before the fee (std. error = 1731.969). Furthermore, without adjusting the COD discharges downward for the rise in GDP, the data would have indicated that the implementation of a fee actually caused a significant rise in COD discharges.

Summary

Generally, the results showed little difference in pounds of COD discharged before and after the implementation of the surcharge fee. The trend for discharges prior to the implementation of the sewer surcharge fee was slightly downward (B = -772.622). After the implementation of the fee, it turned slightly upwards (B = 1185.304), and had a greater standard variation than before. However, the resulting change is not significant ($p = 0.631$). With these results in mind, it would appear that the hypothesis H1 has not been confirmed and that the presence of a fee does not significantly affect the pounds of COD discharged for this sample.

The next chapter will discuss these findings, and the particular insights it might offer policymakers and future researchers.

Chapter 5: Conclusion

Purpose

This chapter will discuss the study's findings from Chapter 4, and the policy implications thereof. Although the analysis found no significant relationship between the implementation of a sewer surcharge fee and pollutant discharges, there are further questions and research objectives for the future. Researchers also interested in exploring this relationship can read the discussion section below for additional areas that subsequent research could explore.

Discussion

The results shared in Chapter 4 might appear disappointing at first, but they are quite exciting when considered from a policymaking perspective. As mentioned earlier, both Bressers & Lulofs (2002) and Gneezy & Rustichini (2000) had findings that indicated that the marginal cost of treatment is a major modulator for the effectiveness of financial incentives. The dischargers in this sample could be demonstrating this effect because of the economics of their business. Although the individual identities of the industrial users in this sample are not known, they are all permitted dischargers under the Clean Water Act, meaning they either discharge large quantities of water, or are engaged in a particular type of business that warrants a discharge permit. For these types of dischargers, it is likely that the costs of introducing new treatment technologies exceeded the surcharge fee levied. It would then be a prudent economic choice to continue paying the fee until it breaks that threshold value.

In contrast, other sewer surcharge programs will often levy sewer surcharge fees on smaller businesses like restaurants or hotels. Future research should study a sample of smaller businesses in comparison to industrial users to determine whether the hypothesized relationship exists when the marginal cost of treatment is lower. Restaurants, for example, would likely have a lower marginal cost of treatment than large industrial facilities. It could be the case that businesses are more responsive to surcharge fees when the additional treatment alternatives are as simple as staff training to scrape food scraps into the trash, or more conscientious water use. Efforts such as these should show a corresponding decrease in the sewer surcharge fee in the subsequent charges. It is also possible, though, that small businesses with low marginal costs of treatment could be similarly insensitive to fees if their profits are proportionally lower, too.

It should be acknowledged that this study alone is not sufficient evidence to guide policymakers. This is because of the varying needs of individual utilities and POTWs, regional economic conditions and, as mentioned before, the economic differences between large and small dischargers. The effects of these variations can only be excluded through a larger sample size across multiple sewer surcharge programs.

However, if future research also failed to find a relationship between sewer surcharge fees and pollutant discharges it would raise the question of whether the objective of decreasing pollution is best accomplished through another method like consultation. Future studies could combine a quasi-experimental design with a gauging, practical-ideal conceptual framework to identify qualities of successful pretreatment programs. One potential measure for examination could be "Frequency of contact with dischargers," integrating the idea from Bressers & Lulofs (2002) that communication is important to program success.

Another area that is ripe for research is quantifying the effect of programs that combine both fines and fees in their regulatory activities. Pretreatment programs have both tools at their disposal, and it is possible that the immediacy of fines after finding a high concentration of pollutants could yield a different incentive effect than fees.

Summary

Considering the popularity of sewer surcharge programs with the lack of research on their effectiveness or particulars of implementation, this topic is deserving of more investigation. As mentioned in Chapter 1, policymakers have little empirical evidence on which to base their sewer surcharge program designs. It is possible that cities and utilities are designing programs in pursuit of an effect that will never come to fruition because of effects like the marginal cost of treatment. Both regulators and regulatees would benefit from a more complete characterization of the relationship between sewer surcharge fees and pollution.

References

Adjustment of Civil Monetary Penalties for Inflation, 40 C.F.R. § 19 (2022).

EPA. (2022). Analyze Trends: EPA/State Wastewater Dashboard. https://echo.epa.gov/trends/comparative-maps-dashboards/state-water-dashboard

Association of Metropolitan Sewerage Agencies. (1994). *Performance measurement and the industrial wastewater pretreatment program: final report.*

Baker, D. L. (2010). Revisiting User Fees in Challenging Fiscal Times. *The Public Manager*. *Summer 2010,* 66-71.

Bressers, H., & Lulofs, K. (2002). Charges and other policy strategies in Dutch water quality management. *Enschede: CSTM.*

Bressers, H., & Lulofs,. K. (2015, Sep. 9-12). *Forty Years of Surface Water Policy: A Longitudinal Assessment of Effectiveness and Efficiency in Waste Water Policy and Implications for Contemporary Issues.* [Conference Presentation] International Conference on Environmental Engineering and Management, Iasi, Romania.

CBO (2009). *Using Pricing to Reduce Traffic Congestion*.

City of San Marcos Code of Ordinances § 86.132.4 (c) (1).

City of Webster Code of Ordinances § 86-91.

Congressional Declaration of Goals and Policy, 33 U.S.C 1251.

Conventional Pollutants, 40 C.F.R. § 401.16.

Davidson, C., Martin, L.W., & Wilson, J.D. (2012, Apr 12). *Pigou, Becker and the Regulation of Punishment-Proof Firms* [Conference Presentation]. Bureau of Economics Seminar Series, Washington, D.C., United States.

Doll, A., Scodari, P. F., & Lindsey, G. (1998). Credits as economic incentives for on-site stormwater management: issues and examples. In *Proceedings of the US environmental protection agency national conference on retrofit opportunities for water resource protection in urban environments* (pp. 113-117).

General Pretreatment Regulations for Existing and New Sources of Pollution, 40 C.F.R. § 403.

Glicksman, R. L., & Earnhart, D. H. (2007). The comparative effectiveness of government interventions on environmental performance in the chemical industry. *Stan. Envtl. LJ*, *26*, 317.

Gneezy, U., & Rustichini, A. (2000). A Fine is a Price. *Journal of Legal Studies, 29*(1). 1-17.

Jung, C., & Bae, S. (2011). Changing Revenue and Expenditure Structure and the Reliance on User Charges and Fees in American Counties, 1972-2002. *The American Review of Public Administration (41)*1. 92-110.

Keiser, D. A., & Shapiro J. S. (2019). Consequences of the Clean Water Act and the Demand for Water Quality. *The Quarterly Journal of Economics, 134*(1). 349-396.

Keiser, D. A., Kling, C. L., & Shapiro, J. S. (2019). The low but uncertain measured benefits of US water quality policy. *Proceedings of the National Academy of Sciences of the United States of America, 116*(12). 5262-5269.

Kelly, J. A., & Clinch, J. P. (2009). Temporal variance of revealed preference on-street parking price elasticity. *Transport Policy (16)*. 193-199.

Shields, P. M. (1984, Apr 8-10). *Cutting Back by Charging More. What Public Administrators Should Know About the Demand for Their Products.* [Conference Presentation]. American Society for Public Administration, Denver, Colorado, United States.

Lesikar, B. J., Garza, O. A., Persyn, R. A., Kenimer, A. L., Anderson, M. T. (2006). Food-Service Establishment Wastewater Characterization. *Water Environment Research, 78*(8). 805-809.

Memphis Nat. Gas Co. v. McCanless, 183 Tenn. 635, 194 S.W.2d 476 (Tenn. 1946)

Miranda, M. L., Everett, J. W., Blume, D., & Roy, B. A. (1994). Market-Based Incentives and Residential Municipal Solid Waste. *Journal of Policy Analysis and Management 13*(4). 681-698.

N.A. (2020). Belgravia fatberg: 'Disgusting' mass cleared from sewer. *BBC.* https://www.bbc.com/news/uk-england-london-54735988

Parikh, P., Taylor, M. A., Hoagland, T., Thurston, H., & Shuster, W. (2005). Application of Market mechanisms and incentives to reduce stormwater runoff: An integrated hydrologic, economic and legal approach. *Environmental Science and Policy, 8*. 133-144.

Pigou, A. (1920). *The Economics of Welfare*. Macmillan.

Restitution and Restoration, 31 T.A.C 69.19. (2005).

Sowell, T. (2015). *Basic Economics.* Basic Books.

Stavins, R. N. (2003). Experience with market-based environmental policy instruments. In *Handbook of environmental economics* (Vol. 1, pp. 355-435). Elsevier.

Stradling, D., & Stradling, R. (2008). Perceptions of the burning river: deindustrialization and Cleveland's Cuyahoga river. *Environmental History*, *13*(3), 515-535.

Su, M. (2020). Taxation by Citation? Exploring Local Governments' Revenue Motive for Traffic Fines. *Public Administration Review (80)*1. 36-45.

Sumar, S., Charles, M. B., & Harrison, J. L. (2022). Usage-based road pricing and potential equity issues: A study of commuters in South East Queensland, Australia. *Transport Policy (118)*. 33-43.

Sweet, M. (2014). Traffic Congestion's Economic Impacts: Evidence from US Metropolitan Regions. *Urban Studies (51)*10. 2088-2110.

Tasca, F. A., Finotti, A. R., & Goerl, R. F. (2019). A stormwater user fee model for operations and maintenance in small cities. *Water Science & Technology, (79)*2. 278-290.

TCEQ (2015). *Supplemental Environmental Projects: Putting Fines to Work Closer to Home* (GI-352).

TCEQ (2021). *Penalty Policy* (RG-253).

U.S. Bureau of Economic Analysis. (2022). *Real Gross Domestic Product: All Industry Total in Tennessee*. [Data set]. FRED, Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/TNRQGSP

U.S. Government. Departments of Commerce and Homeland Security. (2022). *Assessment of the Critical Supply Chains Supporting the U.S. Information and Communications Technology Industry.* https://www.dhs.gov/sites/default/files/2022-02/ICT%20Supply%20Chain%20Report_2.pdf

Vance v. Town of Pleasanton, 261 S.W. 457 (Tex. Civ. App. 1924)

Vartanian, T. P. (2011). Secondary data analysis. Oxford University Press.

Walker, J. (Ed.). (2018). *Road Pricing: Technologies, economics and acceptability*. The Institution of Engineering and Technology.

Victim Rights, Compensation, and Assistance, 34 U.S.C. § 201.

Zhang, P., & Hou, Y. (2019). The Impact of Tax and Expenditure Limitation on User Fees and Charges in Local Government Finance: Evidence from New England. *The Journal of Federalism (50)*1. 81-108.