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Recycling Trends based on Socioeconomic, Demographic, and Regional
Variables: An Analysis of Pennsylvania Counties



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Submitted to The Department of Business and Economics

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I hereby recognize and pledge to fulfill my responsibilities as defined in the Honor Code and to maintain the integrity of both myself and the College as a whole.

A handwritten signature in black ink, reading "Caitlin Comunale". The script is cursive and fluid, with the first name "Caitlin" and last name "Comunale" clearly distinguishable.

Caitlin Comunale

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Abstract

This senior thesis evaluates the United States of America's current methods of sustainability and recycling. As the climate crisis and waste crisis remain prevalent and ongoing, the United States of America must optimize their national recycling output to ensure domestic security, benefit the environment, and accumulate economic growth. In this paper, I question how socioeconomic, demographic, and regional factors impact recycling per capita output. This research studies residential recycling output throughout the 67 counties of Pennsylvania in the United States of America during the year 2019. This research was conducted by generating a multiple linear regression with Stata to evaluate county variables and the impact that the variables have on non-organic residential recycling per capita output. This research finds that a 1% increase in median household income results in a 2.21% increase in non-organic residential recycling per capita and is statistically significant at the 1% significance level. Additionally, this research finds that a 1% increase in Republican registered voters results in a 1.33% decrease in non-organic residential recycling per capita and is statistically significant at the 10% significance level.

Chapter 1: Introduction

To optimize recycling rates, efficiently allocate waste, and ensure sustainability in the long run, the United States of America must enhance recycling efforts. To optimize recycling rates overall, the United States of America must recognize and develop new approaches to increasing recycling rates on national, state, and local levels.

Optimizing recycling output is necessary because the world population and global urbanization are both rapidly increasing (World Bank, 2022). As global urbanization and the world population increases, waste rapidly increases in response; within the next 30 years, annual global waste will increase by nearly 73% (World Bank, 2022).

Currently, the world produces 2.01 billion tons of municipal solid waste (MSW) each year (World Bank, 2022). Surprisingly, developed, high-income countries account for 34% of this amount even though these same countries only account for 16% of the global population (World Bank, 2022). Although the waste produced in developed countries is due to a higher consumption of goods and services relative to developing countries, managing this waste, and considering pro-environmental behavior, on a residential level is necessary. Additionally, the World Bank (2022) estimates that per capita waste production will increase 19% in high-income countries by 2050, while low-income and middle-income countries' waste per capita will increase 40% by 2050. It would be beneficial if economists, scientists, and legislative bodies evaluated current recycling trends to ensure that recycling and waste-reduction measures are occurring at optimized rates.

This research is relevant due to recent legislative action on the matter. In 2019, Pennsylvania House Bill 1322 was established by Representative Wendy Ullman; House Bill 1322 aims at establishing a bottle deposit refund program and other recycling infrastructure in the state of Pennsylvania (Pennsylvania General Assembly, 2019). As Pennsylvania congressional representatives consider the impact that a bottle deposit refund program would have on the environment and the economy of Pennsylvania, evaluating the trends of counties and households becomes beneficial and relevant.

The Pennsylvania Department of Environmental Protection (PADEP, 2022) reports cumulative totals of commercial recycling and residential recycling each year; however, for the purpose of this research, I have chosen to only research residential non-organic recycling to evaluate residential recycling findings and to best approach an answer to the research question. In this paper, I will question how socioeconomic, demographic, and regional factors impact recycling per capita output. This research studies the 67 counties of Pennsylvania in the United States of America and will be conducted by running a multiple linear regression on the software Stata to analyze county variables and how these variables effect residential non-organic recycling per capita output.

Chapter 2: Literature Review

First, the literature review defines recycling. Secondly, this chapter discusses the current nature of recycling in the United States of America. Thirdly, this chapter highlights the economic and environmental benefits of recycling, explains the costs of recycling, and reflects on the history of recycling in the state of Pennsylvania. Lastly, this chapter references the previous literature.

1. Defining Recycling

The United States Environmental Protection Agency (U.S. EPA, 2022) has defined recycling as the process of gathering and processing materials to remanufacture them into new products. In 2021, the U.S. EPA (2022) established a National Recycling Strategy that created a standardized goal for the country to reach a recycling rate of 50% by 2030. Additionally, the National Recycling Strategy has suggested the implementation of a circular economy (U.S. EPA, 2022). The five strategies within the National Recycling Strategy include improving the recycling commodities market, increasing collection and materials management infrastructure, reducing contamination in recycling systems, enhancing policies to increase recycling, standardizing the measuring process, and increasing data collection throughout the country (U.S. EPA, 2022).

According to the U.S. EPA (2020), the total municipal solid waste (MSW) generated in the United States in 2018 was 292.4 million tons and amounted to 4.9 pounds of waste per capita each day. Out of that 292.4 million tons 69 million tons were recycled, and 25 million tons became composted, resulting in a total of 94 million tons of MSW being recycled and composted (U.S. EPA, 2020); this measure established a national recycling rate of 32.1% in 2018 (U.S. EPA, 2020). Out of the 292.4 million tons of MSW, 146 million tons of it was landfilled (U.S. EPA, 2020). The U.S. EPA (2022) has suggested that recycling output in the United States has not reached its optimized output primarily due to consumers' lack of locality education. According to the U.S. EPA (2022), consumers lack information on which materials can be recycled, how these materials can be recycled, and where certain materials can be recycled. This information highlights the importance of education, especially county and locality based,

and points out that the issue is not that residents do not want to recycle, it is a matter of lack of awareness and education. Milbrandt et al. (2022) have found that in 2019, the United States had only recycled 5% out of the total 44 million tons of plastic waste that was managed domestically, resulting in 86% of this plastic being landfilled and 9% of it being combusted. This analysis of plastic recycling in the United States illustrates the current need for enhancing the recycling dynamic throughout the country.

2. Country Comparison: Differences in Recycling Efforts

Other countries are pursuing this essential matter with initiative and efficiency; Sweden is now approaching zero-waste and is attempting to implement a circular economy by establishing infrastructure and a special advisory group, according to the Swedish Institute (SI, 2021). The special advisory group has been established to prioritize a circular economy in government policy, where a circular economy entails the complete reuse of recycled materials in a country (SI, 2021). Hanna Ljungkvist Nordin from the Swedish Environmental Research Institute and Anna-Karin Westöö from Statistics Sweden (2019) have found that in 2016 and 2017 only 6,000 tons of plastic that streamed through the Sweden economy entered landfills and that nearly 84% of polyethylene terephthalate (P.E.T.) bottles were recycled. Milbrandt et al. (2022) have found that in the United States, in 2019, 86% of the 44 million tons of plastic was landfilled. The findings by Milbrandt et al. (2022) and the findings by Hannah Ljungkvist Nordin and Anna-Karin Westöö (2019), reveal a drastic difference in plastic recycling efforts between the two countries.

Sweden's success in aluminum can and bottle recycling can be attributed to their "pant" system that dates back to 1984 for aluminum cans and 1994 for plastic bottles (SI, 2021). Sweden's "pant" system is a can and bottle deposit system that gives monetary refunds when deposits are made, and results in nearly 2 billion bottles and cans being recycled in the "pant" system annually (SI, 2021).

The recycling policies, programs, and infrastructure that have been established by other countries can be a useful model for the United States.

On the other hand, developing countries still lack waste management programs (World Bank, 2022). In low-income countries 90% of waste is dumped in unregulated landfills or is openly burned (World Bank, 2022). Additionally, in low-income countries, only 48% of waste is collected within cities and only 26% of waste is collected outside of urban areas (World Bank, 2022). Some developed countries are also behind on implementing efficient waste-reduction and recycling programs (Valenzuela-Levi, N., 2019); Valenzuela-Levi (2019) has found that only 54.8% of the 345 local governments in Chile had implemented recycling, although Chile had the highest gross domestic product among Latin American countries in 2019 (World Bank, 2019, as cited in Valenzuela-Levi, N., 2019, p.1).

Developed countries and developing countries both must implement efficient recycling programs to optimize and derive economic and environmental benefits.

3. Economic Benefits of Recycling

The economic benefits of recycling are notable. Both the state of Pennsylvania and the United States derive economic benefits from recycling.

In Pennsylvania, recycling acts accumulate necessary funding for recycling development, jobs, and waste reduction (PADEP, 2022). Pennsylvania's Act 101 accumulates nearly \$48 million annually to develop recycling accessibility, waste reduction, and implement program planning (PADEP, 2022).

The U.S. EPA (2022) argues that recycling is a vital part of the United States economy. Recycling has helped drive the agency's development of a Sustainable Materials Management (SMM) program and Resource Conservation and Recovery Act (RCRA) (U.S. EPA, 2022). The U.S. EPA (2022) has suggested that recycling increases economic security by enabling the U.S. to rely on domestic resources, materials, and manufacturers, and results in increased jobs throughout the country. The U.S. EPA (2022) reported in the 2020 Recycling Economic Information (REI) report that recycling and reuse activities in the U.S. has overall contributed to 681,000 jobs, \$37.8 billion in wages, and \$5.5 billion in tax revenue. The U.S. EPA (2022) has explained that recycling and reuse activities equate to 1.17 jobs for

every 1,000 tons of material recycled in the U.S. In Pennsylvania, the different processes of recycling altogether have accounted for 66,041 jobs, according to the PADEP (2022).

The economic benefits of recycling have been noted for decades (Gunter, 2007). Matthew Gunter (2007) found that economists Allen Hershkowitz, Anni Huhtala, and Jeffrey Morris all favor increased government intervention in recycling efforts (Hershkowitz, A., 1997, as cited in Gunter, M., 2007, pp. 86-88; Huhtala, A., 1997, as cited in Gunter, M., 2007, pp. 86-88; Morris, J., 1996, as cited in Gunter, M., 2007, pp. 86-88); these opinions provide insight from economists who have evaluated recycling and the impact that recycling has on the economy (Gunter, 2007). Government intervention may be necessary in the recycling market because recycling may have a higher opportunity cost than garbage disposal; in Chapter 3 I will discuss the theoretical framework of recycling and the need for government intervention within the recycling market further.

Not only does recycling derive economic benefits but recycling also generates environmental benefits.

4. Environmental Benefits of Recycling

Recycling drastically benefits the environment. Recycling prevents landfills from reaching capacity, limits pollution, conserves natural resources, and limits the amount of waste entering combustion facilities (U.S. EPA, 2022). According to Ahmina Maxey (2018), the U.S. and Canada Regional Coordinator with the Global Alliance for Incinerator Alternatives, limiting the amount of waste that enters combustion facilities is recommended because incinerators release pollutants that harm the environment and human lives. MSW landfills in the United States accounted for 14.5 percent of human-related methane emissions in 2020 alone, and these 2020 landfill methane emissions released greenhouse gasses equivalent to 20.3 million vehicles, according to the U.S. EPA (2022). Landfill gasses (LFG) are composed of 50 percent methane and 50 percent carbon dioxide (CO₂), and consist of a small percentage of organic, non-methane compounds (U.S. EPA, 2022). The United Nations Environmental Programme (UNEP, 2022) has reported that methane creates ground-level ozone. Ground-level ozone is a harmful air

pollutant and greenhouse gas that can harm human lives and has accounted for 30 percent of global warming present day since pre-industrial times (UNEP, 2022). Thankfully, landfill gasses have begun to be incorporated into LFG energy projects (U.S. EPA, 2022). Currently, 68% of LFG energy projects generate electricity, according to the U.S. EPA (2022). Although landfill gasses can generate energy, preventing landfills from reaching capacity is still an issue that must be managed.

According to the PADEP (2022), Pennsylvania alone recycled a total of 5.25 million tons in the year 2019. This total amount includes both the total from residential recycling, amounting to 1,516,568.79 tons, and the total from commercial recycling, amounting to 3,738,286.77 tons (PADEP, 2022). This recycling prevented 7.38 tons of carbon dioxide emissions from entering the air, removed equivalent to 1.6 million vehicles from roads in one year, and eliminated equivalent to the electricity used in 1.34 million homes, in just one year of recycling (PADEP, 2022). Additionally, products improve after being recycled rather than when products are made from raw materials, according to the PADEP (2022). For example, the tin in tin cans becomes more refined and therefore has additional added value after being recycled, according to the PADEP (2022).

The United Nations (UN, 2022) has developed seventeen Sustainable Development Goals (SDGs). SDG 13 targets climate change and highlights the importance of regulating climate change in all countries to ensure success for our future generations and planet overall (UN, 2022). The specific targets of SDG 13 are broken down into sections. The sections that apply best to this research are the first section that focuses on promoting resilience and capacity to climate-related hazards and natural disasters globally, the second section of SDG 13 that focuses on implementing climate change practices into policies, and the third section that focuses on increasing education, awareness, human, and institutional capacity on climate measures (UN, 2022).

SDG 11 prioritizes enabling cities and other human settlements to be inclusive, safe, resilient, and sustainable (UN, 2022). One section of SDG 11 focuses on reducing the per capita environmental impact of cities by 2030 by prioritizing air quality and waste management, while another section of SDG 11

focuses on implementing positive economic, social, and environmental perspectives between urban and rural areas through increased regional and national development planning (UN, 2022).

SDG 12 focuses on promoting sustainable consumption and production patterns globally (UN, 2022). Target 12.2 of SDG 12 aims to promote the sustainable management and efficient use of natural resources by 2030, while target 12.5 aims to reduce overall waste accumulation through recycling by 2030 (UN, 2022). These SDGs create awareness of waste accumulation and waste misallocation, as well as establish goals that countries must take to ensure that sustainable dynamics will develop in countries (UN, 2022).

The U.S. EPA (2022) has emphasized how the United States of America has not kept up with the patterns of increasing waste and must develop and incorporate enhanced recycling and waste management programs to keep up with the increasing waste crisis. Changes amongst international policies have limited the United States of America's exports of waste; therefore, the United States must integrate more sustainable domestic programs to handle waste accumulation efficiently (U.S. EPA, 2022). This includes enhancing and requiring pro-environmental packaging of retail products (U.S. EPA, 2022).

5. *Costs of Recycling*

Although there are many benefits to recycling, there are costs associated with recycling as well. Recycling may have increased monetary costs relative to the monetary costs associated with garbage disposal. Hong and Adams (1999) have found that in their study on households in Portland, Oregon, that when garbage disposal costs increase, the demand for recycling increases and the demand for waste disposal services decreases. Therefore, if the monetary costs of garbage disposal services and the monetary costs of recycling services become close in price, recycling demand should increase due to the presence of an alternative option being present. However, in certain regions, especially rural areas, monetary costs of recycling may be increased relative to the monetary costs of garbage disposal due to less accessibility, less recycling infrastructure, and less resources being prevalent in these regions.

Therefore, considering rural counties and urban areas is essential when considering the overall costs of recycling.

Secondly, recycling may have increased time costs. Preparing packaging to be recycled, such as rinsing a container, may take more time than just tossing a package into the trash. Therefore, the opportunity cost may be higher for recycling relative to garbage disposal; opportunity costs will be discussed further in the next chapter.

In addition to the increased time and monetary costs that come with recycling, transportation costs may increase if households and individuals do not have access to nearby recycling services, such as curbside-pickup recycling services. Transportation costs may de-incentivize individuals to participate in recycling programs and pro-environmental behavior.

As we evaluate the benefits and costs of recycling, it is essential that legislative bodies, economists, and environmental and waste professionals consider the differences amongst each individual region, state, county, and city to ensure that the most optimized services are being offered to each region.

6. *History of Recycling: Pennsylvania*

State-wide recycling in Pennsylvania began in 1988 with the establishment of the Municipal Waste Planning Recycling and Waste Reduction Act, Act 101 (PADEP, 2022). Act 101 required larger municipalities to recycle, established a fee amounting to \$2-per-ton of waste that each business sends to municipal waste landfills, and created grants to benefit local collection companies, community education, composting facilities, equipment, training, and material processing facilities, according to the PADEP (2022). Pennsylvania's Small Business and Household Pollution Prevention Program Act, Act 190 of 1996, began the assisting of small businesses and households in the proper management of solid and hazardous wastes and overall pollution prevention, according to the PADEP (2022). In 2010, Pennsylvania established the Covered Device Recycling Act (CDRA), Act 108, that created requirements for the disposal of electronic devices for consumers, manufacturers, landfill facilities, and businesses (PADEP, 2022). Pennsylvania has continued to establish enactments, however for the purpose of this

research the enactments described thus far allow for a general understanding of the recycling dynamic in the state of Pennsylvania (PADEP, 2022).

According to the PADEP (2022), over 11.6 million residents have access to recycling services, accounting for 94% of the state's population. According to the PADEP (2022), 76% of the state's population can recycle with ease due to convenient recycling programs offered by nearly 1,050 curbside-pickup programs throughout the state. Act 101 alone accumulates \$48 million annually, as discussed previously, and helps promote and sustain recycling and waste reduction programs (PADEP, 2022).

Although Pennsylvania has enactments established regarding recycling, Pennsylvania has not participated in a bottle deposit refund program. According to Jennifer Shultz (2020) from the National Conferences and State Legislature, other U.S. states and territories, such as California, Connecticut, Hawaii, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, Vermont, and Guam, have bottle bills established, with the deposit refunds varying from 2 cents to 15 cents; studies have found that these bottle deposit laws do increase recycling (Viscusi et al., 2011; Ashenmiller, B., 2009). Therefore, since the state of Pennsylvania does not have certain recycling incentives established as other states do, such as bottle deposit refund programs, Pennsylvania is a good state to model this research on.

The PADEP (2022) has a sophisticated data collection system and website that each year releases a report of the total recycled materials in terms of total residential recycled materials and total commercial recycled materials; these annual reports are further divided by each material and each county (PADEP, 2022). From my research, I noticed that other states do not report these quantities in a manner that is easily accessible, therefore it is efficient and beneficial that Pennsylvania offers these reports to the public.

Pennsylvania consists of 67 counties, with 48 of these counties being rural and 19 of them being designated as urban, according to the Center of Rural Pennsylvania (2020). In 2020, nearly 3.4 million residents of Pennsylvania lived throughout the 48 rural counties, amounting to about 26% of the state's population, according to the Center of Rural Pennsylvania (2020).

Pennsylvania counties were selected as a model for this research because of the state's high population and due to the accurate, annual recycling data collection and reporting throughout the entire state. Pennsylvania had a population of 12.8 million people in the year 2019, according to the United States Census Bureau (2021). Pennsylvania consists of two major cities, Pittsburgh and Philadelphia, as well as consists of other urban cities and rural regions, according to the Center for Rural Pennsylvania (2020). Evaluating the non-organic residential recycling trends of populous counties and less-populous counties may show greatly differing results, although these counties are within the same state; this makes Pennsylvania a good state to model this research on.

7. *Previous Literature*

Recycling tendencies and trends have been researched and theorized by experts for years. Since garbage disposal is the easiest mode of disposal, based on the assumption that it is the most readily available option throughout the United States, researchers question what factors drive households to recycle (Viscusi et al., 2011). Viscusi et al. (2011) have researched private values, social norms, and economic incentives and the impact that these variables have on the amount of water bottles being recycled in the United States. Viscusi et al. (2011) have found that individuals who value recycling and view themselves as environmentalists are expected to recycle 1.2 water bottles out of 10, and that an individual who claims that they would be disappointed if their neighbors did not participate in recycling are expected to recycle 2 bottles out of 10 bottles. Both findings demonstrate how internally valuing the practice of recycling impacts recycling (Viscusi et al. 2011).

Additionally, Viscusi et al. (2011) have found that economic incentives have the highest impact on recycling. Viscusi et al. (2011) found that recycling laws that mandate recycling or provide accessibility to recycling are expected to incentivize individuals to recycle 2.7 water bottles out of 10 bottles, that plastic water bottle deposit laws are expected to increase recycling by 2.5 bottles out of 10, and that deposit laws that do not include water bottles are expected to increase recycling by 1 water bottle out of 10 water bottles (pp. 68-69). The findings by Viscusi et al. (2011) reveal that not only do economic

incentives, such as recycling mandates and deposit laws, increase recycling, but fostering private values of pro-environmental behavior also play a significant role in the amount of recycling occurring.

This research considers demographic variables' impact on residential recycling output because these variables focus on characteristics of the individuals and households within a county and can denote trends in recycling on an individual level. Viscusi et al. (2011) have found that demographic variables such as higher income statuses, which one would assume, through economic theory, would decrease recycling due to the increase in opportunity costs when an individual earns higher wages, does increase recycling (p. 69). Since Viscusi et al. (2011) have found that individuals with higher income statuses recycle slightly more than individuals with lower income statuses, programs such as bottle deposit refund programs may incentivize impoverished individuals with low or no income to recycle more if a monetary incentive is given, according to findings by Ashenmiller (2009). Ashenmiller (2009) has found that California, a state with a bottle deposit refund program, had created a significant source of income for impoverished individuals through the bottle deposit refund program (p. 550).

Prior research on socioeconomic variables includes findings by Callan and Thomas (1997), who researched the state of Massachusetts and its 351 municipalities during 1994-1995. Callan and Thomas (1997) have found that rural communities and education had positive relationships with recycling rates, while population density had a negative relationship with recycling rates. This may be specific to the time period of their analysis. Additionally, Callan and Thomas (1997) have found that income had a positive effect on recycling rates. Callan and Thomas (2006) studied Massachusetts and its 351 municipalities a separate time, the second time consisting of an analysis of the years of 1996-2000 and 1994. Callan and Thomas (2006) have found that persons-per-household, persons-per-household squared, age, and education were significant regarding recycling rates; specifically, Callan and Thomas (2006) have found that as age and education increases, so does demand for recycling.

Sidique et al. (2010) have found in their analysis of Minnesota that age and education increased recycling, while income had a negative effect on recycling, specifically that a \$1000 increase in annual income per capita will decrease recycling rates slightly by 0.2 percentage points (p. 247). Sidique et al.

(2010) have found that an increased percentage of the population with access to curbside recycling, mandated recycling, and density of drop-off recycling facilities increased recycling. Additionally, Sidique et al. (2010) found no negative effect from population density on recycling rate, and they attributed it to densely populated counties in Minnesota having better recycling facilities and awareness overall.

Starr and Nicolson (2015) found that, in their analysis of Massachusetts, age was significant on recycling in five of the models and had a positive effect on recycling, that education was significant in four of the models and had a positive effect on recycling, that household size was significant in five of their models, that as the ratio of Democrats increased that recycling decreased - however they noted that this may be special to the state of Massachusetts-, and that recycling is influenced the most by policies that financially incentivized recycling. This research analyzed a 13-year period and was not cross-sectional (Starr, J., & Nicolson, C., 2015, p. 17).

Highfill and McAsey (2001) have found that in their analysis, municipalities with higher incomes recycled at higher rates than municipalities with lower incomes, specifically finding that municipalities with lower incomes recycled less and depended more on landfill accumulation, exhausting the landfill if the landfill is small, and not exhausting the landfill if the landfill is large, and ultimately suggested that mandates amongst municipalities will have to differ to some extent to capture differences between the municipalities (p. 49).

Since Pennsylvania does not participate in a bottle deposit refund program, the findings from this research may be beneficial in evaluating whether bottle deposit refund programs will be beneficial to the state of Pennsylvania in the future and which counties, if any, would directly benefit from the establishment of a deposit refund program, based on statistical and economic analysis. Currently, according to Jennifer Shultz (2020) from the National Conference of State Legislatures (NCSL), ten states and Guam have established bottle bills that provide a deposit refund for beverage containers, as mentioned previously. Ashenmiller (2009) has found that curbside recycling programs may be more beneficial in areas with high-population densities and that deposit refund programs may benefit rural areas that are less densely populated (p. 550). Ashenmiller (2009), as mentioned previously, has also

found that individuals with little-to-no income would be incentivized to recycle with these bottle deposit refund programs to earn income, therefore Pennsylvania counties with lower median household incomes may also increase their recycling rates due to this incentive if a deposit refund program is established in the future (p. 550). Additionally, Ashenmiller (2009, 2010) has found that increasing the amount of legal labor market opportunities could lower the prevalence of property crime rates due to individuals earning monetary utility through legal means instead of illegal means, such as scavenging litter around communities to recycle at deposit-refund centers for deposit-refund income (2009, p. 550; 2010, p. 258).

A deposit refund program could potentially supplement money towards recycling accessibility and recycling costs to counties overall (Ashenmiller, B., 2009). Ashenmiller (2009) has found that in California, curbside recycling programs receive funding from the deposit refund program's excess funds, therefore if additional funding is needed in the future to ensure grants to waste businesses, recycling facilities, and communities overall, additional funding could possibly be allocated from establishing a container deposit refund program in the state of Pennsylvania (p. 545).

8. Conclusion of the Literature Review

In the literature review, I explored the environmental and economic benefits of recycling, as well as the costs of recycling. Environmental benefits include decreased landfill accumulation, decreased pollution, and increased conservation of natural resources. Economic benefits include increased domestic economic security and increased quantity of jobs. Meanwhile, the costs of recycling include increased monetary costs, time costs, and transportation costs.

Additionally, the current nature of recycling in the United States and Pennsylvania was evaluated in this literature review. The main findings regarding the current nature of recycling in the United States is that the United States had a national recycling rate of 32.1% in 2018; specifically, in 2018, 146 million tons of MSW was landfilled out of the 292.4 million tons of MSW (U.S. EPA, 2020).

Lastly, findings from the previous literature were discussed. Viscusi et al. (2011) found that economic incentives and internal values increased recycling and pro-environmental behavior. Starr and

Nicolson (2015) have found that policies that offer financial incentives greatly influence recycling.

Ashenmiller (2009) has found that curbside recycling programs may be more beneficial to areas with high population densities and that deposit refund programs may benefit rural areas. Additionally, Ashenmiller (2009) has found that individuals with little-to-no income could increase their incomes in a legal manner by utilizing deposit refund programs, which in turn would decrease pollution and litter production.

Sidique et al. (2010) have found that age and education had a positive relationship with recycling and that income had a negative relationship with recycling. Lastly, Highfill and McAsey (2001), Viscusi et al. (2011), and Callan and Thomas (1997) have found that income had a positive relationship with recycling.

In the next chapters of this paper, the theoretical framework for recycling will be developed, the data will be further defined, results will be found, and the conclusion will be discussed.

Chapter 3: Theoretical Framework

In order to develop the relationship between consumer behavior on the choice of utilizing garbage disposal services or recycling services we must consider several economic theories.

The first framework is derived by indifference curves of preference proposed by Francis Ysidro Edgeworth in 1881 (New World Encyclopedia, 2023). Preferences are derived by different individuals or economic groups based on the utility that the individual gains. For example, counties with a higher percentage of Democratic registered voters may utilize recycling programs instead of garbage disposal programs more than counties with a higher percentage of Republican registered voters; therefore, the indifference curve of preference of Democratic counties may differ from the indifference curve of preference of Republican counties. This ideology could apply to all variables, such as counties with higher incomes' residents preferring to recycle more than the residents of counties with lower incomes, or vice versa, for example.

The indifference curve of preferences theory is based on utility, as mentioned previously, therefore, another theory to consider in the recycling market is the utility theory proposed by Daniel Bernoulli, developed further by Fisher and Marshall (Bernoulli, D., 1738, as cited in Stigler, G. J., 1950; Fisher, as cited in Stigler, G. J., 1950; Marshall, as cited in Stigler, G. J., 1950). The utility theory directly relates to the indifference curve of preference theory since individuals prefer certain actions or goods based on the utility that they earn from that action or consumption. Regarding recycling, individuals may recycle more than others if they earn utility from pro-environmental behavior. Utility theory also suggests diminishing marginal utility, Stigler (1950) explains. Diminishing marginal utility suggests that after so many additional units of utility is derived, utility will remain constant or diminish rather than increase; Viscusi et al. (2011) have suggested that the recycling market may differ, as someone who recycles often will generally continue to recycle, even if additional utility is not earned after they recycle a certain number of materials.

Another theory to consider when discussing utility is the theory of opportunity costs (Jensen, O. W., 1982). Individuals value their opportunity costs of time differently depending on the utility earned

from spending time on certain actions, time constraints, budget constraints, and other personal preferences. Regarding recycling, an individual may prefer to spend the time that it takes to recycle materials on a different activity instead of recycling, while someone else may prefer to spend the additional time that it takes to recycle materials. These preferences are based on the utility earned, as discussed previously; Jensen (1982) has explained that the utility earned must be greater than the opportunity cost for an individual to choose an opportunity.

A final theory to consider is Giffen's Paradox. Giffen's Paradox explains that individuals with lower incomes will demand a higher-priced product if the product has no substitutes (Giffen, R., as cited in Kasztalska, A.M., 2017). Normally, economic theory suggests that as prices increase, demand will decrease, however Giffen's Paradox suggests that goods with no substitutes will be demanded even if the good's prices are high, Kasztalska (2017) has explained. Therefore, in terms of recycling, individuals may not utilize recycling since garbage disposal is a direct substitute for disposing of non-hazardous, normal waste.

Based on the theories and findings mentioned, I believe that the consumer's decision to recycle is based on the incentives offered through government policy and the internal value of recycling, referencing the findings by Viscusi et al. (2011) and Starr and Nicolson (2015). I believe that the internal value of pro-environmental behavior and the utility earned from pro-environmental behavior is a primary driver of recycling output in states where financial incentives are not applicable, based on findings by Viscusi et al. (2011). In regions without financial incentives, even if the opportunity cost of recycling is higher than the opportunity cost of garbage disposal, an individual may recycle if they internally value pro-environmental behavior and therefore, will dismiss the higher opportunity cost.

These theoretical frameworks demonstrate that increased government intervention may be necessary in the recycling market. Since garbage disposal has been the easiest, most-accessible, and most-common choice for centuries, the government may have to implement nationwide incentives for recycling to change the current recycling approach. On the other hand, the recent increase in awareness of the

climate crisis and global waste crisis may be enough to encourage individuals to participate in pro-environmental activities, such as recycling.

1. Hypotheses

Based on this information, I have developed hypotheses on residential recycling trends. The variables and data collected for this research will be discussed in more detail in Chapter 4 of this paper.

My first hypothesis is that population density will positively affect residential non-organic recycling per capita. I will be utilizing population density in my regression to capture counties that are rural or urban. I base this hypothesis off the notion that counties with higher population densities have more resources that enable recycling to be more convenient and cheaper where resources are abundant (Sidique et al., 2010).

My second hypothesis is that Pennsylvania counties with a higher percentage of residents that are 25 years or older and that have earned a bachelor's degree or higher will positively affect residential non-organic recycling per capita. I based this hypothesis on the findings by Callan and Thomas (2006) who have found that educated individuals seem to be more aware of the risks of excess MSW disposal and therefore have found that there is a positive relationship between education and recycling demand. Additionally, I base this hypothesis on the findings by Sidique et al. (2010) who have found that for every dollar spent per person each year on education, recycling rates increased by nearly 2%.

My third hypothesis is that Pennsylvania counties with a higher percentage of registered Republican voters will have a negative effect on residential non-organic recycling per capita. I base this hypothesis on the notion that Republicans generally oppose regulation and government intervention; one finding has suggested that Democratic registered voters are three times more likely than Republican registered voters to suggest that climate change should be a top priority, specifically 78% versus 21% respectively (Kennedy, B., & Johnson, C., 2020).

My fourth hypothesis is that county median age will have a negative effect on residential non-organic recycling per capita. I base this hypothesis on the notion that as world organizations establish

goals to reach by 2030 and 2050, the younger generation is more likely to feel obligated to recycle and act in pro-environmental behavior as these deadlines approach (UN, 2022; World Bank 2022).

My fifth hypothesis is that population will have a positive effect on residential non-organic recycling per capita. I base this hypothesis on the notion that counties with a higher population may have more resources, accessibility, and opportunities to recycle, as suggested by Sidique et al. (2010).

My sixth hypothesis is that income will have a positive effect on recycling per capita; I base this hypothesis on the findings by Viscusi et al. (2011) and Highfill and McAsey (2001).

Table 3.1 below summarizes my predictions on the expected statistical relationships between each variable and residential non-organic recycling per capita.

Table 3.1: Expected Statistical Relationships

Variable	Expected Sign
Income	+
Population	+
Population Density	+
Republican	-
College	+
Age	-

Chapter 4: Data

This research focuses on the non-organic residential recycling of all recycled materials. The recycling data is provided by the PADEP (2022). Some Pennsylvania counties do not report the recycling of specific materials, therefore utilizing the counties' total residential non-organic recycled materials illustrates the general nature of recycling in each county. Although the PADEP (2022) and the respective counties report the recycled tons of organic materials, such as source separated foods, wood waste, and yard and leaf waste, this research does not include the organic recycled materials data due to the notion that organic recycling of these organic materials may not necessarily be recycled by individuals, but instead may be collected by the counties themselves; therefore, this research only evaluates the total non-organic residential recycling per capita of Pennsylvania counties.

The variable *RecCap* captures the total output of residential non-organic recycling per capita for each county and includes the reported residential non-organic recycled totals of single stream recycling, commingled recycling, glass, paper, plastic, metals, household hazardous waste, and miscellaneous materials, all of which are measured in tons, reflect the year 2019, and are provided by the PADEP (2022). Utilizing recycling per capita accounts for the recycling occurring in each county relative to the population of each county. In the manufacturing and commercial sectors, some materials have increased demand and prices relative to other materials, for example, aluminum versus cardboard; this notion may be a shortcoming of this variable. Further research may want to evaluate one material rather than the material totals to find whether certain counties, or potentially all, have specific recycling relationships with highly valuable and less-valuable materials.

The variable *Inc* describes the estimate of median household income for each county in the year 2019 and is provided by the U.S. Census Bureau and is retrieved by Federal Reserve Economic Data (FRED), Federal Reserve Bank of St. Louis (2023). The county in the sample with the highest median household income is Chester County, PA, with a median household income of \$102,233.00. The county

in the sample with the lowest median household income is Forest County, PA, with a median household income of \$41,267.00.

The variable *Pop* describes the total population of each county in the year 2019 and is provided by the U.S. Census Bureau, Population Division (2021). The county with the largest population is Philadelphia County, PA, with a population of 1,584,064 people. The county with the smallest population is Cameron County, PA, with a population of 4,447 people.

The variable *Pd* captures the population density of each county in the year 2020 and is provided by the U.S. Census Bureau (2023). Utilizing population density accounts for the people per square mile in each county and denotes whether a county is rural or urban. The Center for Rural Pennsylvania (2022) has denoted that a county with 291 people per square mile or less is denoted as a rural county. Population density was chosen as a variable instead of a rural binary variable to demonstrate *how rural* or *how urban* a county is. The characteristic of rural or urban counties is reflected through this population density variable throughout this research and may reflect on recycling resources and price of accessing recycling services as well. The county with the highest population density is Philadelphia County, PA, with the population density amounting to 11,936.9 people per square mile. The county with the lowest population density is Cameron County, PA, with the population density amounting to 11.5 people per square mile.

The variable *Rep* captures the percentage of Republican registered voters in each county relative to the total quantity of registered voters of the county; this data is based on November 2019 and is provided by the Pennsylvania Department of State Division of Voter Registration (2023). The county with the lowest percentage of Republican registered voters relative to all registered voters is Philadelphia County, PA, with only 11.1% Republican registered voters. The county with the highest percentage of Republican registered voters relative to all political parties is Potter County, PA, with 66.6%, Republican registered voters.

The variable *Col* describes the percentage of residents that are 25 years or older and have earned a bachelor's degree or higher for each county in the period 2017-2021 and is provided by the U.S. Census Bureau (2022). The county with the lowest percentage of residents with a college education is Cameron

County, PA, with only 10.6% of the population having earned a bachelor's degree or higher. The county with the highest percentage of residents with a college education is Chester County, PA, with 55.2% of the population having earned a bachelor's degree or higher.

The variable *Age* describes the median age of the residents in each county in the year 2019 and is provided by the Federal Reserve Bank of St. Louis (FRED, 2023). The county with the highest median age is Sullivan County, PA, consisting of a median age of 53.7 years old. The county with the lowest median age is Centre County, PA, consisting of a median age of 32.3 years old.

Chapter 5: Methodology

This research began with data collection that was collected through the means of an excel sheet and that was imported into Stata. A multiple linear regression was run with non-organic residential recycling per capita as the dependent variable. The independent variables are county median household income (*Inc*), population (*Pop*), population density (*Pd*), percent Republican (*Rep*), percent of individuals 25 years or older with a bachelor's degree or higher (*Col*), and median age (*Age*). Logarithmic variables will be generated for all variables. Equation (1) is shown below.

$$(1) \log(RecCap_i) = \beta_0 + \beta_1 \log(Inc_i) + \beta_2 \log(Pop_i) + \beta_3 \log(Pd_i) + \beta_4 \log(Rep_i) + \dots \beta_5 \log(Col_i) + \beta_6 \log(Age_i) + u_i, i = 1, 2, \dots, 67$$

Where:

RecCap = Residential non-organic recycling per capita (in tons), where i = county

Inc = Estimate of median household income, where i = county

Pop = Population, where i = county

Pd = Population density, where i = county

Rep = Percentage of Republican registered voters, where i = county

Col = Percentage of residents with a bachelor's degree or higher, age 25 years+, where i = county

Age = Median age, where i = county

The regression began by generating summary statistics, shown in Table 5.1 below.

Table 5.1: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
RecCap	67	.0603319	.0679417	.000168	.3599288
Inc	67	58873.25	11209.48	41267	102233
Pop	67	191074.5	275612	4447	1584064
Pd	67	482.8299	1504.6	11.5	11936.9
Rep	67	.493591	.1090692	.111	.666
Col	67	.2470597	.0922666	.106	.552
Age	67	43.34478	3.508962	32.3	53.7

Then, I ran the first regression, shown in Table 5.2.

Table 5.2: First Regression Results

RecCap	Coef.	Std. Error	T	P> t	[95% Conf. Interval]	
Inc	3.84e-07	1.42e-06	0.27	0.787	-2.45e-06	3.22e-06
Pop	-2.16e-08	7.24e-08	-0.30	0.766	-1.66e-07	1.23e-07
Pd	-1.95e-06	.0000108	-0.18	0.857	-.0000236	.0000197
Rep	-.06699	.1195556	-0.56	0.577	-.3061368	.1721567
Col	.0558315	.2220894	0.25	0.802	-.3884133	.5000764
Age	-.0036593	.0030808	-1.19	0.240	-.0098219	.0025033
_cons	.2206566	.1610211	1.37	0.176	-.1014335	.5427467

R-Squared: 0.0752; Adjusted R-Squared: -0.0173

- *** Indicates statistically significant at the 0.01 level.
- ** Indicates statistically significant at the 0.05 level.
- * Indicates statistically significant at the 0.10 level.

After generating logarithmic variables for each variable, I ran a regression utilizing the logarithmic variables. This regression is shown in Table 5.3 below.

Table 5.3: Regression with Logarithmic Variables

lRecCap	Coef.	Std. Error	t	P> t	[95% Conf. Interval]	
lInc	-1.761219	1.755563	-1.00	0.320	-5.272868	1.750431
lPop	.1682598	.373568	0.45	0.654	-.5789874	.9155071
lPd	.3003267	.4146958	0.72	0.472	-.5291884	1.129842
lRep	.6329219	1.039515	0.61	0.545	-1.446418	2.712262
lCol	1.992741	1.052476	1.89	0.063	-.1125244	4.098007
lAge	2.62151	2.557533	1.03	0.309	-2.494318	7.737337
_cons	5.929529	20.34508	0.29	0.772	-34.76669	46.62575

R-Squared:0.2837; Adjusted R-Squared: 0.2120

- *** Indicates statistically significant at the 0.01 level.
- ** Indicates statistically significant at the 0.05 level.
- * Indicates statistically significant at the 0.10 level.

Then, I tested for heteroskedasticity by utilizing the Breusch-Pagan test of heteroskedasticity. The Breusch-Pagan test of heteroskedasticity revealed that heteroskedasticity is present in the sample. Therefore, I derived a robust linear regression to account for heteroskedasticity. The robust linear regression results are shown in table 5.4 below.

Table 5.4: Robust Linear Regression

lRecCap	Coef.	Std. Error	t	P> t	[95% Conf. Interval]	
lInc	-1.761219	1.65794	-1.06	0.292	-5.077592	1.555155
lPop	.1682598	.3278481	0.51	0.610	-.487534	.8240536
lPd	.3003267	.3567933	0.84	0.403	-.4133662	1.01402
lRep	.6329219	.793507	0.80	0.428	-.9543284	2.220172
lCol	1.992741	1.275746	1.56	0.124	-.5591299	4.544612
lAge	2.62151	2.909562	0.90	0.371	-3.198481	8.441501
_cons	5.929529	16.32536	0.36	0.718	-26.72606	38.58512

R-Squared: 0.2837; Adjusted R-Squared: 0.21203433

- *** Indicates statistically significant at the 0.01 level.
- ** Indicates statistically significant at the 0.05 level.
- * Indicates statistically significant at the 0.10 level.

Then, multi-collinearity was tested by utilizing the variance inflation factor (VIF). The variance inflation factor determined that multi-collinearity was present in the data set. The first variance inflation factor is shown below in Table 5.5.

Table 5.5: First Variance Inflation Factor

Variable	VIF
<i>lPd</i>	11.97
<i>lPop</i>	8.36
<i>lCol</i>	5.23
<i>lInc</i>	3.66
<i>lRep</i>	3.33
<i>lAge</i>	1.78
Mean VIF	5.72

Since multi-collinearity is present in the data, correlated variables had to be removed. I derived a correlation matrix to determine which variables to eliminate; the correlation matrix is shown in Table 5.6 below. For organizational purposes I will only be demonstrating the correlation matrix of the logarithmic variables rather than the correlation matrix of the original variables.

Table 5.6: Logarithmic Variables Correlation Matrix

	lRecCap	lInc	lPop	lPd	lRep	lCol	lAge
lRecCap	1.0000						
lInc	0.3225	1.0000					
lPop	0.4814	0.5579	1.0000				
lPd	0.4719	0.5701	0.9304	1.0000			
lRep	-0.3282	-0.1727	-0.6618	-0.7482	1.0000		
lCol	0.4866	0.7553	0.7760	0.7696	-0.5414	1.0000	
lAge	-0.2468	-0.2658	-0.5734	-0.5901	0.4654	-0.5604	1.0000

Based on the correlation matrix, I decided to eliminate the logarithmic population density variable *lPd*. To determine if multi-collinearity is still prevalent in the sample, I derived a new variance inflation factor, shown in Table 5.7 below.

Table 5.7: Second Variance Inflation Factor

Variable	VIF
<i>lCol</i>	5.12
<i>lPop</i>	3.43
<i>lInc</i>	3.13
<i>lRep</i>	2.23
<i>lAge</i>	1.70
Mean VIF	3.12

Since the second variance inflation factor revealed that multi-collinearity is still present in the sample, I eliminated the variable *lCol*. I derived a third variance inflation factor to test if multi-collinearity is still present in the sample, shown in Table 5.8 below.

Table 5.8: Third Variance Inflation Factor

Variable	VIF
<i>lPop</i>	3.17
<i>lRep</i>	2.01
<i>lInc</i>	1.62
<i>lAge</i>	1.52
Mean VIF	2.08

Since the variable *lPop*, the population variable, had a VIF of 3.17, I eliminated it. Although the variable did not have a VIF above 5.0, the correlation matrix denoted that the population variable is correlated to the Republican variable *lRep*. As a final test for multi-collinearity, I derived a final variance inflation factor test, shown in Table 5.9 below.

Table 5.9: Final Variance Inflation Factor

Variable	VIF
<i>lAge</i>	1.34
<i>lRep</i>	1.28
<i>lInc</i>	1.08
Mean VIF	1.23

Since the variance inflation factor revealed that multi-collinearity is no longer present in the data, I was able to continue my regression. Therefore, the updated equation (2) is shown below.

$$(2) \log(RecCap_i) = \beta_0 + \beta_1 \log(Inc_i) + \beta_2 \log(Rep_i) + \beta_3 \log(Age_i) + u_i, i = 1, 2, \dots, 67$$

Since heteroskedasticity was found to be present in the data from the Breusch-Pagan test of heteroskedasticity, a robust linear regression was conducted with the remaining variables. Results will be discussed in the next chapter.

It is predicted that the excluded variables *lPd*, *lCol*, and *lPop* would have drawn significant conclusions regarding recycling trends. Therefore, utilizing these excluded variables in a separate regression with some of the included variables that are not correlated would be beneficial in future research. The correlation matrix depicted in Table 5.6 denotes that population density is highly correlated to the population variable, the percent Republican registered voters variable, and the percent of college educated individuals variable; additionally, the correlation matrix depicts that the college variable is highly correlated to the income variable and the population variable.

It is predicted that these excluded variables were highly correlated for several reasons. First, population density is highly correlated with the percentage of individuals 25 years and older with a bachelor's degree or higher due to the notion that individuals with college degrees generally live in larger

cities. Individuals with bachelor's degrees or higher move to large cities because large cities generally have more job options, more resources, and more organizations that offer high-level job advancement opportunities. Secondly, population density is highly correlated to population since an increase in residents in a county result in an increase in the number of people per square mile. Thirdly, the percentage of individuals 25 years or older with a bachelor's degree or higher correlates with median household income due to the notion that residents who have obtained higher education generally have increased job opportunities, income, and job advancement. Although individuals who do not hold a college degree can earn high incomes, the correlation in the sample between the variables *lCol* and *lInc* reveals that counties with a higher number of residents who have earned a college degree end up having increased median household incomes.

The variables that remain in the regression *lInc*, *lRep*, and *lAge* are relevant to the research as these variables capture socioeconomic, demographic, and regional variables. The median household income variable and the percent Republican registered voters variable capture the regional outlook of the county regarding resources, incomes, and preferences; the county median age variable captures demographic information; and the median household income variable captures socioeconomic information. Results amongst these variables are denoted in the next chapter.

Chapter 6: Results

The robust multiple linear regression suggests that median household income is statistically significant at the 1% significance level; this reveals that a 1% increase in median household income results in non-organic residential recycling per capita to increase by approximately 2.21%.

Additionally, the robust multiple linear regression suggests that the percentage of Republican registered voters is statistically significant at the 10% significance level. This means that a 1% increase in the percentage of Republican registered voters results in non-organic residential recycling per capita to decrease by 1.33%. However, it is important to note that a significance level of 0.10, 10%, is highly debated in the statistical field.

Table 6.1 below summarizes these findings.

Table 6.1: Robust Multiple Linear Regression Results

lRecCap	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
lInc	2.208441***	.6860212	3.22	0.002	.8375373	3.579345
lRep	-1.334677*	.6834561	-1.95	0.055	-2.700455	.0311006
lAge	-1.01374	1.848341	-0.55	0.585	-4.707354	2.679874
_cons	-24.83334	11.85733	-2.09	0.040	-48.52832	-1.138365

R-Squared:0.1831; Adjusted R-Squared: 0.14416601

- *** Indicates statistically significant at the 0.01 level.
- ** Indicates statistically significant at the 0.05 level.
- * Indicates statistically significant at the 0.10 level.

Chapter 7: Discussion

Several conclusions can be derived from the regression results.

First, my findings on median household income were consistent with the findings of Highfill and McAsey (2001), Viscusi et al. (2011), and Callan and Thomas (1997). Highfill and McAsey (2001) have found that municipalities with a high income will recycle more and utilize landfills less, while lower income municipalities will utilize landfills more and rely on recycling less (p. 49). Viscusi et al. (2011) have found that individuals with higher incomes recycle more. Callan and Thomas (1997) have found that median household income has a positive impact on recycling rates.

An increase in median household income results in an increase in non-organic residential recycling per capita due to several, plausible reasons. First, as a county's income increases, the income may have increased due to the residents having obtained higher education. It is predicted that college education may enable residents to be more conscious of the environmental and economic benefits that recycling generates (Sidique et al., 2010; Callan, Scott, J. Thomas, Janet, M., 1997; Callan, S. J., & Thomas, J. M., 2006; Starr, J., & Nicolson, C., 2015, p. 17). Additionally, it is plausible that the households within counties with higher median household incomes will be willing to pay the additional costs that may come from accessing recycling services, compared to counties with lower median household incomes (Highfill, J., & McAsey, M., 2001).

Second, my findings on the relationship between the Republican registered voters and non-organic residential recycling per capita are not consistent with the findings of Starr and Nicholson (2015); however, Starr and Nicholson (2015) studied Democratic registered voters instead of Republican registered voters. Therefore, it is hard to say whether the findings are or are not consistent with the findings of Starr and Nicholson (2015). Starr and Nicholson (2015) found that as the percentage of Democratic registered voters increased that recycling decreased; however, they noted that this may be specific to Massachusetts (Starr, J., & Nicolson, C., 2015). It seems to be more beneficial to evaluate the relationship between the percentage of Republican registered voters and residential non-organic recycling, since Republicans are less likely to prioritize political actions on climate change (Kennedy, B., & Johnson, C., 2020). It is also

important to note that my findings may be specific to Pennsylvania, the year 2019, and the recycled materials that this research evaluates.

The negative relationship between Republican registered voters and non-organic residential recycling per capita may be due to a multitude of reasons. Republicans may prioritize other political aspects; however, that is not to say that all Republican registered voters do not prioritize the environment, pro-environmental behavior, and sustainability.

Table 7.1 below demonstrates the actual statistical relationships between residential non-organic recycling per capita and the remaining variables. When compared to Table 3.1, my predictions on the statistical relationships between non-organic residential recycling and the variables that remained were accurate to the actual findings.

Table 7.1: Actual Statistical Relationships

Variable	Actual Sign
<i>Inc***</i>	+
<i>Rep*</i>	-

- *** Indicates statistically significant at the 0.01 level.
- ** Indicates statistically significant at the 0.05 level.
- * Indicates statistically significant at the 0.10 level.

Chapter 8: Conclusion

My findings suggest that a 1% increase in median household income results in a 2.21% increase in non-organic residential recycling per capita and is statistically significant at the 1% significance level. Additionally, this research found that a 1% increase in Republican registered voters results in a 1.33% decrease in non-organic residential recycling per capita and is statistically significant at the 10% significance level.

These results can provide beneficial information that can be utilized for the establishment of government policies. Since median household income and non-organic residential recycling per capita have a positive, statistically significant relationship, allocating recycling resources and increased recycling access to counties with lower median household incomes may increase recycling rates in lower-income counties. Additionally, implementing a bottle deposit refund program in Pennsylvania, especially in counties with lower median household incomes, may increase the incomes of individuals who recycle and would therefore incentivize pro-environmental behaviors in these counties. Since percentage of Republican registered voters and non-organic residential recycling per capita have a negative, statistically significant relationship, allocating educational resources - that describe the environmental and economic benefits that are derived from recycling - in counties with a higher percentage of Republican registered voters may increase recycling rates and influence other pro-environmental behaviors.

These results also correspond to economic theory. First, the economic theory regarding indifference curves of preference is applicable in this research; counties with a higher percentage of Republican registered voters are expected to prefer garbage disposal over recycling services due to the increased utility they earn from utilizing garbage disposal methods. Second, the economic theory of opportunity costs is applicable in this research; residents in counties with higher median household incomes are expected to recycle more than residents in counties with lower median household incomes due to the residents in higher income counties having a lower opportunity cost of recycling and pro-environmental behavior relative to garbage disposal since they may have increased resources, accessibility, and, potentially, increased education levels.

Further research will benefit this research and the study of environmental economics. Utilizing other states, time periods, recycled materials, and variables may provide additional, beneficial results. Since multiple variables had to be excluded from this research due to the presence of multi-collinearity, future research that evaluates the variables independently, or jointly in different groupings, will benefit recycling research. Further research that considers highly valuable materials relative to less valuable materials, rather than the combination of both, will be beneficial in understanding the relationships between different materials and recycling. Evaluating waste patterns and the quantity that each county and state produces in waste will benefit further research as well. Additionally, since Pennsylvania does not have a bottle deposit refund program established to incentivize residents, further evaluation of states that do have a bottle deposit refund program established and other recycling infrastructure implemented will benefit future research on recycling output and the economy overall.

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About the Author

Caitlin Comunale is a first-generation college student who attended Allegheny College from 2019-2023. Since a young age she had always been passionate about the concept of economics and economic groups, specifically impoverished economic groups, and she had always wondered how countries can best approach improving the lives of impoverished groups.

At Allegheny College, Caitlin majored in economics and minored in writing. She became a member of Omicron Delta Epsilon, the Internal Honor Society in the Field of Economics, and Sigma Tau Delta, the International English Honor Society. During her junior year, Caitlin earned the title of a Designated Alden Scholar of Allegheny College. At the end of her college career, Caitlin began interning in supply chain. In the future, Caitlin strives to work in a career that provides social output, promotes efficiency, and improves lives.

Caitlin is passionate about environmental economics, labor economics, international economics, and developmental economics. She will forever be thankful for the education and skills that she has derived from her time spent at Allegheny College. She is grateful for the professors who had encouraged, advised, mentored, and supported her throughout her years at Allegheny College. Caitlin will always remember her college career at Allegheny College.

