The Economic Benefits of Recycling in Virginia

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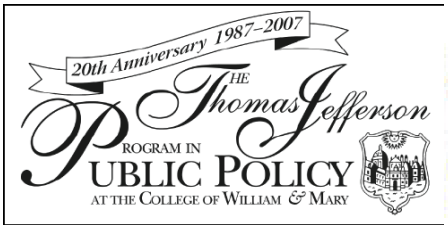
A Study
By the Thomas Jefferson Program in Public Policy
At the College of William and Mary
For the Virginia Department of Environmental Quality



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Executive Summary

This report was created for the Virginia Department of Environmental Quality to provide an overall economic analysis of recycling in Virginia. To begin, a review of the literature is conducted. Specific attention is paid to the various studies analyzing the socioeconomic determinants of recycling performance. Next, an in-depth characterization of similar state and regional reports is made. It is within this framework that the two-pronged approach for this study was developed. The first prong of the analysis focuses only on the private sector of the Virginia recycling industry. The second prong of this analysis focuses only on the public sector recycling efforts in Virginia.

The results of this study indicate that the recycling industry generates $1.9 billion dollars in gross revenues every year and employs at least 8,000 people. This represents 0.6 % of the Commonwealth's gross domestic product (GDP)[1] and 0.2% of Virginia's total employment. From the public sector research, it has been found that state funding has consistent positive impacts on recycling efforts. Urban and highly populated areas are not only more likely to recycle, but along with low income localities, they are able to use available funding most efficiently due to the presence of economies of scale.[2] While state dollars usually result in higher recycling performance, the relationship between local budget and recycling performance is less clear.

Some key results are shown below:

- An additional $10,000 allocated to a Solid Waste Planning Unit (SWPU) as state funding is likely to lead to an additional 73,337 recycled tons increase.

[1] The GDP of a country or a region is defined as the total market value of all final goods and services produced within a country or a region in a given period of time (usually a calendar year).
[2] Economies of scale characterize a production process in which an increase in the scale of the firm causes a decrease in the long-run average cost of each unit.

- Being an urban SWPU is likely to have 10.53 more percentage point in recycling rate.
- An additional $10,000 allocated to an urban SWPU as state funding is likely to create an additional 53,225 tons more recycled than allocate the same amount to a rural SWPU.

Based on these analytical results, the following recommendations can be made. First, the funding of urban, highly populated, and low income areas by the Commonwealth is highly recommended. Also it is clear that local managers require more training to enhance budget management and recycling techniques. Furthermore, the Commonwealth's current units for local recycling are too large. Smaller, more concentrated recycling planning units are recommended.

Going forward, it is clear that future research needs to target the actual amount of recycling activities occurring within the manufacturing and transportation sections of Virginia's recycling industry. Furthermore, an analysis of tax rates and revenues would be extremely helpful in determining the relationship between state revenues generated by the recycling industry and the funding the state spends on recycling programs.

Introduction

The U.S. is currently experiencing a crisis managing its waste. According to the Environmental Protection Agency (EPA), the amount of waste each American creates has almost doubled in the past four decades from 2.7 to 4.4 pounds per day.[3] Because of this, there is a need to build additional and larger landfills. Lobbying for the addition of landfills, however, is no easy task. Citizens, by and large, have a "Not in my backyard!" mentality; they know there is a need for one, but citizens are typically not willing to be a landfill's neighbor. Landfill tipping fees are increasing with the intention of discouraging landfill use, but this is, unfortunately, not having a significant effect on the reduction of waste because recycling is, on average, still more costly.

Recycling has served as a potential method to combat this problem. In 1999, recycling and composting activities prevented about 64 million tons of material from ending up in landfills and incinerators. Today, this country recycles 32.5 percent of its waste, a rate that has almost doubled during the past 15 years.[4] While recycling has grown in general, recycling of specific materials has grown even more drastically: Fifty-two percent of all paper, 31 percent of all plastic soft drink bottles, 45 percent of all aluminum beer and soft drink cans, 63 percent of all steel packaging, and 67 percent of all major appliances are now recycled.[5]

Recycling in Virginia is following this steady growth rate evidenced by the nation as a whole. Here, as elsewhere in the country, recycling is touted as an effective and practical solution to waste. Virginians believe that it has the potential to conserve the Commonwealth's natural resources, reduce the need for landfills, and prevent future environmental degradation.

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[3] EPA (2007)
[4] EPA (2007)
[5] EPA (2007)

But could recycling also be degrading the state economy? Could Virginia be saving trees and other materials at the cost of increasing unemployment? Are recycling programs in "the Commonwealth" *really* designed for the common good?

For many who study recycling on the national level, the economic benefits are obvious. According to the National Recycling Coalition (NRC), returning commodities to the stream of commerce is a "value-adding, job-providing, and economy-spurring activity."[6] So, the NRC claims that recycling saves a variety of resources—not only those that are "natural" to the Earth.

This study attempts to see if the conclusions from this national study hold true for Virginia. Based on the socioeconomic variables it analyzes, the report also proposes strategies for the Commonwealth to implement in order to maximize the economic benefits it reaps from its recycling industry.

Purpose of the Project

In the fall of 2007, the Virginia Joint Legislative Audit and Review Committee (JLARC) began a two-year study on waste minimization in Virginia. This study comes as a mandate from the Commonwealth with the passage in early 2007 of Virginia Senate Joint Resolution 361.

This resolution charges JLARC with the task of evaluating waste minimization, reuse, and recycling in Virginia. According to JLARC, if current conditions continue, landfill capacity in Virginia will be exceeded by 2023. However, less than seven percent of the material delivered to the State's landfills is diverted for recycling or mulching.[7]

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[6] NRC
[7] JLARC

The Virginia Department of Environmental Quality (DEQ) has requested that the Thomas Jefferson Program in Public Policy at the College of William and Mary perform a preliminary investigation into the state of recycling in Virginia.

The results from this study may be used as a reference for economic development agencies, entrepreneurs, and financiers to understand and evaluate recycling businesses; a reference for lawmakers to assist them in evaluating legislation that would affect recycling; a tool for recycling advocates to increase understanding of the industry, promote awareness of recycling and reuse, and target resources for growth; and a baseline of economic information to document future growth and development of the industry.

Design of the Study

This report was designed to address two distinct research questions. The primary question asks, "What is the value of the recycling industry in the Commonwealth of Virginia?" The secondary question asks, "What are the determinants of the amount of recycling at the local level?"

The design of this study was inspired by that of the 2001 report of the National Recycling Coalition, which includes both the public and private sectors.[8] Since the recycling industry is an integrated network where the public and private sectors work together, this study is designed to describe recycling activities in full. Therefore, the data were gathered from both public and private organizations.

The body of this report is organized into four parts. The first portion of this study entails a two-pronged approach to reviewing the available literature on this topic. This discussion is

[8] National Recycling Coalition (2001).

designed to provide background to frame the analysis made in the report. This includes a review of various state and federal recycling reports, as requested by the Virginia DEQ.

The second portion of this report details the methodology and results of an analysis of the recycling industry in Virginia. This portion of the report is focused only on the private sector of recycling in Virginia. The purpose of this section is to provide estimates of recycling related to employment, revenue, and personal income within the Commonwealth of Virginia.

The third piece of this study includes the detailed econometric or multivariate analysis of the socioeconomic determinants on local recycling performance in Virginia. These determinants not only cover demographic variables (like population), but also budget variables (like state and local funding). The goal of this portion of the study is to reveal what distinguishes SWPUs with high recycling performance from those with low recycling performance.

Based on the analysis results presented in the second and the third sections, the fourth part of this study will propose strategies to make state and local funding efforts more efficient and outline future research needs.

Literature Review

Socioeconomic Determinants of Recycling

Recycling as a practice of waste minimization is a relatively young process in the United States. The 1990s saw a dramatic rise in recycling rates across the country. An article published in Public Works Management in 2000 addressed the issues behind the growth in municipal recycling programs.[9] The growth of recycling in the U.S. rose from a rate of 10% to 30% from 1990 to the turn of the new century.[10] Kinnaman's analysis identifies a lack of accurate data as leading to the debate over the cause of the rising recycling rates.

The crux of this debate focuses on whether market or nonmarket factors can be identified as the underlying cause. Kinnaman tackles the issue by conducting a cost-benefit analysis of a municipal recycling program. While this analysis is clearly dated, it provides insights. Kinnaman's analysis suggests that municipal recycling programs are costly. The fundamental question is then why does it remain popular? This article suggests that local governments could be responding to households that perceive a benefit from recycling services.

In layman's terms, Kinnaman acknowledges the idea that recycling programs function as a public service boosting overall social welfare. Within this frame of reference, recycling programs can be viewed as serving the same purpose of public parks, recreation areas, and public events. These are similar public services that are costly yet supported by public funding. These types of public services are viewed as a necessity by the community and are only able to exist due to the presence and willingness of the government to provide public funds to sustain them.

[9] Kinnaman (2000).
[10] Recycling rate is definied as total tonnage of recycling divided by the total tonnage of solid waste collected.

According to a 1994 study performed by Gamba and Oskamp, relevant recycling knowledge was the most significant predictor of observed recycling behavior. In this study knowledge variables are related to recycling practices while attitudinal measures were used to quantify political beliefs and opinions. Relevant recycling knowledge and a few specific attitudinal measures were significant predictors of self-reported recycling behavior.[11]

Berger published a study in 1997 which shows that the size of residential area, the type of dwelling, educational attainment, and household income are significant determinants of whether recycling facilities are available and used. Analyses also show that environmental behaviors are structured around specific environmental issues such as water, energy, or waste disposal and suggest that recycling may operate as a first step toward the adoption of other behaviors.

Owens et. al in 2000 examined the demographic covariates of what Owens terms "residential recycling efficiency."[12] Owens defines "recycling efficiency" as the weight of recycled materials divided by the total weight of materials recycled plus recyclables discarded as solid waste.[13] In this study educational attainment, income level, and residential status (rent vs. own) all had significant impacts on recycling efficiency.

State Reports

Senate Joint Resolution 361 directs JLARC to review reports from other U.S. states as it evaluates the economics of recycling in Virginia. This study reviewed reports of six states as well as two regions.

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[11] Gamba and Oskamp (1994).
[12] Owens, Dickerson, and Macintosh (2000).
[13] This is different from the term "recycling rate," which is defined as total tonnage of recycling dived by the total tonnage of solid waste collected.

❖ **North Carolina**[14]

Nearly 12 million tons of municipal solid waste was generated in North Carolina in 1997, and eight million tons were disposed of into a landfill. Construction and Demolition (C&D) debris made up the largest component of the disposed waste (29 percent), and paper made up another 18 percent. Organic materials comprised about 12 percent of the waste stream, and wood made up 11 percent. All other materials each comprised 10 percent or less.

A conservative estimate of the total tonnage of material recycled in 1997 is 4.1 million tons, which yields a 34 percent recycling rate. The last time the statewide recycling rate was calculated, in 1995, it was estimated at 22 percent (2.1 million tons recycled and 7.6 million tons disposed).

The recycling rates for specific commodities vary. Container recovery rates tend to be low, especially for plastics. Although the paper recovery infrastructure is well established, there is still room for growth in many grades, especially magazines, mixed and office paper. Some other materials are virtually untouched in terms of recycling potential, including C&D, electronics, food residuals, most plastics, and textiles.

Despite limited recovery in some categories, the 1998 assessment found a thriving industry that continues to grow and change. The 1990s had seen the introduction of new technologies, expansion of collection systems, and considerable fluctuations in foreign and domestic economic cycles. In addition, recycling companies (both processors and end users) in 1998 were consolidating in many sectors. Since the last assessment was conducted, North Carolina had provided business management, technical and financial assistance to 608 businesses. In that period, 185 jobs were created and $5.05 million were invested. The total

[14] North Carolina Department of Environment and Natural Resources (1998).

volume of new capacity created was 217,000 tons per year. More than half of that capacity was construction and demolition (C&D) debris processing. Another significant development since the last industry assessment is the inception of a recycling business loan fund, supported by the N.C. Department of Environment and Natural Resources (DENR), the U.S. Environmental Protection Agency (EPA), and the Self-Help Ventures Fund (Self-Help). This fund is administered by Self-Help, and the project will offer at least $660,000 in loans to recycling businesses. These loans are expected to create or retain at least 80 jobs, provide 115,000 tons per year of recycling capacity, and leverage an additional $330,000 of private investment.

- **Southern States[15]**

This study analyzes recycling efforts in sixteen Southern states, including North Carolina.[16] An estimated 138,632 people were employed in firms that process recovered materials or use them in manufacturing in the thirteen states included in the study in 1995. This represented 2.8 percent of the nearly five million jobs in the manufacturing sector in 1995.

Approximately 24 percent of the recycling employment in these states was in processing firms, and 76 percent was in manufacturing firms. Paper manufacturers were the leading recycling employers, with an estimated 47,102 employees, or 34 percent of the total recycling employment in the thirteen states and territories. Ferrous manufacturers were the next largest contributor to employment, with approximately 21 percent of total recycling employment.

Approximately $18.5 billion of value was added to recyclables in the region through processing and manufacturing. This is an estimated 4.9 percent of the total value added by the manufacturing sector.

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[15] Roy F. Weston (1996).

[16] The report includes the following states: AL, AK, GA, FL, KY, LA, MD, MS, MO, NC, OK, SC, TN, TX, VA, WV.

- **Michigan**[17]

Recyclable materials processing has a significant impact on Michigan's economy. Respondents to a survey of recyclable materials processors conducted by the Michigan Recycling Coalition reported $437 million in annual revenue, 1,920 jobs, and over $52 million in annual payroll attributable directly to processing activities. When extrapolated from the 51 percent of entities who responded to the survey to the entire processing industry in Michigan, this implies total annual revenues of over $1.9 billion, total employment of 5,028, and a total annual payroll of more than $137 million.

Economic activity in recyclable materials processing generates additional activity in other sectors that provide goods and services as inputs to processing. This additional activity supports jobs that can be indirectly attributed to recyclable materials processing. Furthermore, workers in processing activities spend their money on other goods and services that support still more economic activity and jobs.

Estimating indirect and induced economic impacts associated with recyclable materials processing in Michigan was beyond the scope of this study. Studies in other states in the region, however, suggest that the total economic impact of recyclable materials processing may be twice as large as the direct impact of processing activities.

- **Northeast Recycling Council (NERC)**[18]

NERC consists of ten states: Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, and Delaware. According to

[17] Michigan Recycling Coalition (2001).
[18] Northeast Recycling Council (1996).

its report, the recycling industry is a significant contributor to the region's economy, adding over 100,000 jobs and $7.2 billion in value added activity.

In New Jersey, for instance, the recycling industry compares favorably to other industries in the state on indicators like the number of businesses comprising the industry and the number of employees in the industry. The state Department of Labor collects payroll information on 72 Goods Producing Industry categories. Recycling is not a recognized category but if it were, it would rank 14th in total employment. Recycling approaches the estimated 14,800 jobs in the manufacture of medical instruments and is almost double the estimated 7,000 jobs in motor vehicle construction within New Jersey.

In Massachusetts, more than 800 recycling businesses contribute $588 million in value added and over 14,000 jobs to the state's economy. The Massachusetts recycling industry compares favorably to other industries in the states on indicators like the number of businesses comprising the industry and the number of employees in the industry.

The recycling industry added nearly $300 million and over 2,000 jobs to the Maine economy in 1992. The average annual salary of all private sector jobs attributable directly to recycling in Maine is $18,476. By comparison, the Maine Dept. of Labor reported that the 1990 average annual earnings of all Maine workers was $19,820.

The study found that recycling businesses stimulate local economies in a number of ways:

1. Local recycling businesses reduce dependence on distant markets for recyclables and are likely to provide greater market stability.
2. Recycling manufacturing can support local recycling programs, stabilizing and possibly reducing waste management costs.

3. Recycling manufacturing with locally collected materials adds value by producing finished goods for export rather than exporting raw materials and importing finished products. Local jobs are created, local manufacturers have access to less expensive raw materials, and the reduced dependence on solid waste disposal facilities saves the money of residents and local governments better spent elsewhere in the local economy.
4. Local ownership ensures that business assets remain in the region, and spin-off purchasing enhances the stability of the local retail business environment and contributes to the local tax base.

❖ **Massachusetts[19]**

By converting raw materials into products, recycling (including reuse and remanufacturing) creates jobs, builds more competitive manufacturing industries and adds significantly to the Massachusetts economy. There are 1,437 recycling businesses and organizations in the Commonwealth of Massachusetts. They offer 19,500 jobs with a $557 million annual payroll, and have $3.5 million in receipts. This represents an increase in recycling businesses and recycling jobs, but a decrease in annual payroll in the eight years since the NERC study was conducted.

The indirect impacts of recycling businesses include their interaction with a wide variety of service-based businesses (e.g., equipment manufacturers, consultants, brokers, transporters, accounting firms, office supply companies). They also provide an additional 11,452 jobs, $470 million payroll, and $1.6 billion in receipts. Recycling businesses also generate roughly $64 million in state tax revenues.

[19] Massachusetts Department of Environmental Protection (2004).

Recycling is a major employer. More than 3 percent of the Massachusetts workforce works in recycling related fields. Recycling employs as many people in Massachusetts as does the child care, the accounting and bookkeeping sector, or the electric utilities industry. Employment in the Massachusetts recycling industry ranks higher per capita than California, New York, and Florida.

Sorting and processing recyclables provides 10 times more jobs than if the same materials were thrown away. Manufacturers that use recyclable materials to make new products employ even more people, and at higher wages, than sorting and processing companies. For instance, some recycling-based paper mills and plastic product manufacturers, employ 60 times more workers than do landfills on a per-ton basis.

- **Pennsylvania**[20]

Recycling adds value to Pennsylvania's economy. For example, collection and processing, the initial steps in the recycling process, involve sorting and aggregating recyclable materials. This includes municipal and private collectors, material recovery and composting facilities, and recyclable material wholesalers. These activities employ nearly 10,000 people in Pennsylvania, with a payroll of $284 million and annual sales of $2.3 billion.

Recycling manufacturing involves the actual conversion of recyclables into products. The primary recycling manufacturers in Pennsylvania in order of magnitude are steel mills, plastic converters, paper and paperboard mills, and nonferrous metal manufacturers. Recycling manufacturing employs over 64,000 people with a payroll of almost $2.5 billion and annual sales of over $15.5 billion.

[20] Pennsylvania Department of Environmental Protection (2007).

Reuse and remanufacturing focus on the refurbishing and repair of products to be reused in their original form. The largest activities are retail sales of used merchandise and reuse of used motor vehicle parts. The amount of value that can be added via this process is limited because of competition from new products. Nevertheless, reuse and remanufacturing contribute over 7,000 jobs, a payroll of $115 million and sales of over a half billion dollars.

In addition to the direct benefits, support businesses that provide goods and services to the recycling and reuse establishments also contribute to the state's economy. These supporting activities include recycling and reuse equipment manufacturers, consulting/engineering services, brokers, and transporters. These contribute an additional 13,297 jobs and $1.8 billion in receipts. Pennsylvania tax revenues from the recycling and reuse businesses are estimated at 305 million dollars per year.

- **California**[21]

While additional work is needed to better define and refine the inputs used in this study, the results to date suggest that disposal and diversion activities have a significant impact on the California economy. In addition to estimates of factors such as jobs and revenue in the recycling industry, the results show that recycling solid waste has a significantly higher impact on the economy than disposing it. When material is diverted rather than disposed in California, total sales and value-added impacts more than double, output impacts and total income impacts nearly double, and the employment impact nearly doubles.

[21] Goldman & Ogishi (2001).

- **Iowa**[22]

In 1999, the Iowa recycling industry reported that more than $101 million in commodity gross receipts based on estimated quantities of recyclable materials collected. There were 1,636 direct processing jobs and 2,720 in total recycling-related processing jobs (including organics and C & D). 1999 also reflected more than $2.268 billion in direct-industrial output. The recycling equipment industry, in itself, provided more than $80 million in total industrial output and 725 total jobs. For every 100 jobs created in the recycling processing industry, 72 additional jobs are sustained in the Iowa economy. For every dollar in total income created in the recycling processing industry, $1.03 of additional income is sustained in the Iowa economy.

[22] Beck (2001).

The Recycling Industry in Virginia

This portion of the report focuses on the private industry involved in recycling activities in Virginia. The overall structure of this analysis involves quantitative estimates of the economic value of the recycling industry in Virginia. These estimates are characterized for the time period ranging from 2002 to 2007. A variety of data sources are pooled to compile this analysis. The discussion below will first identify the various data sources used, outline the analytical methods, and finally present the results.

Methodology

Six industry sectors within the recycling industry as a whole were selected from the North American Industry Classification System (NAICS). The six sectors were then separated into three categories to cover the various stages of the recycling process.

Table 1: Six Industry Sectors within the Recycling Industry as a Whole

Recycling Industry	*NAICS Code*	*Industry Sector*
Core	42393	Recyclable material merchant wholesalers
	56292	Materials recovery facilities
Manufacturing	32211	Pulp, paper, & paperboard mills
	23621	Industrial Building Construction
Transportation	4842303	Other specialized trucking, long-distance
	562111	Solid waste collection

Source: 2002 NAICS U.S. Economic Census

These six industry sectors can be classified in three different categories. The Core category includes Materials Recovery Facilities (MRFs) and Recyclable Material Merchant Wholesalers, which are NAICS codes 56292 and 42393, respectively. The definition of the core

group for the purpose of this study is industry sectors 100% involved in recycling activities. The manufacturing category covers recycling activities, which include processing, manufacturing and end use of recyclable materials. For the purpose of this report the manufacturing category includes two NAICS codes including Pulp, Paperboard, and Paper Mills (32211) and Industrial Building Construction (23621). The transportation category includes Solid Waste Collection (562111) and Other Specialized Trucking (4842303), which involves the transfer of recyclable materials.

The data available from the 2002 U.S. Economic Census utilized in this report include the following variables: number of establishments, number of employees, gross revenue, and annual payroll. These variables are reported for the State of Virginia as a whole. The average annual salary is calculated by dividing the annual payroll value by the number of employees. Personal income is calculated by multiplying average salary by the number of employees related to recycling within an industry sector. The method for qualifying the amount of employees within an industry related to recycling is explained at the end of this section.

The Virginia Employment Commission (VEC) provided data on the number and size of firms in the six industry sectors in Virginia for 2007. These data are used to create a profile of the industry composition by firm size. The data from the VEC are discrete and not continuous as firm size class organizes it. The size classes for the individual firms are listed as follows: zero, one to four, five to nine, ten to nineteen, etc. The complete list of size classes is shown in Table 2. To calculate a valid estimate of the number of employees within each industry sector in 2007, an average of the numbers bounding each size class is taken. This average is then multiplied by the number of firms reported by the VEC in each size class in each of the six industry sectors. The sum of the employee estimates is then made by industry sector.

Table 2: Average Number of Employees within VEC Firm Size Classes

Size Class	*0*	*1-4*	*5-9*	*10-19*	*20-49*	*50-99*	*100-249*	*250-499*	*500-999*
Average Number of Employees	0	2	7	14.5	34.5	74.5	174.5	224.5	749.5

Source: VEC data.

The VEC also provided general time series data for each of the six industry sectors identified above. These data include annual averages (of quarterly data) of total employment and firm numbers from 2002 through 2006. The change in total employment within each industry subsector is used to calculate an industry specific growth rate. The annual growth rate is calculated as follows:

$$\text{Annual Growth Rate} = \frac{(\text{2006 Total Employment}) - (\text{2002 Total Employment})}{(\text{2002 Total Employment})} \div 4\,years$$

The calculated annual growth rate is then used to create revenue projections for each industry sector for the years 2006 and 2007. The formula used is shown below:

$$\text{2006 Gross Revenue} = \text{2002 Gross Revenue} \times (\text{Annual Growth Rate} + 1)^4$$

$$\text{2007 Gross Revenue} = \text{2002 Gross Revenue} \times (\text{Annual Growth Rate} + 1)^5$$

The three groupings used to characterize the recycling industry in this report relate to varying amounts of involvement in recycling activities. While the core category includes industry sectors 100% involved in recycling activities the other two categories do not. Therefore, the revenue and employment estimates for the manufacturing and transportation categories must be qualified to represent the true percentage of recycling related activities occurring in these industry sectors. To accomplish this, a search of the available literature and data was made.

Summary statistics of manufacturing use data from the Institute of Scrap Recycling Industries (ISRI)[23] were identified. Unfortunately, this type of information was only found for the paper manufacturing industry. ISRI reports that 50% of U.S. paper industry relies on scrap paper. The other industry within the manufacturing category is industrial building construction. In the trade the use of recycled materials in this industry is called the reuse of construction and demolition waste. This type of recycling activity is prevalent in Virginia, as shown by the Mid-Atlantic Consortium of Recycling and Economic Development Officials (MACREDO) database of recyclers in Virginia. However, no specific use data are available identifying the proportion of inputs that are reused in this industry. Therefore, a simplifying assumption is made. The 50% scrap use rate is applied uniformly over the manufacturing industry sectors in this study.

Within the transportation industry sectors identified in this study, an absence of accurate data exists as well. For this category, another simplifying assumption is made. The Virginia statewide recycling rate is used to identify the proportion of activities within solid waste collection and specialized transportation related to recycling. The Virginia statewide recycling rate is defined as the total annual recycling tonnage divided by total annual municipal solid waste tonnage. The formula is shown below:

$$\text{VA Statewide Recycling Rate} = \frac{\text{Annual State Total Recycled Tonnage}}{\text{Annual State Total Municipal Solid Waste Tonnage}}$$

The Virginia statewide recycling rate for the calendar year 2006 is used to qualify the true amount of recycling related economic activity within the transportation category.

[23] www.isri.org

Analysis

To begin the analysis portion of this section, the data from the 2002 U.S. Economic Census are presented. Table 3 shows the final summation of the calculations made using the economic census data. The methods for deriving total personal income are discussed above.

Table 3: 2002 Summary of the Recycling Industry in Virginia

Industry Group	*Number of Employees*	*Gross Revenue (2002 $)*	*Total Personal Income (2002 $)*
Core	1790	344,537,000	53,343,000
Manufacturing	3188	1,317,883,000	176,806,500
Transportation	1995	296,107,392	748,820,096

Source: U.S. Economic Census 2002

Based on this analysis the total revenue for the recycling industry in Virginia in 2002 was $1.958 billion. Total employment was 6,973, and total personal income is estimated to have been $978 million. Tables 4-7 below show the specific values of the variables by industry code. The average salary for each industry sector was calculated by dividing the total payroll values presented in the census by the total employment within the industry sector.

Table 4: Average Salary in the Recycling Industry in Virginia in 2002

	Industry Sector	*Average salary ($ per annum)*
Core	Recyclable material merchant wholesalers	30,017.65

	Materials recovery facilities	27,374.15
Manufacturing	Pulp, paper, & paperboard mills	60,840.59
	Industrial building construction	25,895.92
Transportation	Other specialized trucking, long-distance	35,834.92
	Solid waste collection	38,719.72

Source: U.S. Economic Census 2002

As described above, the total gross revenues reported in the 2002 census are adjusted by recycling category. The manufacturing category is adjusted using the 50% recycled material use assumption derived from the Institute of Scrap Recycling Industries. The transportation category is adjustedusing the 2006 recycling rate for the entire state of Virginia. Table 5 shows the results.

Table 5: Gross Revenue in the Recycling Industry in Virginia 2002

	Industry Sector	***Total Gross Revenue***	***Recycling Related Revenue***
Core	Recyclable material merchant wholesalers	322,614,000	322,614,000
	Materials recovery facilities	21,923,000	21,923,000
	Total	**344,537,000**	**344,537,000**
Manufacturing	Pulp, paper, & paperboard mills	2,484,545,000	1,242,272,500
	Industrial building construction	151,221,000	75,610,500
	Total	**2,635,766,000**	**1,317,883,000**
Transportation	Other specialized trucking, long-distance	231,435,000	88,871,040
	Solid waste collection	539,678,000	207,236,352

	Total	**771,113,000**	**296,107,392**

Source: Authors' calculations based on 2002 U.S. Economic Census

Table 6 outlines the total employment within each of the industry sectors and the adjusted recycling related employment. These estimates are made using the two simplifying assumptions discussed above.

Table 6: Employment in the Recycling Industry in Virginia 2002

	Industry Sector	***Total # Employees***	***Recycling related Employees***
Core	Recyclable material merchant wholesalers	1,643	1,643
	Materials recovery facilities	147	147
	Total	**1,790**	**1,790**
Manufacturing	Pulp, paper, & paperboard mills	5,395	2697.5
	Industrial building construction	980	490
	Total	**6,375**	**3187.5**
Transportation	Other specialized trucking, long-distance	2,199	844.416
	Solid waste collection	2,997	1150.848
	Total	**5,196**	**1995.264**

Source: Authors' calculations based on 2002 U.S Economic Census

Manufacturing is the largest employment category within Virginia's recycling industry with 3,187 employees in 2002. The core group is the smallest employer in the industry as a whole in 2002. Once again, the large amount of uncertainty over the amount of recycling activities carried out in the transportation sectors makes it difficult to accurately estimate the true level of recycling employment in this group. Table 7 below shows the number of firms operating in Virginia within each industry sector in 2002.

Table 7: Businesses in the Recycling Industry in Virginia in 2002

	Industry Sector	***Total # of Firms***

Core	Recyclable material merchant wholesalers	114
	Materials recovery facilities	15
	Total	**129**
Manufacturing	Pulp, paper, & paperboard mills	14
	Industrial building construction	38*
	Total	**52**
Transportation	Other specialized trucking, long-distance	121
	Solid waste collection	156
	Total	**277**

Source: U.S. Economic Survey 2002
Note: * Sampling error exceeds 40 percent

In analyzing the Virginia recycling industry over time, data from the Virginia Employment Commission[24] was integrated into the data available from the U.S. Economic Census. The VEC data are described above in the methodology section. Specifically, revenue and payroll data were not available. In the Appendix, Figures 1-6 show average employment from 2002 through 2006 in each industry sector. The VEC creates industry sector growth projections for the decade ranging from 2004 to 2014. It must be noted that the VEC projections reported here are for the most closely related industry sectors available to the recycling sectors. For example, there is no VEC projection available for recyclable material merchant wholesalers. Therefore, the projection for merchant wholesalers of durable goods is used instead. These projected growth rates are compared with the calculated annual growth rates in Table 8 below.

Table 8: Comparison of VEC Projected Growth Rates and Calculated Annual Growth Rates for Industry Subsectors within the Recycling Industry in Virginia

	Industry Sector	***VEC Projected Growth Rate 2004 to 2014***	***Calculated Annual Growth Rate***
Core	Recyclable material merchant wholesalers	15.7%	-0.4%

[24] Personal communications with Tim Kestner, VEC, 9/2007 to 11/2007

	Materials recovery facilities	NA	2%
Manufacturing	Pulp, paper, & paperboard mills	-3.3%	-2%
	Industrial building construction	13.5%	-5%
Transportation	Other specialized trucking, long-distance	12.3%	8%
	Solid waste collection	23.1%	5%

Source: Virginia Employment Commission 2007

The calculated annual growth rates seem to tell a different story than the VEC projected growth rates. Within the manufacturing category, the decline of employment in both industry sectors is greater than the VEC projection. The opposite is true of the transportation category. The calculated growth rates are greater than the VEC projected growth rates. The VEC projected growth rate for all industries in VA for the period from 2004 to 2014 is 17.1%.

The calculated annual growth rates were then used to create revenue projections for 2006 and 2007. Projections for both years were made for specific reasons. First of all, there is data available on the total employment in each of the six industry sectors for 2006 but not for 2007. However, a complete list of firms for each industry sector is available for 2007. Also, the industry composition data by firm size are available only for 2007 and not 2006. Furthermore, the Bureau of Economic Analysis (BEA) has data available for total Virginia GDP and employment for 2006 but not yet for 2007. Table 9 below shows the revenue projections for 2006 using the actual employment numbers reported by the VEC.

Table 9: 2006 Projected Revenue and Recycling Employment

	Industry Sector	*Total Employment*	*Recycling Projected Revenue*
Core	Recyclable material merchant wholesalers	1,990	316,457,496.4
	Materials recovery facilities	325	23,723,977.5
	Total	**2,315**	**340,181,473.9**
Manufacturing	Pulp, paper, & paperboard mills	2522	1,139,141,841
	Industrial building construction	1,680.5	60,944,654.36
	Total	**4,202.5**	**1,200,086,495**
Transportation	Other specialized trucking, long-distance	802.944	123,893,797.7
	Solid Waste Collection	1,286.4	252,794,785.9
	Total	**2,089.344**	**376,688,583.6**

Source: Authors' calculations based on VEC data and the 2002 U.S. Economic Census

Using the numbers from Table 9 above, the total employment within the recycling industry in Virginia in 2006 was 8,607. It is interesting to compare this number with the smaller total employment value of 7,720 projected for 2007 in Table 10 below. The reason for this difference is not that employment declined between 2006 and 2007. Rather, the value for 2007 was created as a projection from the size class data provided by the VEC for all the firms in each of the NAICS codes. The reason for this glaring underestimation is that many firms reported a size of zero employees. While it is apparent that the employment projection for 2007 is inaccurate, the revenue estimates are consistent with the 2006 projections, which are based on the 2002 U.S. Economic Census data.

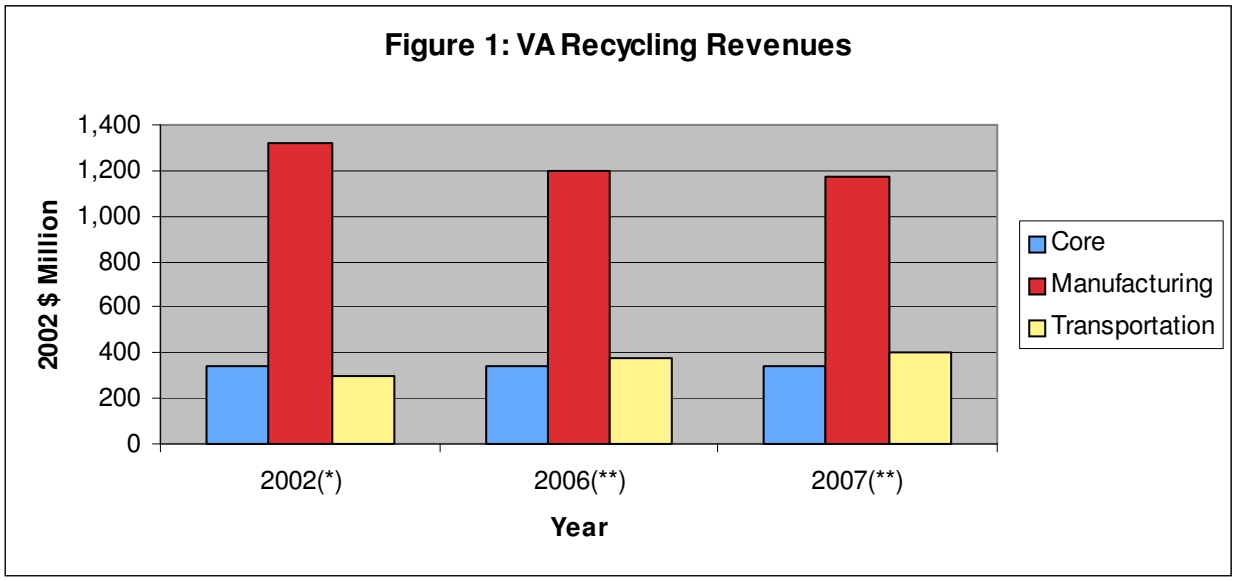
Table 10: 2007 Revenue and Employment Projections

	Industry Sector	*Projected Employment*	*Recycling Projected Revenue*
Core	Recyclable material merchant wholesalers	379	314,936,816
	Materials recovery facilities	2,339	24,196,880
	Total	**2,718**	**339,133,696.72**
Manufacturing	Pulp, paper, & paperboard mills	1,193.25	1,114,725,759
	Industrial building construction	1,636.25	57,746,277.75
	Total	**2,829.5**	**1,172,472,037**
Transportation	Other specialized trucking, long-distance	835.97	44,349,141.32
	Solid Waste Collection	1,336.51	265,670,697.1
	Total	**2,172.48**	**310,019,838.4**

Source: Authors' calculations using VEC data and the 2002 U.S. Economic Census

Combining the data presented in Tables 5, 9, and 10, a comparison of revenue growth and decline within the three categories of the recycling industry in VA can be made. This comparison is expressed below in Figure 1.

Figure 1: Recycling Revenues in Virginia



Source: *Data from 2002 U.S. Economic Census; **Data projected from 2002 Economic Census Data using employment trends calculated from data provided by the VEC.
Note: Please see Table 1 in the Appendix for more information.

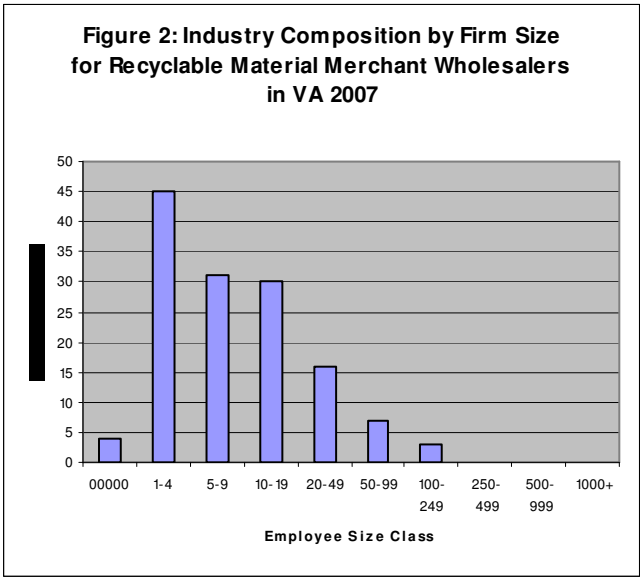
Figure 1 shows that the gross revenues from the core of the recycling industry seem to have fallen from $344 million in 2002 to $339 million in 2007. The decline of this category is driven by the recyclable material merchant wholesalers industry sector. There is distinctive growth in the materials recovery facilities sector. The manufacturing revenues also show an overall declining trend from $1.3 billion in 2002 to $1.17 billion in 2007. Only the transportation category shows an overall growth in revenues from $296 million in 2002 to $400 million in 2007. The trend for the revenues of the recycling industry as a whole in Virginia for this time period is negative. The value of the industry in 2002 was $1.958 billion. The estimated value for 2006 is $1.916 billion, and the value for 2007 is estimated to be $1.911 billion. It is important to remember that the revenue values for 2006 and 2007 are projections based on employment trends. We will know the true revenue values when the 2007 U.S. Economic Census data is published.

The U.S. Bureau of Economic Analysis estimates the total GDP of the Commonwealth of Virginia in 2006 to have been $318.727 billion (expressed in terms of dollars from the year 2000.) Using this value, the recycling industry in Virginia represented 0.6% of the total GDP for the state in 2006. According to VELMA[25], the total size of the Commonwealth of Virginia's workforce was 3,665,764 in 2006. This means that the total private sector recycling workforce of 8,607 in 2006 represented 0.2% of all employment in the state.

The final component of this analysis is the description of the recycling industry composition by firm size. This is accomplished using the VEC data from 2007. Each industry sector is graphed using a histogram. This is designed to illustrate what types of firms exist within Virginia's recycling industry.

Figure 2: Industry Composition by Firm Size for Recyclable Material Merchant Wholesalers in Virginia (2007)

Figure 2 shows the composition of the recyclable material merchant wholesalers industry sector. The total number of firms within this sector was 136 in 2007. The median salary for employees within this subsector in 2007 is reported by VELMA to have been $50,419 per annum.



[25] Virginia Employment Labor Market Analysis (VELMA)

Figure 3: Industry Composition by Firm Size for Materials Recovery Facilities in Virginia (2007)

Figure 3 shows the composition of the materials recovery facility industry sector. The total number of firms within this sector was 28 in 2007. The median salary for employees within this subsector in 2007 is not reported by VELMA.

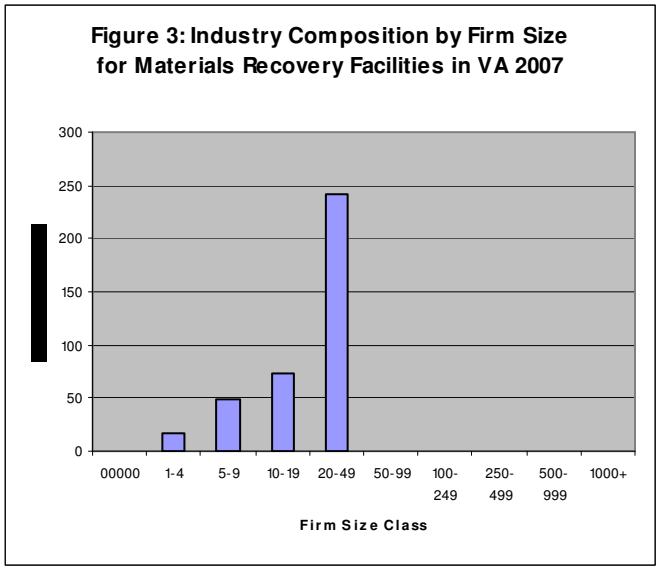


Figure 4: Industry Composition by Firm size for Industrial Building Construction in Virginia 2007

The composition of the industrial building construction industry sector is illustrated in Figure 4. The total number of firms in this sector was 146 in 2007. VELMA reports the median salaries for the top two most common occupations in this industry to be $34,860 per annum for carpenters and $55,334 per annum for supervisors.

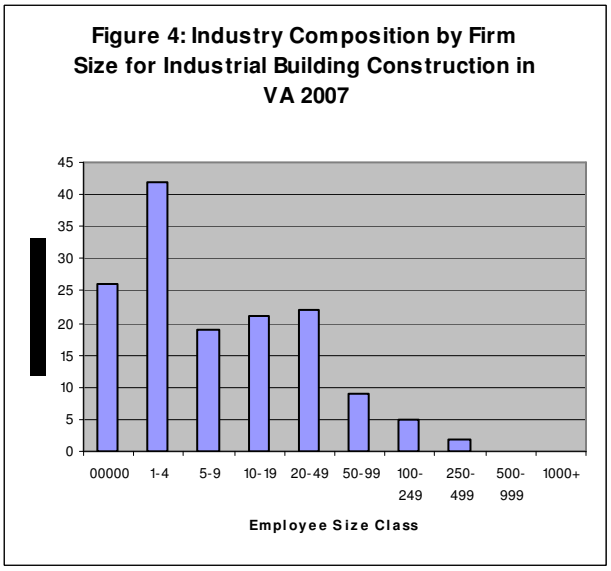


Figure 5: Industry Composition by Firm Size for Paper Manufacturing in Virginia 2007

The industry composition for paper manufacturing in Virginia is shown in Figure 5 below. The total number of firms in this sector was 26 in 2007. VELMA reports the median salaries for the top two most common occupations in this industry to be $25,519 per year for machine operators and $42,214 per year for machine mechanics.

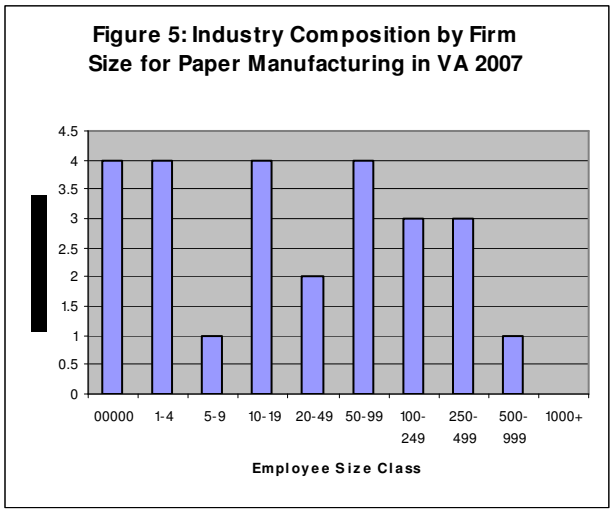


Figure 6: Industry Composition by Firm Size for Solid Waste Collection in Virginia 2007

The industry composition for solid waste collection in Virginia is shown in Figure 6 below. The total number of firms in this sector was 190 in 2007. VELMA reports the median salaries for the top two most common occupations in this industry to be $24,471 per annum for collectors and $33,932 per annum for truck drivers.

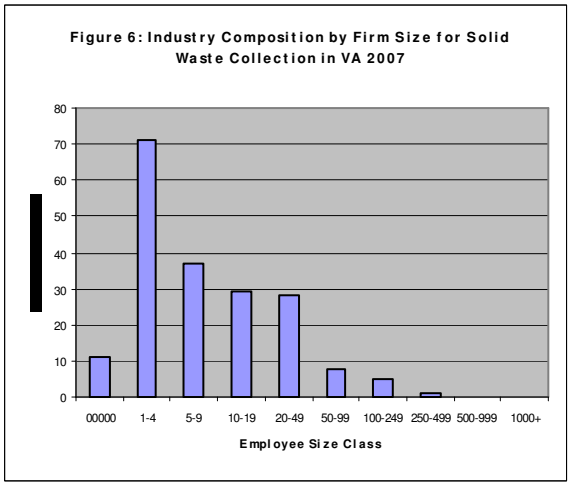
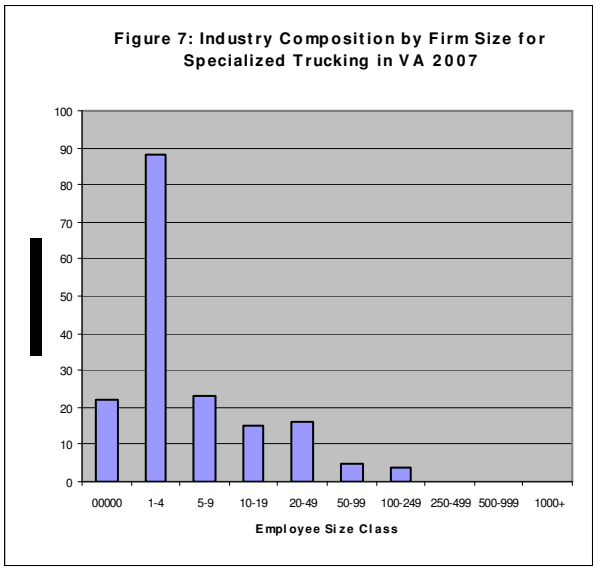


Figure 7: Industry Composition by Firm Size for Specialized Trucking in Virginia 2007

Figure 7 below shows the composition of the specialized trucking industry in 2007. The total number of firms in this sector was 173 in Virginia in 2007. VELMA reports the median salary for employees in this industry to be $33,932 per annum for truck drivers.



One crucial point about Figures 2 through 7 is to note the presence of the 00000 size class. The reason this size class is labeled with five zeros instead of one is that it is highly unlikely that these firms truly have zero employees. Rather, it is more likely that the data for these firms are simply unavailable. In essence, these data from the VEC represent a sample. The firms in the 00000 category represent the non-responders. The total number of firms across the six NAICS codes classified into the 00000 category equals 68 of a total of 699. This equates with a 10% rate of non-response or unavailable data for the recycling industry as a whole in Virginia for 2007.

The median salary values within each industry sector reported by VELMA are used to calculate an estimate for 2006 total personal income. No estimate of personal income is made for 2007. The reason for this is the inherent inaccuracy in the projected total employment for 2007. This issue is discussed both in the preceding sections and in the final section of this report containing recommendations for future research. In the case that two median salaries are reported above, the average of the two values will be used. This value is then multiplied by the

number of recycling related employees, in each sector, in order to calculate total personal income. The results of this are shown in Table 11.

Table 11: Estimates of 2006 Personal Income in the Recycling Industry in Virginia

	Industry Sector	*2006 Personal Income Estimate*
Core	Recyclable material merchant wholesalers	100,333,810
	Materials recovery facilities	10,151,638.43
	Total	**110,485,448.4**
Manufacturing	Pulp, paper, & paperboard mills	85,411,313
	Industrial building construction	75,785,508.5
	Total	**161,196,821.5**
Transportation	Other specialized trucking, long-distance	27,245,495.81
	Solid Waste Collection	37,566,096
	Total	**64,811,591.81**

Source: Authors' calculations based on VEC data and the 2002 U.S. Economic Census

Determinants of Recycling Performance in Virginia

This report is the first attempt to estimate the economic impacts of recycling in Virginia. Based on some sources of secondary data and a survey of the Solid Waste Planning Units (SWPUs), this report provides summary statistics and econometric estimates of the determinants of the recycling performance in Virginia.

Methodology

The objective of this part of the report is to examine the determinants of recycling performance, particularly recycling rate and recycling tonnage, in Virginia. The goal is to estimate the significance and magnitude of the relationship between the determinants and recycling rate or recycling tonnage in Virginia. Based on the results of this exercise, specific policy recommendations are made to help improve the recycling performance in Virginia, and the effectiveness of local budget and state funding used to support recycling programs.

A short statewide survey of the Solid Waste Planning Units (SWPUs)[26] was undertaken to gather information on local recycling budget, size of the public workforce, and average hourly wage of these public employees[27]. Also, other secondary data have been compiled, including recycling rate and tonnage by SWPUs, state funding for litter prevention and recycling programs in local governments, and SWPUs' demographic data such as population density, average income, and educational attainment. The sources for this data include the U.S. Census Bureau and the Virginia Department of Environmental Quality (DEQ).

[26] Solid Waste Planning Units (SWPUs) are politically determined solid waste reporting entities within the State of Virginia which may include one or more localities such as counties, cities, and towns.
[27] This average hourly wage information is different from the average income data to be used in regression models later in the report.

The results of this analysis will be reported in two ways. First, summary statistics for the different determinants will be presented. Then the results of the econometric models will be tabulated and discussed. In order to achieve the econometric estimates, several multivariate regression models have been used. These models specify functions of recycling rate or recycling tonnage on several different sets of determinants with SWPU as the unit of analysis.

The basic analysis equations might be expressed as:

$$\text{RecyclingRate OR Tonnage}_i = \beta_0 + \beta_1\,\text{PopulationDensity}_i + \beta_2\,\text{AverageIncome}_i + \beta_3\,\text{Education}_i + \beta_4\,\text{MandatedRate}_i + \beta_5\,\text{RecyclingBudget}_i + \beta_6\,\text{StateFunding}_i + \beta_7\,\text{Urban}_i + \varepsilon_i$$

As shown above and discussed in detail in the introduction of this report, the basic set of determinants included in this analysis are listed as follows::

- **Population density** is generated by dividing population estimates of 2006 by land area in square miles;
- **Average income** is collected by SWPUs for 2005 from the Bureau of Economic Analysis website;
- **Educational attainment** is the percentage of population 25 years and over with bachelor's degree or higher (Census 2000);
- **Mandated recycling rates**, as explained in the introduction, are the minimum recycling rates that all SWPUs must meet based on two sets of criteria[28];
- **Local recycling budget** is gotten from the SPWU survey where SWPUs are asked the following question: "What is the local budget for recycling of your SWPU?";

[28] According to §10.1 1411 of the Code of Virginia, "all Solid Waste Planning Units (SWPUs) must meet the minimum recycling rate of 25% **unless** their population density is less than 100 persons per square mile or if their civilian unemployment rate is 50% above the statewide average. Those SWPUs qualifying under these new criteria must meet a minimum recycling rate of 15%."

- **State funding** is the amount of money allocated to local governments within SWPUs by the State of Virginia through the Virginia Department of Environmental Quality (DEQ) to support their litter prevention and recycling programs. Currently, this funding includes only grants and is allocated based on localities' population and road miles; and
- **Urban**, which is a dummy variable, is coded 1 if an SWPU is urban and 0 if rural.

Due to the impact these socioeconomic variables are expected to have on recycling performance, there exists the assumption that there is variation in the effectiveness of spending money on recycling in different types of localities. For example, spending on recycling by rural and urban SWPUs is expected to yield significantly different returns. For this reason a broader set of determinants has been used in the same multivariate regression models to estimate the potential of targeting State funding for recycling programs. The set of determinants was broadened to include the following interaction variables[29]:

- State funding and urban/rural;
- State funding and population size;
- State funding and area (square miles);
- State funding and average income;
- Local recycling budget and urban/rural;
- Local recycling budget and population size;
- Local recycling budget and are (square miles); and
- Local recycling budget and average income.

In summary, the regression results of the two models discussed above will provide estimations of how many more tons of waste can be expected to be recycled given a one dollar

[29] These interaction variables are generated by respectively multiplying state funding variable or local recycling budget variable with four other variables, urban/rural dummy variable, population size, area, and average income.

increase in state funding or in local recycling budget at the SWPU level. Likewise, the expected percentage point increase in recycling rate will also be estimated given a one dollar increase in state funding in local recycling budget at the SWPU level. The use of the multiple regression method allows the calculation of these estimates when other determinants are statistically controlled for. With the interaction variables, the regression results imply differential marginal effects between groups of SWPUs on recycling performance.For example, it shows whether providing state funding to local governments in urban SWPUs is more effective than funding those in rural SWPUs.

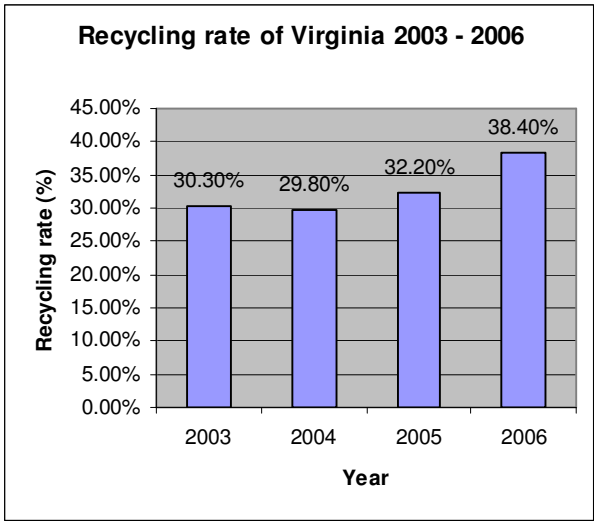
Summary statistics

To date, Virginia as a whole has done a good job in its recycling effort. The following two graphs provide a picture of recycling for the State in terms of the recycling rate and total tonnage recycled. The data for these two graphs were compiled and adjusted for consistency using the annual DEQ recycling summary from the reports submitted by the 74 SWPUs and represents recycling information from 325 Virginia cities, counties, and towns.[30]

[30] The Virginia Annual Recycling Rate Report 2006, DEQ.

Figure 8: Recycling Rate of Virginia 2003 - 2006

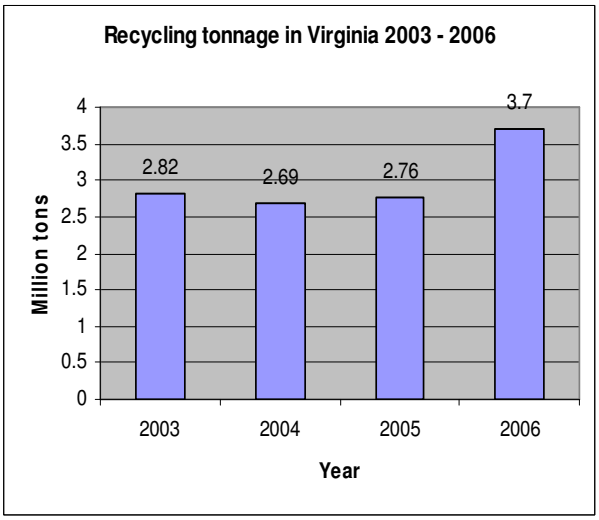
From 2003 to 2006, Virginia has made significant progress in recycling rate, from 30.3% in 2003 to 38.4% in 2006, an increase of 8.1 percentage points. A slight decrease in 2004 does not represent a true decline. An explanation from DEQ reveals that this decline is attributed to changes in definitions of recyclable materials.[31]



Source: DEQ

Figure 9: Recycling Tonnage in Virginia 2003 - 2006

Consistent with the changes in recycling rates, there is also a sizable increase in recycling tonnage in Virginia from 2.82 million tons in 2003 to 3.7 million tons in 2006, a percentage increase of 31.2% and a net increase of 880,000 tons, with a slight decline as in recycling rate in 2004.



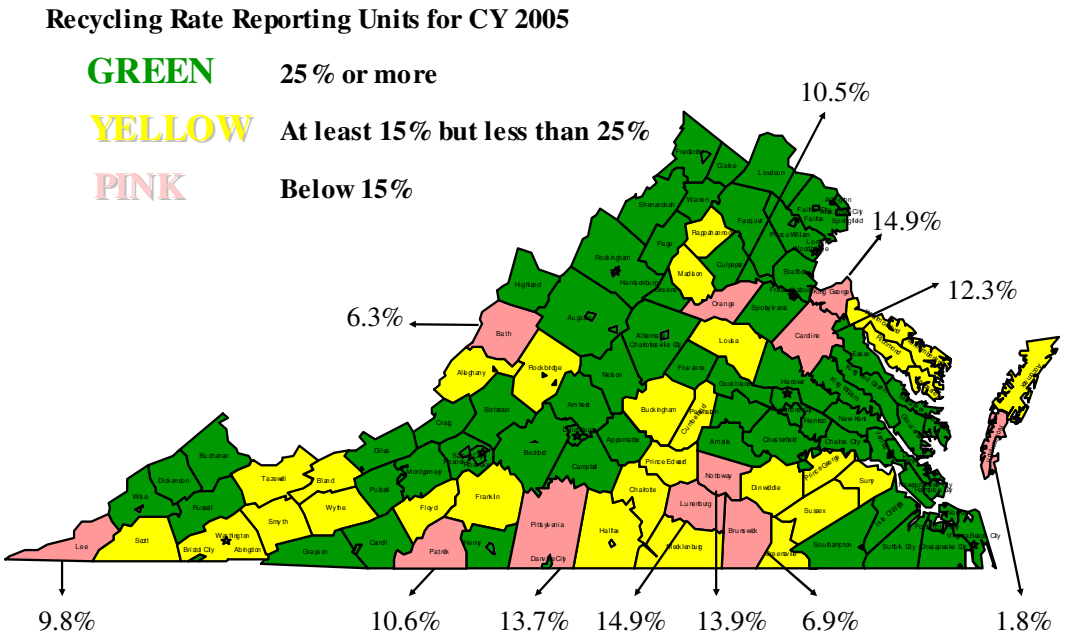
Source: DEQ

[31] It is mentioned in the 2004 report that the DEQ asked that storm debris and ash not be included in the calculations as they would skew the overall calculation of MSW recycling.

The following two maps depict the recycling rate distribution in Virginia in 2005 and 2006. In the maps, Virginia is divided into 74 SWPUs. In turn, these 74 SWPUs are categorized into three groups:

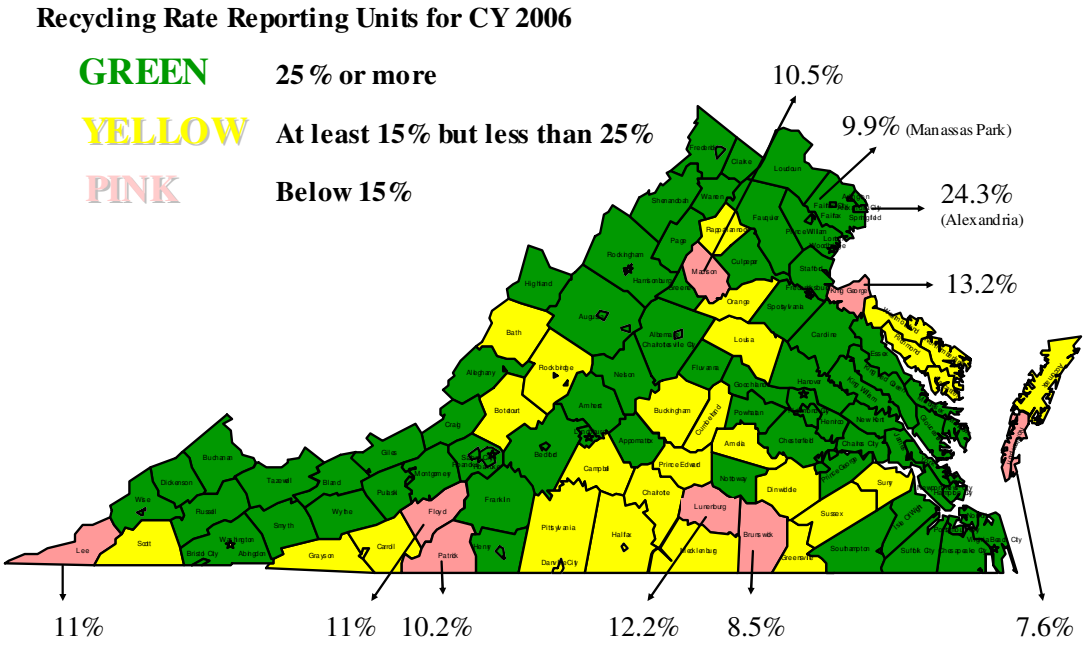
- Group 1 with recycling rates below 15%, which in the maps are shown in pink;
- Group 2 with recycling rates at least 15% but less than 25%, which in the maps are shown in yellow; and
- Group 3 with recycling rates at 25% or more, which in the maps are shown in green.

Figure 10 : Recycling Rate Distribution Map of Virginia 2005[32]



[32] Source: DEQ

Figure 11: Recycling Rate Distribution Map of Virginia 2006[33]



Comparing the two maps, it is notable that in the 2006 map, there are more green areas, a bit more yellow, and much less pink. In the 2005 map, there are 12 SWPUs in pink, meaning these 12 SWPUs have the reported recycling rates less than 15%. However, in the 2006 map, there are only nine SWPUs in pink. In total, between 2005 and 2006, seven SWPUs remained in pink, three turned from pink to yellow, two turned from pink to green, and two SWPUs changed from yellow to pink.

In examining the mandated recycling rates, of the 74 SWPUs, 31 belong to the 25% group and 43 belong to the 15% group. According to the 2005 recycling data, 61 out of 74 SWPUs have met or exceeded the mandated thresholds, of which 32 and 29 have met or exceeded the 15% and 25% thresholds respectively. For 2006 the mandated numbers remained

[33] Source: DEQ

the same. However, there is an increase in the number of SWPUs meeting the required rates, from 61 to 64, and this increase of 3 SWPUs in attributed totally to the 15% mandated group. Consequently, this increase of 3 SWPUs meeting the mandated rates from 2005 to 2006, equates with an increase of 4.05 percentage points from 82.43% in 2005 to 86.48% in 2006.

- **Urban vs. Rural SWPUs**

Distinction between urban and rural areas has always been an interest in general policy research, and so is it within the scope of this study. The following two tables present the comparison between urban and rural SWPUs, in terms of their recycling rate, recycling tonnage, local recycling budget, state funding, meeting mandated rates status, and responsiveness to the survey. The key difference between the two tables is that Table 12 uses the US Census Bureau definition of urban to differentiate urban and rural SWPUs while Table 13 uses the Virginia definition of urban.

The US Census Bureau definition of urban states that "urban areas equate to SWPUs with population density equal to or greater than 1,000 people per square mile with some exceptions given to SWPUs with some big cities." Whereas, §10.1-1411 of the *Code of Virginia specifies* that "urban areas equate to SWPUs with population density greater than or equal to 100 people per square mile."

Table 12: Urban vs. Rural SWPUs (by US Census Bureau definition of urban)

	Total	***Urban***	***Rural***
	74	23	51
Recycling rate	38.4%	42.3%	27.9%
Recycling tonnage	3.7	2.9	0.8
(million tons)		(78.9%)	(21.1%)
Average (tons)	49,982.44	126,912	15,288.7

Recycling budget	31.4	24.7	6.7
(million $)		(78.7%)	(21.3%)
Average ($)	424,729.5	1,074,808.9	131,556.5
State Funding	557	210	347
(thousand $)		(37.6%)	(62.4%)
Average ($)	7,528.3	9,112	6,814
Meeting mandate	64 (86.48%)	21 (91.3%)	43 (84.3%)
Response	57	15 (65.2%)	42 (82.4%)

Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

Table 13: Urban vs. Rural SWPUs (by Virginia definition of urban)

	Total	***Urban***	***Rural***
	74	37	37
Recycling rate	38.4%	40.33%	23.99%
Recycling tonnage	3.7	3.4	0.3
(million tons)		(91.5%)	(8.5%)
Average (tons)	49,982.44	91,438	8,527
Recycling budget	31.4	29.2	2.2
(million US$)		(93%)	(7%)
Average (US$)	424,729.5	790,447	59,012
State Funding	557	334	223
(thousand US$)		(59.9%)	(40.1%)
Average (US$)	7,528.3	9,016	6,041
Meeting mandate	64 (86.48%)	34 (91.9%)	30 (81.08%)
Response	57	28 (75.68%)	29 (78.38%)

Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

According to the US Census Bureau definition of urban, there are 23 urban and 51 rural SWPUs, while according to the Virginia definition of urban; there are 37 SWPUs of each group.

The similarity between the two tables is that urban SWPUs consistently report higher recycling rates, higher amounts of recycling tonnage, higher recycling budgets per SWPU, higher state funding per SWPU, and greater ability to meet mandated rates. This comparison is supported by the econometric estimates to be presented in the next part of this report.

It is important to note that the magnitude of the differences between the two groups is not the same in the two tables. Again, there is consistency as the differences indicated in Table 13 are always larger than those documented in Table 12. For illustration, the difference in recycling rates between urban and rural SWPUs in Table 12 is 14.4 percentage points while that reported in Table 13 is 16.34 percentage points[34]. Likewise, in Table 12, the tonnage recycled by urban SWPUs is 3.625 times higher than that recycled by rural SWPUs, while the number in Table 13 is much higher, 11.33 times[35]. These facts can most likely be attributed to the wider range of the Virginia definition of urban, which captures more SWPUs in the urban category, and thus widening the gap between urban SWPUs and rural SWPUs. Local recycling budget, state funding, and meeting mandated rates also show gaps between the two tables, and thus, between the two definitions. Urban SWPUs in Table 12 has average local recycling budgets of 8 times higher than rural SWPUs while the gap shown in Table 13 is more than 13 times[36]. Similarly, the difference in average state funding between urban and rural SWPUs in Table 13 is higher than that in Table 12 ($2,975 compared to $2,298)[37]. The same situation applies in calculation of the difference in meeting mandated rates between the two groups as the meeting mandated rate

[34] Calculated by taking the difference between recycling rates of urban and rural SWPUs.
[35] Calculated by dividing the total recycling tonnage of urban SWPUs by that of rural SWPUs.
[36] Calculated by dividing the average local recycling budget of urban SWPUs by that of rural SWPUs.
[37] Calculated by taking the difference between average state funding of urban and rural SWPUs.

among urban SWPUs in Table 13 is around 10 percentage points higher than the rate among rural SWPUs while the gap in Table 12 is only 7 percentage points[38].

❖ **Response vs. Non-response SWPUs**

It is instructivve to report summary statistics of response and non-response in a survey. The reason for this is to determine any biases in response rate, the results of which would probably direct implications for future surveys. Table 14 provides a comparison between response and non-response SWPUs in terms of their recycling rates, recycling tonnage, population size, area, average number of localities within an SWPU[39], average income, and educational attainment, state funding, and meeting threshold rates.

Table 14: Response vs. Non-response SWPUs

	Total	***Response***	***Non-response***
	74	57	17
Recycling rate	38.4%	35.81%	40.76%
Recycling tonnage	3.7	1.9	1.8
(million tons)		(50.3%)	(49.7%)
Average (tons)	49,982.44	32,625.67	108,178.7
Population	7.7	4.6	3.1
(million people)		(59.74%)	(40.26%)
Average (people)	103,884	80,633	181,843
Area (square miles)	39,601.92	27,674.08	11,927.84
		(69.9%)	(30.1%)
Average (square miles)	535.2	485.5	701.6
Average # of localities	4.4	3.77	6.53
Average Income ($)	30,930.13	30,066.84	33,951.66

[38] Calculated by subtracting the meeting threshold rate among urban SWPUs by that among rural SWPUs.
[39] As each SWPU may cover several counties, cities, and towns, this variable asks for the total number of localities/units that each SWPU covers.

Educational attainment	20.95%	20.11%	23.87%
State Funding	557	388.4	168.6
(thousands $)		(69.7%)	(30.3%)
Average ($)	7,528.3	6,814	9,923
Meet mandate	64 (86.5%)	47 (82.46%)	17 (100%)

Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

As of November 29th, 2007 the Project Team[40] received 57 responses and 17 non-responses, making the response rate 77% Interestingly, the response rate of urban SWPUs is lower than that of rural SWPUs. Compared to respondent SWPUs, non-respondent SWPUs report higher recycling rates (40.76% vs. 35.81%), higher average recycling tonnage (108,178.7 tons vs. 32,625.67 tons), bigger population size (almost 182 thousand people compared to only 81 thousand on average among response SWPUs), larger area (701.6 square miles vs. 485.5 square miles), higher average income (almost 34 thousand dollars compared to merely 30 thousand dollars), higher educational attainment (23.87% vs. 20.11%), and higher state funding per SWPU ($9,923 vs. $6,814). It is also interesting that 100% of the non-respondent SWPUs meet the required recycling rates, while the number for respondent SWPUs is only 82.46%.

Average number of localities within SWPUs, a newly generated variable, indicates that non-respondent SWPUs contain more localities than respondent SWPUs on average. For illustration, the average number of localities of the non-response group is 6.53, higher than that of the response group, which is only 3.77.

It seems like the missing SWPUs in the survey are not randomly distributed. This means that the response rate might have been affected by some specific determinants. In order to answer

[40] The Project Team refers to the three co-authors of this report.

this question, an econometric probit model[41] was used to determine the significance and magnitude of the impacts of measured determinants on SWPU response rate. The estimated model is significant at 10%. Significant differences have been found between the two groups with several determinants having an impact on the responsiveness of SWPUs to this survey. These determinants include the number of localities within an SWPU, population size, recycling tonnage, and average income. For example, having one more locality within an SWPU decreases the probability of that SWPU's responding to our survey by 4.4 percentage points[42]. These results support the previous conclusion concerning the relationship between SWPUs' response rate and the number of localities located within an SWPU bulkiness.

Multivariate Regression Results

As mentioned, the Project Team used multivariate regression models to estimate the relationship between recycling rate/tonnage and various determinants. Table 15 below illustrates descriptive statistics of all the variables, including recycling rate, recycling tonnage, and all determinants. Definitions of the variables can be found in the methodology part of this report.

Table 15: Descriptive Statistics

Variable	*# of obs.*	*Mean*	*Range*
Recycling rate 2006	74	27.703 (10.882)	7.6 - 55.1
Recycling tonnage 2006	74	49,982.45 (129,059.4)	624 – 908,103
Local recycling budget	54	582,036.7 (1,846,405)	0 - 1.15e+07
State funding	74	7,528.279 (9,136.947)	0 – 51262.5
Educational attainment	72	20.949	8.28 – 63.7

[41] In statistics, a probit model is a popular specification of a generalized linear model, using the probit link function, in which the dichotomous dependent variable is the probability of response.

[42] See Appendix – Table 2 for more estimates on the impacts of population size, recycling tonnage, and average income on the probability of an SWPU's responding to the survey.

		(13.259)	
Average income	72	30,930.13	20,085 – 61,147
		(9,616.573)	
Population density	74	926.67	6.04 – 9,023.32
		(1,791.356)	
Mandated recycling rate	74	.419	0 – 1
		(.497)	
State funding & Urban/rural (US Census Bureau definition of urban)	74	2,832.112	0 – 51,262.5
		(8,595.519)	
State funding & Urban/rural (Virginia definition of urban)	74	4,508.023	0 – 51,262.5
		(9,501.79)	
Recycling budget & Urban/rural (US Census Bureau definition of urban)	54	457,788.9	0 - 1.15e+07
		(1,858,128)	
Recycling budget & Urban/rural (Virginia definition of urban)	54	541,602.7	0 - 1.15e+07
		(1,856,525)	
Recycling budget & Average income	53	2.23e+10	0 - 4.32e+11
		(7.04e+10)	
Recycling budget & area	54	6.57e+08	0 - 2.81e+10
		(3.82e+09)	
Recycling budget & population size	54	3.03e+11	0 - 1.21e+13
		(1.68e+12)	
State funding & Average income	72	2.57e+08	0 - 3.09e+09
		(4.30e+08)	
State funding & area	74	6,905,660	0 - 7.91e+07
		(1.42e+07)	
State funding & population size	74	2.21e+09	0 - 5.18e+10
		(8.05e+09)	

Note: Standard deviations appear in parentheses below unweighted means.
Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

Except for recycling rate, educational attainment, average income, and mandated recycling rate, other variables are rather widespread.[43] For example, recycling tonnage 2006 reports a mean of 49,982.45 tons and a standard deviation[44] (or deviation from the mean) of

[43] With standard deviations significantly higher than unweighted means.
[44] In probability and statistics, the standard deviation of a random variable is a measure of the spread of its values. It is defined as the square root of the variance. Standard deviation, being the square root of that quantity, therefore measures the spread of data about the mean, measured in the same units as the data.

129,059.4 tons. A look at the range of the indicator (from 624 to 908,103 tons) supports the argument.

The average recycling rate documented in this table is different from the number reported in the summary statistics because this number is calculated by taking the average of the recycling rates of all 74 SWPUs while the previous one is calculated by dividing the total recycling tonnage by total waste for the entire State of Virginia. Likewise, local recycling budget also demonstrates different average number compared to the previously mentioned one because the previous average is calculated by dividing total recycling budget by 74 while with this average, the denominator is only the number of SWPUs having responded to the survey with budget information.

The following tables present interpretation of some key results of the regression models. All the models are significant at 5% with 53 observations. Table 16 reports results from the models of recycling performance on the basic set of independent variables[45]. Table 17 demonstrates results from the models run on the full set including the interaction variables[46] to test for potential targeting of funding. The results highlighted in the tables are of only those determinants that have impacts at 10% statistical significance at least on recycling performance. Some of these determinants are significant in the US Census Bureau definition of urban models, some are significant in the Virginia definition of urban models, and some are significant in both *(see number of asterisks)*.

[45] The basic set of independent variables includes: population density, urban/rural dummy variable, educational attainment, average income, mandated recycling rate, state funding, and local recycling budget.
[46] The full set of independent variables includes the basic set and eight interaction variables, which are state funding and urban/rural, three variables of state funding and population size, area, and average income respectively, recycling budget and urban/rural, and three variables of recycling budget and population size, area, and average income respectively.

Table 16: Determinants of Recycling Performance – Interpretation of Key Results[47]

(Basic set of independent variables)

	Recycling rate
Population density*	An SWPU with population density of 1,000 more people per square mile is likely to have recycling rate of 2.8 less percentage point.
Urban/rural*	Being an urban SWPU is likely to have 10.53 more percentage point in recycling rate.
Mandated recycling rate**	Being in the 25% mandated group makes it likely for an SWPU to have 8.48 more percentage point in recycling rate.
State funding*	An additional $10,000 allocated to an SWPU as state funding is likely to make a 3 percentage point increase in recycling rate.
	Recycling tonnage
State funding***	An additional $10,000 allocated to an SWPU as state funding is likely to make an increase of 20,289 (US Census Bureau definition of urban) or 19,450 tons (Virginia definition of urban) recycled.
Local recycling budget***	An additional $10,000 spent on recycling budget is likely to make an increase of 270 (US Census Bureau definition of urban) or 277 tons (Virginia definition of urban) recycled.

Note: * statistically significant when using US Census Bureau definition of urban, ** Virginia definition of urban, and *** both.

Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

As can be seen from Table 16, population density indicates a negative relationship with recycling performance, which means SWPUs with higher population density are likely to have

[47] See Appendix – Table 3 for more details (more variables and more coefficients).

lower recycling rate. This result is supported throughout the models in this report, except for the one of recycling tonnage on the full set of variables. This is a strange result and counter to our hypothesis that recycling performance is subject to economies of scale.

Consistently these models report, urban/rural dummy variable and mandated recycling rate are positively related to recycling performance. This means that being an urban SWPU and/or being in the 25% mandated group equates with increasing an SWPU's recycling rate/tonnage. These results are similar to those reported in the summary statistics and are useful for policy recommendations stated later in this report.

State funding and local recycling budget, especially state funding, prove to have statistically and also economically significant impacts on recycling performance. This means investment in recycling, especially by the state government, would bring sizable benefits.

Table 17: Determinants of Recycling Performance – Interpretation of Key Results[48]

(Full set including interaction variables)

	Recycling rate
Population density*	An SWPU with population density of 1,000 more people per square mile is likely to have recycling rate of 4.15 less percentage point.
Mandated recycling rate***	Being in the 25% mandated group makes it likely for an SWPU to have 9.75 (US Census Bureau definition of urban) 8.84 (Virginia definition of urban) more percentage point in recycling rate.
Recycling budget & urban/rural*	An additional $10,000 spent by an urban SWPU on recycling yields 0.347 more percentage point in recycling rate than if spent by a rural SWPU.
State funding & area*	An additional $10,000 allocated to an SWPU with

[48] See Appendix – Table 4 for more details (more variables and more coefficients).

	one square mile larger of area is likely to make a 0.00786 percentage point decrease in recycling rate.
	Recycling tonnage
Population density***	An SWPU with population density of 1,000 more people per square mile is likely to recycle 8,938 tons less (US Census Bureau definition of urban) and 5,308 tons more (Virginia definition of urban).
Educational attainment***	An additional percentage point in an SWPU's average number of people 25 years old or more with bachelor's degree or higher is likely to recycle 849.67 tons less (US Census Bureau definition of urban) or 1,061.7 tons less (Virginia definition of urban).
Average income***	An additional $1,000 in an SWPU's average income makes it likely for the SWPU to recycle 2,593 tons more (US Census Bureau definition of urban) or 1,341 tons more (Virginia definition of urban).
State funding*	An additional $10,000 allocated to an SWPU as state funding is likely to lead to an additional 73,337 recycled tons increase.
Local recycling budget**	An additional $10,000 spent by an SWPU recycling is likely to lead to an additional 1,139 recycled tons increase.
State funding & urban/rural*	An additional $10,000 allocated to an urban SWPU as state funding is likely to create an additional 53,225 tons more recycled than allocate the same amount to a rural SWPU.
Recycling budget & urban/rural*	An additional $10,000 spent on recycling budget by an urban SWPU increases the recycled tonnage by 519 tons more than if the same amount is spent by a rural SWPU.
Recycling budget &	An additional $10,000 spent on recycling budget by

income**	an SWPU with one additional dollar in average income would decrease the recycling tonnage by 0.016.
Recycling budget & area**	An additional $10,000 spent by an SWPU with one square mile larger of area on recycling is likely to make a decrease of 0.491 tons recycled.
Recycling budget & population*	An additional $10,000 spent on recycling budget by an SWPU with one more people per square mile is likely to make a decrease of 0.002 tons recycled.
State funding & income*	An additional $10,000 allocated as state funding to an SWPU with one additional dollar in average income would decrease the recycling tonnage by 3.179.
State funding & area***	An additional $10,000 allocated as state funding to an SWPU with one square mile larger of area on recycling is likely to make a decrease of 18.786 (US Census Bureau definition of urban) and 17.647 (Virginia definition of urban) tons recycled.
State funding & population***	An additional $10,000 allocated as state funding to an SWPU with one more people per square mile is likely to make an increase of 0.443 (US Census Bureau definition of urban) and 0.39 (Virginia definition of urban) tons recycled.

Note: * statistically significant when using US Census Bureau definition of urban, ** Virginia definition of urban, and *** both.

Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

Similar to the results in Table 16, mandated recycling rate, state funding, and local recycling budget continue to demonstrate positive relationships with recycling performance. Average income is also positively related to recycling tonnage. This means that SWPUs with higher average income are likely to recycle more, which is reasonable as people with higher

income are in a better financial position to afford recycling storage space and transportation cost. Educational attainment, on the other hand, shows a counterintuitive negative relationship with recycling performance. This means that SWPUs containing citizens with higher levels of educational attainment are on average less likely to recycle. This result remains unexplainable.

Just like basic variables, interaction variables in Table 17 indicate some expected and some unexpected results. First, interaction variables with an urban/rural dummy variable consistently show strong positive impacts on recycling performance This not only reiterates that urban SWPUs are likely to recycle more than rural ones, but also unveils an interesting implication that funding or investing in recycling programs in urban SWPUs is more effective than in rural ones.

Interaction variables with area, on the other hand, show a negative relationship. This means that state funding allocated to or recycling budget spent on recycling in SWPUs of larger area is less efficient than dollars spent in SWPUs of smaller area. This result can be explained by transportation cost which makes it more difficult to collect recyclable materials from households located in a widespread area.

Third, interaction variables with population size document different results in different models and is for this reason unexplainable. It can be stated that state funding allocated to higher populated SWPUs is more efficient than state dollars allocated to lower populated ones. However, the local budget spent by higher populated SWPUs turns out to be less efficient. This raises a question of how local recycling budget is defined and spent by SWPUs. The Project Team experienced difficulty when trying to get this local recycling budget information from SWPUs. Some of them responded with huge budget numbers which include administrative fees and budget for recycling programs; some provided with modest numbers including only

administrative fees (salary) for half or one full-time recycling official; and some even reported no budget as they have no assigned employee to work on recycling program and all recycling activities are contracted out to private firms.

Combining the results of interaction variables with population size, area, and population density, one can see that the sign of the population density interaction variables is sometimes positive and sometimes negative.[49] Specifically there is a positive relationship of population size interaction variables with recycling performance and negative relationship of area interaction variables with recycling performance, which equate to an ambiguous relationship between population density interaction variables and recycling performance. The final result illustrates an overall negative relationship with recycling performance. It can be argued that the area effects (i.e., the transportation costs effects) have outperformed the population size effects (i.e., the economies of scale effects).

Finally, another challenging interpretation is related to the interaction variables with average income. These variables illustrate a negative relationship with recycling performance. This means that the allocation of funding to or spending money in higher income SWPUs is less efficient in improving recycling performance than allocating to or spending in lower income SWPUs. Though the magnitude of the relationship is not large, the relationship is worth considering. One explanation for the negative sign is probably the diminishing returns to investment. It was obvious in the basic models[50] that higher income SWPUs are likely to recycle more than lower income ones, possibly due to affordability. Thus, the story that these interaction variables tell is that the returning benefit of an additional dollar allocated to or spent in richer and already recycling dedicated SWPUs is smaller than if the dollar is allocated to or spent in poorer

[49] Remember that population density is calculated by dividing population size by area.
[50] Refer back to table 16.

SWPUs, which are still at lower levels of recycling. This raises another policy implication of needs versus effectiveness in the targeting of funding. In this case, it seems like both requirements, needs and effectiveness, are met in lower income SWPUs.

Policy Recommendations

Public sector recommendations

The previous section presents results from the regression models and some interpretations of the results. In this part of the report, some policy recommendations are provided based on the interpretation of the statistical results discussed in detail above.

First, state funding has consistent positive impacts on SWPU recycling effort. Moreover, funding urban and highly-populated SWPUs has proven to be more effective than funding of rural and geographically large SWPUs. Thus, it is recommended that the State focus on additional funding for recycling in urban and highly-populated SWPUs.

Second, besides urban/rural status and population size, it is also important to include average income in the priority list of funding criteria as indicated in the previous section of this report. The regression results show that lower income SWPUs are those mostly in need for funding and potentially more efficient in recycling performance improvement.

Third, the local recycling budget sometimes significantly affects recycling performance and sometimes does not. Like state funding, recycling budget spent by urban SWPUs is more effective than spent by rural SWPUs. However, budget spent by SWPUs with bigger population, larger area, and higher average income turns out to be less effective. As explained in the previous

section, large SWPUs might have suffered from diseconomies of scale[51] or local budgets might not have been efficiently allocated. We suggest more training and instructions on recycling be provided to the localities; and/or if feasible, SWPUs should be rearranged in the future towards more SWPUs covering less area.

Fourth, it was obvious that SWPUs assigned to the 25% mandated recycling rate are more likely to have better recycling performance. Within the limitations of the study, the Project Team has not been able to answer the question as to whether this is because these SWPUs have more pressure to meet the threshold, or the results just report reality that SWPUs that belong to the 25% mandated group are inherently more efficient in recycling effort. The policy recommendation to raise current mandated rates, thus, remains unverified.

Last but not least, there are some small recommendations for future survey/research activities in the field. As the number of localities within an SWPU has a significant impact on whether or not that SWPU responded to our survey, we would recommend using smaller units of analysis, for example smaller SWPUs (if these SWPUs can be rearranged) or counties, cities, and towns instead of SWPUs, in future surveys. Also, it seems that the US Census Bureau definition of urban of urban areas works better in regression models as a predictor of recycling performance. We recommend using this definition for impacts/relationship approach of the topic.

Private sector recommendations – future research

The Project Team developed a survey instrument to send to the 699 firms identified by the VEC to be operating within the Virginia recycling industry. Unfortunately, funding shortfalls prohibited the distribution of the survey. Please see the Appendix for a copy of the

[51] Diseconomies of scale characterizes a production process in which an increase in the scale of the firm causes an increase in the long-run average cost of each unit.

survey instrument. The collection of the data requested in this survey would resolve many of the inaccuracies within the analysis of the private sector. First and foremost, the two simplifying assumptions would no longer be needed. The survey seeks to identify the true percentage of recycling activities occurring within each industry sector in Virginia. Therefore, the over-application of the paper use rate from ISRI would no longer be needed. Rather, a value for the actual use rate of construction and demolition recycled materials would be available. The same would be true within the solid waste and specialized trucking industry sectors. The industry survey would also allow a much more accurate estimate of employment to be made for 2007. Specifically, the 10% rate of missing data within the VEC firm size data set would be resolved.

Beyond this, the next step is to collect recent and accurate revenue estimates from these industry sectors. These data can then be used to determine whether or not revenues are actually tracking employment trends. In this vein, it would be interesting to analyze the tax rates imposed on these industries, especially because this is what matters most to the State government. Any increase in state funding for recycling programs should equate with an increase in general revenues available to the government. Sadly, tax revenue data was not available to the Project Team. Therefore, this final component of this analysis must be left to future researchers.

APPENDIX

Table 1: Gross Revenues for the Recycling Industry in VA

	Industry Sector	*2002(*)*	*2006(**)*	*2007(**)*
Core	Recyclable material merchant wholesalers	322,614,000	316,457,496.40	314,936,816
	Materials recovery facilities	21,923,000	23,723,977.50	24,196,880.70
	Total	**344,537,000**	**340,181,473.90**	**339,133,696.72**
Manufacturing	Pulp, paper, & paperboard mills	1242272500	1,139,141,841	1,114,725,759
	Industrial building construction	75610500	60,944,654.36	57,746,277.75
	Total	**1,317,883,000**	**1,200,086,495**	**1,172,472,037**
Transportation	Other specialized trucking, long-distance	88871040	123,893,797.70	134,623,814.32
	Solid waste collection	207236352	252,794,785.90	265,670,697.10
	Total	**296,107,392**	**376,688,583.60**	**400,294,511.42**

Source: * 2002 U.S. Economic Survey
**Authors' calculations based on VEC data and 2002 U.S. Economic Census

Table 2: Probability of Survey Response

Variable	*Marginal effects*	*Standard errors*
Number of localities within SWPUs	-.04422	.02115**
Population size	2.02e-06	.00000*
Area	-.00006	.0002
Recycling rate 2006	-.00429	.00713
Recycling tonnage 2006	-4.98e-06	.00000*

State funding	.00001	.00001
Urban/rural	.13501	.16689
Average income	-.00001	.00001*

Note: * denotes statistically significant at 10% and ** denotes statistically significant at 5%.
Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

Table 3: Determinants of recycling performance

(Basic set of independent variables)

Variable	***US Census Bureau definition of urban***	***Virginia definition of urban***
Recycling rate		
Population density	-.0028	-.0008
	(.0016)*	(.0011)
Urban/rural	10.5294	1.2210
	(6.2228)*	(4.4234)
Educational attainment	.0770	.0464
	(.1862)	(.1911)
Average income	.0004	.0002
	(.0003)	(.0003)
Mandated recycling rate	6.2074	8.4824
	(3.8431)	(5.0089)*
State funding	.0003	.0003
	(.0002)*	(.0002)
Local recycling budget	-3.05e-07	6.61e-07
	(9.44e-07)	(7.86e-07)
Constant	6.9966	12.5123
	(7.1994)	(6.8431)*
Recycling tonnage		
Population density	3.3317	4.7301
	(4.6991)	(3.2997)
Urban/rural	5,230.289	11,754.22
	(18,659.56)	(12,763.41)
Educational attainment	-534.6594	-523.6864
	(558.3013)	(551.2692)
Average income	.1066	-.1757
	(.8761)	(.8471)
Mandated recycling rate	17,154.83	9,055.934
	(11,523.66)	(14,452.71)
State funding	2.0289	1.9450
	(.5947)***	(.5769)***
Local recycling budget	.0270	.0277

	(.0028)***	(.0023)***
Constant	-1,401.228	4,591.12
	(21,587.75)	(19,745.42)

Note: Standard errors in parentheses below marginal effects;
* denotes statistically significant at 10% and *** denotes statistically significant at 1%.
Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

Table 4: Determinants of recycling performance

(Full set including interaction variables)

Variable	***US Census Bureau definition of urban***	***Virginia definition of urban***
Recycling rate		
Population density	-.0041464	-.0002789
	(.0021057)*	(.0016074)
Educational attainment	.2153446	.071701
	(.2091902)	(.218673)
Average income	.000656	.0004768
	(.000396)	(.0003931)
Mandated recycling rate	9.752099	8.836536
	(4.12208)**	(4.668294)*
State funding	.0016349	-.0001036
	(.0013408)	(.0013264)
Local recycling budget	-.0000137	.0000318
	(.0000158)	(.000023)
State funding & urban/rural	.0000244	.0001129
	(.001063)	(.0005744)
Recycling budget & urban/rural	.0000347	-.0000213
	(.000015)**	(.0000213)
Recycling budget & income	-8.94e-11	-5.49e-10
	(4.91e-10)	(5.00e-10)
Recycling budget & area	2.17e-08	-1.26e-08
	(1.44e-08)	(1.01e-08)
Recycling budget & population	-6.88e-11	4.20e-11
	(4.61e-11)	(3.17e-11)
State funding & income	-2.26e-08	3.48e-08
	(5.15e-08)	(5.04e-08)
State funding & area	-7.86e-07	-2.05e-07
	(4.58e-07)*	(3.09e-07)
State funding & population	1.93e-09	-1.52e-09
	(3.54e-09)	(3.47e-09)
Constant	-2.036246	3.527044
	(10.37675)	(10.46312)
Recycling tonnage		
Population density	-8.938725	5.308219

	(2.783609)***	(2.988783)*
Educational attainment	-849.6707	-1061.695
	(276.5342)***	(406.6025)**
Average income	2.592974	1.341088
	(.5234744)***	(.7308851)*
Mandated recycling rate	2156.156	-4082.336
	(5449.089)	(8680.265)
State funding	7.533669	1.858854
	(1.772499)***	(2.46636)
Local recycling budget	.0330325	.1139261
	(.0208308)	(.0428282)**
State funding & urban/rural	5.322542	.467138
	(1.405238)***	(1.068057)
Recycling budget & urban/rural	.0518992	-.0227227
	(.0198709)**	(.0395474)
Recycling budget & income	1.19e-07	-1.60e-06
	(6.49e-07)	(9.29e-07)*
Recycling budget & area	.0000172	-.0000491
	(.0000191)	(.0000189)**
Recycling budget & population	-2.08e-07	2.08e-08
	(6.10e-08)***	(5.90e-08)
State funding & income	-.0003179	-.0000823
	(.0000681)***	(.0000937)
State funding & area	-.0018786	-.0017647
	(.0006058)***	(.0005753)***
State funding & population	.0000443	.000039
	(4.68e-06)***	(6.46e-06)***
Constant	-49024.97	-15558.24
	(13717.31)***	(19455.21)

Note: Standard errors in parentheses below marginal effects;
* denotes statistically significant at 10%, ** at 5%, and *** at 1%.

Source: Based on authors' calculations from the compiled dataset (SWPUs survey, US Census 2000, Bureau of Economic Analysis, and VA DEQ).

Figure 1: Employment in VA Materials Recovery Facilities Industry Sector 2002 through 2006

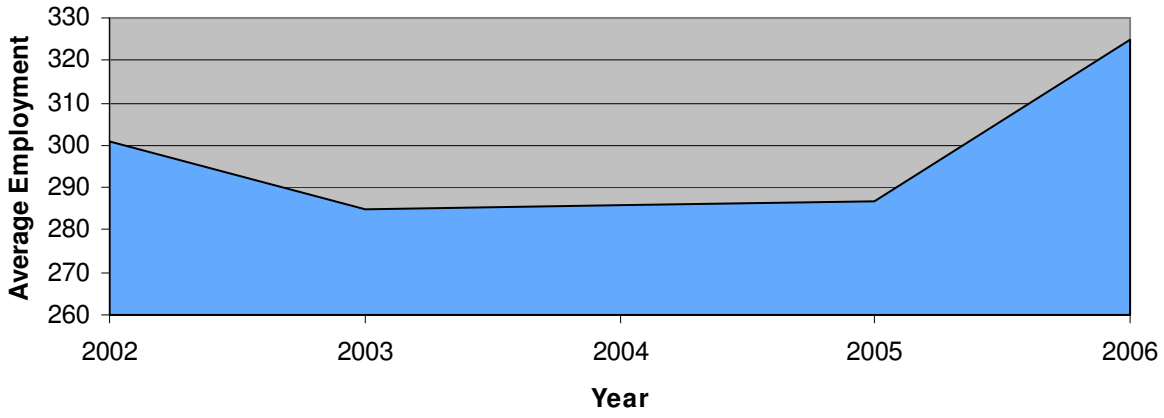


Figure 2: Employment in VA Recyclable Material Merchant Wholesalers Industry Sector 2002 to 2006

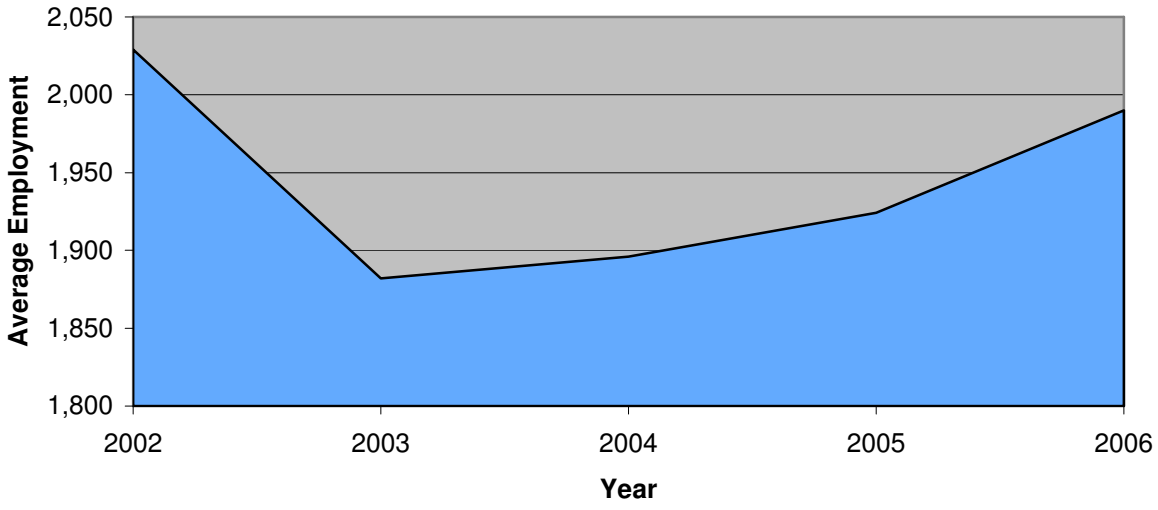


Figure 3: Employment in the VA Paper Manufacturing Industry 2002 to 2006

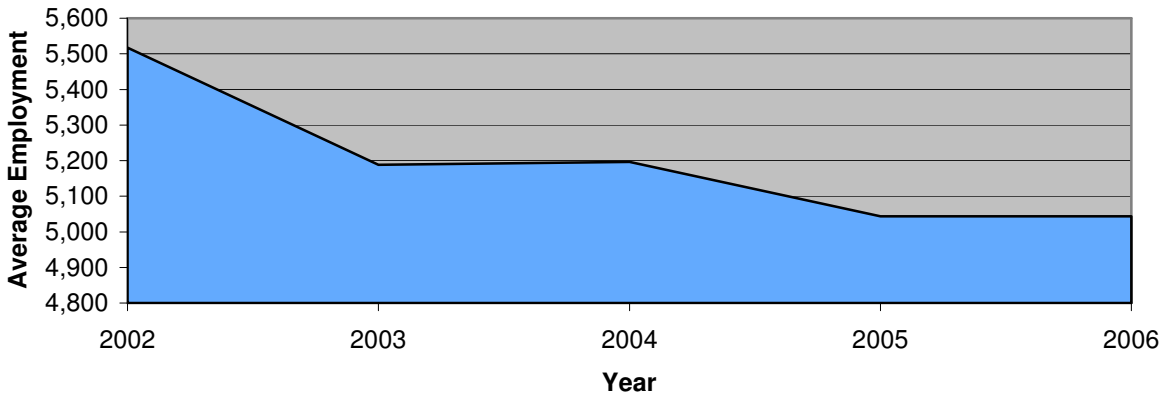


Figure 4: Employment in VA Industrial Building Construction 2002 to 2007

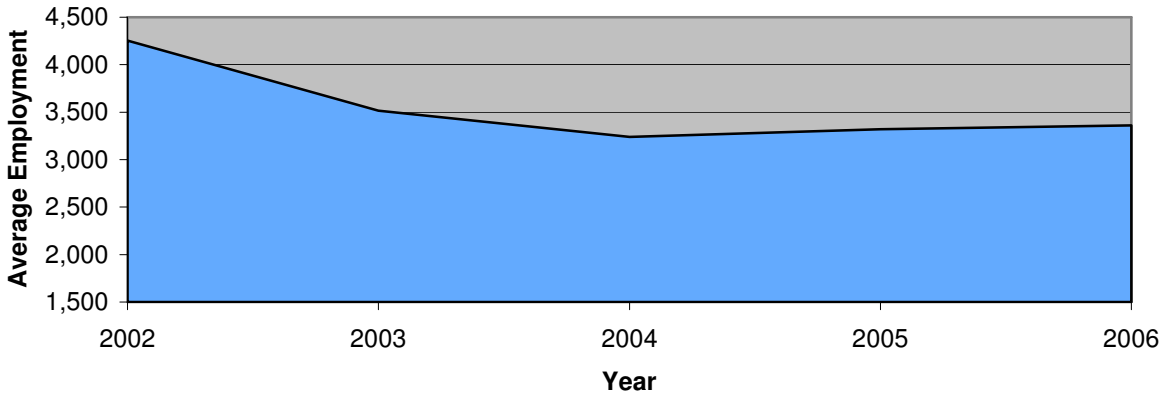


Figure 5: Employment in the VA Solid Waste Collection Industry 2002 to 2007

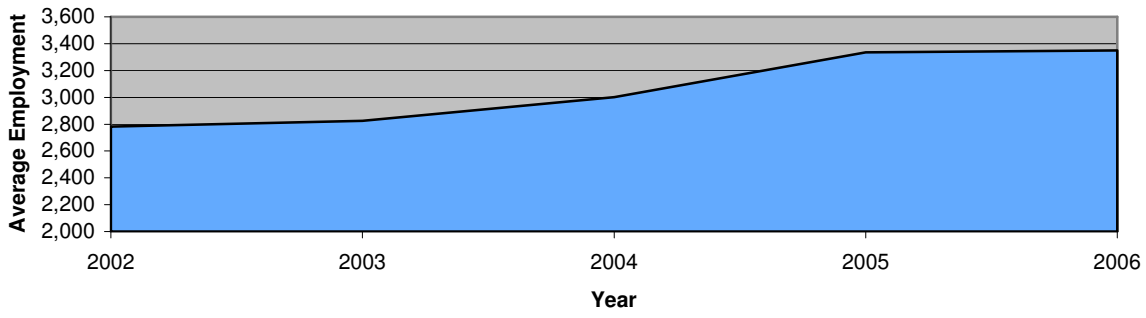
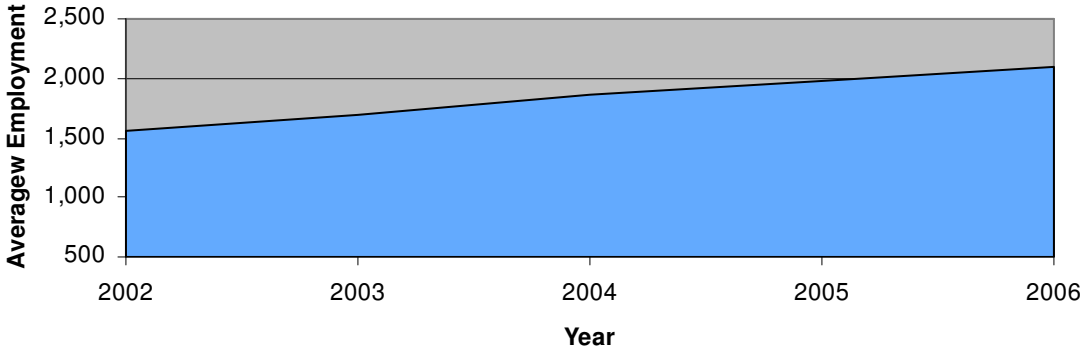


Figure 6: Employment in the VA Specialized Freight (except Used Goods) Trucking, Long-Distance Industry Sector 2002 to 2007



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