FACULTY OF ENGINEERING OF THE UNIVERSITY OF PORTO

Efficiency and Financial Sustainability of Water Supply and Sanitation Services in Brazilian Municipalities

Marco Tourinho

A thesis submitted to the Faculdade de Engenharia da Universidade do Porto for the doctoral degree in Civil Engineering

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"Water is the driving force of all nature."
—Leonardo da Vinci, engineer and inventor

"Sanitation is more important than political independence"
—Mahatma Gandhi, lawyer, politician and social activist

Declaration

- Chapter 5 is based on the paper "Performance assessment of water services in Brazilian municipalities: an integrated view of efficiency and access", *Socio-Economic Planning Sciences* (2021), 101139. The paper is co-authored with Paulo Rosa-Santos, Francisco Taveira-Pinto and Ana S. Camanho.

- Chapter 6 is undergoing final formatting for submission to the Socio-Economic Planning Sciences. The paper's title will be "Productivity change in Brazilian water services: a benchmarking study of national and regional trends". It will be co-authored with Paulo Rosa-Santos, Francisco Taveira-Pinto, Ana S. Camanho, and Flávia Barbosa.

- Chapter 7 is based on the conference paper "A Non-Convex Global Malmquist index to Compare the Performance of Water Services among Brazilian Macro-Regions" paper accepted for publication in: *Lecture Notes in Networks and Systems, Springer (ICIT' 22 - The 2022 International Conference on Information Technology & Systems)*, co-authored with Paulo Rosa-Santos, Francisco Taveira-Pinto, Ana S. Camanho and Flávia Barbosa.

Abstract

This Thesis focuses on developing innovative models based on optimization techniques for benchmarking in Brazil's water supply and sanitation sector using *Data Envelopment Analysis* (DEA). The performance measures are constructed using quantifiable criteria and reflect economic, environmental, and social aspects of water and sanitation services. To ensure that the results meet the needs of service providers, governmental and regulatory entities, the studies that make up this Thesis include applications of the developed methodologies to actual data from companies providing water supply and sanitation services.

Furthermore, this Thesis aims to broaden the discussion on estimating, analyzing, and controlling performance and productivity in the water industry, focusing on maximizing economic, environmental, and social benefits in the water sector without neglecting companies' financial sustainability. Finally, although the proposed methodology is illustrated in the context of water supply and sanitation services, it can be generalized to other sectors.

The first topic concerns the exploratory analysis of revenues and expenses of water supply and sanitation services in the state of Mato Grosso, Brazil. The main objective of this topic is to present and explore concepts that are widely used in the following chapters, namely operating expenses (OPEX) and total expenses (TOTEX) incurred in the provision of services. The OPEX is detailed, and the most relevant components are identified. In addition, the relationship between the level of spending and the population size of municipalities is assessed. Finally, the expenditure levels of the different service providers are characterized.

The second topic concerns exploring the performance of water supply and sanitation services under the dimensions of efficiency and access. The subject is addressed by proposing an integrated analysis framework that identifies the best national practices and assists the identification of appropriate measures of government action. The application of weight restrictions to ensure an adequate representation of the importance of the different service components is also an innovative feature of the DEA model used.

The third topic concerns the development of an innovative framework to evaluate the evolution of the productivity of water supply and sanitation services in large Brazilian municipalities between 2012 and 2019. It is evident the need to monitor the evolution of the productivity of public services, specially in the case of water services, considered a fundamental right and a necessary condition for good quality of life. The topic is presented from two perspectives, national and regional, which allows us to assess whether the evolution of service performance is balanced across the country. From a methodological point of view, a Global-Malmquist Productivity Index is used in the analysis.

The fourth topic concerns the use of an innovative framework, consisting of a Benefit-of-the-Doubt formulation and a Pseudo-Malmquist Index model to perform benchmarking among the most populous Brazilian macro-regions (*i.e.*, Northeast, Southeast, and South) in the provision of water and sanitation services.

Overall, this Thesis presents advanced optimization models for quantifying the efficiency and productivity change of water supply services. It overcomes the limitations of alternative approaches typically based on subjective judgments of company performance. The methodologies proposed in this Thesis contribute to the literature on performance evaluation, especially in utility governance and regulation.

The results showed that the performance of water supply and sanitation services in Brazilian municipalities has remained stable over the past years. The relatively low levels in efficiency indices evidenced the high heterogeneity in the performance of services, even when considering municipalities within a given region. The regional difference was remarkable. On the one hand, the Southeast region stood out in all the analyses performed, explained by the region's high economic development. On the other hand, the Northeast region had the lowest performance in the analyses performed.

The research suggests that public policies that aim to control overall spending and invest equally across the country can promote services with a most balanced performance. Finally, the results also evidenced that the government must adopt public policies that stimulate the reduction of regional inequalities. Furthermore, service providers should increase efforts to make services more efficient to improve the Brazilian population's welfare and help the country reach international targets.

***keywords*:** Data Envelopment Analysis, water sector, composite indicators, Malmquist index, efficiency analysis, productivity change.

Resumo

Esta Tese centra-se no desenvolvimento de modelos inovadores baseados em técnicas de otimização para o *benchmarking* no sector do abastecimento de água e saneamento no Brasil, utilizando *Data Envelopment Analysis* (DEA). As medidas de desempenho são construídas utilizando critérios quantificáveis e refletem aspetos económicos, ambientais, e sociais dos serviços de água e saneamento. Para assegurar que os resultados satisfazem as necessidades dos fornecedores de serviços, entidades governamentais e reguladoras, os estudos que compõem esta Tese incluem aplicações das metodologias desenvolvidas aos dados reais das empresas fornecedoras de serviços de abastecimento de água e de saneamento.

Além disso, esta Tese visa alargar a discussão sobre a estimativa, análise e controlo do desempenho e produtividade na indústria da água, centrando-se na maximização dos benefícios económicos, ambientais e sociais no setor da água, sem negligenciar a sustentabilidade financeira das empresas. Finalmente, embora a metodologia proposta seja focada no contexto dos serviços de abastecimento de água e de saneamento, pode ser generalizada a outros sectores.

O primeiro tópico diz respeito à análise exploratória das receitas e despesas dos serviços de abastecimento de água e saneamento no estado de Mato Grosso, Brasil. O principal objetivo deste tópico é apresentar e explorar conceitos que são amplamente utilizados nos capítulos seguintes, nomeadamente despesas de exploração (OPEX) e despesas totais (TOTEX) incorridas na prestação de serviços. O OPEX é detalhado, e os componentes mais relevantes são identificados. Além disso, é avaliada a relação entre o nível de despesas e a dimensão da população dos municípios. Finalmente, são caracterizados os níveis de despesa dos diferentes prestadores de serviços.

O segundo tópico diz respeito à exploração do desempenho dos serviços de abastecimento de água e saneamento sob as dimensões de eficiência e acesso. O tema é abordado propondo uma estrutura de análise integrada que identifica as melhores práticas nacionais e ajuda na tomada de decisões para a adoção de medidas mais adequadas de ação governamental. A aplicação de restrições de peso para assegurar uma representação adequada da importância das diferentes componentes dos serviços é também uma característica inovadora no modelo utilizado.

O terceiro tópico diz respeito ao desenvolvimento de um procedimento inovador para avaliar a evolução da produtividade dos serviços de abastecimento de água e saneamento em grandes municípios brasileiros entre 2012 e 2019. É evidente a necessidade de acompanhar a evolução da produtividade dos serviços públicos, especialmente no caso dos serviços de abastecimento de água e de saneamento, considerados um direito fundamental e uma condição necessária para uma boa qualidade de vida. O tema é apresentado sob duas perspetivas, a nacional e a regional, o que permite avaliar se a evolução do desempenho dos serviços é equilibrada em todo o país. Do ponto de vista metodológico, o Índice de Produtividade Global-Malmquist é utilizado na análise.

O quarto tópico diz respeito à utilização de uma abordagem inovadora, que consiste numa formulação de "Benefit-of-the-Doubt" e no modelo do Índice Pseudo-Malmquist para realizar benchmarking entre as macrorregiões brasileiras mais populosas (*i.e.*, Nordeste, Sudeste e Sul) na prestação dos serviços de abastecimento de água e de saneamento.

Esta Tese apresenta modelos avançados de otimização para quantificar a eficiência e a mudança de produtividade dos serviços de abastecimento de água. Esta abordagem supera as limitações das alternativas tipicamente baseadas em avaliações subjetivas do desempenho das empresas. As metodologias propostas nesta Tese contribuem para a literatura sobre avaliação do desempenho, especialmente na governança e regulação dos serviços de abastecimento de água e de saneamento.

Os resultados mostraram que o desempenho dos serviços de abastecimento de água e saneamento nos municípios brasileiros permaneceu estável ao longo dos últimos anos. Os níveis relativamente baixos dos índices de eficiência evidenciaram a elevada heterogeneidade no desempenho dos serviços, mesmo quando se consideram os municípios dentro de uma determinada região. A diferença regional foi notável. Por um lado, a região Sudeste destacou-se em todas as análises realizadas, explicada pelo elevado desenvolvimento económico da região. Por outro lado, a região Nordeste teve o desempenho mais baixo nas análises realizadas.

A investigação sugere que as políticas públicas que visam controlar a despesa global e investir igualmente em todo o país podem promover serviços com um desempenho mais equilibrado. Finalmente, os resultados também evidenciaram que o governo deve adoptar políticas públicas que estimulem a redução das desigualdades regionais. Além disso, os prestadores de serviços devem aumentar os esforços para tornar os serviços mais eficientes a fim de melhorar o bem-estar da população brasileira e ajudar o país a atingir as metas internacionais.

***Palavras-chave*:** *Data Envelopment Analysis*, setor da água, indicadores compósitos, índice de Malmquist, análise de eficência, mudança da produtividade.

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Acronyms

3Ts	Tariffs, Taxes and Transfers
ADERASA	Asociación de Entes Reguladores de Agua Potable y Saneamiento de las Américas
AWWA	The American Water Works Association
CESB	Companhia Estadual de Saneamento Básico (State Sanitation Company, in English)
CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DMU	Decision-Making Unit
DOR	Direct Operating Revenue
DPA	Direct Public Administration
EC	Efficiency Change
ERSAR	Entidade Reguladora dos Serviços de Águas e Resíduos (Portuguese Water and Waste Services Regulatory Entity)
FCR	Full-Cost Recovery
GMI	Global-Mamquist Productivity Index
IBNET	The International Benchmarking Network for Water and Sanitation Utilities
IBT	Increasing-Blocks Tariff
IPA	Indirect Public Administration
IPTU	Imposto Predial e Territorial Urbano
IPVA	Imposto sobre a Propriedade de Veículos Automotores
IWA	International Water Association
KPI	Key Performance Indicator
MI	Malmquist Productivity Index
NDRS	Non-Decreasing Return to Scale
NIRS	Non-Increasing Return to Scale
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
OFWAT	The Water Services Regulation Authority (England Regulation Entity)
OPEX	Operational Expenses
PASEP	Programa de Formação do Património do Servidor Público
PGMI	Pseudo Global-Malmquist Productivity Index
PI	Performance Indicator
PIS	Programa de Integração Social
PPP	Public-Private Partnership
PPS	Production Possibility Set
SCR	Sustainable Cost Recovery
SDG	Sustainable Development Goals
SDG6	Sustainable Development Goal number 6
SFA	Stochastic Frontier Analysis
SNIS	Sistema Nacional de Informações sobre o Saneamento (Brazilian National Sanitation Information System)
TC	Technology Change
TOTEX	Total Expenses
UN	United Nations
VRS	Variable Return to Scale
WSAA	The Water Services Association of Australia
WSS	Water Supply and Sanitation Services
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

List of Symbols

Φ	technology of production
$x \in \Re_{+}^{m}$	feasible combinations of inputs
$y \in \Re_{+}^{s}$	feasible combination of outputs
j	determined DMU
x_{ij}, $i = 1, \ldots, m$	vector of inputs (equal to X)
y_{rj}, $r = 1, \ldots, s$	vector of outputs (equal to Y)
e	relative efficiency (input-orientation)
h	relative efficiency (output-orientation)
u_r	weight attached to outputs
v_i	weight attached to inputs
ε	mathematical infinitesimal
$\delta_{j_0}^{*}$	In the input-oriented model, is the efficiency score of DMU j_0
λ_j	intensity variable
s_i^{*} and s_r^{*}	slack variables
$\theta_{j_0}^{*}$	radial efficiency of DMU j_0
t	time
T	technology of production
T^M	Metatechnology of production
D	Shephard´s output distance
MI	Malmquist index
E	efficiency score
E^M	Metaefficiency score
EC	efficiency change
FS	frontier shift
m^3	cubic meter
$P_{i,t}$	maximum price of the service i in period t
I	Price Consumer Index
X	factor of expected productivity gains (for section 3.4.3)
s	seconds (for section 3.5)
km	kilometers
l	liters
$R\$$	Brazilian reais
R^2	coefficient of determination
km^2	square kilometre
w	scalar which implement the VRS assumption
$\bar{y}_r$	average value of output y_r
ϕ	bounds of weight restrictions
B	unstandardized regression coefficient
SEB	standard error of coefficient B
β	standardized coefficient
g	group
GMI	Global Malmquist index
BPC	best-practice change
GCI	group comparison index
ESG	efficiency spread gap
BPG	best-practice gap
CI	composite indicator

CHAPTER 1

Introduction

This chapter contextualizes the research topic investigated in this Thesis. Section 1.1 states the research motivation and the reasons for examining the water sector. Section 1.2 presents the research objectives of the Thesis. Finally, the Thesis outline is described in section 1.3.

1.1 Motivation

It is well known that water supply and sanitation, as part of the urban infrastructure, are essential services for population well-being. Their importance has been recognized by the United Nations General Assembly that conferred to public water supply the status of a fundamental human right, through Resolution 64/292 of July 2010 (UN, 2010). In addition, the UN General Assembly also introduced the Sustainable Development Goals (SDGs), known as the 2030 Agenda for Sustainable Development, in September 2015 (Resolution 70/1). Among the goals, SDG number 6 aims to ensure the availability and sustainable management of water and sanitation for all (UN, 2015a).

To achieve the SDG6, it is estimated that approximately $114 billion per year are needed by 2030. These are just the costs of building new infrastructure without considering the expenses of operating and maintaining old and new infrastructure over time (Hutton and Varughese, 2016). This significant investment amount reflects the current worldwide shortage of access to water supply and sanitation. It is also essential to consider operation and maintenance (OM) expenditures, which are sometimes overlooked when planning total expenditures (Fonseca and Cardone, 2006). Logically, spending on the OM of water supply and sanitation services rises as infrastructure expands and service coverage increases, and can represent two-thirds of the total investment needed (Hutton and Varughese, 2016). It is noteworthy that many providers have problems precisely in the OM of services, from the very execution of activities to their financing.

In addition to investments, the need to minimize the providers' operational costs and make water supply and sanitation services more efficient justifies a research effort on understanding the efficiency and productivity drivers of the water sector.

This work is framed in the context of seeking potential performance improvements in the management of water supply and sanitation services (WSS). The efficiency analysis is essential because it is expected to have a balanced growth between expenses (especially operational expenses) and WSS coverage. Moreover, it is essential that WSS are financially viable and of good quality.

It is important, when evaluating the efficiency of water supply and sanitation management entities, to consider the quality of the service provided. Maintaining a high quality of service has a clear impact on costs (Picazo-Tadeo et al., 2008). As a result, efficiency results can be significantly influenced if the quality of service is not considered (Cabrera Jr et al., 2018).

The main product (or output) to be managed in WSS is water (raw or potable, supply or waste, treated or not). Quality-related factors such as leakages and losses in water supply systems and contextual factors such as customer density and water source will be explored to investigate their interference in the efficiency and productivity levels of water supply and sanitation services.

All costs related to providing a sustainable service must be combined with all available funding sources. These funding sources can be from consumers alone and include external funding from national governments or national and international funding agencies (in the case of transfers). The crucial point is that unless all costs related to the provision and maintenance of a service (technical, human resources, institutional) are identified and financed by consumers or others, a service cannot be considered financially sustainable in the long run.

By conducting this work, it is expected to globally improve the management of water supply and sanitation services, particularly in terms of the strategies to be adopted to achieve efficiency and enhance productivity.

It is noteworthy that since this Thesis is structured as a collection of papers, some concepts and definitions may be repeated in different chapters.

1.2 Research Objectives

This Thesis fits into the topic of frontier methods, focusing on the use of the Data Envelopment Analysis technique for assessing the performance of water supply and sanitation services. With this in focus, the following paragraphs describe the scientific contributions of this Thesis to the water sector's performance assessment field.

Chapter 4 proposes an analysis of the expenditure on water supply and sanitation services in the Brazilian state of Mato Grosso. It is an exploratory study of an essential factor in water service delivery. The chapter further explores the expenditures for operating the services and details their main components in order to understand the patterns of expenditures in service delivery and the relationship between expenditures and municipality characteristics, such as population size or type of ownership of water utilities. The characterization of the expenses of the different types of providers is also discussed.

To address what is proposed in this chapter, the following specific research objectives will be pursued:

1. To characterize the state of Mato Grosso according to the population of its municipalities and the types of providers;
2. To examine the expenditures of water and sanitation services, identifying the proportion of OPEX in TOTEX;

3. To examine the representativeness of each component of operating expenses (*e.g.*, labor, electricity and tax expenses);
4. To check whether the population size of the municipalities and the type of provider influence the cost structure of the services, to see if there are comparative advantages between them.

Chapter 5 proposes a benchmarking approach to assess water supply and sanitation services' performance in Brazilian municipalities from an integrated perspective of efficiency and access. The chapter aims to look beyond traditional efficiency analysis by exploring equity in water supply and sanitation services.

To achieve the contributions intended for this part of this doctoral research, the specific objectives set are the following:

1. To provide an expanded view of the state of the art for efficiency analysis of water supply and sanitation services, using frontier techniques;
2. To explore the main contextual variables used in water supply and sanitation performance studies, in order to identify the main drivers of efficiency in the water sector;
3. To evaluate the efficiency of water supply and sanitation services in large Brazilian municipalities, and combine the results into an integrated analysis that includes service coverage, enabling the identification of best practices in both dimensions.

Chapter 6 aims to evaluate the evolution of the productivity of water supply and sanitation services in the Brazilian municipalities over the years 2012-2019 using the Global-Malmquist Productivity index. This innovative approach allows identifying improvement and decline trends in service productivity over time. The different macro-regional trends are also explored. The specific objectives of this chapter are:

1. To provide an expanded view of the state of the art for productivity change analysis of water supply and sanitation services that use frontier techniques;
2. To assess the productivity change of the large Brazilian municipalities to explore the evolution of performance over the years and its drivers;
3. To understand the different regional trends, controlling for the bias of national diversity, and identify the impact of regional trends on the evolution of the country's productivity.

Chapter 7 also proposes an innovative framework based on optimization techniques that can support decision-making in water services. The framework developed estimates a Best-Practice frontier recurring to a 'Benefit-of-the-Doubt' composite indicator formulation that enables benchmarking performance across decision-making units that belong to different groups. This formulation departs from the traditional DEA perspective that focuses on the production process in which inputs generate outputs, and proposes a new perspective that focuses only on the achievements, expressed as Key Performance Indicators. Also, the three most populous Brazilian macro-regions (*i.e.*, Northeast, Southeast, and South) are considered to illustrate this benchmarking methodology, which adopts an innovative Global Pseudo-Malmquist Index to compare the performance of groups. The specific objectives of this chapter are:

1. To review the state of the art literature on frontier methods used to evaluate the water and sanitation services performance considering regional differences in efficiency analysis;
2. To study regional differences in water supply and sanitation services performance among Brazilian macro-regions.

1.3 Thesis Outline

This Thesis is composed of eight chapters. Chapter 2 provides an overview of the concept of efficiency used in this work and also provides basic definitions of performance assessment methods, focusing on the Data Envelopment Analysis technique and productivity change indices. It includes a brief discussion of the performance assessment methods that support the developments proposed in this Thesis. Chapter 3 provides an expanded view of the Brazilian water sector, namely the Brazilian particularities. Chapter 4 provides an exploratory analysis of the revenues and expenses of water supply and sanitation services in the Brazilian State of Mato Grosso, based on the SNIS indicators. The chapter also explores the main components of operating expenses and compares their representativeness across different types of providers. Chapter 5 proposes a benchmarking approach to assess water supply and sanitation services' performance in Brazilian municipalities from an integrated perspective of efficiency and access. Chapter 6 provides the estimation of the Global-Malmquist Index to evaluate the evolution of productivity level of large Brazilian municipalities over the years 2010-2019. Chapter 7 proposes an innovative estimation of a pseudo-Malmquist index to compare the performance of three Brazilian macro-regions, using data of the Brazilian water and sanitation regulator, collected at the municipality level for the year 2019. Chapter 8 presents the main conclusions of this Thesis, including the contributions achieved and the research limitations. Insights extracted from the illustrative applications and directions for future research are also highlighted.

CHAPTER 2

Overview on Performance Assessment

The literature on performance assessment is comprehensive and multidisciplinary. Notwithstanding, this Thesis evaluates relative efficiency and productivity change over time using non-parametric frontier methods. Thus, this chapter aims to provide an overview of the concepts that will be further explored throughout this Thesis, namely efficiency and productivity measures.

2.1 Introduction

In discussing the economic performance of producers (the WSS, in the case of this Thesis), it is common to describe them as more or less efficient or more or less productive. Although these are often used synonymously, they are distinct concepts for determining the level of performance.

The concept of productivity refers to the ratio between outputs (results or products) and inputs (resources). The ratio would be easily calculated in a hypothetical situation of a producer using only one input to generate one output. However, in the more common situation where multiple inputs generate multiple outputs, it is necessary to aggregate both the outputs and inputs to obtain a ratio between two scalars. The difference in productivity, either between different producers or over time, is usually attributed to: i) difference in production technology, ii) difference in scale of production, iii) difference in operational efficiency, and iv) difference in the environment in which production takes place. While the first three are endogenous elements of production and thus more "easily" controllable, the fourth refers to a factor exogenous to production, which is much more difficult to control. Since production technology and service scale change over a more extended period, there is usually more focus on the efficiency factor as a strategy for improving productivity in the short term.

Economic efficiency has technical and allocative components. The concept of efficiency used throughout this Thesis refers to comparing an observed productivity value (an output to input ratio) and an optimal value. Thus, the observed output value is compared with the maximum potential output obtained with a given level of inputs (output orientation). Similarly, the observed input values are compared to the minimum possible amount of inputs needed to produce a particular output level (input-orientation). In both cases, the optimum value is defined considering the production possibility set (PPS), and the efficiency measure is called technical. Thus, Technical Efficiency is the level of success in transforming inputs into outputs. It can be estimated by comparing the productivity level of a unit against the maximal feasible productivity level observed in a set of homogeneous units.

In the specialized literature, efficiency measurement is strongly linked with productivity concepts. The technology of production (Φ) or production possibility set (PPS) can be described as all feasible combinations of inputs ($x \in \Re^m_+$) and outputs ($y \in \Re^s_+$) for a certain production process, as in (2.1).

$$\Phi = \{(x,y) : x \text{ can produce } y\} \tag{2.1}$$

Usually, the researcher wants to evaluate the efficiency of a set of units, called Decision Making Units (DMUs), comparing them to the reference frontier. Note that all units under assessment must be part of the PPS in this evaluation.

It is noteworthy that a high productivity level is highly desirable, although it cannot be incremented indefinitely. A production frontier can represent the maximal feasible level of output obtained from a given set of inputs. Estimating the PPS frontier requires estimating a production function, which is a mathematical representation of the relationship between inputs and outputs. It is defined as the maximum possible outputs obtained from a given set of inputs. The inputs usually represent the factors of production (*e.g.*, capital and labor). At the same time, the output is the result of firms' activities (Shephard, 1970).

Detailed knowledge of the production function is seldom readily available, *i.e.*, the true frontier is unknown, therefore, many methods have been proposed to estimate it. These methods involve empirical estimations of the location of the frontier that envelops the firms under assessment. In this context, deviations from the frontier are observed empirically. Despite the differences in the available methods, the frontier represents optimal levels of operation (efficiency) given the technology used.

In the 1950s, alternative definitions of technical efficiency were formulated by Debreu (1951), Farrell (1957) and Koopmans (1951).

Koopmans (1951) definition of Technical Efficiency states that a feasible input-output vector can be called efficient if it is technologically impossible to increase any output and (or) to reduce any input without simultaneously reducing other outputs and (or) increasing other inputs. Thus, a technically inefficient producer could produce the same outputs with less of at least one input or could consume the same inputs to produce more of at least one output (Koopmans, 1951).

According to Pareto (1906), efficiency is a state of allocation of resources in which it is impossible to make any individual better off without making at least one other individual worse off. This concept was used in the studies of economic efficiency and income distribution (Pareto, 1906).

Combining the Pareto' and the Koopmans' concepts, the general so-called Pareto-Koopmans concept of efficiency was formed, which states that a DMU can only be considered efficient if and only if it is not possible to improve one input or output without making some other input or output worse (Cooper et al., 2007).

Debreu (1951) and Farrell (1957) introduced a measure of technical efficiency that is given by (one minus) the maximum equiproportionate (radial) reduction in all inputs that still allows the production of given outputs for an input-orientation. With an output orientation, their measure is defined as the multiplicative inverse of maximum radial expansion in all feasible outputs with given technology and inputs. A value of one indicates technical efficiency, and values less than unity indicate the existence of technical inefficiency (Fried et al., 2008, p.20).

Shephard (1953) and Malmquist (1953) also contributed to the efficiency and productivity analysis field. They introduced the notion of distance functions as a tool for economics. Malmquist applied this notion to index number theory, while Shephard mainly used it for duality theory. The development of technology and distance functions models provided the basis for assessments involving multiple outputs and inputs. Shephard's work enabled a comprehensive characterization of the framework of a multi-input, multi-output production technology and a reciprocal measure of the distance from each DMU to the efficient frontier (Johansen, 2011, p.16). Shephard distance functions are also the basis for estimating the Malmquist productivity index and a range of other indices available in the literature (see Färe et al., 1989; Chambers et al., 1994).

2.2 Methods for the Assessment of Efficiency

2.2.1 Introduction

The efficiency measurement methods based on estimating an efficient frontier evolved following two approaches: parametric and non-parametric, which differ in how the frontier is specified and estimated.

The parametric approach estimates the frontier using a function defined by a precise mathematical form (usually the translog or the Cobb-Douglas functions). This line of research requires an *a priori* specification of the functional form to represent the frontier. On the other hand, the non-parametric approach does not require defining a functional form for the frontier. Instead, a set of postulates allow the estimation of the frontier.

Figure 2.1 classifies some of the types of parametric and non-parametric frontiers. These methods can also be classified in terms of their stochastic or deterministic nature. In the non-parametric approach, the most common method for evaluating efficiency is Data Envelopment Analysis (DEA) (Charnes et al., 1978). In the parametric approach, the method most frequently reported in the literature is Stochastic Frontier Analysis (SFA) (Aigner et al., 1977). Furthermore, other common methodologies referred in the literature and showed in Figure 2.1 are the Corrected Ordinary Least Squares (COLS) (Greene, 1980), the Free Disposal Hull (FDH) (Deprins et al., 1984), the Directional Distance Function (DDF) (Chung et al., 1997), the Bootstrap DEA (Simar and Wilson, 1998) and the Stochastic non-parametric envelopment of data (StoNED) (Kuosmanen and Kortelainen, 2012), the order-m (Cazals et al., 2002) and the order-α (Daouia and Simar, 2007).

The stochastic approach allows for recognizing random noise and measurement errors in the data. Thus, the DMUs' deviations from the estimated frontier are explained by the DMUs' inefficiency and the presence of noise or data error. In these cases, the estimation of the production frontier involves using statistical techniques. In SFA, deviations from the frontier can be distinguished between a non-normal residual (*i.e.*, inefficiency) and a normal residual (*i.e.*, noise or measurement error).

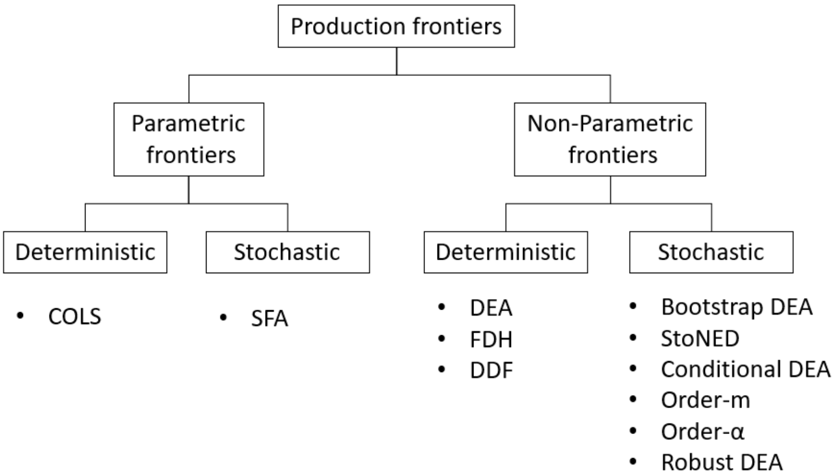


Figure 2.1: Production frontier techniques.

Deterministic approaches rely on mathematical programming techniques to estimate the production frontier and assume no random noise in the data. Consequently, the deviations from the frontier are interpreted exclusively as inefficiency.

This Thesis follows the deterministic non-parametric research line and reports evaluations involving DEA-based models, including Composite Indicator "Benefit-of-the-Doubt" models. The following sections present the main models used in this Thesis to estimate efficiency.

2.2.2 Overview on Data Envelopment Analysis

Data Envelopment Analysis, developed by Charnes et al. (1978), is a Linear Programming (LP) approach that is grounded on the seminal concepts of efficiency proposed by Farrell (1957). The DEA model seeks to measure the efficiency of homogeneous production units which use multiple inputs to generate multiple outputs (Figure 2.2).

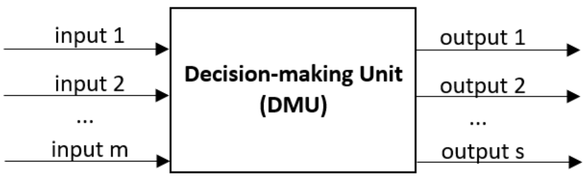


Figure 2.2: Production process involving the transformation of inputs into outputs by a DMU.

It is important to note that the use of DEA requires that the DMUs under analysis are of the same nature, *i.e.*, use the same set of inputs and outputs for given production activity. Therefore, the efficiency is estimated by comparison to other observed DMUs, and thus it is a relative measure. DEA uses linear programming to construct a piecewise linear frontier that envelops the sample data. The efficiency measure for each DMU is then estimated relative to the frontier constructed.

With the purpose of presenting the DEA formulations intuitively, the starting point is the fractional model (Charnes et al., 1978) for the estimation of relative efficiency.

Consider a performance assessment of n DMUs, $j = 1,...,n$, each consuming inputs x_{ij}, $i = 1,\ldots,m$, to produce outputs y_{rj}, $r = 1,\ldots,s$. The relative efficiency of the DMUj_0 under assessment is obtained by comparing the ratio of all its outputs by all its inputs with the corresponding ratios of similar DMUs. The multiple inputs (and outputs) are reduced to a single value by defining weights for each input and output. These weights are defined using an optimization procedure to evaluate the efficiency of the DMU j_0 with the best possible combination of weights. The relative efficiency of the DMU j_0 under analysis is obtained from the fractional model shown in (2.2).

$$
\begin{aligned}
&\text{Max } e_{j_0} = \frac{\sum_{r=1}^{s} u_r\, y_{rj_0}}{\sum_{i=1}^{m} v_i\, x_{ij_0}} && && (2.2)\\
&s.t.\ \frac{\sum_{r=1}^{s} u_r\, y_{rj}}{\sum_{i=1}^{m} v_i\, x_{ij}} \leq 1 && j = 1,\ldots,n\\
&u_r \geq \varepsilon && r = 1,\ldots,s\\
&v_i \geq \varepsilon && i = 1,\ldots,m
\end{aligned}
$$

In (2.2), the variables v_i and u_r are the weights attached to the inputs and outputs, respectively. Note that ε is a mathematical infinitesimal ensuring that the weights are strictly positive so that all inputs and outputs are taken into account in the evaluation. This model searches for the optimal input and output weights that maximize the efficiency of DMU_{j_0}, subject to the constraint that the efficiency of all DMUs in the sample is less than or equal to one when evaluated with the same set of weights. It is noteworthy that the optimal weights assigned to DMU_{j_0} may be different from the set of weights assigned to the other DMUs in the optimization model defined for their efficiency assessment. Therefore, each DMU under analysis will have its weights defined to maximize its efficiency compared to the other DMUs.

Models (2.3) and (2.4) show the linear version of model (2.2). Both formulation assume constant return to scale (CRS). Returns to scale refer to the proportion by which products (outputs) change as a function of changes in factors of production (inputs). They can take two forms: CRS or variable returns to scale (VRS). In CRS, an increase in input results in a proportional increase in output (if an activity x,y is viable, so is activity tx,ty, where t is a positive scalar value). Conversely, in VRS, an increase or decrease in inputs does not result in a proportional change in outputs. Returns to scale will be detailed in the next section.

For the input-oriented case (model (2.3)), the conversion of the fractional model into a linear programming model is done by maximizing the numerator of the objective function in (2.2) and setting the denominator of the objective function equal to one. For the output-oriented case (model (2.4)), the linearization is obtained by minimizing the denominator of the objective function in (2.2) and setting the numerator of the objective function equal to one.

DEA input-oriented model under CRS (multiplier formulation):

$$
\begin{aligned}
&\text{Max } e_{j_0} = \sum_{r=1}^{s} u_r\, y_{rj_0} && (2.3)\\
&s.t. \sum_{i=1}^{m} v_i\, x_{ij_0} = 1 \\
&\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i\, x_{ij} \leq 0 \quad j = 1, \ldots, n \\
&u_r \geq \varepsilon \qquad\qquad\qquad\qquad r = 1, \ldots, s \\
&v_i \geq \varepsilon \qquad\qquad\qquad\qquad i = 1, \ldots, m
\end{aligned}
$$

DEA output-oriented model under CRS (multiplier formulation):

$$
\begin{aligned}
&\text{Min } h_{j_0} = \sum_{i=1}^{m} v_i\, x_{ij_0} && (2.4)\\
&s.t. \sum_{r=1}^{s} u_r\, y_{rj_0} = 1 \\
&\sum_{r=1}^{s} u_r\, y_{rj} - \sum_{i=1}^{m} v_i\, x_{ij} \leq 0 \quad j = 1, \ldots, n \\
&u_r \geq \varepsilon \qquad\qquad\qquad\qquad r = 1, \ldots, s \\
&v_i \geq \varepsilon \qquad\qquad\qquad\qquad i = 1, \ldots, m
\end{aligned}
$$

If using the optimal weights for DMU_{j_0}, no other DMU reaches a value of the output to input ratio higher than the value of this ratio for DMU_{j_0}, then it is considered efficient and is assigned a score equal to one. Otherwise, DMU_{j_0} is considered inefficient. The linear programming problem is solved for each DMU to allow the DMU under assessment to be assigned its own set of weights.

The relative efficiency score for the assessed DMU_{j_0} is given by $e^*_{j_0}$ in (2.3) and $1/h^*_{j_0}$ in (2.4), where "*" indicates the value at the optimal solution. The result of the objective function of model (2.3) ranges between 0 (worst) and 1 (best) so that if the DMU under assessment j_0 is radially efficient, the score obtained equals one. Otherwise, it is considered inefficient. Under CRS, both models provide identical efficiency scores.

The multiplier DEA models (2.3) and (2.4) can be expressed in their dual form, called envelopment formulations, as reported in (2.5) and (2.6).

In the input-oriented model (2.5), $\delta^*_{j_0}$ is the efficiency score of DMU j_0. It can also be interpreted as the factor by which the input levels of the DMU under assessment can be decreased radially (equiproportionally). At the same time, the outputs maintained at least the current levels. Similarly to the multiplier model (2.3), the value of the objective function ranges from 0 (worst) to 1 (best).

DEA input-oriented model under CRS (envelopment formulation):

$$\text{Min } e_{j_0} = \delta_{j_0} - \varepsilon \left(\sum_{i=1}^{m} s_i + \sum_{r=1}^{s} s_r \right) \tag{2.5}$$

$$s.t.\ \delta_{j_0}\, x_{ij_0} - \sum_{j=1}^{n} \lambda_j\, x_{ij} - s_i = 0 \qquad i = 1,\ldots,m$$

$$\sum_{j=1}^{n} \lambda_j\, y_{rj} - s_r = y_{rj_0} \qquad r = 1,\ldots,s$$

$$\lambda_j \geq 0 \qquad j = 1,\ldots,n$$

$$s_i \geq 0 \qquad i = 1,\ldots,m$$

$$s_r \geq 0 \qquad r = 1,\ldots,s$$

DEA output-oriented model under CRS (envelopment formulation):

$$\text{Max } h_{j_0} = \theta_{j_0} + \varepsilon \left(\sum_{i=1}^{m} s_i + \sum_{r=1}^{s} s_r \right) \tag{2.6}$$

$$s.t.\ \sum_{j=1}^{n} \lambda_j\, x_{ij} + s_i = x_{ij_0} \qquad i = 1,\ldots,m$$

$$\theta_{j_0}\, y_{rj_0} - \sum_{j=1}^{n} \lambda_j\, y_{rj} + s_r = 0 \qquad r = 1,\ldots,s$$

$$\lambda_j \geq 0 \qquad j = 1,\ldots,n$$

$$s_i \geq 0 \qquad i = 1,\ldots,m$$

$$s_r \geq 0 \qquad r = 1,\ldots,s$$

A value of $\delta^* = 1$ means that the DMU j_0 is radially efficient, but it may not be efficient in Pareto-Koopsman's sense. A DMU j_0 is efficient in Pareto-Koopman's sense if, and only if, the following conditions are satisfied:

- The radial efficiency score is 1;
- There are no positive slacks values; *i.e.*, $s_i^* = s_r^* = 0\ \forall\ i, r$.

The variables λ_j are the intensity variables. They can be interpreted as the multipliers defining a point on the frontier estimated from the convex combination of other DMUs in the sample (peers). s_i^* and s_r^* are the slack variables transforming the constraints inequalities. These variables indicate the extent to which each input or output can be improved beyond the amount indicated by the radial factor $\delta_{j_0}^*$. They are multiplied by the infinitesimal ε in the objective function to ensure that the slacks are only optimized on a second stage without affecting the efficiency scores.

For the output-oriented model shown in (2.6), the radial efficiency of DMU j_0 is obtained as the inverse of $\theta_{j_0}^* (i.e., 1/\theta_{j_0}^*)$. This means that $\theta_{j_0}^*$ is the factor by which the outputs levels of the DMU under assessment can be increased equiproportionally, while keeping the inputs fixed. Therefore, DMU j_0 is considered radially efficient when $\theta^*_{j_0} = 1$ and efficient in the Pareto-Koopmans' sense when $\theta^*_{j_0} = 1$ and $s^*_i = s^*_r = 0 \; \forall \; i, r$.

One should note that $\delta^*_{j_0}$ matches the Debreu-Farrell radial efficiency measure, and $\theta^*_{j_0}$ matches the inverse of the Debreu-Farrel radial efficiency measure.

The envelopment formulation of the DEA model also enables extracting further managerial information for benchmarking purposes. This feature is supported by the identification of peers for each inefficient DMU. These peers are the firms operating at the frontier, selected as a reference for the evaluation of DMU j_0 in models (2.5) and (2.6). The inputs and outputs observed in the reference firms are used to build one composite DMU estimated from the linear combination of the inputs and outputs observed in the peers. The composite DMU uses the same or lower levels of input and produces equal or higher levels of output than DMU j_0. Therefore, when $\lambda_j > 0$ it means that DMU j is a peer to DMU j_0.

2.2.3 Returns to scale

Depending on the technological features of the production process underlying the transformation of inputs into outputs, a decision-maker may need to represent other returns to scale rather than CRS.

The VRS can be further divided into increasing and decreasing returns to scale.

Increasing returns to scale is when the output increases significantly more than the increase in input. Decreasing returns to scale is when all production variables are increased by a certain percentage resulting in a less-than-proportional increase in output.

The returns to scale are a characteristic of the frontier of production technology. They are used to define technology behavior when changes to the scale of operation occur. It is possible to relax the assumption of constant return to scale with the inclusion of additional constraints to models (2.5) and (2.6). The additional constraints will characterize different DEA models, reflecting a variety of frontier shapes (Banker et al., 1984a; Zhu, 2014, p.21):

- Variable Returns to Scale (VRS) is obtained adding $\sum_{j=1}^{n} \lambda_j = 1$ to the envelopment model (2.5) or (2.6);
- Non Increasing Returns to Scale (NIRS) is obtained adding $\sum_{j=1}^{n} \lambda_j \leq 1$ to the envelopment model (2.5) or (2.6);
- Non Decreasing Returns to Scale (NDRS) is obtained adding $\sum_{j=1}^{n} \lambda_j \geq 1$ to the envelopment model (2.5) or (2.6).

Figure 2.3 shows the CRS and VRS frontiers, considering an example with one input and one output.

Figure 2.3 shows that the efficient frontier under constant returns to scale (CRS) is simply the line passing through point C from the origin (0,0). As previously referred to, under constant returns to scale, one assumes that the maximum productivity (*i.e.*, the ratio of output to input) found at C is replicable whatever the level of scale size. Under VRS, the efficient frontier is the segmented

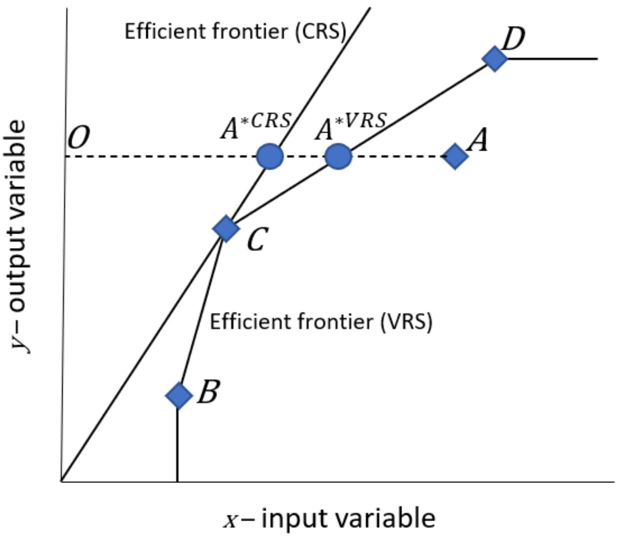


Figure 2.3: CRS and VRS frontiers, with an input-orientated efficiency assessment example.

line BCD. Each production unit can now be assessed under CRS and VRS. For instance, DMU A is an inefficient unit. Suppose efficiency is measured with an input orientation to hold output constant. In that case, unit A's efficiency under VRS is the ratio between OA^{*VRS} and OA, meaning that the Unit A could become efficient, in a purely technical sense, by decreasing its input level until reaching point A^{*VRS}. However, at this point, DMU A would be considered scale inefficient because it is not possible to achieve the maximum productivity level (observed at DMU C).

The ratio $\frac{OA^{*CRS}}{OA^{*VRS}}$ is known as "scale efficiency" for the unit A. It evaluates the distance between the CRS and VRS frontiers and measures input loss attributable to having a scale size that prevents attaining maximum productivity.

2.3 Malmquist Productivity Index

The Malmquist index (MI), introduced by Caves et al. (1982a) and developed by Färe et al. (1989, 1992), can be used to evaluate productivity change over time. As originally presented by Färe et al. (1989) (see also Färe et al. (1992); Fare et al. (1994)), it relies on ratios of Shephard distance functions Shephard (1970). It requires the estimation of two within-period Shephard distance functions and two mixed-period Shephard distance functions.

Consider two different time periods defined by t and $t+1$. The technology of production can be defined in relation to t (T^t) or in relation to $t+1$ (T^{t+1}). Expression (2.7) shows the Shephard output distance function defined for a DMU with the input-output vector (X^t, Y^t), evaluated with regard to the technology T^t.

$$D_o(X^t, Y^t) = \min\{\theta : (X^t, \frac{Y^t}{\theta}) \in T^t\} \tag{2.7}$$

This function gives the reciprocal of the maximum factor $\frac{1}{\theta}$ by which the output vector Y^t can be proportionally expanded, whilst the inputs are kept at their current level. $D_o(X,Y) \leq 1$ for all input-output combinations that belong to technology T^t. $D_o(X,Y) = 1$ if and only if (X^t, Y^t) is located on the frontier of the technology T^t.

It has been shown (see Färe and Lovell (1978)) that the Shephard distance function is equivalent to the technical efficiency measure of Farrell (1957). Therefore, it can be computed using a Data Envelopment Analysis (DEA) model, as originally developed by Charnes et al. (1978).

In accordance with Färe et al. (1989), the Malmquist index can be defined as shown in (2.8), which requires the computation of two single period-efficiency scores, $E^t(X^t, Y^t)$ and $E^{t+1}(X^{t+1}, Y^{t+1})$, and two mix-period efficiency scores, $E^{t+1}(X^t, Y^t)$ and $E^t(X^{t+1}, Y^{t+1})$. The superscript next to letter "E" indicates the period of the technology considered in the assessment, *i.e.*, T^t or T^{t+1}.

$$MI^{t,t+1} = \left[\frac{E^t(X^{t+1},Y^{t+1})}{E^t(X^t,Y^t)} \frac{E^{t+1}(X^{t+1},Y^{t+1})}{E^{t+1}(X^t,Y^t)}\right]^{\frac{1}{2}} \tag{2.8}$$

Färe et al. (1992) showed that the MI could be decomposed in two sub-indices. The first measures the efficiency change (EC) between two periods, as shown in (2.9), and the second measures frontier shift (FS) between two periods, as shown in (2.10). EC evaluates the distance to the frontier of the Technology in period t (T^t) for DMU j_0 in t, compared with the distance to the frontier of T^{t+1} of DMU j_0 in $t+1$. FS compares the distance between the best practice frontiers in t and $t+1$, evaluated at the input-output mix of the DMU j_0 in t and in $t+1$.

$$EC^{t,t+1} = \frac{E^{t+1}(X^{t+1},Y^{t+1})}{E^t(X^t,Y^t)} \tag{2.9}$$

$$FS^{t,t+1} = \left[\frac{E^t(X^t,Y^t)}{E^{t+1}(X^t,Y^t)} \frac{E^t(X^{t+1},Y^{t+1})}{E^{t+1}(X^{t+1},Y^{t+1})}\right]^{\frac{1}{2}} \tag{2.10}$$

The values of $MI^{t,t+1}$ and its components can be greater, equal, or smaller than one. These values indicate respectively growth, stagnation or decline in performance between periods t and $t+1$.

2.4 Conclusions

This chapter provided an overview of the conceptual foundations for assessing efficiency and productivity change using frontier techniques. First, the standard DEA model was presented. In addition, the measures of productivity change estimated using DEA, based on the construction of a Malmquist index, were also reviewed.

CHAPTER 3
The Water Supply and Sanitation Sector

The purpose of this chapter is to present an overview of the features that characterize the functioning of the water supply and sanitation sector with focus on the Brazilian case, as it is the object of analysis in this Thesis. Finally, some aspects of water sector financing and services regulation are also explored.

3.1 Introduction

Water supply and sanitation services are considered essential for the population's well-being. They include activities that directly interfere with society, the economy, and the environment. Therefore, the efficiency in managing these services represents a highly relevant factor in ensuring the prosperity of a population and the sustainable development of nations.

The management of water supply and sanitation services includes the continuous search for efficiency, either by adjusting expenditures and revenues and maintaining (or increasing) the quality of services at reasonable prices. Moreover, it is crucial to understand the different factors that can influence the efficiency of service provision.

Water supply and sanitation are part of urban infrastructures, which depend on several elements working together. The interconnection of these components characterizes the arrangement of services into systems. The constitution and functioning of these systems will be discussed in the following sections.

3.2 Water Supply and Sanitation Systems

Public water supply systems are urban infrastructures designed and built to obtain water from a source and transport it to the final consumers. The origin can vary from groundwater (wells) to surface water (*e.g.*, from lakes and rivers). Likewise, the system itself develops in the most varied configurations, with the most diverse types of components. There are simplified systems that serve small communities or a small number of consumers and others that serve thousands or millions of consumers in one or more cities. Typically, water supply systems are composed of (Figure 3.1):

- intake infrastructures, which withdraw the water from the available source;

- raw water mains, which transport the water directly from the source to the water treatment plant (WTP);
- water treatment plants, where the raw water is made suitable for human consumption;
- storage tank, which regularizes the volume of water necessary for maintaining the flow rates, compensating the consumption fluctuation;
- distribution network; and
- building connections, which are the final water delivery components to the population.

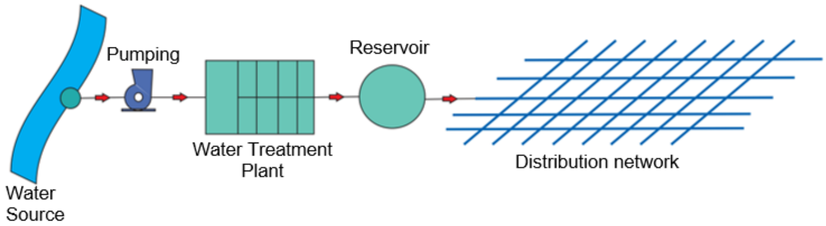


Figure 3.1: Simplified scheme of a water supply system.

Like water supply systems, Sanitation systems have many configurations. They are responsible for collecting and transporting the wastewater to treatment facilities and, subsequently, to final disposal (in a body of water or by infiltration into the soil). These systems generally consist of (Figure 3.2):

- sewer pipes, which collect wastewater from buildings;
- pumping units (when necessary), which transmit energy to the flow allowing it to reach higher elevations;
- interceptors, which transport the wastewater to the wastewater treatment plants (WWTP); and
- wastewater treatment plant, where the organic load and contaminants present in the wastewater are removed.

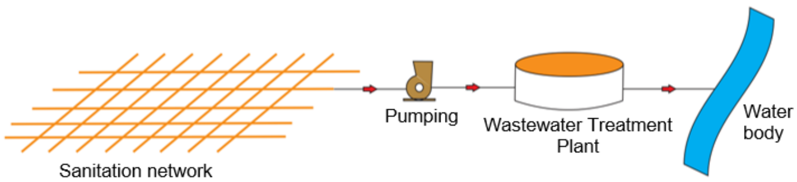


Figure 3.2: Simplified scheme of a sanitation system.

Water supply and sanitation systems are part of the urban infrastructures of cities, which explains the predominance of local competence in the management of these services. It is important to note that the characteristics of water supply and sanitation services vary significantly depending on several factors, such as climate, geography, the historical, political, cultural and economic situation.

As with municipalities, each country has its particularities and challenges. There is, however, a global consensus on the need for a joint effort to achieve high levels of efficiency in WSS in the short and medium term. In the coming years, there will be a need to significantly increase investments worldwide in the infrastructure to develop, modernize, maintain and operate water supply and wastewater (OECD, 2009).

3.3 Finance in the Water Sector

The discussion on financing the water supply and sanitation sector strengthened with the adoption of Agenda 2030. The Pact for Sustainable Development (UN, 2015a) has as one of its goals (goal number 6), ensuring the availability and sustainable management of water and sanitation for all by 2030 (SDG6). Estimates of the resources required to achieve this goal run into the billions of dollars (Hutton and Varughese, 2016). On the other hand, not having access to WSS also carries high costs (e.g., premature deaths and healthcare costs linked to economic activity lost due to sanitation-related sickness). In 2015, lack of access to WSS cost the global economy approximately $222.9 billion, which compares to about $182.5 billion in 2010, representing an increase of over $40 billion in just five years (LIXIL, 2016).

In the coming years, countries and providers are expected to significantly increase investment in infrastructure to develop, modernize, maintain, and operate their water supply and wastewater drainage systems.

Humphreys et al. (2018) state that taxes and tariffs are considered domestic public revenue sources, and external (cross-country) operations usually characterize transfers. According to the authors, even though revenues from tariffs are an essential source of public revenue, they are less "stable" than those from taxes. The uncertainty regarding their support base causes this instability. For example, suppose water consumption or even the payment of bills by users (for non-payment) decreases. In that case, the volume of resources from tariffs may be insufficient to cover the expenses of operation and maintenance of services. This scenario is quite characteristic of small municipalities, which have tax collection as the primary source of financial resources to meet the expenses of WSS (Humphreys et al., 2018; OECD, 2018).

Figure 3.3 shows the amounts received by the source of funds as a function of country income. In developing countries, regardless of income category, tax-sourced revenues predominate, accounting for 40-80% of available resources. In addition to taxes, sources of funds include:

- remittances, which are amounts sent by expatriates to their home countries;
- bilateral sources, which are amounts transferred from an official government source to an official destination in another country; and
- multilateral sources, which originate in multilateral development support agencies.

In addition to being a scarce source of resources, tax revenue is also used for other local public policies. Often, in this competition for available resources, WSS are left behind. Studies conducted on small municipalities show that governments often prioritize other sectors, such as education and health, in using public resources (Humphreys et al., 2018; WaterAid, 2014).

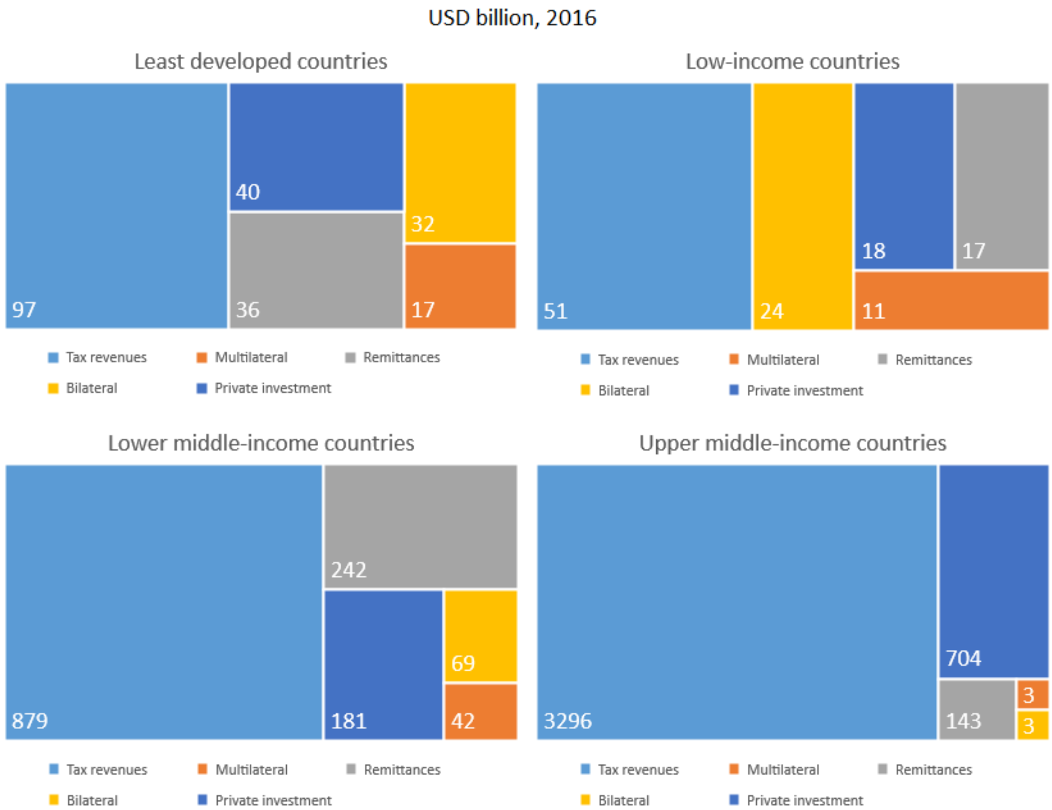


Figure 3.3: Sources of WSS resources as a function of country income (adapted from OECD, 2018).

On the other hand, more developed countries use tariff revenues as the primary resources to cover WSS expenses. Countries like Austria, Belgium, Denmark, France, and Norway adopt the Full-Cost Recovery (FCR) principle. The full coverage of WSS expenses is carried out exclusively with resources from tariff payments (EurEau, 2014). As the WSS evolves towards a more efficient service, the systems tend to rely less on "external" resources (in this case, amounts that do not come from the services' operation) and be increasingly sustained by the use of tariff resources.

Similarly, the OECD (OECD, 2009) recommends using the 3Ts (tariff, taxes, transfers) proportion that is most convenient for the services, according to local, regional or national planning. It means that it is not mandatory to use one resource over another on the 3Ts. Figure 3.4 shows the composition of the 3Ts used in different countries.

As shown in Figure 3.4, in France, the WSS expenditures are mainly covered by tariff revenues, in contrast to Egypt, where most resources come from the public budget through taxes. The ability to pay the expenses with revenues coming mainly from tariff collection shows the sustainability of the services. On the other hand, some services require external resources, either from taxes or international aid (in the case of transfers). Although there is no ideal model for the division of resources, the preponderance of tariff revenues funding the services in more developed countries, such as France and Austria, is evident. Conversely, the importance of resources originating from taxes and transfers is high for developing countries, such as Ethiopia and Mozambique.

The importance of using the 3Ts to finance the coverage of expenditures for the provision of

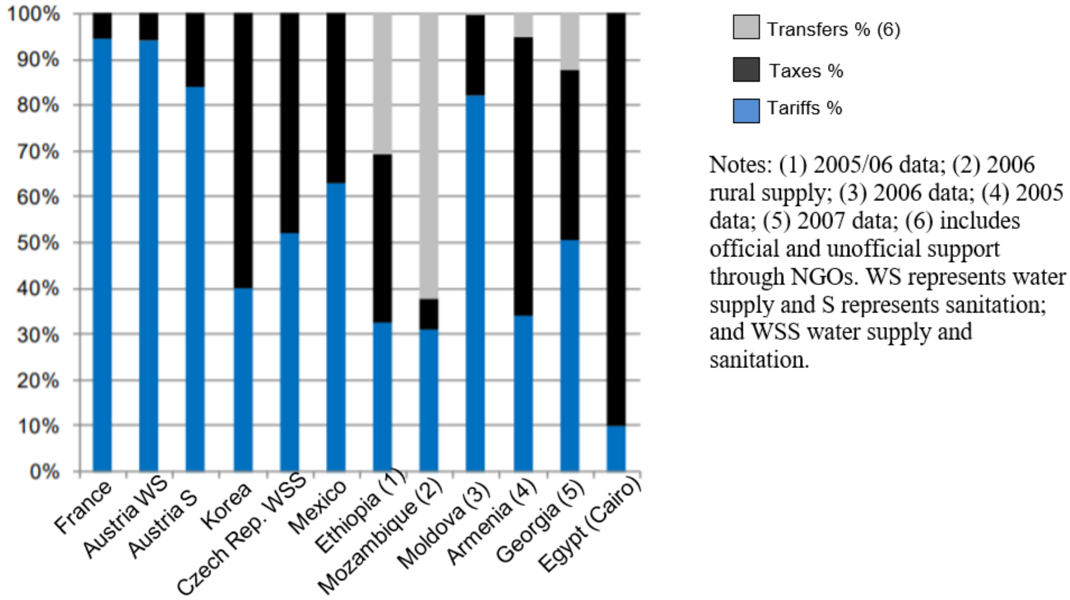


Figure 3.4: Distribution of representative shares of the 3Ts in some countries (adapted from OECD, 2009a).

water supply and wastewater drainage services is the possibility of covering all expenditures, thus using several sources of financing to meet the country's needs.

The resources collected from taxes, including the central government, are considered "domestic public" finance and are essential to cover part of the expenditures related to capital costs or finance the municipalities' investments, especially the smaller ones. Usually, the establishment of new infrastructures requires a high investment. Therefore, the central government allocates a percentage of its gross domestic product to municipalities' water supply and sanitation services.

Thus, it is clear that any strategy to be developed to assist small municipalities in managing their WSS must have as a critical element the improvement (or achievement) of the economic viability of the services, either by increasing revenues or by reducing expenses.

One of WSS's financial sustainability principles is the “Full-Cost Recovery". This principle determines that operating expenses (related to operation and maintenance) and capital costs necessary for current and future investments must be covered exclusively by resources from tariff payments. Full cost recovery for water supply and wastewater services ensures that municipalities develop operational and capital long-term plans covering all aspects of the systems. As noted by Massarutto (2007), the FCR is commonly regarded as a cornerstone of sustainable water management and has been adopted by the European Union as one of the fundamental principles underpinning the Water Framework Directive (European Commission, 2000 - Dir. 2000/60).

When thinking about a high tariff to generate the revenue required to pay all the costs of operating the WSS, the dilemma that the decision-maker will face arises: on the one hand, the payment of a high tariff may considerably compromise the family income, depending on their economic level and on the other hand, non-payment may result in disconnection and non-use of the services. However, a study conducted in several European countries has demonstrated that the adoption of the FCR does not have a very relevant impact on reducing user access, except for Bulgaria. In this case, the explanation for the reduction in access is due to the percentage of income used to pay water tariffs, which in that country exceeds 3% (Reynaud, 2016).

On the other hand, Rusca and Schwartz (2018), in a study conducted in African countries, observed that the implementation of FCR principles might increase, rather than reduce, inequalities in access to drinking water. According to the authors, water utilities in Africa tend to outsource service provision in low-income areas to the small-scale or “social" private sector. These providers apply the principles of full recovery more strictly because they cannot operate at a deficit. On the other hand, they cannot use cross-subsidization as they lack economies of scale. As a result, wealthier neighborhoods, where the water utility provides services directly, often access water at subsidized rates. In contrast, in low-income areas, where service provision is outsourced, people access lower quality services at a higher price (Rusca and Schwartz, 2018). This regional inequality is a critical element in WSS management. As can be seen, the population’s income to be served can significantly influence the management strategy to be used.

Although the full-cost recovery is the goal of most utilities (Kayaga et al., 2003), the adoption of FCR is not an easy principle to achieve, especially in small cities. The principle of Sustainable Cost Recovery (SCR) was proposed to operate as an intermediate step to the FCR principle. The SCR principle states that tariff revenues should be sufficient to cover the operation and maintenance expenses of the WSS. Although the SCR is less severe than the FCR, it remains an almost utopian goal for small municipalities.

It is noteworthy that some studies question the goal of achieving cost coverage, particularly the FCR because the WSS providers act to raise tariffs instead of reducing expenses. This contrast creates the dilemma of achieving full-cost recovery or having an affordable service for those most in need (Schwartz et al., 2017).

In large cities, the possibility of creating cross-subsidization (when the financial surplus obtained by part of the population finances the provision of these services for the deficit part) promotes access to WSS by the poorest. However, this operation is more challenging to realize in smaller cities due to lower revenues and lack of service scale. Moreover, the dilemma becomes even more significant if environmental aspects are considered. With this new dimension of the problem, the tariffs to be applied in providing the services should be low enough to make the WSS accessible to the poorest and high enough to ensure at least the coverage of the operation and maintenance costs. Also, they need to serve as a brake on water wastage, acting as a reducer of exacerbated consumption (Favre and Montginoul, 2018; Nauges and Whittington, 2017; Suárez-Varela et al., 2015).

The most widely used charging methodology in water services is the Increasing-Block Tariff (IBT) (Nauges and Whittington, 2017; Whittington et al., 2015). The IBT is applied to the bill’s volumetric part based on incrementally charging the water consumption on blocks that characterize the consumption groups. In this strategy, lower values are charged in the lower consumption block to promote access to water for the poorest, having higher values in higher consumption blocks to prevent water waste. Using IBT is a strategy to address environmental, social, and economic aspects. Table 3.1 shows an example of the use of IBT. It is the tariff used by the company Águas do Porto, Portugal, to charge for water supply in the domestic category in the year 2021.

Table 3.1: Charging for water use by Águas e Energia do Porto using the IBT model.

Consumption Tariff		Availability rates	
Level	**€/m^3**	**Meter size**	**€/m^3**
1.° level (0-5 m^3)	0.5200	$\leq$ 25 mm	3.4684
2.° level (6-15 m^3)	0.9856	$>$ 25 e $\leq$ 30 mm	11,4457
3.° level (16-25 m^3)	1.8036	$>$ 30 e $\leq$ 50 mm	34,3372
4.° level ($>$ 25 m^3)	3.0661	$>$ 50 e $\leq$ 100 mm	103,0115
		$>$ 100 e $\leq$ 300 mm	309.0344

Adapted from the tariffs of the company Águas e Energia do Porto, available at https://www.aguasdoporto.pt/tarifario/tarifario.

Providers can incur loans through banking entities as a financial instrument to enable investment in water supply and sanitation infrastructures. The bank loan is a solution that can partially solve the incompatibility between the time needed for the receipt of revenues and expenses. With this strategy, the capital can be applied to the expansion of assets (*i.e.*, the system's infrastructures), and the respective amortization and interest payment are diluted in the expenses incurred in the future.

Finally, despite representing a small portion of the number of resources used in WSS management OECD (2018), transfers are considered a necessary financial instrument, particularly for low-income countries to expand their systems and improve their services. Therefore, municipalities with little or no tax collection base and revenues from tariff payments rely on financing through external investments to develop their water supply and sanitation infrastructure. Humphreys et al. (2018) noted that this dependence leaves these municipalities vulnerable to changes in financing and can also lead to inequalities as some municipalities are better at attracting investment funds than others. According to the authors, some small towns are thus faced with a double bias. First is an urban bias in which most public funding goes to large urban centers. The second is an investor bias, in which some towns favor project implementation due to favorable site characteristics.

3.4 Main Regulation Models on Price Setting

3.4.1 Introduction

The economic theory of regulation of sectors with natural monopoly characteristics has, basically, two models (Decker, 2014):

- Cost Regulation: defines the tariffs based on the costs incurred by the provider, ensuring cost recovery and fair remuneration;
- Price Regulation: it unburdens the provider's cost tariffs and stimulates operational efficiency through incentive mechanisms that allow for the appropriation of part of the surplus.

Each model has advantages and disadvantages. Its adoption depends on the context of the sector, its maturity, and its needs. In the sequence, a brief description of the two main models will be made and others with some relevance in the water sector regulatory context.

3.4.2 Cost of Service or Rate of Return Regulation

In this model, the tariffs are defined according to the provider's costs for maintaining a certain level of remuneration and are considered fair since they allow providers to recover the costs incurred and prevent the establishment of high profits, characteristic of the natural monopoly. It is represented by

$$R = Opex + s.(Base) \tag{3.1}$$

where R is the necessary revenue, $Opex$ is the operating expenses of the services, s is the 'fair' remuneration applied to the $Base$, which represents the net capital of the regulated company (Decker, 2014). In this case, the rate of return allowed (s) must be such that the company's revenues are equal to its costs so that the overall economic profit is zero. Among the advantages of this model are:

- business sustainability achieved by adapting tariffs to changing conditions over time;
- low business risk, as there is a guarantee of return on the capital invested;
- reduction of the cost of capital and attraction of investments;
- maintaining profits at an adequate level for both investors and consumers;
- continuous monitoring of profit; and
- the possibility of maintaining high-quality services.

However, there are serious disadvantages:

- there are no incentives to operate efficiently and reduce operating costs;
- emphasis on cost recovery can result in high tariffs;
- Guaranteed return on investment represents a stimulus to unnecessary or imprudent investments, as well as allocative inefficiency (capital to labor ratio), especially when the rate of return is attractive (Averch-Johnson effect);
- risk of accounting manipulation;
- high administrative costs for the regulator.

To maximize profit, the company tends to invest beyond what is necessary, including replacing labor with capital beyond the optimal point of allocative efficiency, known as the Averch-Johnson effect. Therefore, it is fundamental that the regulator monitors investments and considers only prudent, beneficial, and the use of investments based on remuneration. A striking feature of Cost Regulation is the absence of a pre-defined periodicity to review rates. The costs must be constantly monitored, and the revision is carried out when a perceived economic-financial imbalance occurs. The Cost Regulation model has allowed advances in the sectors in which it has been applied, mainly in expanding services and maintaining adequate quality. However, the most significant criticism of the Cost Regulation is the inexistence of incentives for efficiency, which often leads to swelling costs and high tariffs.

This regulation model is widely used in the water sector, particularly in the United States of America.

3.4.3 Price-Cap Regulation (Incentive Regulation)

Price-Cap regulation, one of the forms of Incentive Regulation, decouples the tariff from costs and aims to promote operating efficiency. Since prices do not keep pace with the costs of a particular provider, the surplus may be more significant if productivity is improved. Thus, profitability depends no longer on capital investments but can also come from cost reduction. This model is characterized by "RPI-X". The price revision reflects the inflationary update (retail price index) minus a factor x. The price adjustment equation is as follows (Marques, 2011):

$$P_{i,t} = P_{i,t-1} \times (1 + \frac{I_{i,t,t-1} - X_{i,t,t-1}}{100}) \tag{3.2}$$

where $P_{i,t}$ represents the maximum unit price of the service i in period t, $P_{i,t-1}$ the maximum unit price of service i in $t-1$ period, $I_{i,t,t-1}$ refers to the Price Consumer Index associated with the supply of service i, expressed in percentage, between period t and $t-1$, and $X_{i,t,t-1}$ a factor, in percentage, of the expected productivity gains between period t and $t-1$ in providing the service i.

The calculation of the correct price requires the forecast of future gains in productivity (Factor X), which is one of the biggest challenges for the regulatory agency. If the value of X is deficient, prices will be high concerning cost, generating a loss of welfare. Conversely, if the value of Factor X is high, prices will have a reduced limit, which may be insufficient to cover costs. Thus, the Price Cap Factor X model portrays the expected productivity gain of the Concessionaire in the years following each tariff review process. This gain is due to greater management efficiency over its operating costs and external effects such as the increase in the scale of the business and price variation. Thus, to comply with affordability, the productivity gain reflected in the provider's revenues must be shared with consumers and its effect passed on to tariffs.

The basic idea behind Price Regulation is that the regulator is at a disadvantage to the provider concerning the potential for operational efficiency due to the asymmetry of information (Jamasb and Pollitt, 2000). The evaluation of the provider's productivity change over time does not conclude whether it is the result of management effort or natural (related to external context) by more appropriate conditions. It is an approach that seeks, through rewards and penalties, to induce the provider to achieve desirable goals with greater freedom of action. The incentives replace regulation with command and control. The regulator's task evolves to defining appropriate tariffs for the provision of services in a regime of efficiency considering a virtual competition, without considering the level of costs incurred by the regulated provider, which tends to cause management effort for cost control. The main advantages of this model are (Decker, 2014):

- incentives to improve operational efficiency;
- mitigation of information asymmetry effects between the regulator and the regulated firm;
- discouragement of non-prudent investments;
- greater freedom of action for the provider;
- lower administrative costs for the regulator during the tariff cycle due to the simplicity of readjustments (only inflationary effects) between tariff reviews;

- greater price stability;
- possibility of establishing a price trajectory.

But there are also disadvantages:

- by decoupling tariffs from costs, more risk is allocated to the provider since variations in input and demand costs are not offset by the tariff;
- There is a higher risk of increasing the cost of capital, which can compromise investments;
- there may be deterioration in the quality of services or low investment in expansion;
- at the beginning of the cycle, there tends to be more significant investment in productivity gain, which results in increased remuneration, and, at the end of the cycle, an increase in capacity;
- possibility of high profits, which is not well accepted by society;
- risk of increased supplier indebtedness.

Regarding the two models above, there is a dilemma between incentives: investment in infrastructures or operational efficiency. By reducing the risk allocated to the provider and ensuring a return on invested capital, the Cost Regulation model is more appropriate for sectors that need significant investments. The Price Regulation model is more appropriate to increase efficiency in an already mature sector. The regulator can combine both models, adopting a hybrid approach that adds incentives to operational efficiency but does not entirely separate the prices from the provider's costs, ensuring economic-financial balance and low cost of capital by reducing risk.

It is important to emphasize that although they are treated as extremes of a scale, cost and price regulation models are not so different in practice. The main difference between the models is the period between tariff reviews. The price regulation model (Price-cap), when applied in short periods, does not provide the expected gain in productivity since regulated companies do not have time to absorb any reductions in costs (Laffont and Tirole, 1993). On the other hand, as there is usually a time gap between the determination of costs and the definition of prices in the "Rate of Return" regulation model, the regulated companies can undertake actions to reduce costs and thus claim this surplus.

The Price-cap model is widely used in the water sector, particularly in England and Wales, Italy, and Australia.

3.4.4 Revenue-Cap

The Revenue-cap regulation is similar to price regulation and based on the RPI-X equation. However, in this case, the regulatory agency defines the revenue-cap, which allows flexibility on the part of the regulated company in the definition of prices and in the control of demand (where the income 'R' represents the price 'P' multiplied by the quantity, or by the demand 'q'). While on the one hand, the regulation by revenue allows the removal of part of the risk related to the demand of the regulated company, on the other hand, it can induce the reduction of the quality of the services or actions aiming at the reduction of the demand to increase the prices. This type of regulation is currently adopted in Portugal's water supply and sanitation services by the regulator, Entidade Reguladora dos Serviços de Águas e Resíduos.

3.4.5 Yardstick competition

The Yardstick competition is essential for cases where regulatory agencies do not have accurate information on the regulated company's cost, demand, and expected productivity. Faced with this scenario, the regulatory agency may audit the company, comparing performance data with other similar companies. The performance of other companies becomes a benchmark to evaluate the performance of a given regulated company and thus estimate the value of the tariff. If this mechanism regulated all companies in the sector, the prices of each company would be independent of its cost structure. In this way, all companies would have an incentive to reduce costs to increase profits in the sector. Besides, a company that did not reduce costs, and showed poor performance compared to others, would be penalized in setting its price.

Armstrong and Sappington (2006) state that in yardstick competition, as companies are not at all similar, the analysis can be carried out with a cost or revenue function incorporating exogenous factors to normalize cost variations. Some countries that use benchmarking, such as England and Wales, use it in conjunction with the Price-Cap mechanism, allowing a higher price limit for the best-performing companies.

3.4.6 Sunshine Regulation

Regulators in many countries undertake benchmarking exercises (*i.e.*, the yardstick competition) as a means of public reporting on the comparative performance of different operators. This approach, sometimes referred to as 'sunshine regulation', is intended to 'name and shame' operators who are performing poorly, hoping that this will lead them to improved performance (*i.e.*, when the benchmarking performed in yardstick competition is made public to stimulate performance improvement). This approach has been adopted in Australia, Brazil, Germany, The Netherlands, and Portugal. For example, a study reviewing the impact of sunshine regulation in the Netherlands' water industry concluded that the regulation was associated with improved productivity in the industry, some of which had been passed through to consumers via lower prices (De Witte and Saal, 2010; Marques, 2008).

3.4.7 Regulation by Contract

The regulation by contract (menu-regulation) is a model in which prices, besides demand and performance estimates, are determined and controlled contractually. In this case, the companies regulated by this model already know how the revisions and readjustments of prices will be carried out. Also, the regulated company can choose, in agreement with the regulatory agency, if the performance goals will be more challenging, leading to greater returns to the company if the goals are met, or define more conservative goals that do not allow such a significant return. This regulatory model is widely adopted in France, where predominantly private entities provide water supply and sanitation services.

3.5 Brazilian water supply and sanitation services

3.5.1 Overview of Water Supply and Sanitation Services in Brazil

Brazil currently has 5570 municipalities. These municipalities comprise 26 Brazilian states and the Federal District (where Brasília, the Federal Capital, is located). In turn, the states are organized into five macro-regions: the North region with seven states; the Northeast region with nine states; the Southeast region with four states; the South region with three states and the Center-West region with three states and the Federal District as can be seen in Table 3.2.

Table 3.2: Identification of Brazilian states and their macro-regions.

State	Acronym	Macro-region
Acre	AC	
Amapá	AP	
Amazonas	AM	
Pará	PA	North
Rondônia	RO	
Roraima	RR	
Tocantins	TO	
Alagoas	AL	
Bahia	BA	
Ceará	CE	
Maranhão	MA	
Paraíba	PB	Northeast
Pernambuco	PE	
Piauí	PI	
Rio Grande do Norte	RN	
Sergipe	SE	
Espírito Santo	ES	
Minas Gerais	MG	Southeast
Rio de Janeiro	RJ	
São Paulo	SP	
Paraná	PR	
Rio Grande do Sul	RS	South
Santa Catarina	SC	
Distrito Federal	DF	
Goiás	GO	Center-West
Mato Grosso	MT	
Mato Grosso do Sul	MS	

Figure 3.5 shows the division of the states by Brazilian regions.

In developing the Brazilian water sector policy, municipalities are typically divided by size. Overall, while municipalities with more than 50,000 inhabitants have federal funds managed by the Ministry of Regional Development, those with less than 50,000 inhabitants have the funds under the responsibility of the National Health Foundation (FUNASA). Table 3.3 shows how the municipalities are divided according to size by Brazilian regions.

Figure 3.5: Map of the political division of the Brazilian states and regions.

Table 3.3: Brazilian Population in function of size and region.

	Total		Greater than 50,000 inhab.	
	Nº Municipalities	**Inhabitants (million)**	**Nº Municipalities**	**Inhabitants (million)**
Brazil	5570	210.1	673 (12%)	144.6 (69%)
North	450	18.4	74 (16%)	12.4 (67%)
Northeast	1794	57.1	184 (10%)	32 (56%)
Southeast	1668	88.4	260 (16%)	70.2 (79%)
South	1191	30	111 (9%)	18.9 (63%)
Center-West	467	16.3	44 (9%)	11.2 (69%)

Source:SNIS(2020)

Only 673 municipalities are classified as large (which corresponds to 12% of all municipalities). Nevertheless, they comprise 69% of the country's population. Although the Southeast region is behind the northeast region in the number of municipalities, it is the most populous in the country. Furthermore, it is noteworthy that the 260 large municipalities in the southeast region (or 12% of the municipalities) comprise almost 80% of the population in that region.

Brazil is one of the richest countries in surface water resources globally, with average flows generated in Brazilian territory totaling approximately 180 thousand m^3/s. According to the National Water Agency, the total surface water availability in the country is around 91 thousand m^3/s. Of the Brazilian municipalities, 47% are supplied exclusively by surface water sources, 39% by groundwater, and 14% by mixed sources (both surface and groundwater). Brazil's estimated population in 2019 was approximately 210 million inhabitants. The country's water supply service coverage is about 81%, with approximately 59.1 million connections and 680,362 kilometers of network. Despite the high coverage (which rises to 91% when considering only the country's urban areas), the public network does not supply almost 40 million people [1].

UN-Water [2] similarly found that Brazil has a securely managed water supply coverage level of 85.77%. The value is higher than the Latin America and Caribbean group of 75.38% and the world average of 74.27%, but far below the group of developed countries, represented by North America and Europe, with 95.57% (UN-Water, 2020).

The following information is from the National Sanitation Information System (SNIS), which will be explored in more detail in section 3.5.4.

In 2019, the water loss in Brazil was 39.2% (BRASIL, 2020), which represents the volume of water made available in the system and not consumed, whether due to leaks, failures in the measurement systems, or illegal connections. Water losses are characterized as technical inefficiencies inherent to any water supply system. It is a relevant issue in the face of water scarcity scenarios and high electricity costs and its direct relationship with the financial health of service providers since they can represent a waste of natural, operational, and revenue resources. Thus, the costs arising from losses should be minimized and subject to appropriate management because they are passed to the final consumer. Liemberger and Wyatt (2019) also identified that Brazil has a Non-Revenue Water level of 94 l/capita/d. The value is lower than observed in Latin America and the Caribbean (121 l/capita/d) and the United States (123 l/capita/d) but much higher than in Europe (50 l/capita/d).

Nevertheless, water losses are not homogeneous throughout the country. Of the five Brazilian macro-regions, the North region has the highest water losses, 55.7%, followed by the Northeast region, with 46.5% water losses. Conversely, the regions with the lowest value of this indicator are the Center-West and Southeast regions, with 31.7% and 36.3% (BRASIL, 2020).

Regarding sanitation, only about 54.1% of the Brazilian population has access to services, which means that almost 100 million Brazilians still lack access to sewage collection and treatment services. The most alarming access index macro-regions are the North and Northeast regions, with 12.3% and 28.3% access to sanitation services. However, even in the macro-regions with the best access rates (*i.e.*, Southeast and Midwest), the values are still significantly low (79.5% and 57.7%).

The indicator for coverage of safely managed sanitation services indicates a value of 48.71% for Brazil. Again, the value is higher than the average obtained for Latin America and the Caribbean (34.07%) but much lower than the group composed of North American and European countries (77.75%).

Table 3.4 shows the overall characterization of water supply and sanitation services in Brazil.

In Brazil, the municipalities are legally responsible for the water supply and sanitation services. They provide those services directly, indirectly, or by delegation. A department or secretariat inserted in the local administration operates the services in the direct provision. On the other hand, when the provision is indirect, the operator has a greater level of independence (*e.g.*,

[1] The non-service by the public network does not mean a lack of service. Part of this population (mainly in rural areas) is supplied by individual solutions (*e.g.*, wells and water trucks).

[2] UN-Water is an inter-agency mechanism that coordinates the efforts of United Nations entities and international organizations working on water and sanitation issues

Table 3.4: Characterization of Brazilian water supply and sanitation services.

Information	Unit	Value
Total population served with water supply	habitants	170,804,516
Number of total water connections	connections	59,132,877
Total water network length	km	680,362
Volume of water produced	1,000 m^3/year	16,613,022
Volume of water consumed	1,000 m^3/year	9,761,352
Average per capita water consumption	l/inhab/day	153.9
Distribution Water Losses	%	39.2
Total population served sanitation	habitants	110,300,342
Number of total water connections	connections	34,570,713
Total water network length	km	354,299
Volume of sewerage collected	1,000 m^3/year	5,826,685
Volume of sewerage treated	1,000 m^3/year	4,516,114

Source:SNIS(2020)

municipal company or autarchy). However, it is also part of the local administration. Finally, delegating the services to other public or private entities is also an option allowed by the Brazilian legislation. In these cases, the public entities delegated are usually the state-owned water and sanitation companies (Companhias Estaduais de Saneamento Básico - CESBs, in Portuguese) or a multi-municipal entity. Private entities have a local or multi-municipal scope.

It should be noted that the Brazilian regulatory framework does not restrict the privatization of CESBs. Companies such as SABESP, which operates in the state of São Paulo, and COPASA, in Minas Gerais state, have their stocks traded in the stock market. In Tocantins state, the state-owned company was privatized in the late 1990s and is now the only private regional entity, so this type of provision (*i.e.*, regional provision by private entities) may be a trend in the future.

It is also worth mentioning that in July 2020, law 14.026 was published, which updates the regulatory framework for the water supply and sanitation sector in Brazil. The most relevant innovations brought by the law were the greater openness to private participation in the sector and the incentive for scale gain. In addition, the National Water Agency became the central regulator for water supply and sanitation services. Furthermore, the agency became responsible for issuing reference standards for sub-national regulators.

3.5.2 Juridical Nature of water and sanitation service providers in Brazil

As referred above, the provision of water supply and sanitation services in Brazil is based on four main models (BRASIL, 2020):

1. Direct Public Administration (DPA) - This involves providing services directly by the City Hall through a department linked to it. In general, a secretary is designated to manage the services. In this model of service provision, the responsible bodies do not have financial or patrimonial autonomy. Service revenues and expenses are mixed up with the city government's budget since there are no instruments binding tariff revenues to the services. Examples of management entities based on this model are: the Secretariat of Public Services, Water and Sewerage of Birigui (Prefeitura Municipal de Birigui/São Paulo-SP) and

the Secretariat of Public Works and Services of Itatiaia (Prefeitura Municipal de Itatiaia/Rio de Janeiro-RJ);

2. Indirect Public Administration (IPA) - This is the provision of services through a decentralized entity, in this case, a municipal autarchy. The term autarchy is formed by two juxtaposed elements, autós (own) and arquia (command, government), meaning "own command, own direction, self-government". According to art. 5, clause I, of Decree-law no. 200/67 (Brazil, 1967), an autarchy is defined as an autonomous service, created by law, with legal personality, assets, and revenue of its own, to perform typical activities of the Public Administration, which require, for their best operation, decentralized administrative and financial management. This model of an entity may receive some names, such as the Autonomous Service of Water and Sewer - SAAE (Itabira/Minas Gerais-MG); the Superintendence of Water and Sewer - SAE (Araguari/MG), and the Municipal Autonomous Service of Water and Sewer - SAMAE (Tangará da Serra/Mato Grosso-MT);
3. State Companies - The State Companies of Basic Sanitation (CESBs) are entities whose creation is usually authorized by state law, being endowed with the legal personality of private law to explore economic activities or provide public services, being linked to governmental control to the purposes specified in the law. Some examples of this model of providers are the Companhia de Saneamento de Minas Gerais - COPASA and the Companhia de Saneamento Básico do Estado de SãoPaulo - SABESP;
4. Private Administration - This is the provision of services by companies with exclusively private capital by the delegation of the municipal government. Since the enactment of the Concessions Law of February 13, 1995, municipalities no longer have any legal impediments to privatizing their sanitation services. Furthermore, in 2004, Law No. 11.079 was published in Brazil, dealing with Public-Private Partnerships (PPP), a new instrument to do feasible projects destined for the country's growth, e.g., investments in sanitation. The PPP is an agreement signed between the public administration and private entities, which establishes a legal link between them, aiming at the implementation or management, in whole or in part, of services, undertakings, and activities of public interest (Brazil, 2004). According to SNIS data (BRASIL, 2020), entities with this management model are responsible for providing WSS in approximately 3% of Brazilian municipalities

It is noteworthy that all Brazilian states, except the state of Mato Grosso, have a CESB that operates in a monopoly within its boundaries[3]. Table 3.5 shows the distribution of water supply and sanitation services providers according to their Legal Nature.

Note that of the 28 CESBs, one has the practical legal nature of a private company, and three are indirect public administration, despite being all four State companies.

[3]The difference between a CESB and a multi-municipal entity is that the latter operates in two or more municipalities but has a smaller scope

Table 3.5: Distribution of the providers participating in the SNIS 2019 according to their Juridical Nature.

	Juridical Nature				
	DPA	**IPA**	**CESB**	**Private**	**Total**
Brazil	1063	440	28	109	1640
North	48	15	8	9	80
Northeast	214	91	9	4	318
Southeast	493	213	5	45	756
South	243	90	3	15	351
Center-West	65	31	3	36	135

Source:SNIS(2020)

Minas Gerais has two regional entities in the southeast region, COPANOR being a subsidiary of COPASA. The first one operates mainly in small municipalities and rural areas. In contrast, the second one, the main one, operates in most state municipalities.

Finally, despite the reduced number of CESBs, these entities are responsible for providing services to almost 80% of the country's population. It is noteworthy that, despite providing sanitation services in some municipalities, most CESBs are only responsible for water supply services, leaving the provision of sanitation services (if any) under the management of the municipalities. Figure 3.6 shows the distribution of the population served with water supply services (in million of inhabitants and percentage) according to the juridical nature of the provider.

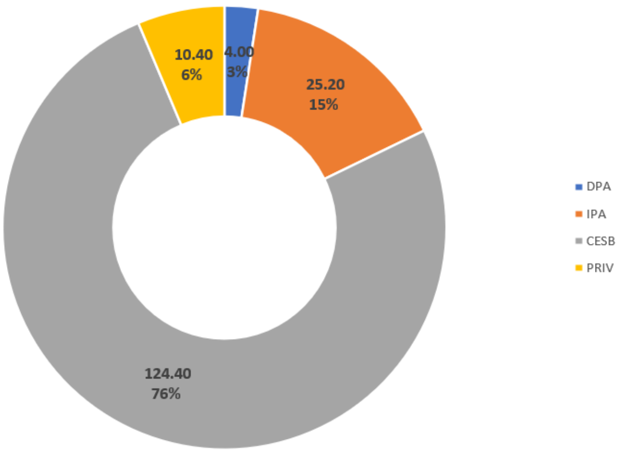


Figure 3.6: Population served according to the juridical nature of the provider.

3.5.3 Overview of expenses in Brazilian water services

According to the SNIS, the total operating revenue is the annual invoiced value resulting from the service provider's core activities. The total expenses (TOTEX) with services are the total annual value of all expenses incurred to provide the services. It is worth noting that the TOTEX value represents the sum of the Operating Expenses (OPEX) and the Capital Expenses (CAPEX) components. The SNIS only collects information on OPEX and TOTEX. Therefore, it is possible to estimate CAPEX by the difference between them. The service providers participating in the SNIS in 2019 reported total operating revenue of R$ 71.9 billion. The TOTEX totaled 62.4 billion, and the OPEX totaled R$ 46.1 billion in 2019.

In addition, total collection is the annual amount collected from all operating revenues, either directly in the service provider's cashbooks or through authorized third parties (banks and others). The total collection in 2019 was R$ 66.0 billion. The balance between collection and current expenses shows the cash capacity to pay current expenses, indicating the service providers' financial situation. In the SNIS, the Cash Sufficiency Index simulates this situation by dividing the total collection by the TOTEX. In 2019, the average indicator for providers participating in the SNIS was equal to 117.1%, revealing fine collection to cover current expenses.

The OPEX comprises expenses with own personnel, chemicals, electric power, third-party services, imported water, exported sewage, fiscal and tax expenses (operation-related), and other operating expenses. Figure 3.7 shows the percentages of each of the components in the total value of operating expenses of service providers participating in the SNIS in the year 2019.

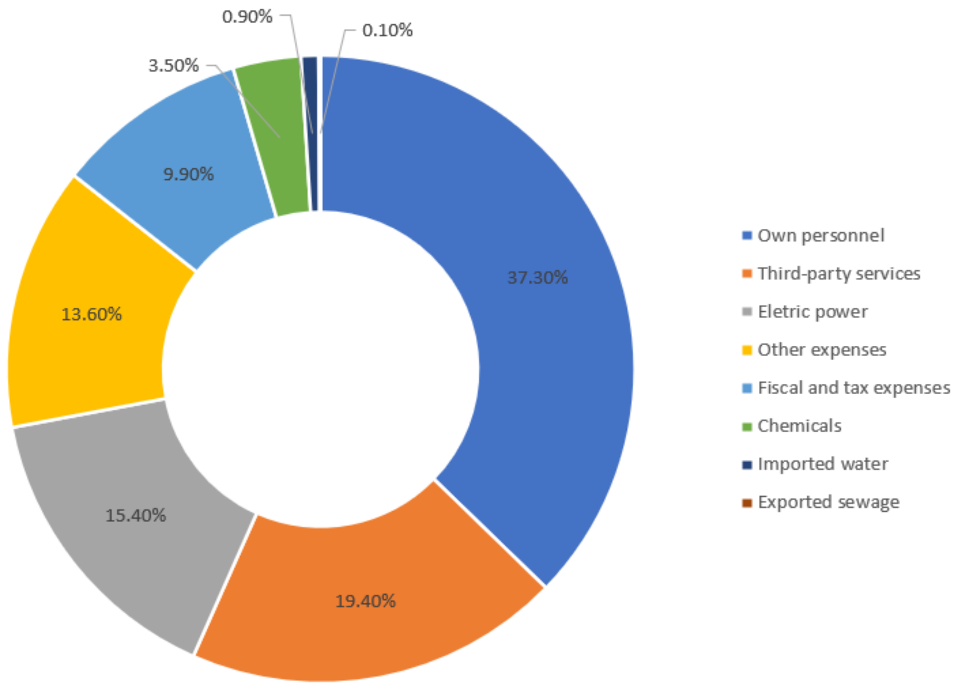


Figure 3.7: Average composition of operating expenses.

It is noteworthy that most of the operating expenses are related to own personnel expenses. For the whole set of service providers participating in the SNIS in 2019, the sum corresponds to R$17.2 billion. The other item that also refers to personnel expenses is the expense with third-party services, which in 2019 equals R$8.9 billion, equivalent to 19.4% of OPEX.

Therefore, the personnel configures the most significant OPEX component, corresponding to 56.7% (own personnel and third parties). The third more relevant component of OPEX is the expenses with electricity, which equaled in 2019 the amount of R$ 7.1 billion (15.4%). In addition, the following expenses are also significant: other operating expenses, with R$6.2 million (13.6%), and fiscal or tax expenses, with R$4.6 billion (9.9%). The other components combined (chemicals, imported water, and exported raw sewage) sum R$2.0 billion in 2019, about 4.4% of the total.

3.5.4 The Brazilian National Sanitation Information System

In Brazil, one of the primary sources of information on water supply and sanitation services is the National Sanitation Information System (SNIS). The SNIS is an instrument linked to the National Sanitation Secretariat (Secretaria Nacional de Saneamento, in Portuguese) of the current Ministry of Regional Development. It is the largest and most important information system in the Brazilian sanitation sector. a The system has a database containing information and indicators on the provision of water supply and sanitation services and urban solid waste management, and urban rainwater drainage and management. Its data are provided annually by the entities that manage the services (*i.e.*, state companies, municipal companies or city halls, and private companies). The information and indicators of the SNIS have an operational, administrative, financial, and quality character on the supply of services. Although not mandatory, the Brazilian federal government's investment programs currently request managing entities to send information regularly to the SNIS as a selection criterion.

The SNIS data and information are collected annually. This data collection and subsequent analysis and processing results in the diagnosis report of the water supply and sanitation services. The latest diagnosis was published in June 2020 and referred to data and information collected in 2019. Thus, even though the information refers to 2019, the reference for the last diagnosis will be SNIS (2020). The SNIS collected, in 2019, data regarding water supply from 5,126 municipalities, with an urban population of approximately 172.1 million inhabitants, ensuring the representativeness of 92% of the total number of Brazilian municipalities and 98% of the country's urban population. Concerning data on sanitation services, 3,865 municipalities and an urban population of approximately 161.4 million inhabitants were covered, representing 69.4% of the total number of municipalities and 91.9% of the urban population in Brazil. a One of the limitations of the SNIS is that it cannot characterize the supply of water and sanitation services in places where the service provider is not clearly defined (Nirazawa, 2016), such as households located in rural areas.

The original conception of the SNIS is based on implementing a nationwide system consisting of a database on the WSS, managed at the federal level, integrating a decentralized and articulated network aimed at enabling the control of the services under a more comprehensive approach.

The SNIS includes operational, financial, and administrative information provided by the managing entities. The data can be explored at the provider level and the municipality level.

At the federal level, these data are intended for the planning and execution of public policies, aiming to guide the selection of investments, the construction of action strategies and the monitoring of programs, and the evaluation of services' performance. In addition, these data contribute to the regulation and supervision of service provision at the state and municipal levels, which is expected to raise the efficiency and effectiveness of the services' entities. Thus, comprehending the reality, the government can guide the selection of investments, reduce costs, and set appropriate tariffs, encouraging the participation of society in social control, monitoring, and evaluation of the effects of public policies.

In SNIS, information of the same nature constitutes groups whose summary is presented in the Diagnosis of Water and Sewage Services (SNIS, 2020). The information is identified by alphanumeric codes, where the letters indicate the groups, and the numbers identify the primary information. As it follows:

- Operational information of water supply systems (code initiated by the letter A): corresponds to the operational data of water supply systems, such as number of connections, number of consumer units, volumes, network extension, and other similar data;
- Economic and financial information (code initiated by the letter B): corresponds to data extracted from the companies' balance sheets;
- Operational information of domestic sanitation systems (code initiated by letter E): corresponds to operational data of domestic sanitation systems, such as number of connections, number of consumer units, volumes, network extension, and other similar data;
- Financial information (code initiated by the letter F): corresponds to data on revenue, expenses, and investments made in the reference year. The information is calculated in a manner compatible with the accounting legislation that governs each type of service provider;
- General information (code initiated by letter G): corresponds to general data on the provision of services, such as the status of the concession contracts, the number of municipalities and localities served, the total population and urban population, and the number of employees of the service provider;
- Information on the quality of services (code initiated by letter Q): corresponds to data on the quality of services, such as the number of water system shutdowns, sewage overflows, the quality of the water distributed, and intermittences in water supply systems.

The SNIS database comprises 195 primary information elements aggregated by their respective families. The most important information for the development of this work is those related to operational aspects (families A and E) and financial aspects (family F).

3.5.5 Indicators

The SNIS database is composed of 84 indicators, calculated from the primary information referred to in the section 3.5.4 and classified by types:

- Operational water supply indicators (22);
- Accounting balance indicators (9);
- Sanitation operational indicators (8);
- Economic-financial and administrative indicators (32);
- Quality indicators (13).

The main indicators are identified as shown in the Tables 3.6, 3.7, 3.8, 3.9.

Table 3.6: Economic-financial and administrative indicators.

Indicator	Unit	ID
Total expenditures per m^3 sold	R$/$m^3$	IN003
Operating expenditures per m^3 sold	R$/$m^3$	IN026
Operating expenditures per consumer unit	R$/year/unit	IN027
Average tariff	R$/$m^3$	IN004
Water average tariff	R$/$m^3$	IN005
Wastewater average tariff	R$/$m^3$	IN006
Financial performance indicator	percentage	IN012
Revenue evasion rate	percentage	IN029
Incidence of personnel and third-party service expenditures on total expenditures	percentage	IN007
Average annual expenditures per employee	R$/employee	IN008
Operating expenditures margin	percentage	IN030
Expenditures with own personnel margin	percentage	IN031
Total personnel expenditures (equivalent) margin	percentage	IN032
Debt service margin	percentage	IN033
Other operating expenditures margin	percentage	IN034
Share of expenditures with own personnel in operating costs	percentage	IN035
Share of total personnel expenditures (equivalent) in operating expenditures	percentage	IN036
Share of electric power expenditures in operating expenditures	percentage	IN037
Share of expenditures on chemical products in operating costs	percentage	IN038
Share of other expenditures in operating expenditures	percentage	IN039
Share of direct water operating income in total operating income	percentage	IN040
Share of direct operating income from wastewater in total operating income	percentage	IN041
Share of indirect operating income in total operating income	percentage	IN042
Billing days committed to receivables	days	IN054
Equivalent total staff	employees equiv.	IN018
Productivity index: active consumer units per total staff (equivalent)	units/employee.equiv.	IN019
Total staff productivity index (equivalent)	connections/employee equiv.	IN102
Productivity index: own employees per 1,000 water + wastewater connections	employees/1,000 conn.	IN048
Productivity index: active consumer units by own personnel	unit/employee	IN002
Productivity index: own employees per 1,000 water connections	employees/1,000 conn.	IN045
Cash sufficiency ratio	percentage	IN101
Consumption of electricity in water and sewage systems expenditures index	R$/kWh	IN060

Table 3.7: Operational water supply indicators.

Indicator	Unit	ID
Total water coverage index	percentage	IN055
Urban water coverage index	percentage	IN023
Density of water consuming units per connection	units/connection	IN001
Share of residential water consuming units in total water consuming units	percentage	IN043
Macro meter index	percentage	IN011
Water metering index	percentage	IN009
Micrometer index of available volume	percentage	IN010
Water metered relative to consumption	percentage	IN044
Water fluoridation index	percentage	IN057
Water consumption index	percentage	IN052
Volume of water available per consumer unit	m^3/month/unit	IN025
Average water consumption per consumer unit	m^3/month/unit	IN053
Metered consumption per consumer unit	m^3/month/unit	IN014
Billed water consumption per consumer unit	m^3/month/unit	IN017
Average water consumption	L/inhab. x day	IN022
Electricity consumption index in water supply systems	kWh/m^3	IN058

Continuation of Table 3.7

Indicator	Unit	ID
Water network length per connection	m/conn.	IN020
Revenue water index	percentage	IN028
Non-revenue water index	percentage	IN013
Water losses in distribution	percentage	IN049
Gross linear loss index	m^3/day/km	IN050
Water losses per connection index	L/day/conn.	IN051

Table 3.8: Operational wastewater indicators.

Indicator	Unit	ID
Total wastewater coverage index	percentage	IN056
Urban wastewater coverage index	percentage	IN024
Urban wastewater coverage index referring to municipalities served with wastewater	percentage	IN047
Wastewater collection index	percentage	IN015
Wastewater treatment index	percentage	IN016
Treated wastewater referring to water consumed index	percentage	IN046
Wastewater network length per connection	m/conn.	IN021
Index of electricity consumption in wastewater sanitation systems	kWh/m^3	IN059

Table 3.9: Quality of service indicators.

Indicator	Unit	ID
Consumer units hit by stoppages	unit/stop.	IN071
Average duration of stoppages	hours/stop.	IN072
Consumer units hit by intermittent	unit/interm.	IN073
Average duration of intermittent	hours/interm.	IN074
Average duration of wastewater overflow repairs	hours/overflow	IN077
Wastewater overflows by network extension	overflow/km	IN082
Average duration of services performed	hours/service	IN083
Sample quantity compliance index - residual chlorine	percentage	IN079
Incidence of out-of-standard residual chlorine analysis	percentage	IN075
Sample quantity compliance index - turbidity	percentage	IN080
Incidence of non-standard turbidity analysis	percentage	IN076
Sample Quantity Compliance Index - total coliforms	percentage	IN085
Incidence of total coliform analyses outside the standard	percentage	IN084

It is noteworthy that the classification of the SNIS dataset is basically by municipality, state, name of the service provider, the scope of the provider's activities (*i.e.*, local, multi-municipal, or regional), legal nature of the provider (*i.e.*, direct public entity, indirect public entity, regional public or private entity and private entity) and type of service provided (*i.e.*, water supply and sanitation only).

It should be noted that several entities can provide the services in the same municipality. For example, the municipality of Água Boa in Minas Gerais has the water supply service provided by two regional entities, COPASA and COPANOR (COPASA's subsidiary that operates in specific state regions). On the other hand, the local administration operates the sanitation services directly. In turn, the municipality of Rio das Ostras, in the state of Rio de Janeiro, has three service providers: a municipal authority (indirect public management) that operates the water supply and sanitation services in part of the municipality; CEDAE (the Rio de Janeiro State CESB) operates the water supply service in another part of the municipality; while a private entity (BRK Ambiental) is responsible for the sanitation services. The complexity of the organizational structure of water and sanitation services provision in the country is thus evident.

Finally, it is important to note that a project called "Projeto Acertar" is being developed in Brazil. The project aims to qualify the information in the SNIS in the process of guidance to providers of best practices in information management and to develop a process of audit and certification of information by regulators.

3.6 Performance Monitoring in the Water Sector

In their most clear conception, indicators are tools whose primary purpose is to represent the condition of a system. The Organisation for Economic Cooperation and Development (OECD) has defined an "indicator" as a parameter, or a value derived from parameters, that points to provide information about, describes the state of a phenomenon/environment/area, with a meaning beyond that directly associated with a parametric value (OECD, 2006). Indicators are essential tools for evaluating a specific action, situation, or event since they aggregate information essential for the user's knowledge. In addition, indicators can monitor a given situation over time.

Performance indicators (PIs), in this same way, are tools used in various sectors to assess the situation, punctually or continuously, of a particular activity or process. PIs are tools used in the management universe to help define objectives and goals and control whether the results are achieved.

In addition, they are used for strategic planning and results control. A performance indicator should contain in itself relevant information. However, it is inevitably a partial view of management reality, generally not incorporating all its complexity. Thus, its decontextualized use may lead to misinterpretations. It is always necessary to analyze performance indicators and consider the context in which they are inserted.

Performance evaluation systems based on indicators are frequently used in various industries and sectors, mainly due to their unquestionable potential to monitor entities' processes and support their management. Organizations increasingly recognize the value of these tools due to the added value for companies, given the potential to promote the monitoring and control of deviations from desirable goals at various levels and processes. Performance evaluation systems also help define and pursue the entity's general objectives in the use of resources and in assessing user satisfaction.

Typically PIs have to be objective enough to convey the intended message. In this case, the information should be as complete and reliable as possible to avoid inaccurate results and biased interpretations. Additionally, PIs allow for utility performance benchmarking. However, practitioners should consider that different entities produce information and indicators according to their own needs and standards. Therefore, benchmarking that uses varied sources of information should be conducted with caution.

A performance indicator system comprises a set of the following essential components (ISO, 2007):

- Variables;
- Contextual information;
- Performance indicators.

Additionally, performance indicators should be uniquely and collectively suited to represent the relevant aspects of the service in a reliable and unbiased manner. Each performance indicator should (ISO, 2007):

- Be clearly defined, with a concise and unambiguous interpretation;
- Be assessed from variables that are easily and reliably measured at a reasonable cost;
- Contribute to the expression of the current level of performance achieved in a given domain;
- Correspond to a specific geographical area (and, in the case of comparative analysis, it should be for the same geographical area);
- To be related to a specific period (*e.g.*, annual, quarterly);
- Allow a clear comparison with the objectives pursued and simplify an analysis that would otherwise be complex;
- To be verifiable;
- To be simple and easy to understand;
- To be objective and avoid personal or subjective judgments.

It is clear that, in addition to the indicators chosen, the search for contextual elements that complement this analysis is a work of high importance, which can mean the achievement or the loss of robustness of the results. Thus, performance indicators will typically be used as internal management indicators. Finally, it is important to stress that the comparison of performance indicators of providers should always be cautious, correctly analyzing the differences and specificities of each one within a local contextualization.

In the water sector, performance indicators are typically expressed by ratios between variables (operator data) (Alegre et al., 2016). They can be non-dimensional (*e.g.*, in %) or intensive, *i.e.*, somehow expressing intensity rather than extent (*e.g.*, in $US\$/m^3$). In the latter case, the denominator should represent a dimension of the system under analysis or the operator (*e.g.*, number of household branches, length of pipelines, annual costs). The use of variables that are likely to vary significantly from year to year due to factors external to the operator (*e.g.*, water consumption, which depends, for example, on climate) should not be adopted as a denominator unless this variation is reflected in the numerator in the same proportion (Alegre et al., 2016).

Consequently, as a tool to support the management of water utilities, PIs should be used strategically. Their use should assist the definition and control of targets achievement (*e.g.*, reduction in water losses by 2% per year or the increase in service coverage by 10%). In this sense, PIs should help define short, medium, and long-term goals and support the construction of strategies adopted by municipalities to achieve these goals. They also control deviation from intended performance over time, enabling corrections and operational adjustments.

The Brazilian legislation institutionalizes the use of performance indicators, so their use is typically integrated into WSS's planning, regulation, and supervision (Sperling and Sperling, 2013).

The authors point out that several organizations have developed, over the last decade, indicators with different objectives and priorities. Among these organizations, the following had a prominent role in the development of indicators for the water sector in recent years: International Water Association (IWA), Entidade Reguladora dos Serviços de Águas e Resíduos de Portugal (ERSAR/IRAR), Asociación de Entes Reguladores de Agua Potable e Saneamiento de las Americas (ADERASA), International Benchmarking Network for Water and Sanitation Utilities (IBNET), Six-Cities Group from Scandinavia, Water Services Association of Australia (WSAA), American Water Works Association (AWWA) and Office of Water Services (OFWAT). In the water supply and sanitation sector, PIs are management tools used to evaluate the efficiency of WSS provision. They can have an operational, financial, management, and quality character.

Haider et al. (2014) conducted a review of water supply and sanitation performance assessment frameworks and their respective PIs and concluded that most of these frameworks were built for large systems. The authors evaluated the PIs individually concerning their understandability, measurability, comparability, and evaluation framework to simplicity and understandability.

The result of the evaluation is presented in Table 3.10. According to Table 3.10, the IWA system (Alegre et al., 2009) was the most suitable for municipalities with lower technical capacity (Haider et al., 2014). Indeed, the IWA system provides a wide variety of PIs with a comprehensive classification system (Haider et al., 2014). The finding that the IWA indicators are the most suitable may derive from the fact that the system was developed in ranges varying from 1 to 3, depending on the availability of data and information in the management entities (Alegre et al., 2016).

Table 3.10: Suitability of the indicator system for use in municipalities with lower technical capacity.

	Performance Indicators			**Performance Assessment Framework**		
Performance assessment system	Understandability	Measurability	Comparability	Simplicity	Comprehensiveness	Overall applicability to SM-WSS utilities
WB (2011)	Medium	Medium	Low	Medium	Medium	Medium
OFWAT (2012)	Low	Medium	Low	Low	Medium	Low
ADB (2012)	Low	Medium	Medium	Low	Medium	Medium
NWC (2012)	High	Low	Low	Medium	Medium	Medium
NRC (2010)	Low	Medium	Low	Medium	Low	Low
IWA (2006)	Medium	Medium	High	Medium	High	High
AWWA (2008)	Low	Medium	Low	Low	Medium	Low
CSA (2010)	Medium	Medium	Medium	Low	Medium	Medium

Source:Haider et al. (2014)

Based on the analysis of indicators and evaluation frameworks, Haider et al. (2014) proposed a conceptual performance evaluation system for small municipal utilities based on a list of PIs grouped as follows:

- Water resources and environment;
- Personnel and employees;
- Physical and patrimonial infrastructure;
- Operational;

- Water quality and public health;
- Quality of services;
- Financial services and economic indicators.

The conceptual system proposed by Haider et al. (2014) has many similarities with the system proposed by IWA, including the division by information levels (further information, see Haider et al. (2014)).

It should be noted that the technical and administrative capacity hampers the small municipalities' ability to collect and use performance indicators. Thus, the adequacy of the structure proposed by Haider et al. (2014) derives from the possibility of being built on a layered basis, where the municipality can start building its indicator base with more basic information.

Some indicators that are considered fundamental for a minimum monitoring of the services are, among others, the volume of water produced (or delivered to the supply system), the volume of water consumed (or billed), the annual operating expense of services, and the respective annual revenue. Consequently, as services evolve, the information (and indicators) base keeps pace with this evolution.

3.7 Conclusions

This chapter presented an overview of the Brazilian water sector. It has been shown that despite the small number of large municipalities (*i.e.*, with more than 50,000 inhabitants), they contain almost 70% of the country's entire population. This reality suggests that a large part of the structural problems of water supply and sanitation are concentrated in the large metropolises, with their economic and social inequalities.

Regarding the coverage of services, it was shown that despite the good access of the population to water supply services, almost half the population has no access to sanitation services, which represents almost 100 million Brazilians without sanitation. In addition, almost 1.5 billion cubic meters of collected sewage is discharged untreated into the environment.

The chapter also addressed the concepts used in financing water supply and sanitation services and explored the main regulatory models in the sector.

Finally, the leading international frameworks for performance indicators in the water sector were presented. In addition, the Brazilian performance indicator framework, the National Sanitation Information System (SNIS), was further explored.

CHAPTER 4

Expenditures of Water Supply and Sanitation Services in the state of Mato Grosso

This chapter aims to present an exploratory analysis of the water supply and sanitation services expenses in Mato Grosso based on the SNIS indicators. In addition, the financial sustainability of the services will be addressed, and the most representative components of operating expenses will also be identified. The importance of this chapter in the context of this Thesis is to explore the financial variables of water supply and sanitation services through a simplified case study covering the year 2017 in a state with large territorial dimensions and good information sources.

4.1 Introduction

The state of Mato Grosso was chosen because there is reliable data available about its water supply and wastewater drainage services, namely because it was one of the first Brazilian states to have municipal water supply and sanitation plans in almost all of its municipalities. Moreover, Mato Grosso is a state with two unique characteristics. Firstly, the state comprises in its territory three different large hydrographic basins (*i.e.*, Amazon Basin, Tocantins-Araguaia Basin, and Paraguay Basin), which guarantees a great environmental diversity. Secondly, it is the only state in Brazil that does not have a state sanitation company, which allows for a better evaluation at the municipal level.

4.2 The State of Mato Grosso

Located in the Brazilian Center-West region, Mato Grosso is the largest state in the territorial extension of that region and the third-largest in the country. The state has an area of approximately 903,329.7 km^2. It borders the states of Goiás (to the east), Tocantins (to the northeast), Pará (to the north), Amazonas (to the northwest), Rondônia (to the west), and Mato Grosso do Sul (to the south), in addition to having a small border with Bolivia in the southwestern portion of the state (Figure 4.1).

Its territorial extension corresponds to 10.6% of the Brazilian territory. The last census conducted by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e

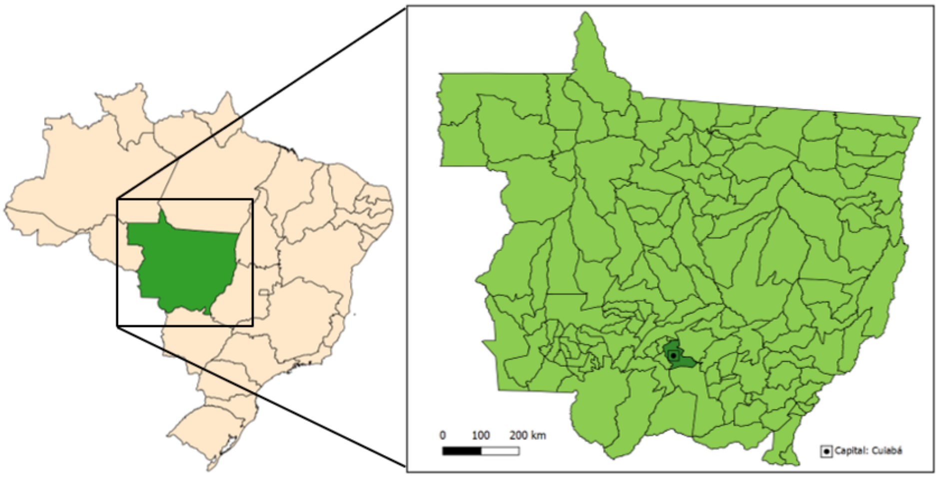


Figure 4.1: Location of the state of Mato Grosso.

Estatística - IBGE, in Portuguese) found that the population of Mato Grosso reached 3,035,122 inhabitants in 2010, with the majority living in urban areas (82%). For 2017, the IBGE estimated the state's population at 3,344,544 inhabitants. The state's demographic density is the lowest in the Center-West (only 3.3 inhabitants per km^2). The demographic growth was estimated at 2.4% per year. The state of Mato Grosso has 141 municipalities. However, the state's population is unevenly distributed, with demographic gaps in the northern part and populous urban areas, such as, for example, its capital, Cuiabá (551,098 inhabitants), and Várzea Grande (252,596 inhabitants).

Also, according to IBGE, the topography is slightly rugged, composed of plateaus in the center, with altitudes between 400 and 800 m, plains with swamps to the west, depressions to the south, and residual plateaus to the north. The highest point in Mato Grosso is Serra Monte Cristo, 1,118 m high. The state vegetation comprises Cerrado in the eastern territory (40% of the state area), Amazonian forest to the northwest, and Pantanal to the west (10% of the territory). The state economy is associated with agriculture and cattle raising. This activity is responsible for 28.1% of the state's Gross Domestic Product (GDP). At the same time, the service sector, representing 55.5% of the GDP, is highly dependent on agriculture and cattle-raising. Mato Grosso is the largest national cotton producer (of the 35 largest cotton producers in the country, 20 municipalities are from Mato Grosso). The production of cereals and oilseeds also stands out.

The Human Development Index (HDI) of the state of Mato Grosso is 0.796, occupying the 11^{th} position in the national hierarchy. The infant mortality rate is the highest in the Midwest - 19.2 deaths per thousand children born alive.

4.3 The state's Water Supply and Sanitation Services

The state of Mato Grosso is the only state in Brazil that does not have in its administrative structure a state company that manages water supply and wastewater drainage services, such as SABESP in São Paulo or COPASA in Minas Gerais. Thus, the management of WSS in the state of Mato Grosso is decentralized and adopts three basic types of structure (Table 4.1 and Figure

4.2): i) direct management by the municipalities, through a body within the city hall structure (*e.g.*, municipal secretariat, works department); ii) direct management by the municipality but by entities with greater autonomy, called autarchies (*e.g.*, autonomous water services, water, and sewage department) and iii) concession of the services to private entities.

Table 4.1: WSS management models in the state of Mato Grosso.

Management model	Number of municipalities	%	Population	%
Direct Public Administration	63	56.8	614.132	20.0
Indirect Public Administration (Autarchies)	12	10.8	906.196	29.5
Private Administration	36	32.4	1.552.661	50.5
Total	111	100	3,072,989	100

Note: Table prepared based on SNIS data (reference year 2017), which presents information on 111 of the 141 municipalities in the state of Mato Grosso.

It is important to note that the state of Mato Grosso has followed the national trend of granting the WSS to private administration entities. The population in the 111 municipalities of Mato Grosso that provided information to the SNIS in 2017 totals 3,072,989 inhabitants, representing 91.88% of the estimated population for that year. Thus, based on the information analyzed, it is possible to understand that more than half of the state's population of Mato Grosso is already served by private companies in approximately one-third of its municipalities (Table 4.1 and Figure 4.2).

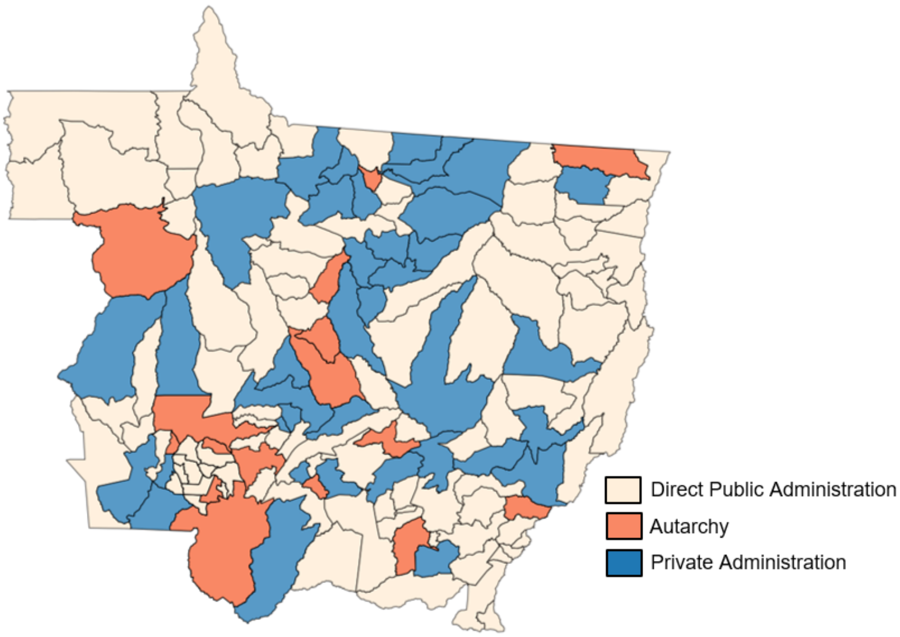


Figure 4.2: WSS management type classification in the state of Mato Grosso.

As previously mentioned, the state of Mato Grosso, despite being preponderantly focused on agricultural practices, has a large part of its population in urban areas. Furthermore, of the 141 municipalities in the state, only 11 have a population greater than 50,000 inhabitants, with most municipalities having less than 10,000 inhabitants (Table 4.2 and Figure 4.3).

The characterization allows us to conclude that more than 90% of the municipalities in Mato

Table 4.2: Stratification of population groups in the state of Mato Grosso.

Population size	Number of municipalities
Less than 10,000 inhabitants	67
10 to 20,000 inhabitants	37
20 to 50,000 inhabitants	26
More than 50,000 inhabitants	11

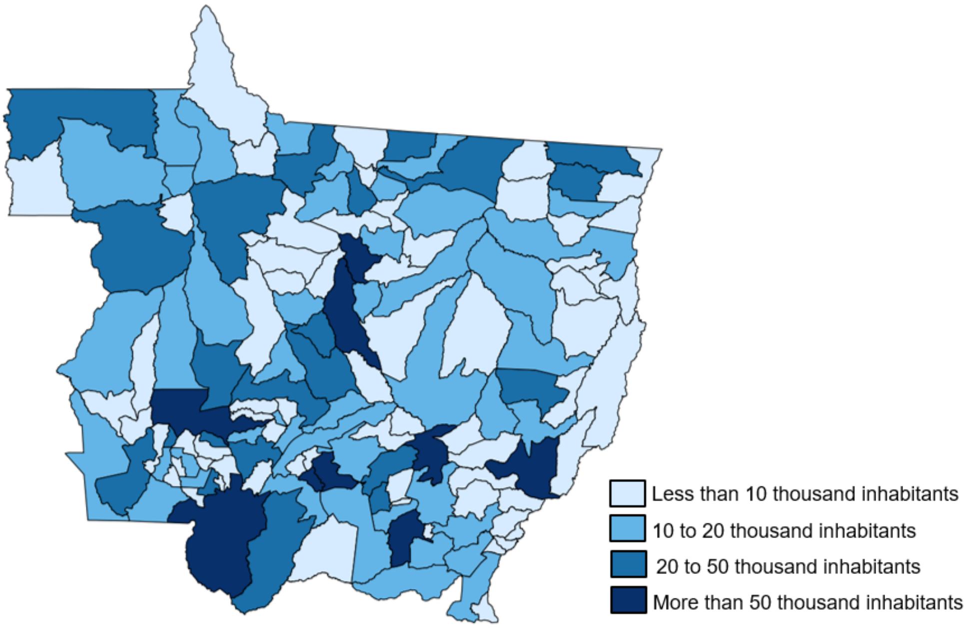
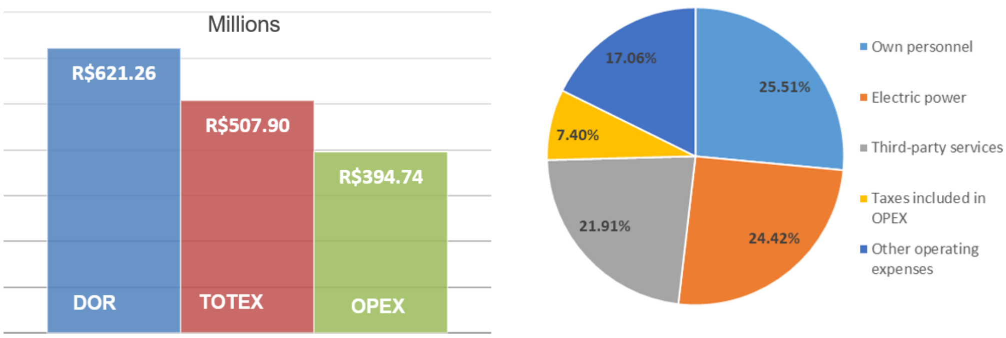


Figure 4.3: Classification of the Mato Grosso municipalities based on their population.

Grosso can be classified as small municipalities (in parallel with the national situation, where 88% of the municipalities are small). On the other hand, the large municipalities contain almost 70% of the population, which may justify a more immediate governmental action in the large metropolises.

4.4 Operating expenses and total expenses in the water services provision

According to SNIS data (2019), the state of Mato Grosso presents, on average, financial performance of 122.32%, an indicator that corresponds to the ratio between direct operating revenues (DOR) and total service expenses (TOTEX) (Figure 4.4a). The TOTEX is the total annual value of all expenses incurred to provide the services. It is the sum of the operating expenses (OPEX) and the capital expenses (CAPEX). CAPEX are expenses with interest and debt charges (including expenses arising from monetary and exchange rate variations), expenses with depreciation, amortization of deferred assets, and provision for doubtful accounts, fiscal or tax expenses not included in the OPEX but that make up the TOTEX, in addition to other expenses with the services. Usually, the OPEX represents a significant part of the TOTEX. In Mato Grosso's state, the OPEX represents 77.72% of the TOTEX (Figure 4.4a). In Figure 4.4b, it is possible to observe the various components of the OPEX.



(a) (b)

Figure 4.4: Average financial performance of the managing entities in the state of Mato Grosso for the year 2017 (a) and average composition of operating expenses for the year 2017 (b).

It can be concluded that the portions that contribute the most to the operating expenses in the state of Mato Grosso are those related to labor (*i.e.*, own personnel, and third-party services, representing together 47.42%) and electricity (24.42%). Thus, any strategy involving reducing operating costs in the state should consider aspects such as energy efficiency and optimized management of human resources.

The fiscal or tax expenses included in the OPEX refer to the annual value of expenses with taxes, fees, and contributions, whose costs belong to the set of operating expenses, namely the Social Integration Program (PIS), the Public Service Employee Savings Program (PASEP) and the Contribution for Social Security Financing (COFINS), the motor vehicle property tax (IPVA), the urban land and property tax (IPTU), union contributions and public service fees.

It is important to mention that a legislative update in 2003 changed the taxation regime from cumulative to non-cumulative, which allowed the taxes included in the prices of the inputs acquired by an entity to be discounted from the tax payable. Thus, for example, an entity can discount from the COFINS and PIS/PASEP the taxes paid on the purchase of chemicals for water treatment or the purchase of meters or equipment for network maintenance. However, these legislative changes seem to have harmed the water sector because its production chain is short, accumulating minor credits to be discounted. Also, as shown above, its operational costs are primarily concentrated in personnel expenses, which do not generate credits to be discounted in the payment of PIS/COFINS. This situation causes the WSS managing entities to have an excessive tax burden for providing a type of service considered essential.

The SNIS designates the "other operating expenses" as those not included in the previous expenses (own personnel, third-party services, electricity, and fiscal or tax expenses). In this work, "other operating expenses" include expenses related to the import (purchase) of treated water, expenses with chemical products, and the export (sale) of raw wastewater (untreated) because they are not very representative (concerning their values, although the cumulative amount of all other expenses ends up representing little more than 17% of operating expenses, Figure 4.6).

It is essential to understand how the performance of the WSS operating expenses is in the municipalities of the state of Mato Grosso. Thus, in Figures 4.5 to 4.8, the relationships between some of WSS characteristics and the structure of expenses are presented.

From the analysis of Figure 4.5, it seems clear that population size does not influence the cost structure of municipalities concerning the OPEX. The less populated municipalities and those with more inhabitants can present a similar cost structure. On the other hand, municipalities with similar populations present different spending structures. Nevertheless, the predominance of the Labor and Electricity components is notable. There are municipalities in which expenses with labor and electricity represent 100% (or close) of the total expenses related to the WSS. Finally, the inequality in tax expenditures is remarkable, which is explained by the different revenue levels of the water and sanitation service providers, which serve as the basis for calculating taxes.

Figure 4.6 shows the relationship of the different components of OPEX and the population of the municipalities in the state of Mato Grosso with less than 50,000 inhabitants that provided information to the SNIS, namely concerning labor expenses (Figure 4.6a), electricity expenses (Figure 4.6b), fiscal and tax expenses (Figure 4.6c), and other expenses (Figure 4.6d). Although the relationship between the parameters is always positive (*i.e.*, as one grows, so does the other), the dispersion of values around the trend line is significant. It is worth clarifying that regressions showed in Figure 4.6 presented statistical significance (p-value = 0.000). The tax expenditures (Figure 4.6c) are the only component that does not have a significant association with the municipalities' population ($R^2 = 0.21$). This result is somewhat unexpected since more customers suggest a more extensive tax collection base (as mentioned earlier, taxes are collected based on revenues). As expected, all other components of OPEX show a positive and significant correlation with the population size of the municipalities, since the larger the municipality, the greater the need for labor to maintain service infrastructures. In addition, the population growth of cities demands higher capacity infrastructures, which is also reflected in a greater need for electricity.

An analysis considering unitary costs (i.e., the value of each component of OPEX divided by the population), reinforces the dispersion of the expenses in the different municipalities (Fig 4.7). Furthermore, the results showed that only the electricity expenses component showed a downward trend due to population increase, suggesting that electricity expenses can get a more significant advantage from economies of scale.

Figure 4.8 shows that the TOTEX becomes more distant from the OPEX as the population increases. This result indicates that more populous municipalities have proportionally higher CAPEX than smaller municipalities. In fact, the municipalities can allocate part of the resources to extra operational expenses, such as system expansion and modernization investments.

It is noteworthy that although costs are expected to grow with population growth, the focus of the investigation is more on the dispersion found in spending in the different municipalities.

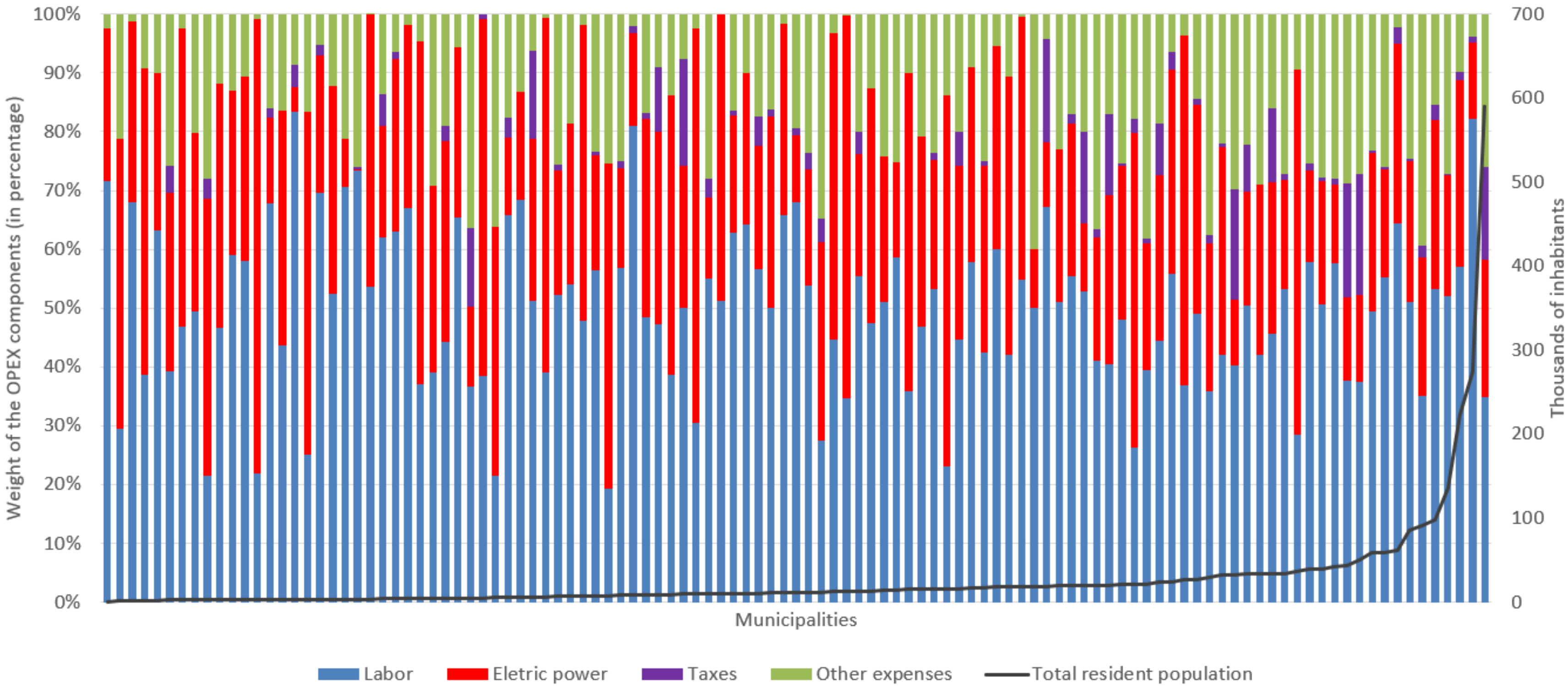
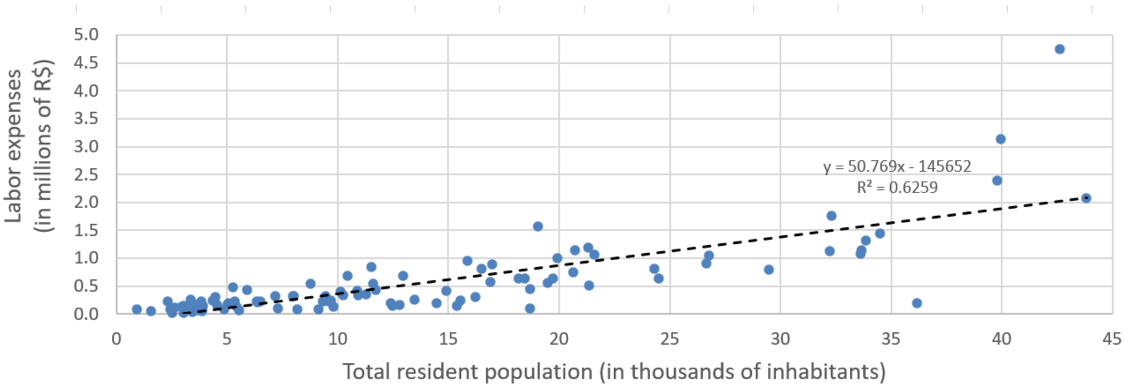
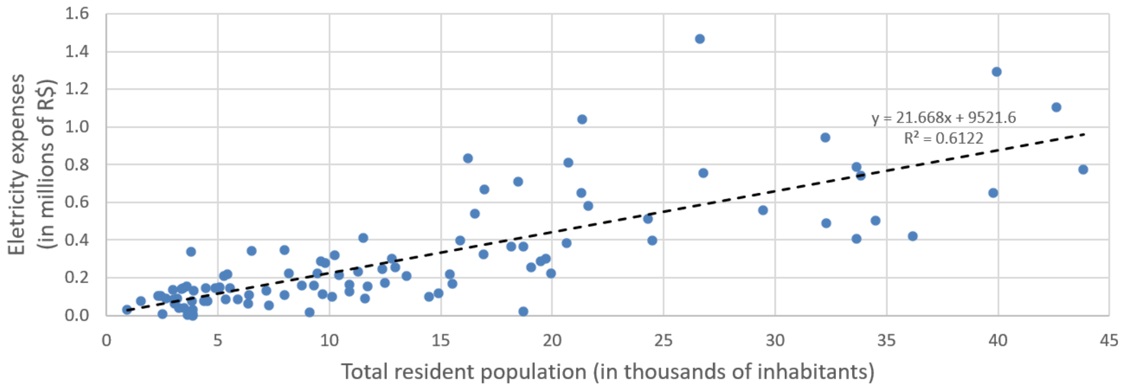


Figure 4.5: Composition of the OPEX of the Mato Grosso municipalities according to the size of their population.



(a)



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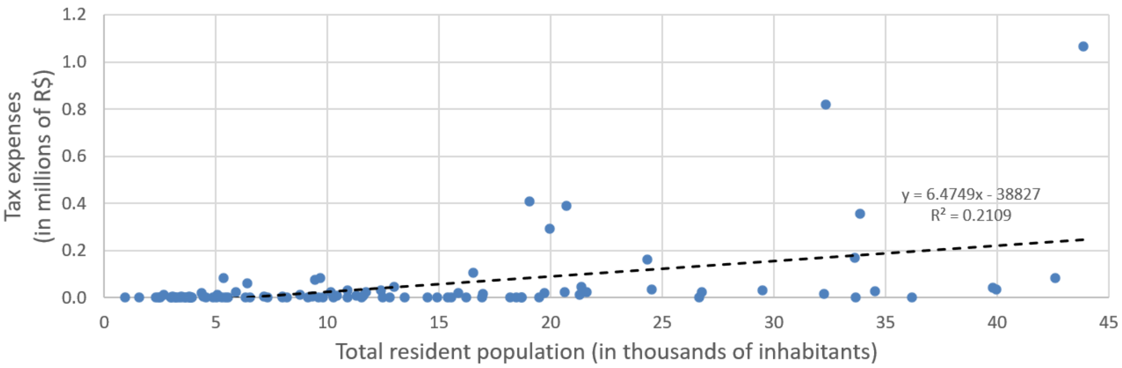

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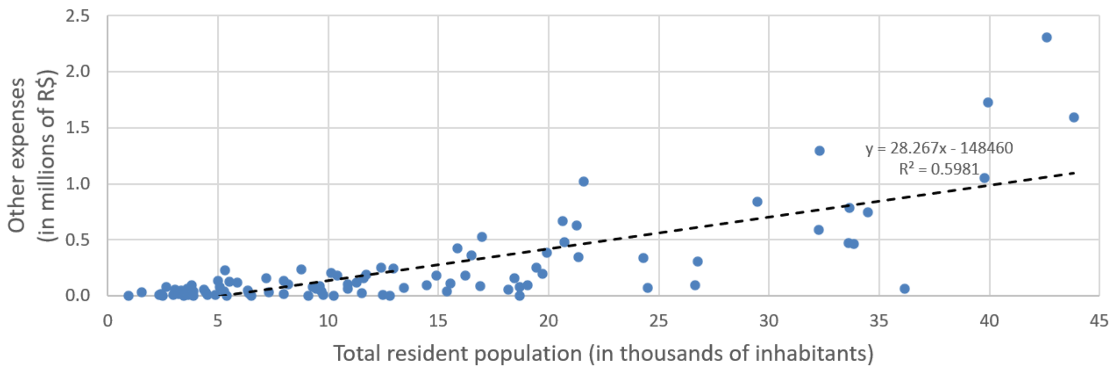
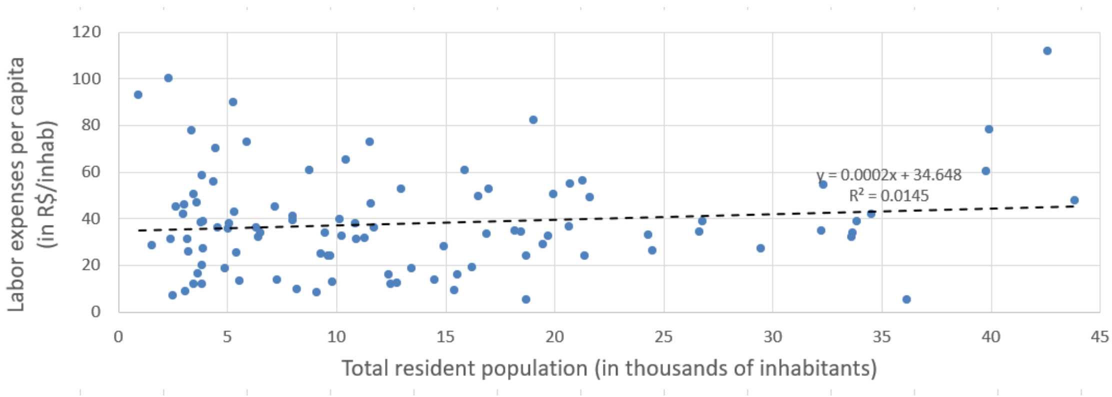
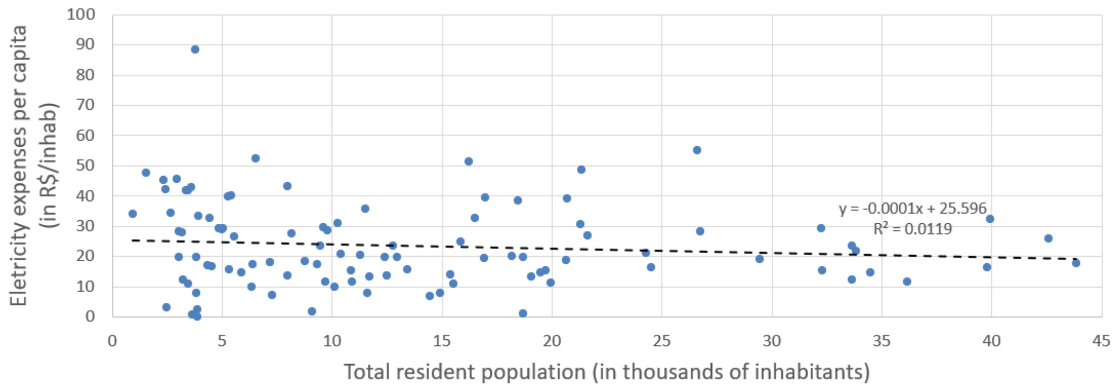


(d)

Figure 4.6: Relationship between labor expenses (a), electricity expenses (b), fiscal and tax expenses (c), and other expenses (d) and the population size of the Mato Grosso municipalities with less than 50 thousand inhabitants that provided information to the SNIS.



(a)



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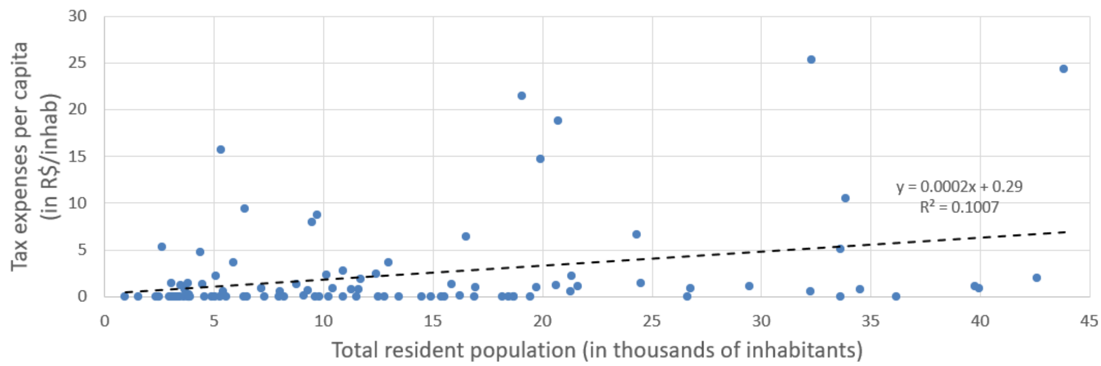

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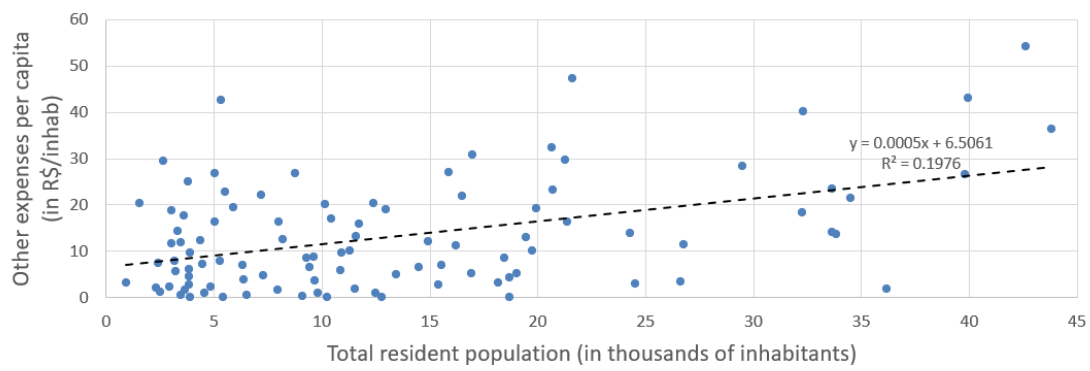


(d)

Figure 4.7: Relationship between labor expenses per capita (a), electricity expenses per capita (b), fiscal and tax expenses per capita (c), and other expenses per capita (d) and the population size of the Mato Grosso municipalities with less than 50 thousand inhabitants that provided information to the SNIS.

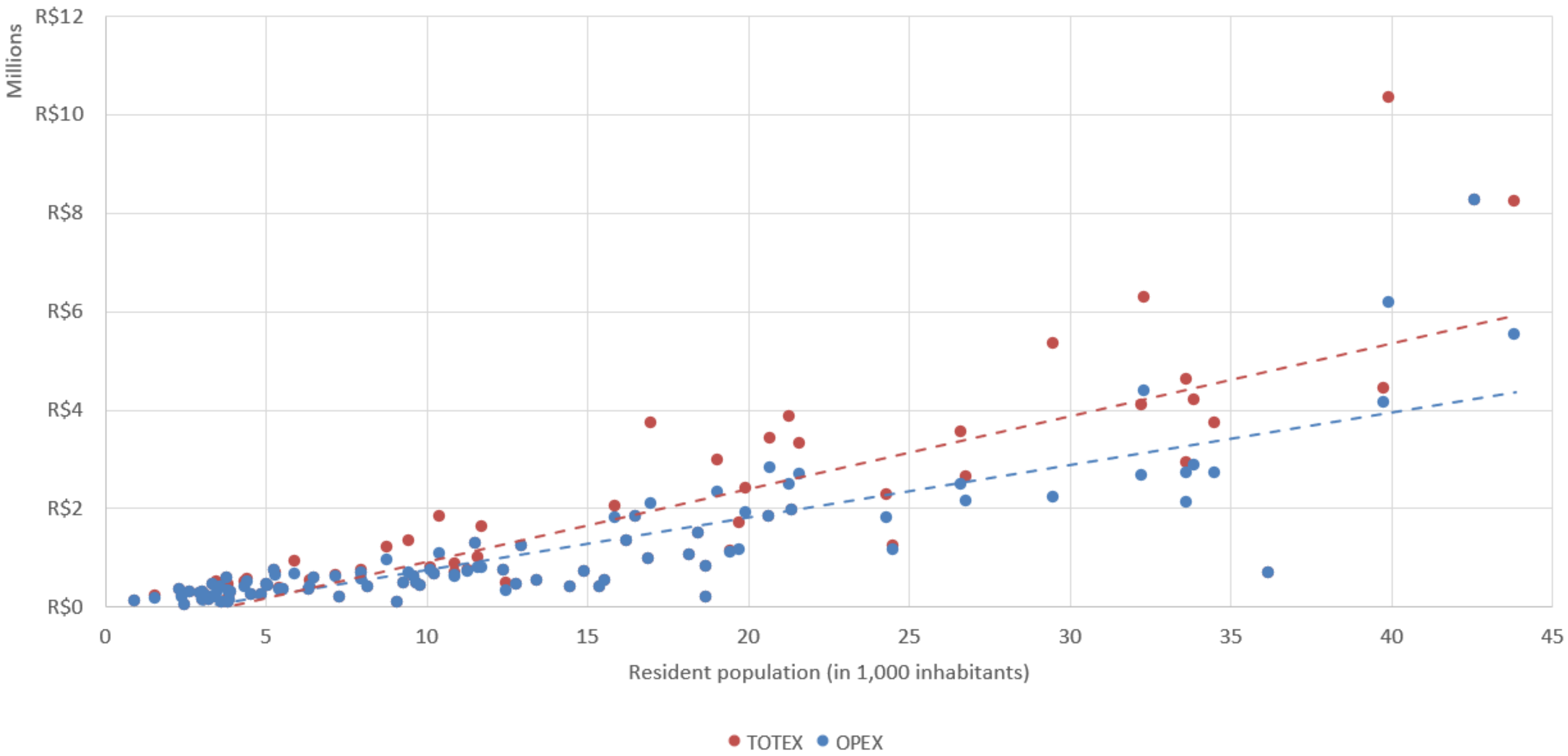


Figure 4.8: Relationship between OPEX, TOTEX and total resident population of the 111 municipalities of Mato Grosso analyzed.

An alternative way to perform exploratory analyses is by population groups. Figure 4.9 shows the relationship between OPEX and TOTEX as a function of the population of municipalities aggregated by groups. As the population size increases, the operational component of expenditures loses relevance. On the one hand, in 75% of the municipalities with less than 10 thousand inhabitants, the OPEX represent more than 90% of the WSS expenditures. On the other hand, in more than half of the large municipalities, the OPEX do not reach 70% of TOTEX. The Kruskal-Walis test identified statistically significant differences in the distribution of the OPEX/TOTEX relationship among the different population groups ($p < 0.05$). This result reinforces the finding that the population size of the municipalities influences the relevance of OPEX in TOTEX, which suggests that the increase in the number of customers allows obtaining resources not only to cover operation and maintenance activities but also to make investments in expansion and modernization.

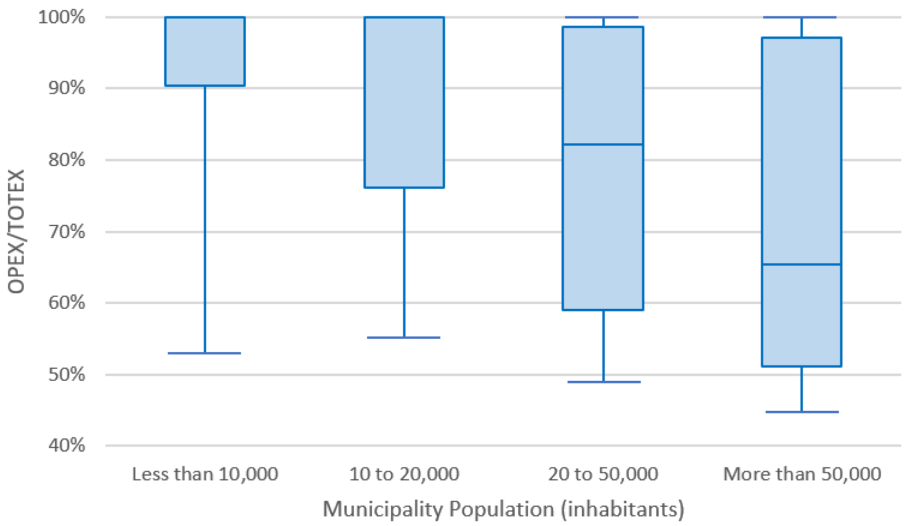


Figure 4.9: Boxplot analysis of the relationship between OPEX and TOTEX.

Considering that, in addition to the OPEX, the expenses related to investments and loans (*i.e.*, expenses with amortizations, depreciation, interests, and debt charges) make up the TOTEX, in a first analysis, it seems that the larger municipalities have more capacity for indebtedness and investment than the smaller ones since most of the municipalities in Mato Grosso have as the main element of expense, the exploration of services (Figure 4.9).

It is also necessary to analyze the proportion of the OPEX in the TOTEX of the municipalities that have private management companies as managing entities and to understand some peculiarities of this management model. Figure 4.10 shows the proportion of OPEX in TOTEX according to the legal nature of the WSS providers in the state of Mato Grosso. Note that OPEXs are very relevant (above 90%) in municipalities with Direct Public Administration (DPA) and Indirect Public Administration (IPA). Contrarily, in most municipalities with WSS under private administration (PRIV), the OPEX/TOTEX ratio does not exceed 80%. This result suggests that private entities have a greater financial capacity (possibly due to their ability to manage resources more effectively), which allows them to spend resources for activities beyond operational functioning.

Additionally, Figure 4.11 shows the ratio between OPEX and TOTEX as a function of different

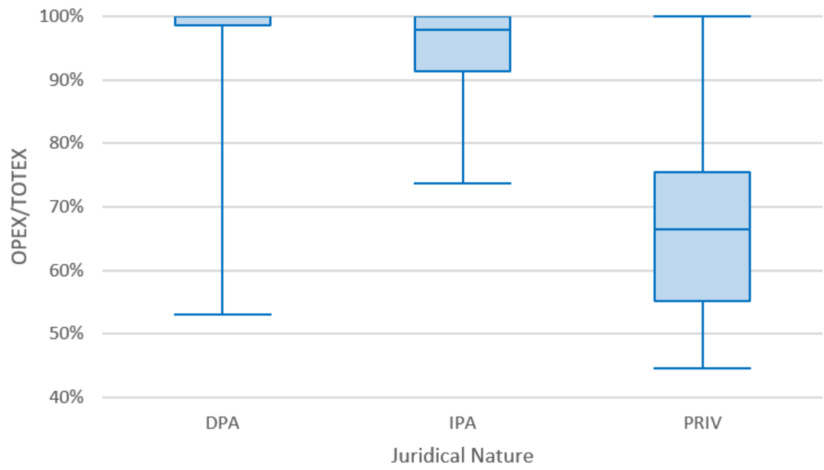


Figure 4.10: Representation of OPEX in TOTEX, as a function of the WSS Juridical Nature.

population groups for municipalities with privately managed WSS. Again, it can be seen that there is a similar trend as observed in the overall picture, where the relative importance of CAPEX grows as the population increases.

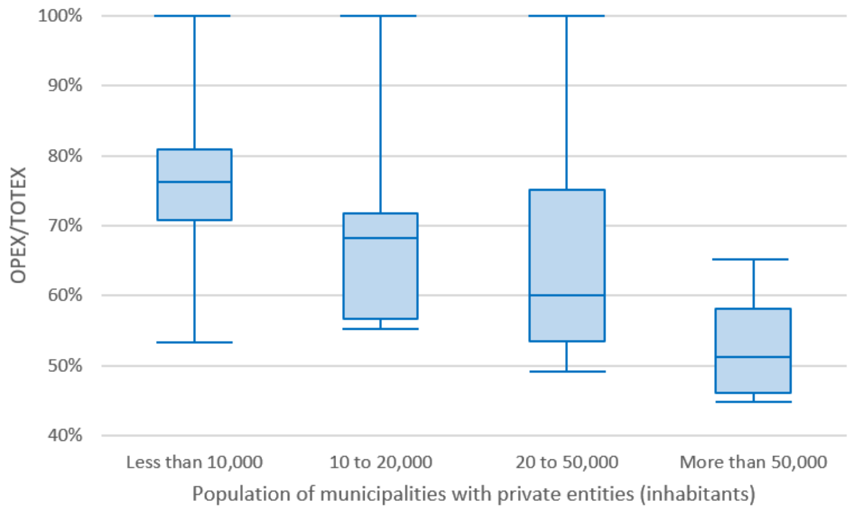


Figure 4.11: Boxplot analysis of proportion OPEX/TOTEX for municipalities whith private WSS management.

On the other hand, when considering only municipalities with private providers, the proportion of OPEX in TOTEX is lower than that observed in municipalities with public provision. For example, in the large municipalities (more than 50,000 inhabitants) with private provision, the OPEX/TOTEX is lower than 70%. At the same time, in the overall picture, the average is 65%, reaching in some cases a maximum close to 100% (see Figure 4.9).

4.5 Conclusions

This chapter presented an exploratory analysis of the expenses related to water supply and sanitation services in the state of Mato Grosso as a case study. Similarly to what happens in the national scenario (see the previous chapter, Section 3.5.3), the components that most contribute to the operating expenses in the state of Mato Grosso are those related to labor (*i.e.*, own personnel and third-party services) and electricity. Thus, cost reduction strategies should consider energy efficiency and optimized management of human resources.

It was evident that the composition of OPEX is indifferent to the population size of the municipalities. On the other hand, it was observed that with population increase, there is a clear tendency of reduction in the OPEX/TOTEX ratio. From the point of view of WSS governance, this result suggested that larger municipalities have a greater financial capacity, which makes it possible to apply resources in activities other than those related to operation and maintenance.

Furthermore, it was found that the OPEX/TOTEX ratio is lower in municipalities with private providers than in municipalities with public providers. From a public policy perspective, this result may indicate that public entities do not reduce operational costs and that private entities have a greater capacity to invest in system expansion and modernization. This situation was expected since the concession of public services is conditioned to investments throughout the concession period.

CHAPTER 5

Performance assessment of water services in Brazilian municipalities: an integrated view of efficiency and access

This chapter proposes a benchmarking approach to assess water supply and sanitation services' performance in Brazilian municipalities from an integrated perspective of efficiency and access. The regional differences and the impact of the governance models adopted by different municipalities (local public entities, regional public entities, and private entities) on efficiency levels are also explored. The results revealed significant heterogeneity in the efficiency levels of Brazilian municipalities, as the average efficiency score is relatively low (45%). The Southeast and Center-west regions stand out both in terms of efficiency and access dimensions. There is evidence that municipalities with services provided by local entities have higher efficiency than those with regional providers. On the other hand, efficiency differences between municipalities with public and private providers are statistically significant. Finally, regulatory strategies are suggested based on the outcome of the integrated analysis.

5.1 Introduction

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared vision to ensure peace and prosperity, for people and the planet, for current and future generations (UN, 2015b). This Agenda consists of 17 Sustainable Development Goals, covering issues that are relevant to citizens' daily lives and that should be closely monitored by local/national authorities. One of these goals is specifically directed to water needs (Goal 6 - 'Clean Water and Sanitation'), aiming to ensure availability and sustainable management of water for all. This chapter contributes to this goal by proposing a bi-dimensional benchmarking approach to assess the performance of water supply and sanitation services in Brazilian municipalities from the perspectives of efficiency and access.

Benchmarking is a valuable tool for both practitioners and regulators of water supply and sanitation services (WSS). It allows guiding the design of public policies and helps the dissemination of best practices in the sector. In the water sector, the use of benchmarking in regulatory settings has been gaining increased attention worldwide. This is reflected in the growth of the number of papers recently published in this area (Henriques et al., 2020; Guerrini et al., 2018; Carvalho and Sampaio, 2015).

It is noteworthy that regulatory authorities play a crucial role in the sector's governance, by supervising providers and ensuring the services' sustainability. In addition, the regulators' role to foster efficiency is well established (Sampaio and Sampaio, 2020; Byatt, 2017). In this context, sunshine regulation actions, including the access to information and endorsement of reliable studies about WSS' performance, can contribute to enhanced decision-making processes and continuous improvement.

In this scenario, understanding the impact of contextual factors on providers' operations is fundamental, both from regulatory and managerial perspectives (Carvalho and Marques, 2011). These factors refer to variables that affect services' performance but are not under providers' control. It is noteworthy that in the water sector, the operational environment can increase further the complexity of services that are already intrinsically complex. Thus, ignoring environmental variations can lead to biased performance measures (Dyson et al., 2001). In the water sector, the contextual variables most investigated in the literature are ownership (*i.e.*, public or private) and the impact of regulatory reforms and incentives. Studies that evaluate the impact of market structure (economies of scale, scope and density) are also common (*e.g.*, Caldas et al. (2019); Lavee and Bahar (2017); Pinto et al. (2017b); Guerrini et al. (2013); Marques and De Witte (2011)). For further details on this topic, see also the literature reviews by Cetrulo et al. (2019) and by Berg and Marques (2011).

In recent years, due to sustainability concerns, the studies have evolved from the strict focus on economic aspects, to o a broader scope concerning other sustainability dimensions, reflecting customers' requirements and respect for the planet. An increasing number of studies have evaluated performance considering the influence of variables associated with quality of service and access to water supply and sanitation services. Nevertheless, studies with this broader scope are still relatively scarce, notably in developing countries (Cetrulo et al., 2019). Likewise, recently Goh and See (2021) concluded that, as the water industry in developing countries is still in the early stages of regulatory reform, information concerning quality indicators such as non-revenue water, quality of service, universalization, or infrastructure investments is often unavailable.

According to the most recent official data in Brazil (BRASIL, 2020), on average, approximately 16% of the Brazilian population has no access to a water supply network, and 46% have no access to sanitation services. It is worth noting that of the wastewater collected, only 78% is treated, which means that currently, in Brazil, about 4.7 billion m^3 of sewage per year are disposed on the environment without treatment (BRASIL, 2020). This Brazilian reality reinforces the need to conduct analytical studies that provide evidence to professionals and regulators about the current situation of water services, in the search for best practices that may lead to improvements in the sector.

This chapter intends to fill this gap by assessing the performance of water supply and sanitation services in 448 large Brazilian municipalities (with more than 50,000 inhabitants) using Data Envelopment Analysis (DEA). The output indicators reflect both quantity and quality issues related to services' provision. This research also contributes to the literature by proposing enhanced formulations of the DEA model that include weight restrictions to reflect the relative importance of the output indicators. This intends to ensure a balanced estimation of efficiency in the provision of water and sanitation services. Non-parametric hypothesis tests are used to evaluate the impact of a comprehensive list of contextual variables on municipalities' water/sanitation services' performance. The variables tested reflect the governance structure (*e.g.*, local public , regional public or private entities), geographic location (*e.g.*, brazilian macro-regions), operational dimensions (*e.g.*, customer density, water source) and regional socio-economic development (life expectancy index, LEI). Finally the chapter also contributes to the literature by exploring the relationship between efficiency and water services' coverage, which are crucial performance dimensions to be considered in the design of public policies in the water sector of developing countries. The results highlight the lack of national cohesion in water supply and sanitation services, from the perspectives of efficiency and access. This information is very relevant for national/local authorities and regulators, to guide the design of pubic policies.

The remainder of this chapter is organized as follows. Section 5.2 presents a brief literature review, discussing the studies that assessed companies or municipalities performance in the provision of water and sanitation services. The objectives, methodological approaches and main conclusions of these studies are discussed, giving particular emphasis to empirical studies conducted on developing countries. This section also discusses the variables most commonly used in second-stage analysis to explore the impact of contextual conditions on water supply and sanitation services. Section 5.3 describes the DEA model used in the empirical study. The variables and sample are described in section 5.4. Section 5.5 reports the results of the study of Brazilian municipalities' performance regarding water and sanitation services. Finally, conclusions are provided in the last section.

5.2 Literature review

Several studies have been carried out in the last decades, aiming to assess water supply and sanitation services. Table 5.1 shows an overview of the selected literature on water supply and sanitation efficiency analysis conducted at company or municipality level using frontier techniques.

Most efficiency studies conducted in the water sector have used the Data Envelopment Analysis technique (Charnes et al., 1978), as noted by Goh and See (2021); Cetrulo et al. (2019); Cabrera Jr et al. (2018); Molinos-Senante et al. (2016b). This can also be confirmed from the analysis of Table 5.1. A few studies have also used Stochastic Frontier Analysis (SFA) (Aigner et al., 1977). This parametric technique requires the *a-priori* specification of the functional form for the production function, which may be challenging to establish in the water sector (De Witte and Marques, 2010b). However, it has the advantage of allowing for random noise in the estimation of the frontier, so it is less sensitive to the effect of outliers in the estimation of the efficiency score.

Table 5.1: Summary of Water and Sanitation services performance studies using frontier techniques.

Reference	Country	Method	Sample	Year
Sala-Garrido et al. (2021)	Chile	DEA (BoD CI)	24 water companies	2017
Salazar-Adams (2021)	Mexico	DEA (Double Bootstrap)	359 water utilities	2016
Henriques et al. (2020)	Portugal	DEA (BoD CI with weight restrictions)	12 wholesale and 200 retail operators	2018
Maziotis et al. (2020b)	Chile	DEA	21 water and sanitation companies	2007-2017
Cetrulo et al. (2020)	Brazil	DEA	77 water utilities	2010
Molinos-Senante et al. (2020a)	Chile	Malmquist Productivity Index (with SFA)	22 private water companies	2007-2015
Molinos-Senante et al. (2020b)	England and Wales	Parametric distance function	10 water and sewerage companies	1993-2016
lo Storto (2020)	Italy	Parallel network DEA	53 utilities in 2011 and 51 in 2017	2011 & 2017
Ananda (2019)	Australia	DEA	49 water and sanitation utilities	2006-2011
Lombardi et al. (2019)	Italy	DEA	68 water companies	2011-2013
Benito et al. (2019)	Spain	DEA (Double Bootstrap)	577 municipalities over 5,000 inhabitants	2014
Walker et al. (2019)	UK, Ireland	DEA (Double Bootstrap)	13 water and sanitation companies	2015
Villegas et al. (2019)	England and Wales	DEA (Double Bootstrap)	18 water companies	2001-2016
Güngör-Demirci et al. (2018)	California (USA)	DEA	17 districts	2014
Molinos-Senante and Maziotis (2018)	England and Wales	SFA (Fixed effects cost frontier)	11 water only companies and 10 water and sanitation companies	1996-2009
See and Ma (2018)	Malaysia	Malmquist Luenberger Index	14 state water utilities	1999-2012
Pinto et al. (2017b)	Portugal	DEA (order-m)	261 water utilities	2012
Barbosa et al. (2016)	Brazil	DEA	41 water and sanitation companies	2005-2013
Carvalho and Sampaio (2015)	Brazil	DEA	27 water and sanitation utilities	2006 & 2011
Carvalho et al. (2015)	Brazil	DEA	4900 utilities	2001-2011
See (2015)	Southeast Asia	DEA (Double Bootstrap)	40 water utilities in 7 countries	2003
Molinos-Senante et al. (2015)	Chile	DEA	18 water and sanitation companies	2008–2012
Zschille (2015)	Germany	DEA	651 companies	2006
Ferro et al. (2014)	Brazil	SFA	127 companies	2003-2010
Faust and Baranzini (2014)	Switzerland	SFA	141 water utilities	2002–2009
Marques et al. (2014)	Japan	DEA	1144 water utilities	2004-2007
Carvalho and Marques (2011)	Portugal	DEA (order-m)	66 water utilities	2002-2008
De Witte and Marques (2010b)	France	DEA (order-m)	325 water only utilities	2009

Continued on next page

Table 5.1 - Continuation

Reference	Country	Method	Sample	Year
Sabbioni (2008)	Brazil	SFA	unbalanced pannel - 180 comapnies in 2000 and 340 companies in 2004	2000-2004
Nauges and Van den Berg (2008)	Brazil	SFA	27 regional entities	1996-2004
Faria et al. (2008)	Brazil	SFA	342 companies	2002-2004
Da Silva e Souza et al. (2007)	Brazil	SFA	164 water and sanitation companies	2002
da Motta and Moreira (2006)	Brazil	DEA	104 water and sanitation companies	1998-2002
Tupper and Resende (2004)	Brazil	DEA	27 regional entities	1996-2000

Note: DEA stands for Data Envelopment Analysis, SFA for Stochastic Frontier Analysis and BoD CI for Benefit-of-the-Doubt Composite Indicator

The DEA model allows the evaluation of the efficiency of a set of decision-making units (DMUs), considering the use of multiple inputs to produce multiple outputs. In DEA, efficiency is defined as the ratio of a weighted sum of outputs to a weighted sum of inputs relative to the best-practice frontier. Efficiency is estimated using linear programming (LP), with an objective function that maximizes the DMU's relative efficiency benchmarked against observed peers and decision variables corresponding to the input and output weights that show it in the best possible light. The restrictions of the LP model impose that the efficiency score of the DMUs under assessment cannot exceed one. However, the complete flexibility in the selection of weights may result in some inputs and/or outputs being assigned a zero or negligible weight, meaning that these factors are in fact ignored in the efficiency assessment. Moreover, the weights may vary a lot from one DMU to another, and they may conflict with *a priori* beliefs about the relative importance of the inputs and outputs considered in the model.

One way to limit the range of values that the weights can take is to use weight restrictions (Allen et al., 1997). In the efficiency literature in the WSS, this issue remains underexplored. Only Henriques et al. (2020) applied weight restrictions in the construction of a composite indicator to account for different perspectives in the performance evaluation of Portuguese wastewater operators. Nevertheless, this approach of restricting weights in efficiency evaluations has already been successfully adopted in other regulatory sectors, *e.g.*, electricity distribution (Bjørndal et al., 2008) and hydropower plants (Calabria et al., 2018).

Being a deterministic technique, DEA is sensitive to measurement errors and outliers. Furthermore, statistical inferences cannot be drawn from conventional DEA models. Two approaches commonly used to overcome these limitations, which have been regularly applied in the water sector, are order-m (Pinto et al., 2017b; Carvalho and Marques, 2011) and bootstrapping (Salazar-Adams, 2021; Walker et al., 2019). Order-m is a partial frontier technique (based on stochastic approaches to generate sub-samples of data) that does not envelope all observations and thus is less sensitive to outliers (Cazals et al., 2002). In turn, bootstrapping is a resampling technique that allows the estimation of bias-corrected efficiency scores (Simar and Wilson, 2007).

More recently, studies in the water sector have focused on the construction of composite indicators to explore the performance of water companies, considering only the outputs attained by the companies and their alignment with the regulatory context. These studies have adopted the Benefit-of-the-Doubt approach proposed by Cherchye et al. (2007).

A few studies have explored the evolution of productivity over time. The Malmquist index is the approach most often used for this purpose. The index is usually estimated with DEA models, but SFA has also been used for this purpose (Molinos-Senante et al., 2020a). The study of See and Ma (2018) used a Directional Distance Function (DDF) to explore productivity change over time with the Malmquist-Luenberger index.

In addition, the literature shows that the sample size of the units assessed varies considerably. In the studies reported in Table 5.1, the sample size varies from 10 to 4900, with the majority of studies (20 out of 34) using a sample smaller than 100 DMUs. Only 4 studies used a sample larger than 400 DMUs.

Although the number of studies on water and wastewater utilities efficiency assessment in developing countries has increased in recent years (*e.g.*, Salazar-Adams (2021) in Mexico, Cetrulo et al. (2019) in Brazil, See (2015) in Southeast Asia countries), research in developed countries is predominant in the literature (Cetrulo et al., 2019). The lack of systematized and reliable information about water services and their contextual environment is one of the main obstacles to research in this sector, especially acute in developing countries.

Brazil has the advantage of having a comprehensive official database with financial and operational information on water supply and sanitation services, which is the National Sanitation Information System (SNIS). This may explain the larger number of studies focusing on Brazil compared to other developing countries (*e.g.*, Cetrulo et al., 2020; Barbosa et al., 2016; Carvalho et al., 2015; Carvalho and Sampaio, 2015; Ferro et al., 2014).

Tupper and Resende (2004) characterized state companies' relative efficiency in Brazil and discussed the possibility of implementing yardstick schemes. The authors used the DEA model, complemented with econometric techniques, to control for regional heterogeneity. The results suggested that important cost savings appeared to be possible.

In fact, due to the country's size and organizational complexity, most Brazilian studies have related water services' performance with the governance structure of the utilities, either considering the services' scope (*i.e.*, regional or local) (Carvalho et al., 2015; Sabbioni, 2008; Faria et al., 2008) or the region were the services are provided, exploring the extent to which regional differences affect performance (Barbosa et al., 2016; Carvalho and Sampaio, 2015; Faria et al., 2008).

Another consequence of the predominance of studies in developed countries is that most of them do not consider access to services as a performance dimension, as service coverage in these countries is usually universal (Carolini and Raman, 2021). However, according to the United Nations, in 2017, 2.2 billion persons still lack access to safely managed drinking water, while 4.2 billion lack safely managed sanitation, mostly in developing countries (UN, 2020). Thus, regulators should pay special attention to improving access to water services in developing countries. As mentioned in Hutton and Varughese (2016), billions of dollars will be needed to ensure the availability and sustainable management of water and sanitation for all (which corresponds to the

SDG 6 of the 2030 Agenda). Under this scenario, reducing service inefficiency emerges as an effective strategy for saving resources to further expand access.

Furthermore, there is consensus in the literature on the importance of considering contextual (or exogenous) factors in evaluating water utilities' performance (Villegas et al., 2019; Pinto et al., 2017b; Molinos-Senante et al., 2015; Carvalho and Marques, 2011). Many studies used a two-stage approach to assess the impact of contextual variables on DEA efficiency scores (Sala-Garrido et al., 2021; Maziotis et al., 2020b). In this second stage, the techniques more often used are regression (*e.g.*, truncated bootstrap regression) (Walker et al., 2019; Benito et al., 2019; Villegas et al., 2019) and hypothesis testing (lo Storto, 2020; See and Ma, 2018). Alternatively, there are techniques, such as Conditional Efficiency (Daraio and Simar, 2005, 2007) and Parametric Input Distance Functions (Molinos-Senante et al., 2020b), that allows assessing WSS' performance by accounting for the effect of contextual factors directly in the efficiency score (Pinto et al., 2017b; Zschille, 2015; Carvalho and Marques, 2011).

Table 5.2 summarises the contextual variables most frequently used in the efficiency assessment in the water sector. The Table only reports variables that were used more than twice in the selected studies. The papers that used additional contextual variables not shown in the table are marked with '*'.

Table 5.2: Overview of the contextual variables used in selected studies of WSS' performance.

	Organizational structure			Market features		Operational Factors		
Reference	Ownership	Regional differences	Services' scope	Customer density	Population density	Water source	Water losses	Peak factor
Tupper and Resende (2004)*		1		1			1	
Faria et al. (2005)*	1	1						
da Motta and Moreira (2006)*	1		1					
Da Silva e Souza et al. (2007)*	1	1			1	1		
Faria et al. (2008)*	1	1	1		1			
Sabbioni (2008)*	1		1				1	
De Witte and Marques (2010b)*				1		1		
Carvalho and Marques (2011)*	1			1		1		1
Marques et al. (2014)*	1			1		1	1	1
Faust and Baranzini (2014)*				1		1		
Ferro et al. (2014)*	1	1	1	1			1	
Carvalho and Sampaio (2015)*	1	1	1					
Carvalho et al. (2015)*	1		1					
Molinos-Senante et al. (2015)*				1		1		1
Barbosa et al. (2016)*	1	1		1				
Pinto et al. (2017b)*				1		1		
Villegas et al. (2019)*					1	1	1	
Benito et al. (2019)*	1				1			
Lombardi et al. (2019)*	1			1				
Maziotis et al. (2020b)	1			1		1	1	
lo Storto (2020)	1			1				
Molinos-Senante et al. (2020a)					1	1	1	
Molinos-Senante et al. (2020b)				1			1	
Salazar-Adams (2021)*	1				1			
Sala-Garrido et al. (2021)*	1			1				1
No. times used	**17**	**7**	**6**	**14**	**6**	**10**	**8**	**4**

* Studies that used other variables beyond those mentioned in the Table.

Regarding market features, density is widely explored in the literature. One may expect that this variable positively affects services' performance, given the possibility of serving more people in a reduced area. The literature explores both population density (*i.e.*, inhabitants per square kilometer) and customer density (*i.e.*, customers per meter or kilometer of network length). In both cases, the results presented in the studies are not consensual. Salazar-Adams (2021) found a positive and significant impact of population density on Mexican utilities. Similar results were found in England and Wales (Molinos-Senante and Maziotis, 2018; Villegas et al., 2019), in Southeast Asia (See, 2015) and Spain (Benito et al., 2019). Similarly, a positive impact of customer density on performance was observed in Chile (Maziotis et al., 2020b) and in Brazil (Barbosa et al., 2016; Ferro et al., 2014; Faria et al., 2008).

By contrast, Molinos-Senante et al. (2020b), for England and Wales and Picazo-Tadeo et al. (2009), for Spain, found inconclusive evidence of the impact of population density on efficiency levels in their empirical studies. In Chile, Molinos-Senante et al. (2020a) and in Italy lo Storto (2020), found a negative impact of customer density on utilities' efficiency.

Sala-Garrido et al. (2021) also evaluated the impact of contextual variables on a service quality indicator, aggregating the outcomes of water services using a Benefit-of-the-Doubt (BoD) model. The authors concluded that for Chilean water companies customer density had no impact on the quality of the services provided.

Finally, in Japan, Marques et al. (2014) concluded that customer density was not a significant determinant of utilities' efficiency. The results also suggested that increased complexity in service delivery in high-density zones may cause a decline in efficiency levels.

Concerning operational factors, the water source may influence the cost structure of the services providers, and consequently their efficiency. Groundwater has higher costs associated with pumping (*i.e.*, electricity) while surface water may have higher treatment costs. Although there is evidence that the water origin influences operating costs (Maziotis et al., 2020b; Faust and Baranzini, 2014), the results concerning the impact on efficiency are mixed. Ananda (2019), Villegas et al. (2019) and Pinto et al. (2017b) found that water utilities abstracting a higher proportion of water from surface sources tend to be less efficient than the utilities which use groundwater. In contrast, Molinos-Senante et al. (2020b) and Marques et al. (2014) concluded that the water source did not have a significant impact on WSS' efficiency.

Conflicting results were also reported regarding water losses. Molinos-Senante et al. (2020b), Maziotis et al. (2020b) and Villegas et al. (2019) found that higher losses reduce the efficiency of the services. This result can be explained by the fact that repair expenditures tend to be high, so companies that invest in technology that predicts leaks can benefit from the reduction of costs in the long run (Molinos-Senante et al., 2020b). On the other hand, some studies concluded that water losses did not have a significant impact on efficiency (Molinos-Senante et al., 2020a; Marques et al., 2014).

Regarding the peak factor, which refers to the ratio between the highest monthly water consumption and the average monthly water consumption, the literature shows that this variable has a positive impact on services' efficiency (Molinos-Senante et al., 2015; Marques et al., 2014; Carvalho and Marques, 2011). The high peak factor may indicate that the services are provided in a touristic area, with seasonality demand, which requires more investment to reduce inefficiencies in the sector (Marques et al., 2014). From another perspective, Sala-Garrido et al. (2021) found that utilities with a low peak factor have a higher Quality of Service Index than those with a high peak factor. According to the authors, the low peak factor allows investments to be redirected to quality improvements, that would otherwise have to be directed to the expansion of supply (considering the seasonal population).

Concerning the organizational structure, the variable 'ownership' was also highly investigated. Its importance derives from the growing presence of private entities in water and sanitation service delivery. Marques and Simões (2020) recently shed new light on the controversy concerning the impact of public and private ownership on the performance of water and sanitation services. The authors applied hypothesis tests on key indicators audited by the Portuguese Water and Waste Services Regulation Authority (ERSAR) and concluded that, on average, private water utilities' performance exceeds that of public utilities. In developing countries, Cetrulo et al. (2019) also found a trend for private operators to perform better than public operators. On the other hand, lo Storto (2020) and Maziotis et al. (2020b) found that ownership did not have a statistically significant impact on Italian and Chilean operators' efficiency.

In Brazil, the presence of private entities in the provision of WSS is not very relevant, although the market share of private operators has been gradually increasing. Currently, private entities are responsible for water services in 4% of the Brazilian municipalities. Some studies compared the efficiency of private versus publicly owned utilities in Brazil, despite the small proportion of the former in the sample studied. Carvalho et al. (2015) concluded that services with private participation were the most efficient. On the other hand, Barbosa et al. (2016), Da Silva e Souza et al. (2007) and da Motta and Moreira (2006) found no evidence of better performance by private entities compared to public ones.

In a country with continental dimensions such as Brazil, it is also relevant to evaluate regional differences in water services' performance. Brazil is divided into five macro-regions (North, Northeast, Southeast, South, and Center-West), which have entirely distinct environments, namely topography, climate, and water availability. Furthermore, each region has its own economic, social, and cultural characteristics. Carvalho and Sampaio (2015), Ferro et al. (2014) and Faria et al. (2008) found heterogeneity in efficiency levels among regions. By contrast, Barbosa et al. (2016) and Faria et al. (2005) found no statistical difference in the efficiency levels of water services among regions. It is noteworthy that the studies conducted in Italy (Lombardi et al., 2019) and Japan (Marques et al., 2014) found that geographical differences within the country had a significant impact on water services' performance.

In Brazil, the scope of services can take three formats: local-level entities, state-level (or regional) entities, and multi-municipal (or micro-regional) entities. The regional entities (*i.e.*, the Companhias Estaduais de Saneamento Básico - CESBs, in Portuguese) were created in the 1970s as a part of a national policy aiming to stimulate economies of scale among the providers, making them responsible for providing water supply and sanitation services for most municipalities in their state jurisdiction. Even today, CESBs are responsible for 70% of the services' provision in the country. On the other hand, local-level entities are entities that provide services in only one municipality. Finally, micro-regional entities operate services in a small number of municipalities (they are usually private entities and operate municipalities within the same state). Carvalho and Sampaio (2015), Carvalho et al. (2015) and da Motta and Moreira (2006) found that local entities are the most efficient. Similarly, Ferro et al. (2014) also concluded that local entities have better performance, despite having costs approximately 10% higher than regional entities. By contrast, Sabbioni (2008) and Faria et al. (2008) concluded that regional entities perform better due to lower operating costs associated with economies of scale.

This study aims to look beyond traditional efficiency analysis by exploring equity in the provision of water supply and sanitation services. To conduct a fair evaluation of efficiency from an economic perspective, an input reflecting the operational costs, alongside a set of outputs reflecting both the quantity and quality of the services provided to customer will be considered. The use of weight restrictions to ensure that all output variables are given due account in the efficiency evaluation is also a distinctive feature of this study, that fills the gap identified in the existing literature in the water sector.

5.3 Methodology

5.3.1 Efficiency estimation

Data Envelopment Analysis (DEA) was used in this chapter to estimate the efficiency of water services provided in Brazilian municipalities. DEA has several features that make it very useful for assessing the efficiency of water utilities. It relies on Linear Programming (LP) for the assessment of relative efficiency, which involves the estimation of a best-practice frontier enveloping the observations under assessment. The non-parametric nature of the DEA technique does not require any assumptions about the functional form of the production frontier. Furthermore, its multidimensional nature allows considering several inputs and outputs measured in different scales.

Consider a set of j DMUs $(j = 1,2,\dots n)$, where each one uses a vector of inputs x_{ij} $(i = 1,...m)$ to produce a vector of outputs y_{rj} $(r = 1,...s)$.

Following the specialized literature in the water sector, an input orientated formulation of the DEA model was used to explore potential reductions to the resources used that still ensure the provision of the current level of services to the customers. A Variable Returns to Scale formulation (Banker et al., 1984b) was used to compare the municipalities taking into account their scale size.

The DEA model used to estimate the efficiency scores is shown in (5.1):

$$\begin{aligned}
E_{j_0} = \quad & \max \sum_{r=1}^{s} u_r y_{rj_0} + w \\
\text{s.t} \quad & \sum_{i=1}^{m} v_i x_{ij_0} = 1 \\
& \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \leq 0 \quad j = 1,\dots,n \\
& u_r, v_i \geq 0 \quad \forall r,i \\
& w \text{ is free}
\end{aligned} \tag{5.1}$$

In model (5.1), v_i and u_r are the weights attached to the inputs and outputs, respectively, that together with w (which implements the variable returns to scale assumption) correspond to the decision variables of the LP model. The input and output weights at the optimal solution can be used to indicate the relative importance of the input and output variables in determining the efficiency level of the DMU j_0 under assessment. However, as the 'raw' weights depend on the scaling of each input and output, 'virtual' inputs $(v_i x_{ij})$ and 'virtual' outputs $(u_r y_{rj})$ are used instead. The virtual inputs and outputs are in fact normalised weights, adding up to one for efficient DMUs, both in terms of inputs and outputs. For inefficient DMUs, the sum of the virtual output weights reflects the efficiency level, and corresponds to the objective function of model (5.1).

5.3.2 Specification of weight restrictions

In order to bring additional information to the efficiency assessment concerning the relative importance of the indicators considered in the DEA model, weight restrictions can be added to model (5.1). In this study, these restrictions were formulated as Assurance Regions type I (ARI) (Thompson et al., 1990), adopting the specification of bounds proposed by Zanella et al. (2015). This specification enhances the approach of Wong and Beasley (1990) by expressing the relative importance of outputs, in percentage, via an artificial DMU corresponding to the average values of the output variables in the sample under assessment. A recent example of the application of this type of restrictions in efficiency analysis in the water sector can be found in Henriques et al. (2020).

Following Zanella et al. (2015), the ARI weight restrictions associated with specific outputs r $(r = 1, \ldots, s)$ can be expressed as shown in (5.2), where $\bar{y}_r$ corresponds to the average value of output y_r in the sample considered.

$$\frac{u_r \bar{y}_{r_k}}{\sum_{r=1}^{s} u_r \bar{y}_r} \geqslant \phi_{r_k}, \quad r_k = 1, \ldots, s \tag{5.2}$$

For modelling purposes, expression (6.13) should be rewritten as a linear restriction, as shown in (5.3):

$$u_r \bar{y}_{r_k} - \phi_{r_k} \sum_{r=1}^{s} u_r \bar{y}_r \geqslant 0, \quad r_k = 1, \ldots, s \tag{5.3}$$

The use of weight restrictions mitigates a limitation associated with full flexibility in the specification of weights in DEA models, by preventing (quasi-)zero weights and avoiding the disregard of one or more output indicators (Lavigne et al., 2019). Furthermore, as stated by Zanella et al. (2015), the specification of ARI weight restrictions implemented in this work ensures that all DMUs in the sample share the same weight restrictions and are assessed against a single frontier. Note that as these restrictions are ratios of virtual weights, the bounds ϕ_{r_k} are expressed in percentage, and consequently are independent of the measurement scale of the outputs.

5.4 Sample and variables selection

5.4.1 Sample studied

This study uses data from the National Sanitation Information System (SNIS), created as an integral part of the National Sanitation Policy of Brazil. Providers voluntarily join the SNIS, which started collecting data in 1995. Although the provision of information by water service operators is not mandatory, the Brazilian Federal Government investment programs use as selection criterion the submission of information to SNIS.

The providers submit the information annually. These data includes indicators reflecting operational, administrative, financial, and quality of service activities. The data collection and subsequent analysis results in the publication of an annual diagnostic report of the water supply and sanitation services. The information, regardless of the type of provider, is presented segmented by the municipality and by type of service (*i.e.*, water supply and sanitation information is presented separately).

This study uses a sample of 448 Brazilian municipalities with over 50,000 inhabitants, with only one provider responsible for both water supply and sanitation services. The municipalities (corresponding to the DMUs of the DEA model) comprise about 60% of the country's population. The data used in this study is from the 2019 financial year and is the most up-to-date information currently available from the SNIS.

5.4.2 Variable selection for efficiency assessment

The selection of inputs and outputs is essential in DEA studies. Recent literature reviews evidenced that the input and output variables vary notably according to the aim of the analysis (Cetrulo et al., 2019; See, 2015). Nevertheless, the variables' choice is crucial to enable an adequate characterization of the water and sanitation services' activity, and their alignment with the purpose of the analysis must be ensured.

Regarding inputs, the most widely used variables in efficiency assessment studies include operating expenditure (Maziotis et al., 2020a; Molinos-Senante et al., 2020a; Byrnes et al., 2010), network length (De Witte and Marques, 2010a), number of employees (Caldas et al., 2019; De Witte and Marques, 2010a), and capital expenditure (Walker et al., 2019; Guerrini et al., 2018).

On the other hand, the output variables most used are the volume of water delivered (Guerrini et al., 2013) and the number of connections (Ananda, 2014).

This analysis aims to assess the efficiency of services provided in Brazilian municipalities and identify its main drivers, considering the contextual features characterising each municipality. The results obtained intend to provide new insights that may support managers and regulators in water sector governance.

In this study, the DEA model included only one input corresponding to operating expenditure (OPEX). Adopting a single expenditure variable aligns this study with the best regulatory practices implemented worldwide, to search for efficient spending and better resource allocation

(Portela et al., 2011; Thanassoulis, 2002, 2000). The main reason for not considering capital expenditure as an input of the DEA model was avoiding a potential penalization of efficiency scores for municipalities that invest more in infrastructure and thus have higher capital expenditures.

In Brazil, in the tariff review for water services, the regulatory authorities (*e.g.*, ARPE, ARSESP, ADASA) deal with capital remuneration separately from the specification of the "efficient" operating expense component. Benchmarking techniques are only applied to the identification of optimal levels of operating expenditure. In this sense, Thanassoulis (2000) refers that in the tariff review methodology by the regulatory agency of England and Wales (OFWAT), the agency noted that "there is no convincing evidence that relatively high operating expenditure can be explained by relatively low capital expenditure or vice versa" (OFWAT, 1994a). Moreover, the two can be modeled separately in the absence of trade-offs between capital and operating expenditure.

Regarding the outputs, this study considered seven variables: i) the number of water connections (See and Ma, 2018; See, 2015; De Witte and Marques, 2010a); ii) the number of wastewater connections (da Motta and Moreira, 2006); iii) the volume of water consumed; iv) the volume of wastewater collected (Walker et al., 2019); v) the volume of wastewater treated; vi) the water supply network length (Lombardi et al., 2019; Guerrini et al., 2018); vii) the wastewater network length.

Given the importance of reflecting the quality and sustainability of services in the efficiency assessment, the variable 'volume of water consumed' was used. It is directly related to the services' operation, as providers must guarantee water demand satisfaction. This variable was preferred to 'volume of water produced' (obtained as the sum of 'volume of water consumed' and 'volume of water losses'), because the latter could classify as more efficient, among two DMUs with identical water consumption, the DMU with higher water losses.

Concerning sanitation services, this study simultaneously considered the variables 'volume of wastewater collected' and 'volume of wastewater treated'. This strategy aims to ensure that both the wastewater collection and its treatment are valued in the efficiency assessment, as they are important components of the service provided to customers.

The pictorial representation of the model is shown in Figure 5.1. Table 5.3 shows the descriptive statistics of the input and output variables used in this study.

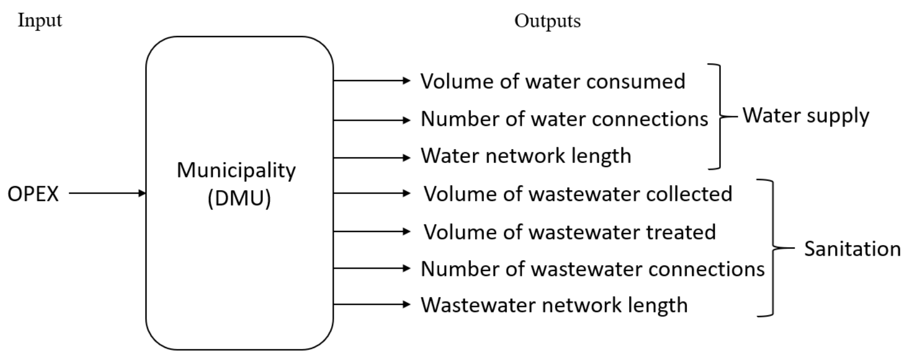


Figure 5.1: Illustration of DEA model variables considered.

Table 5.3: Variables descriptive statistics.

Variables	Unit	Code	Mean	St.Dev.	Min	Max	IQR
OPEX	000s R$	I	56,368.67	113,280.11	583.84	1,427,447.35	35,882.74
No. water connections	Number	O_1	57,379.84	80,254.07	1,200.00	688,562.00	38,698.00
No. wastewater connections	Number	O_2	38,958.14	68,560.85	78.00	614,720.00	35,031.00
Volume of water consumed	000s m^3	O_3	11,612.06	20,690.83	115.00	200,555.45	7,464.44
Volume of wastewater collected	000s m^3	O_4	7,196.65	14,498.08	10.10	129,923.00	5,748.30
Volume of wastewater treated	000s m^3	O_5	6,210.42	13,909.40	3.10	129,923.00	4,873.27
Water network length	kilometers	O_6	708.14	944.04	20.00	9,269.00	484.92
Wastewater network length	kilometers	O_7	410.74	701.98	1.43	7286.00	408.02

Note: IQR stands for Interquartile range.

In relation to weight bounds specified for the output restrictions, the values used in the empirical analysis are shown in Table 5.4. The minimum virtual weight bounds ϕ_r were specified as a commitment between ensuring that the weights are equitably distributed among the seven output indicators, and giving some flexibility to assess each DMU using the system of weights that shows it in the best possible light.

Table 5.4: Lower bound of the virtual weight restrictions specified for the output indicators.

Indicator	Value of ϕ_r (%)
Number of water connections	2.5
Number of wastewater connections	2.5
Volume of water consumed	10
Volume of wastewater collected	5
Volume of wastewater treated	5
Water network lenght	2.5
Wastewater network lenght	2.5

The total virtual weight of the variables associated with water supply (O_1, O_3, and O_6) must be greater or equal to 15% ($\phi_1 + \phi_3 + \phi_6 = 15\%$). Similarly, the virtual weight of the variables associated with sanitation (O_2, O_4, O_5 and O_7) must be greater or equal to 15% ($\phi_2 + \phi_4 + \phi_5 + \phi_7 = 15\%$). A minimum weight of 10% was specified for the variable 'volume of water consumed' since the supply of drinking water (with a quality standard suitable for consumption) is the main purpose of water services. On the other hand, considering that in Brazil less than 80% of the collected wastewater is treated, it was decided to set the minimum of 5% for the variables volume of collected wastewater and volume of treated wastewater, as both are key components of sanitation services. With this strategy, a certain symmetry is guaranteed to the model, since the minimum weight of the drinking water distribution and wastewater collection/treatment variables ensures equal importance of the two service components.

5.4.3 Contextual variables

Table 5.5 shows descriptive statistics of the categorical contextual variables, namely the number of DMUs in each group.

The geographic location seeks to explore whether there are significant differences in efficiency among Brazilian macro-regions (*i.e.*, North, Northeast, Southeast, South, and Center-West).

The juridical nature is another relevant factor in Brazilian water services' organizational structure since it comprises two essential aspects: the services' scope (local or regional provision) and the ownership. In a simplified way, the Brazilian services can be provided by four types of entities: i) local public entities (*e.g.*, direct administration, by the municipalities); ii) local private entities; iii) regional public entities; and iv) regional private entities. Understanding whether the provider's adoption of a specific type of legal nature affects service performance is fundamental from both a regulatory and operational point of view. Thus, this variable will make it possible to evaluate whether regional management has advantages over local management and whether public management has advantages over private management.

It is noteworthy that local entities provide services restricted to the jurisdiction of a single municipality. Regional entities provide services in many municipalities within a Brazilian state's jurisdiction. Furthermore, in Brazil, public entities usually have exclusively public capital, although some may have private capital participation in their assets (in this case, both the shareholding control and the management remain public). Conversely, private entities have both capital and management entirely private. Despite their reduced current participation in the market, they have gained particular prominence in constructing public infrastructures, given the State's low investment capacity.

The customer density is measured by the number of connections per kilometer of network.

The percentage of water treated in the water treatment plant (WTP) is a variable measured by the ratio between the volume of water treated in the WTP and the total volume of water treated. This variable indirectly reflects the origin of the water since, in Brazil, surface water requires a more complex treatment (*e.g.*, decanting and filtering at WTP) while groundwater usually undergoes a simplified treatment (*e.g.*, adding chlorine).

Table 5.5 highlights that most of the 448 municipalities considered in this study are in the Northeast and Southeast regions. Also, the regional entities operate services in 68% of the municipalities, which is proportional to the service structure at the national level.

Table 5.5: Descriptive statistics of categorical contextual variables.

Variable	**No. of municipalities**	**(%)**
Geographic location (macroregion)		
North	22	5%
Northeast	125	28%
Southeast	186	41%
South	79	18%
Center-West	36	8%
Juridical nature (ownership & scope)		
Local public entities	114	25%
Regional public entities	303	68%
Local private entities	23	5%
Regional private entities	8	2%

Finally, Table 5.6 shows that Brazilian municipalities use predominantly surface water.

Table 5.6: Descriptive statistics of quantitative contextual variables.

Variable	**Mean**	**St.Dev.**	**Min**	**Max**
Customer density (No of connections/km of network)	96.12	238.67	11.27	5,087.53
Water source (% of water treated at WTP)	79.49	34.54	0	100

5.5 Results and discussion

5.5.1 Efficiency assessment

The efficiency scores were computed using the PIMDEA software (Emrouznejad and Thanassoulis, 2014). Aditionaly, the SPSS software was used to perform hypothesis tests to explore the statistical significance of efficiency differences among municipalities with different features. In these cases, the null hypothesis is that the groups of municipalities (DMUs) under evaluation have the same distribution of efficiency scores, and the alternative hypothesis is that some groups of operators have different efficiency distributions. All tests were performed with a level of significance of 5% (*i.e.*, the null hypothesis is rejected in case the p-value is lower than or equal to 0.05; otherwise, the null hypothesis is not rejected).

To determine the extent of the impact of the weight restrictions on the efficiency score, a sensitivity analysis was conducted. Four scenarios were defined considering different magnitudes of the weight bounds (between 0 and 45% of total weight constrained), but maintaining the balance reflecting the relative importance among the output restrictions. It can be seen in Table 5.7 that the results are quite sensitive to variations in the weight bounds, with the average efficiency score ranging from 53.23% to 38.52% with a linear evolution. For each additional 1% of total weight restricted, the average efficiency value decreases by approximately 0.33%. Additionally, Table 5.8 shows that the correlation between the efficiency scores obtained with the different formulations of the weight constraints is high (always above 90%) and statistically significant. The statistically significant correlation among the efficiency scores considering different weight formulations ensures robustness in the results of this study, demonstrating stability in the performance measures.

Table 5.7: Scenarios of weight bounds explored.

Indicator	**Value of ϕ_r (%)**			
Scenarios	S0	S1	Base Scenario	S2
Number of water connections	0	1.25	2.5	3.75
Number of wastewater connections	0	1.25	2.5	3.75
Volume of water consumed	0	5	10	15
Volume of wastewater collected	0	2.5	5	7.5
Volume of wastewater treated	0	2.5	5	7.5
Water network length	0	1.25	2.5	3.75
Wastewater network length	0	1.25	2.5	3.75
Total weight restricted $\sum_{r=1}^{s} \phi_r$	0	15	30	45
No. of DMUs at the frontier	30	25	19	17
Average efficiency	53.23	49.67	44.62	38.52
Standard deviation	21.73	21.47	20.78	19.62

In face of these results, an intermediate value of total weight restricted equal to 30% (*i.e.*, the base scenario) was considered appropriate for the efficiency assessment. The results obtained with the base scenario are reported in section 5.

Experts in the water sector were contacted to validate the relative weight bounds assigned to the output variables. They also ratified the option to adopt the Base Scenario to estimate the efficiency levels, as this would allow keeping a large proportion of the total virtual weight (70%) with a flexible assignment among all output variables.

Table 5.8: Spearman Correlation between the weight restriction scenarios.

	S0	S1	Base	S2
S0	1.000			
S1	0.993	1.000		
Base	0.974	0.989	1.000	
S2	0.926	0.948	0.981	1.000

** Correlation is significant at the 0.01 level.

Table 5.9 shows the average efficiency scores, the standard deviation, and the number of efficient DMUs in the sample, for the base scenario considered in the empirical study. The results are also shown by geographic location (Brazilian macro-regions) and juridical nature of companies providing water and sanitation services in the municipalities analysed. It is also shown the ratio of efficient DMUs to the total number of DMUs in the same group.

Table 5.9: Technical efficiency scores obtained for the Base Scenario.

	No. Eff DMUs	**% Eff DMUs within group**	**Mean Efficiency**	**Std.dev.**	**K-W Test**
Country level results					
Brazil (all DMUs)	19	4%	44.62	20.78	
Geographic location					
North	2	9%	46.14	23.82	
Northeast	5	4%	39.23	19.38	0.000
Southeast	8	4%	48.61	19.12	
South	2	2%	40.13	21.77	
Center-west	2	6%	51.69	23.87	
Juridical nature					
Local Public Entities	7	6%	53.68	20.63	
Regional Public Entities	11	4%	40.03	19.20	0.000
Local Private Entities	1	4%	56.15	22.16	
Regional Private Entities	0	0%	56.56	20.03	
Customer density					
G1 (< 64)	6	32%	48.30	23.37	
G2 ($64-79$)	3	16%	43.18	18.95	0.164
G3 ($79-98$)	3	16%	41.35	19.08	
G4 (> 98)	7	37%	45.67	21.03	
Water source					
Predominantly surface water ($> 95\%$)	12	4%	42.97	20.65	
Mixed sources ($50-95\%$)	3	3%	44.87	18.90	0.026
Predominantly groundwater ($< 50\%$)	4	5%	49.75	22.46	

Table 5.9 highlights the existence of significant heterogeneity in the efficiency levels of Brazilian municipalities, as the average efficiency score is quite low (44.62%). The majority of DMUs located on the frontier belong to the Southeast and Northeast regions (8 and 5, respectively, out of 19). Nevertheless, all regions have benchmark municipalities located on the country best-practice frontier.

Furthermore, the results show that only the Center-west, Southeast and North regions obtained efficiency scores higher than the national average (51.69%, 48.61% and 46.14%, respectively). Conversely, the Northeast and South regions have the lowest average efficiency scores (around 40%). This result is in line with the literature, as Carvalho and Sampaio (2015) and Sato (2011) also identified the Southeast and Center-west regions as the most efficient and the Northeast as the most inefficient. Table 5.10 shows the municipalities located on the efficient frontier. It is possible to notice six state capitals among the municipalities, besides Brasilia, the Federal Capital.

Table 5.10: List of efficient municipalities in each macro-region

Efficient municipalities				
North	Northeast	Southeast	South	Centre-west
Altamira	Camocim	Americana	Curitiba†	Brasília‡
Manaus†	Fortaleza†	Araguari	Pinhais	Goiânia†
	Morada Nova	Belo Horizonte†		
	Salvador†	Birigui		
	São Gonçalo do Amarante	Duque de Caxias		
		Santo André		
		São Gonçalo		
		Uberlândia		

† State Capital. ‡ Federal Capital.

The Kruskal-Walis test identified statistically significant differences in the distribution of efficiency among the different Brazilian macro-regions ($p < 0.000$). Next, Dunn's pairwise test confirmed that the difference between the two most efficient and the two most inefficient regions is statistically significant (Table 5.11).

Table 5.11: Comparison by the pairwise method of the geographic location groups.

Region A - Region B	p value
Northeast - South	0.832
Northeast - North	0.184
Northeast - Southeast	**0.000**
Northeast - Center-West	**0.003**
South - North	0.252
South - Southeast	**0.000**
South - Center-West	**0.009**
North - Southeast	0.276
North - Center-West	0.353
Southeast - Center-West	0.974

Concerning the difference in the level of efficiency of services according to the legal nature of the provider, Table 5.9 shows that the municipalities that have services provided by regional public entities have the lowest average efficiency. On the other hand, despite the small representativeness of private providers (only 7% of Brazilian municipalities, see Table 5.5), local and regional private entities exhibit higher average efficiencies than their public counterparts.

The Kruskal-Walis test identified a statistically significant difference between the distribution of efficiencies in the groups for the variable 'juridical nature' ($p < 0.000$). Table 5.12 shows Dunn's pairwise test for the 'juridical nature' variable. The classification adopted in the table makes it possible to compare the different ownership and the different service scope. Regarding ownership, only the regional entities show statistically significant differences between public and private types ($p < 0.018$). Regarding the scope of operation, there are statistically significant differences between the efficiency distributions of Local Public Entities and Regional Public Entities ($p < 0.000$).

Table 5.12: Dunn' pairwise of the juridical nature groups.

Group A - Group B	p value
Ownership	
Local Public Entities - Local Private Entities	0.786
Regional Public Entities - Regional Private Entities	**0.018**
Scope	
Local Public Entities - Regional Public Entities	**0.000**
Local Private Entities - Regional Private Entities	0.859

Regarding contextual factors that may affect the water and sewage operations, the customer density variable was grouped according to quartiles, forming four groups, separated by the value of the first, second and third quartiles. Table 5.9 shows that the municipalities' clusters with the highest and lowest densities have the highest average efficiency values (in both cases, higher than the national average efficiency score). However, the K-W test reveals that customer density is not statistically significant in explaining the difference in efficiency scores.

On the other hand, the variable water source was separated in three groups according to the percentage of water treated in WTP. Were only considered municipalities with predominantly surface supply those with values of water treated in WTP above 95%, municipalities supplied by mixed source those with values between 50% and 95%, and municipalities with predominantly groundwater supply those with values below 50%. It is evident that municipalities that use surface water tend to have lower efficiency levels (see Table 5.9). Surface supply requires more complex treatment systems and specialized labor, which may lead to higher operational costs (the input of the DEA model). Consequently, the provision of water services at a higher cost can potentially reduce the efficiency score.

Furthermore, the Kruskal-Walis Test identified a statistical difference in the distribution of efficiency between the groups for the water source variable ($p < 0.026$). Moreover, Dunn's pairwise test shows that the statistical difference lies between the Predominantly Surface and Predominantly groundwater groups (Table 5.13).

Table 5.13: Comparison by the pairwise method of the water source.

Group A - Group B	p value
Predominantly surface water - Mixed sources	0.212
Predominantly surface water - Predominantly Groundwater	**0.009**
Mixed sources - Predominantly Groundwater	0.249

Additionally, Figure 5.2 shows the distribution of the efficiencies for the three groups of municipalities based on the water origin. It can be seen that the Kernel density curve for municipalities that predominantly use groundwater for supply overlaps the others in the highest efficiency range.

5.5.2 Access inequalities

Access to water supply and sanitation services is one of the most widely used key performance indicators to assess the development of the sector (Berg, 2010). In the case of Brazil, access is measured by the indicators 'Water supply coverage' and 'Sanitation service coverage', which

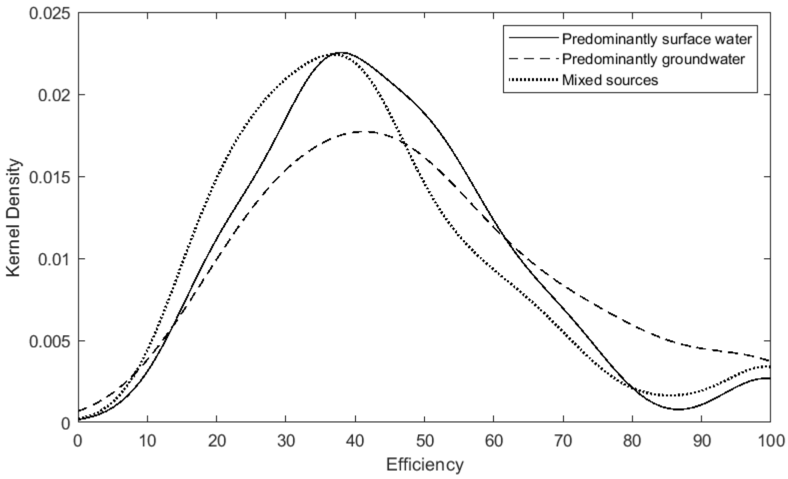


Figure 5.2: Kernel distribution as a function of the water source variable.

are calculated by the ratio of the total population served by the service (either water supply or sanitation) to the total resident population of the municipality (BRASIL, 2020). In this work, to evaluate access to services, a composite index was defined calculated by the arithmetic average of the two indicators mentioned above, ensuring that municipalities with higher coverage of water supply and sanitation services have a higher value of the index. This overall index will be referred to as 'Coverage' along the chapter.

Table 5.14 shows the average service coverage in the five Brazilian macro-regions. The values of coverage are also detailed according to the juridical nature of the providers in each municipality.

Table 5.14: Services coverage.

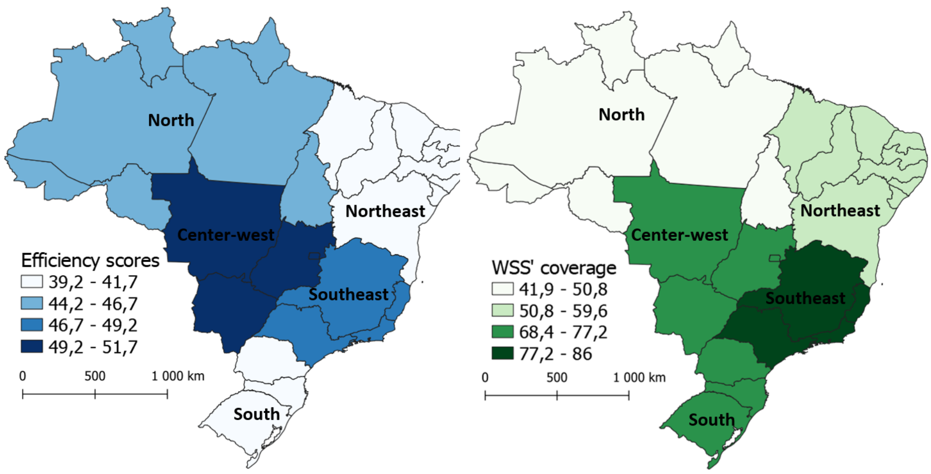
	Mean Coverage (%)
Country level results	
Brazil (all DMUs)	72.38
Geographic location	
North	41.94
Northeast	55.33
Southeast	86.04
South	74.85
Center-West	74.14
Juridical nature	
Local Public Entities	81.46
Regional Public Entities	68.54
Local Private Entities	81.19
Regional Private Entities	61.24

The unequal access to water supply and sanitation services throughout Brazil is remarkable. While the Southeast region presents values of coverage around 86%, the North and Northeast regions are significantly below the national average (42% and 55%, respectively, with the national average being 72%).

Regarding the juridical nature, as expected, the groups of municipalities with local entities have higher access to water and sanitation services than the municipalities with services provided by Regional Public Entities. This result was expected since the municipalities whose providers are local entities are those that historically had better-established services and, therefore, did not need to subject the control and operation of their services to the intervention of a state-level entity. Moreover, local entities tend to have lower levels of bureaucracy than regional entities. On the other hand, the reduced service coverage index in municipalities with regional providers also reflects the historical burden these entities have carried over the years, providing services to the poorest and most technically deficient municipalities. These entities will have to face a huge challenge to reduce the gap in relation to other areas in Brazil, and meet national and international goals. It is noteworthy that, regarding local entities, there is no relevant difference in service coverage between public and private entities. Surprisingly, the municipalities with regional private entities have lower service coverage than their public counterparts. However, the sample size of regional private entities is very small, so these results should be interpreted with caution.

5.5.3 Overall performance: efficiency and access

Understanding the overall performance of water services in Brazilian municipalities requires integrating the access dimension with the technical efficiency results. Figure 5.3 (a) and (b) illustrates the regional differences in terms of WSS' Efficiency and Coverage. Better performance corresponds to higher values of efficiency and coverage indices, which are displayed in Figure 5.3 with darker colors.



(a) Efficiency (b) Coverage

Figure 5.3: Average levels of Efficiency and Coverage in Brasilian macroregions.

One may expect a direct relationship between the dimensions 'Access' and 'Efficiency'. Notwithstanding, the Figure 5.3 show that the best and the worst performers present a distinct configuration for each dimension evaluated. Only the Southeast and Center-west regions stand out in both dimensions. The North region, which stands out for technical efficiency (third highest regional average efficiency), fails for low service coverage (lowest regional WSS' coverage). On the contrary, the South region stands out for the second high WSS' coverage, but operates inefficiently. This result has operational and public policy relevance since it allows practitioners and local authorities to understand the current situation of the services and define objectives and priorities in addressing performance improvements in the water sector.

Figure 5.4 depicts the integrated performance analysis, where the horizontal axis shows the service coverage and the vertical axis displays the efficiency. If the graph is divided into quadrants, by Efficiency and Services Coverage means (44.62% and 72.38%, respectively), the positioning of the municipality on the graph signals to regulators and operators four different incentive strategies that may be adopted to improve performance.

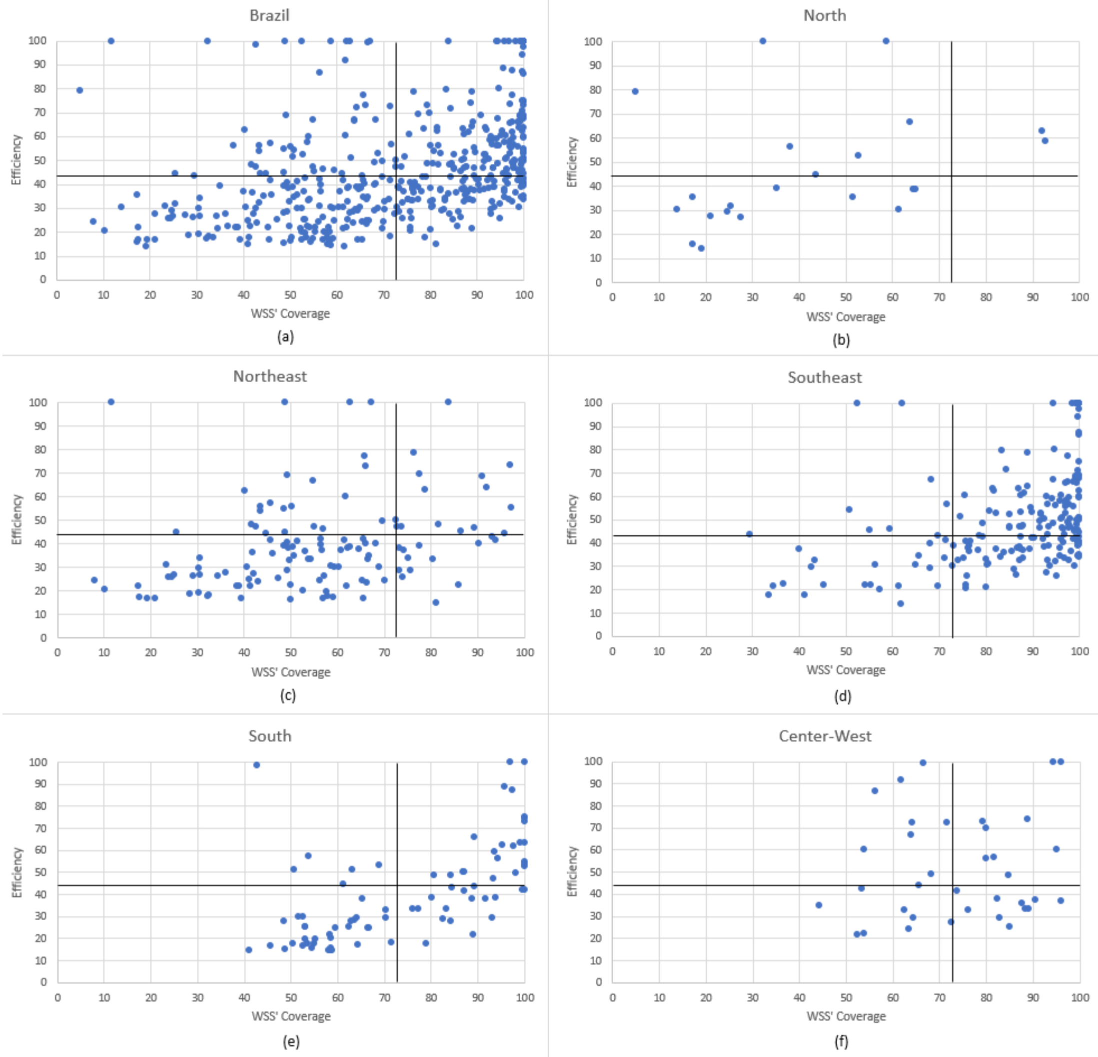


Figure 5.4: Efficiency scores and Services coverage as a function of the Brazilian macro-regions.

The first quadrant (upper-right) includes the benchmark municipalities, which may provide examples of best-practices in the water sector in Brazil. The second quadrant (upper-left) includes the municipalities with above-average technical efficiency and below-average service coverage. In this case, the demand for investments in services' expansion is evident, so it would be necessary to stimulate technical efficiency to ensure operational surplus and look for alternative sources of financial resources to improve coverage (Federal government, bank loans, international cooperation). The third quadrant (lower-left) includes the municipalities in critical situations both in terms of coverage and efficiency. Administrative authorities and regulators should joint efforts to trigger and sustain systematic performance improvements in these municipalities. The fourth quadrant (lower-right) includes the municipalities with above-average service coverage and below-average technical efficiency. In these cases, the regulator should stimulate the reduction of operational expenses, either by reducing waste/misuse of resources or by developing policies that encourage investment in more efficient equipment.

The result of this analysis indicates that 153 (34%) of Brazilian municipalities are in the first quadrant area, 49 (11%) in the second, 137 (31%) in the third and 109 (24%) in the fourth. This means that nearly one third of the large Brazilian municipalities require improvements both in coverage and efficiency levels, which will require an expressive amount of investment to expand service coverage, alongside the implementation of strict policies to control operational expenses.

Both the North and Northeast have approximately 60% of their large municipalities in the third quadrant region (Figures 5.4 b and c). The South region also has a significant portion (43%) of its large municipalities located in the third quadrant (Figure 5.4 e). In fact, only the Southeast region has most of its municipalities (48%) in the first quadrant (*i.e.*, the best performing quadrant, Figure 5.4 d). In turn, the Center-West region presents a balanced distribution, with a slight predominance of municipalities (31%) in the fourth quadrant (Figure 5.4 f).

Figure 5.5 shows the result of the performance analysis according to the juridical nature of the providers. One can observe a preponderance of municipalities with services operated by Local Entities (both public and private) in the first quadrant. It is also noticeable that even the remaining municipalities are close to this quadrant. In contrast, many municipalities with regional public providers are located in the third quadrant (*i.e.*, the worst-performing quadrant), suggesting a compelling need of public policies geared towards the improvement of water and wastewater services in these municipalities.

As a final point, the importance of improved water supply and sanitation services on well-being and socio-economic development is well known (Ferreira et al., 2021). In this context, it is worth evaluating the relationship between the good performance of services and the level of socio-economic development of Brazilian municipalities. Thus, the research question to be tested is whether there is an influence of the coverage and efficiency dimensions on the life expectancy index (LEI), the health-related component of the human development index. A regression was run to explore the impact of efficiency and WSS' coverage on LEI. Table 5.15 shows the regression coefficients and standard errors.

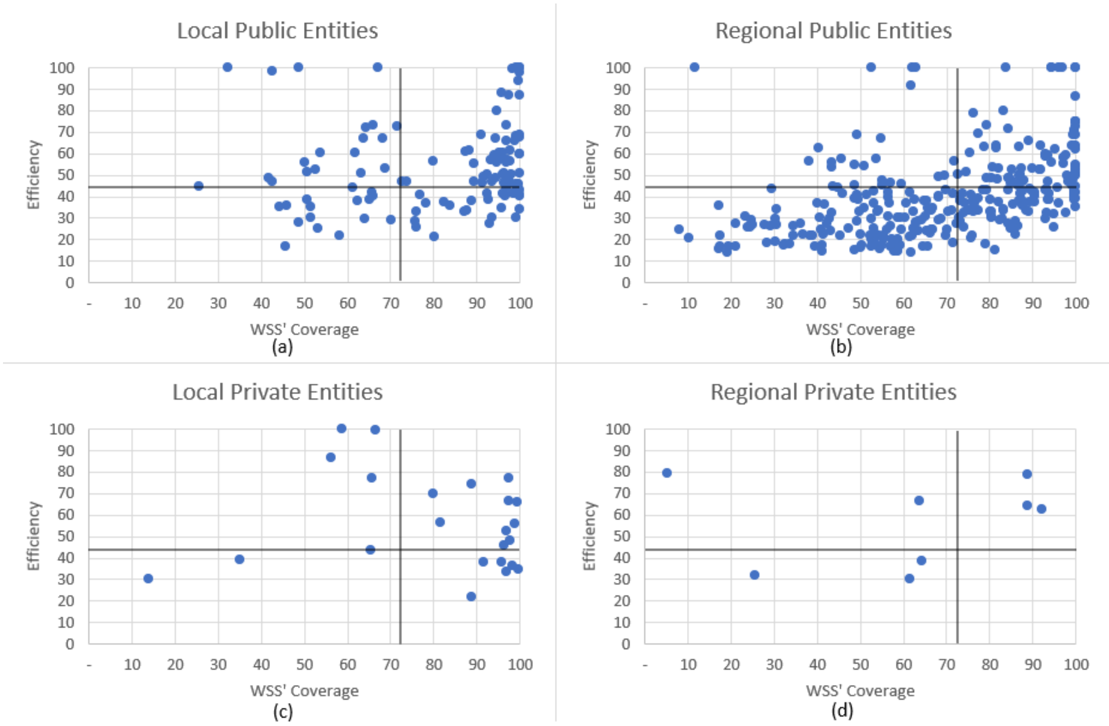


Figure 5.5: Efficiency scores and Services coverage as a function of the juridical nature.

Table 5.15: Regression results for the dependent variable Life Expectancy Index.

	B	SE B	β
Constant	76.929*	0.451	
Efficiency	-0.012	0.007	-0.073
WSS' coverage	0.092*	0.006	0.618*

B = unstandardized regression coefficient
SE B = standard error of the coefficient
β = standardized coefficient;
*p value $<$ 0.05.

The adjusted R^2 of the regression is 0.349 (p value $<$ 0.001). It can be concluded that WSS' coverage variable has a positive and statistically significant impact on LEI ($p < 0.05$), while the efficiency variable is not statistically significant ($p = 0.07$).

The robustness of the model was also tested. Regarding multicollinearity, the results of the Variable Inflation Factor (VIF) (Daoud, 2017) showed that there are no problems of multicollinearity among variables (according to HAIR (1995) a value lower than 10 is acceptable for conducting the regression; a value of VIF equal to 1.177 was obtained in this study). The independence of the error term was assessed by visual inspection of a plot of standardized residuals versus unstandardized predicted values. It was concluded that residuals are independent as the spread of the values does not increase or decrease across the range of the predicted values. The normality assumption of the error term was met, as assessed by a P-P Plot of the regression standardized residuals.

Of course, there can be no development without access to services. Likewise, it is difficult to discuss the efficiency of services in a municipality with low service coverage. However, it is a natural process for the population's expectations regarding the efficiency of these services to increase. Thus, it is clear that water supply services in Brazil, particularly in large cities, might face a transition from focusing on access to services to focusing on efficiency.

5.6 Conclusions

This part of study has shown that water supply and sanitation services performance should not be benchmarked only from the standpoint of operational efficiency. An integrated perspective considering the efficiency and access dimensions can bring critical insights into the quality of service provided to the population and guide the design of performance improvement strategies for the sector. Water services are essential to human welfare and require well-designed policies that combine infrastructure investment strategies with incentives to overcome inefficiencies. To this end, it is proposed a benchmarking approach to assess the performance of water supply and sanitation services in Brazilian municipalities from an integrated perspective of cost efficiency and access.

The results revealed significant heterogeneity in the efficiency levels of Brazilian municipalities, as the average efficiency score is relatively low (45%). Water supply and sanitation services in municipalities in the Southeast and Center-West regions have the best performance among Brazilian macro-regions. In contrast, the Northeast region had the worst performance on the efficiency dimension, while the North Region was the worst performer on the coverage dimension.

Regarding the contextual factors that can potentially affect operational performance, the impact of customer density on efficiency is not statistically significant for Brazilian municipalities. Concurrently, the predominant use of groundwater for supply has a positive and statistically significant effect on efficiency.

Additionally, the juridical nature of the providers was explored to establish the most advantageous form of operation in terms of geographical scope and ownership type. The results revealed better performance of local entities compared to regional ones, especially in the access dimension. Concerning the ownership of services, no relevant differences were found between the performance of public and private local entities. As for the regional entities, the analysis showed that while public entities have superiority in the coverage dimension, private entities show higher scores in the efficiency dimension. Nevertheless, this result should be viewed cautiously since the small number of municipalities with regional private providers may undermine their statistical representativeness.

From the regulatory perspective, the integrated performance analysis (considering the efficiency and coverage dimensions) allowed to establish three main strategies that municipalities with low performance could adopt: i) for municipalities with low coverage but above-average efficiency, regulators should encourage the maintenance of the efficiency level, while administrative authorities need to explore alternative sources of financial resources for the expansion of the infrastructure; ii) for municipalities with low efficiency but above-average coverage, the regulator should stimulate the reduction of operational expenses by reducing waste/misuse of resources, while administrative authorities should develop policies that encourage investment in more efficient equipment; iii) for municipalities with low levels of efficiency and coverage, administrative authorities and regulators should joint efforts to trigger and sustain systematic performance improvements. Privatizing services may be a possibility to consider in these cases since private management is usually focused on efficiency gains and cost reduction. In addition, private investment can be a viable way to finance the expansion of coverage.

Finally, multiple regression showed the moderate influence of water supply and sanitation services on the life expectancy index. However, only the coverage dimension was statistically significant.

The results of this study are relevant for regulators in characterising the current state of performance of water supply and sanitation services. Benchmarking projects can help decision-makers to develop strategies that disseminate good practices.

CHAPTER 6

Productivity change in Brazilian water services: a benchmarking study of national and regional trends

Assessing the evolution of the performance of water supply and sanitation services is essential to monitor progress towards the universalization of water services, as specified by the Sustainable Development Goal 6 of Agenda 2030, adopted by United Nations member countries. Brazil, a developing country with a continental size and geographical diversity, will face significant challenges to achieve this goal. The main objective of this chapter is to evaluate the evolution of productivity of water supply and sanitation services in Brazilian municipalities in the period 2012-2019. The analysis also explores whether water services' performance is balanced across the country, which involves a specific analysis of performance at the macroregion level. From a methodological perspective, this research evaluates productivity change over time using a Malmquist Productivity Index that satisfies the circularity property, estimated with a metafrontier. It also develops a pseudo Malmquist index that compares productivity levels across regions. The results revealed a productivity loss of approximately 4% at the national level, with an unequal profile across the macroregions. The Southeast municipalities stand out for exhibiting, on average, higher productivity levels than the South and Northeast municipalities. In contrast, a few municipalities in the South and Northeast are able to operate with proportionally lower costs, such that the frontiers of these macroregions dominate the frontier of the Southeast.

6.1 Introduction

Water is a fundamental resource inherent to human life, and a critical support for ecosystems, biodiversity and to sustainable and resilient societies. Access to water needs, in quantity and quality, is at the core of sustainable development and is critical for socio-economic welfare, healthy ecosystems and dignity of human life.

Water supply and sanitation are essential services for the well-being of the world's population and development of societies. It is vital for improving the health, welfare and productivity of populations. Notably, the United Nations Assembly has set the ambitious goal of ensuring universal and equitable access to water services by 2030 (UN, 2015b). Attaining this goal will be challenging, and inevitably requires taking measures to eliminate inefficiencies and improve the productivity of the water sector worldwide.

It is noteworthy that research on efficiency and productivity in the water industry has seen significant growth in the last twenty years. The use of advanced operational research, statistics, and econometric techniques allowed important contributions to the improvement of the performance of public utilities. As noted in the systematic literature review of Abbott and Cohen (2009), the first studies dedicated to the assessment of performance in the water sector are dated from the late seventies. The authors observed that the studies in the water industry typically fall into one of four categories: economies of scale, economies of scope, public versus private ownership, and the effects of regulation on water services improvement. Notably, in the water sector, analyzing productivity change over time allows assessing whether public policies promoted by the government or regulator's actions have achieved the intended goals. (*e.g.*, Guerrini et al., 2018; Molinos-Senante and Sala-Garrido, 2015; Saal and Parker, 2000).

In this context, it is worth highlighting the situation in Brazil, a developing country where the five macro-regions have distinct physical, environmental and socio-economic characteristics. One of the main challenges is the universalization of water supply and sanitation services, given regional inequalities. Even though these differences are evident, no studies in the literature have yet evaluated the evolution of productivity in the Brazilian water sector taking into account the country's diversity. This brings up the following research questions to be explored in this paper: Is the evolution of productivity of water supply and sanitation services bringing Brazil closer to the objectives of the 2030 Agenda? Is the evolution of productivity of water supply and sanitation services consistent among the Brazilian macro-regions? To answer these questions, this study will use the Global Malmquist Productivity Index (Pastor and Lovell, 2005) to assess the evolution of productivity in 283 large Brazilian municipalities (with over 50 thousand inhabitants) in the period 2012-2019. It will also develop and apply a pseudo Malmquist index to compare productivity levels across regions.

The increase in the coverage of water supply and sanitation services in the country is evident, despite the different paces among regions. According to BRASIL (2020), the Southeast region has the highest WSS' coverage throughout the study period. However, it has the lowest percentage evolution among the regions (from 83 to 84% in 2012-2019). It is noteworthy that raising service coverage from a certain level can be more challenging, particularly in irregular areas, such as urban slums (favelas) and rural areas. In turn, the South region increased the service coverage by approximately 1.5% per year over the same period (from 70 to 78%).

Water losses are another critical factor in the productivity of water supply services. Brazil is internationally recognized for its abundance of water, being one of the countries with the largest amount of fresh water on the planet. However, the country has been facing recurring water scarcity scenarios due to climate change.

The year 2021 was marked by one of the biggest water crises. The lack of water is reflected in public health and the economy since the national energy matrix is based on hydroelectric generation. In a country where it is usually cheaper to increase water production than to promote measures to control water losses, the worsening of water availability is likely to increase the costs of providing supply services in the coming years significantly.

Data from the SNIS show that the water losses increased approximately 4.5% in Brazil (between 2012 and 2019), emphasizing the Northeast region, where water losses increased by approximately 1% per year. This difference in operational indicators of WSS' coverage and water loss further reinforces the effort in investigating regional differences in the evolution of productivity of water supply and sanitation services.

The remainder of this paper is organized as follows. Section 2 presents a brief literature review, discussing the studies that assessed productivity change in the water sector using frontier techniques. Section 3 describes the Global Malmquist Productivity index and the Data Envelopment Analysis (DEA) models used to estimate efficiency. The sample studied is described in section 4. Section 5 reports the performance assessment results of Brazilian municipalities' water and sanitation services. Finally, conclusions are presented in the last section.

6.2 Literature review

Over the last decades, the literature on water utility benchmarking has seen considerable growth, including technical efficiency and total factor productivity (TFP) change topics. Improving the productivity of water supply and sanitation services is a goal that managers and regulators must pursue to ensure the long-term sustainability of the services. Moreover, benchmarking the performance of water companies can contribute to identify the best practices and reduce operational costs (Carvalho and Marques, 2014).

As noted by Abbott and Cohen (2009), the assessment of performance in the water sector has been primarily focused on efficiency topics, involving the analysis of economies of scale, economies of scope, and the impact of ownership on utilities' performance. The study of productivity change has been less explored, and the first studies on this topic only appeared in the last decade.

Table 6.1 shows an overview of the literature on the assessment of productivity change using frontier techniques applied to water supply and sanitation services. Most studies were conducted in England and Wales (*e.g.*, Mocholi-Arce et al. (2021), Maziotis et al. (2017) and Portela et al. (2011)) and Chile (*e.g.*, Sala-Garrido et al. (2018) and Molinos-Senante and Sala-Garrido (2015)). This may have been triggered by the regulatory reforms that occurred in these countries, particularly with the privatization of the water services. In fact, the main objective reported in the studies is the assessment of the impact of regulatory reforms on the productivity of water services (Maziotis et al., 2021; Mocholi-Arce et al., 2021).

In Brazil, only Carvalho and Sampaio (2015) have conducted a study to evaluate the productivity change of water and sanitation companies. The authors identified productivity gains between 2006 and 2011, mainly due to the frontier shift. One limitation of the study is that the authors calculated the Malmquist index only for the first and final year studied, which does not allow exploring the annual trends within this period. The research conducted in our paper aims to address this gap by considering the most recent period with data available (2012-2019), and explore annual trands in productivity change, at national and macroregion levels.

Table 6.1: Summary of water utilities studies on productivity change over time.

Reference	Country	Method	Sample	Period
Maziotis et al. (2021)	Chile	Luenberger-Hicks-Moorsteen productivity indicator (LHMPI)	20 Water and Sanitation Companies (WaSCs)	2007-2018
Mocholi-Arce et al. (2021)	England and Wales	Metafrontier Malmquist Luenberger productivity index (MMLPI)	7 Water only Companies (WoCs) and 10 WaSCs	2001-2018
Molinos-Senante et al. (2020a)	Chile	Malmquist Productivity Index (MPI) (with SFA)	22 water companies	2007-2015
Sala-Garrido et al. (2019)	Chile	MMLPI	22 water companies	2010-2016
Ananda and Pawsey (2019)	Australia	Malmquist-Luenberger productivity index (MLPI)	50 WaSCs	2009-2016
Guerrini et al. (2018)	Italy	Luenberger productivity indicator (LPI) and MPI	136 water companies	2009-2014
See and Ma (2018)	Malaysia	MMLPI	14 water utilities	1999-2012
Sala-Garrido et al. (2018)	Chile	LHMPI and LPI	23 water utilities	2010-2016
Molinos-Senante and Maziotis (2018)	England and Wales	SFA	11 WoCs and 10 WaSCs	1996-2009
Molinos-Senante et al. (2017a)	England and Wales	Färe-Primont Productivity Index (FPI)	12 WoCs and 10 WaSCs	2001-2008
Maziotis et al. (2017)	England and Wales	MLPI	12WoCs and 10 WaSCs	2001-2008
Molinos-Senante and Sala-Garrido (2015)	Chile	LPI	18 WaSCs	1997-2013
Carvalho and Sampaio (2015)	Brazil	MPI	27 WaSCs	2006 & 2011
Molinos-Senante et al. (2014)	England and Wales	LPI and MPI	22 water companies	2001-2008
De Witte and Marques (2012)	Belgium and Netherland	MPI	52 water utilities	1999-2005
Portela et al. (2011)	England and Wales	meta-Malmquist productivity index (MMPI)	22 water companies	1993-2007

Most of the studies in the selected literature applied the Malmquist Productivity index (*e.g.*, Molinos-Senante et al., 2020a; Carvalho and Sampaio, 2015; De Witte and Marques, 2012), the Luenberger Productivity Indicator (LPI) (*e.g.*, Guerrini et al., 2018; Molinos-Senante and Sala-Garrido, 2015) or extensions of these approaches.

Furthermore, some authors estimated productivity change using as reference a metafrontier (*e.g.*, Mocholi-Arce et al. (2021); Sala-Garrido et al. (2019); See and Ma (2018)), which ensures the circularity of the productivity index. The use of a metafrontier to estimate productivity change was first proposed by Pastor and Lovell (2005). This index has been applied to the water sector in England and Wales in the pioneering work of Portela et al. (2011).

Many studies have adopted variables related to service quality, specified as undesirable outputs, *e.g.*, water losses (Maziotis et al., 2021; Mocholi-Arce et al., 2021; Sala-Garrido et al., 2019; See and Ma, 2018), which require the use of Directional Distance Function (DDF) models (Chung et al., 1997). This explains the existence of a number of papers using the Luenberger productivity indicator proposed by Chambers et al. (1996). The LPI assesses productivity change as a difference between Directional Distance Functions, allowing the simultaneous evaluation of potential input savings and output improvements.

Some authors have used the Malmquist-Luenberger Productivity Index (MLPI) (*e.g.*, Ananda and Pawsey, 2019; Maziotis et al., 2017). The MLPI, introduced by Chung et al. (1997), also allows for modeling approaches where desirable and undesirable outputs coexist. In opposition to the LPI, the MLPI is expressed as a ratio of distance measures, allowing a proportional interpretation of the magnitude of productivity change. This enables the integration of service quality in water sector assessments, preventing 'low cost and low quality' water utilities from being incorrectly labeled as efficient (Ananda and Pawsey, 2019).

The literature review showed that most articles on the assessment of productivity change use companies (both water only, or water and sanitation) as the decision-making unit (DMU). This study innovates by adopting the municipality as the unit of analysis. This strategy allows for a more comprehensive evaluation of the performance of services from a national public policy perspective. In addition, considering a broad group of municipalities from different regions of Brazil allows exploring whether the evolution of water supply and sanitation services is balanced throughout the country. Finally, consolidating municipal information in a national panorama seems an appropriate strategy to study the impact of the Agenda 2030 on the pattern of productivity change in the Brazilian water sector.

6.3 Methodology

6.3.1 Global Malmquist index

In recent years, the Malmquist index has become the standard approach to productivity measurement within the non-parametric literature. Malmquist indexes were introduced by Caves et al. (1982b). They named these indexes after Malmquist, who had earlier proposed constructing input quantity indexes as ratios of distance functions. The Malmquist index was treated as a theoretical concept until its enhancement by Färe et al. (1992); Färe et al. (1994). A major contribution of these papers was to relax the efficiency assumption underlying the production activity, and provide DEA models for the calculation of the Malmquist index. Another major achievement of Färe et al. (1992) and Färe et al. (1994) was to show how to decompose the Malmquist index into an index of technical efficiency change, and an index reflecting the change in the frontier of the production possibility set (or technology).

However, the original formulation of the Malmquist index proposed by Färe et al. (1992) fails the circular property, *i.e.*, the value of the index between time period t and $t+2$ cannot be derived from the values of the productivity index between t and $t+1$ as well as $t+1$ and $t+2$. Therefore, in this paper we use an alternative formulation of the MI, proposed by Pastor and Lovell (2005), that satisfies the circular property. This index evaluates efficiency considering a metafrontier that envelops all data.

Let $X^{g,t}$ and $Y^{g,t}$ be nonnegative real input and output vectors of a DMU in group g and period t. The technology $T^{g,t}$ can be specified as follows:

$$T^{g,t} = \{(X^{g,t}, Y^{g,t}) : X^{g,t} \geq 0;\ Y^{g,t} \geq 0;\ X^{g,t} \text{ can produce } Y^{g,t}\} \tag{6.1}$$

Following the concept defined by O'Donnell et al. (2008), the metatechnology can be seen as the union of the period and group technologies for all periods t $(t = 1, ..., p)$ and all groups g $(g = 1, ..., z)$ considered. The metatechnology T^M is then defined as follows:

$$T^M = \bigcup_{\forall g,\ \forall t} T^{g,t} \tag{6.2}$$

This is the technology that will be used to estimate productivity change in the national analysis of Brazilian municipalities' performance in the period 2012-2019.

However, to explore in more detail the distinctive features of Brazilian macroregions, we will also conduct separate analysis with subsamples corresponding to data of municipalities from the same macroregion. In this case, the metatechnology is obtained only using data from a given group (g), and is estimated as follows:

$$\begin{aligned} T^g &= \bigcup_{\forall t} T^{g,t} \\ &= T^{g,t_1} \cup T^{g,t_2} \cup \ldots T^{g,t_p} \end{aligned} \tag{6.3}$$

The Global Malmquist index (GMI) computed using efficiency estimates based on a metafrontier is formulated as shown in (6.4). This specification follows the formulation proposed by Pastor and Lovell (2005).

$$GMI^{t,t+1} = \frac{E^M(X^{g,t+1}, Y^{g,t+1})}{E^M(X^{g,t}, Y^{g,t})} \tag{6.4}$$

In expression (6.4), $E^M(X^{g,t}, Y^{g,t})$ corresponds to a DEA efficiency estimate of DMU $(X^{g,t}, Y^{g,t})$, observed in group g and time period t, evaluated against the metafrontier of technology T^M. $E^M(X^{g,t+1}, Y^{g,t+1})$ has a similar interpretation for a DMU in time period $t+1$.

Model (6.5) shows the linear programming formulation corresponding to the assessment of a DMU k in period t and group g against the metatechnology T^M. The formulation is presented with an output orientation, as this is the orientation adopted in the empirical application reported in this paper.

$$\begin{aligned} &\left[E^M(X^{g,t}, Y^{g,t})\right]^{-1} = \text{Min} \sum_{i=1}^{m} v_i x_{ik}^{g,t} \\ &\text{s.t.} \sum_{r=1}^{s} u_r y_{rk}^{g,t} = 1 \\ &\sum_{r=1}^{s} u_r y_{rj}^{g,t} - \sum_{i=1}^{m} v_i x_{ij}^{g,t} \leq 0 \quad j \in T^M \\ &u_r, v_i \geq 0 \qquad r = 1, \ldots, s \quad, i = 1, \ldots, m \end{aligned} \tag{6.5}$$

In model (6.5), $y_{rj}^{g,t}$ are the outputs $(r = 1, ..., s)$ generated by DMU j $(j = 1, ..., n)$ in period t and group g, and $x_{ij}^{g,t}$ are the inputs $(i = 1, ..., m)$ consumed in the production process. The models decision variables u_r and v_i are the weights attached to the outputs and inputs, respectively.

The optimal value of the objective function corresponds to the value of radial efficiency score for DMU k evaluated against the technology T^M. A DMU is on the frontier of the technology if the efficiency score is equal to one, while values lower than one are associated with inefficient DMUs.

Following Pastor and Lovell (2005), the Global Malmquist index can also be decomposed in the Efficiency Change (EC) component and Best-Practice Change (BPC), as follows:

$$\begin{aligned} GMI^{t,t+1} &= \frac{E^{t+1}(X^{g,t+1},Y^{g,t+1})}{E^t(X^{g,t},Y^{g,t})} \times \left(\frac{E^M(X^{g,t+1},Y^{g,t+1})}{E^{t+1}(X^{g,t+1},Y^{g,t+1})} \times \frac{E^t(X^{g,t},Y^{g,t})}{E^M(X^{g,t},Y^{g,t})} \right) \\ &= \frac{E^{t+1}(X^{g,t+1},Y^{g,t+1})}{E^t(X^{g,t},Y^{g,t})} \times \left(\frac{\frac{E^M(X^{g,t+1},Y^{g,t+1})}{E^{t+1}(X^{g,t+1},Y^{g,t+1})}}{\frac{E^M(X^{g,t},Y^{g,t})}{E^t(X^{g,t},Y^{g,t})}} \right) \\ &= EC^{t,t+1} \times \left(\frac{BPG^{t+1,M}(X^{g,t+1},Y^{g,t+1})}{BPG^{t,M}(X^{g,t},Y^{g,t})} \right) \\ &= EC^{t,t+1} \times BPC^{t,t+1} \end{aligned} \tag{6.6}$$

$EC^{t,t+1}$ is the usual efficiency change component of the Malmquist index (Färe et al., 1994) and $BPG^{\,t,M}(X^t,Y^t)$ is a best practice gap between the frontiers of T^M and T^t measured along ray (X^t,Y^t). $BPC^{t,t+1}$ is the change in BPG, and provides an estimate of frontier shift between t and $t+1$. $BPC^{t,t+1} > 1$ indicates that the frontier in period $t+1$ is closer to the metatechnology than is the frontier in period t. A value $BPC^{t,t+1} < 1$ indicates that the frontier in $t+1$ is further away from the metatechnology than the frontier in t.

The estimation of the EC and BPC components of the GMI requires the estimation of two efficiency scores for the DMU k under evaluation in period t and in period $t+1$, represented by $E^t(X^t,Y^t)$ and $E^{t+1}(X^{t+1},Y^{t+1})$, which consider as reference the technology T^t and T^{t+1}. This technology for a given time period t is defined as follows:

$$\begin{aligned} T^t &= \bigcup_{\forall g} T^{g,t} \\ &= T^{g_1,t} \cup T^{g_2,t} \cup \ldots T^{g_z,t} \end{aligned} \tag{6.7}$$

The estimation of $E^t(X^{g,t},Y^{g,t})$ for a DMU k in group g observed in time period t, with outputs $y_{rj}^{g,t}$ and inputs $x_{ij}^{g,t}$, is done using model (6.8). The adaptation of model (6.8) to the estimation of $E^{t+1}(X^{g,t+1},Y^{g,t+1})$ is straightforward, as it only requires using as reference the technology t^{t+1} in the second restriction of the model.

$$\left[E^t(X^{g,t},Y^{g,t})\right]^{-1} = \text{Min} \sum_{i=1}^{m} v_i x_{ik}^{g,t} \tag{6.8}$$

$$\begin{aligned} &\text{s.t.} \sum_{r=1}^{s} u_r y_{rk}^{g,t} = 1 \\ &\sum_{r=1}^{s} u_r y_{rj}^{g,t} - \sum_{i=1}^{m} v_i x_{ij}^{g,t} \leq 0 \quad j \in T^t \\ &u_r, v_i \geq 0 \qquad r = 1,\ldots,s \quad, i = 1,\ldots,m \end{aligned}$$

The optimal value of the objective function corresponds to the value of radial efficiency score for DMU k evaluated against the technology T^t. A DMU is on the frontier of the technology if the efficiency score is equal to one, while values lower than one are associated with inefficient DMUs.

6.3.2 Pseudo Malmquist index for group comparisons

The assessment of performance reported in this paper also involves a comparison of municipalities from different macro-regions in the decade considered. This required the development of a new index for the comparison of groups in a given time period t. Consider z groups $(g = g_1, g_2, ..., g_z)$ whose performance needs to be compared considering data from j DMUs that belong to each group. The number of DMUs in each of the groups can vary, and it is denoted for group g as n_g. The metatechnology is denoted as T^M and is defined as in the previous section.

The resulting pseudo-Malmquist index to evaluate the productivity gap between two groups, is presented in expression (6.9). To distinguish this index from the standard formulation of the Global Malmquist index to assess productivity change over time, we will name this index Group Comparison Index (GCI).

$$GCI^{g_1g_2,t} = \frac{\left[\prod_{j=1}^{n_{g_2}} E^M((X_j^{g_2,t}, Y_j^{g_2,t})\right]^{1/n_{g_2}}}{\left[\prod_{j=1}^{n_{g_1}} E^M(X_j^{g_1,t}, Y_j^{g_1,t})\right]^{1/n_{g_1}}} \tag{6.9}$$

A value of $GCI^{g1g2,t} > 1$ indicates that the average productivity of group g_2 is higher than the average productivity of group g_1 in the year under assessment t.

Note that for comparisons involving more than two groups, observations from all groups and periods involved in the analysis should be considering in the specification of T^M technology to ensure the circularity of the index, as follows:

$$GCI^{g_1g_3,t} = GCI^{g_1g_2,t} \times GCI^{g_2g_3,t} \tag{6.10}$$

This index can also be decomposed in the components of Efficiency Spread Gap (ESG) and Best-Practice Gap (BPG), as shown in (6.11) and (6.12).

$$ESG^{g_1g_2,t} = \frac{\left[\prod_{j=1}^{n_{g_2}} E^{g_2,t}(X_j^{g_2,t}, Y_j^{g_2,t})\right]^{1/n_{g_2}}}{\left[\prod_{j=1}^{n_{g_1}} E^{g_1,t}(X_j^{g_1,t}, Y_j^{g_1,t})\right]^{1/n_{g_1}}} \tag{6.11}$$

$$BPG^{g_1g_2,t} = \frac{\left[\prod_{j=1}^{n_{g_2}} E^M(X_j^{g_2,t}, Y_j^{g_2,t})\right]^{1/n_{g_2}}}{\left[\prod_{j=1}^{n_{g_2}} E^{g_2,t}(X_j^{g_2,t}, Y_j^{g_2,t})\right]^{1/n_{g_2}}} \cdot \frac{\left[\prod_{j=1}^{n_{g_1}} E^{g_1,t}(X_j^{g_1,t}, Y_j^{g_1,t})\right]^{1/n_{g_1}}}{\left[\prod_{j=1}^{n_{g_1}} E^M(X_j^{g_1,t}, Y_j^{g_1,t})\right]^{1/n_{g_1}}} \tag{6.12}$$

When exploring the components of the index, a value of $ESG^{g_1g_2,t} > 1$ indicates that there is more homogeneity in group g_2 than in group g_1, meaning that the average distance to the group-specific frontier is smaller in group g_2 than in group g_1. Finally, a value of $BPG^{g_1g_2,t} > 1$ means that the frontier of group g_2 is more productive (dominates) the frontier of group g_1.

6.3.3 Specification of weight restrictions

In our empirical study, we added weight restrictions to models (6.8) and (6.5), formulated as Assurance Regions type I (ARI) (Thompson et al., 1990), with the specification of bounds as proposed by Zanella et al. (2015). This specification enhances the approach of Wong and Beasley (1990) by expressing the relative importance of outputs in percentage via an artificial DMU corresponding to the average values of the output variables in the sample under assessment. Recent examples of the application of this type of restrictions in efficiency analysis in the water sector can be found in Henriques et al. (2020) and Tourinho et al. (2021). Applications in other sectors, namely education and health, include Stumbriene et al. (2020) and Pereira et al. (2021).

Following Zanella et al. (2015), the ARI weight restrictions associated with specific outputs r ($r = 1,\ldots,s$) can be expressed as shown in (6.13), where $\bar{y}_r$ corresponds to the average value of output y_r in the whole sample considered (all years, all groups).

$$\frac{u_r \bar{y}_{r_k}}{\sum_{r=1}^{s} u_r \bar{y}_r} \geqslant \phi_{r_k}, \quad r_k = 1,\ldots,s \tag{6.13}$$

For modelling purposes, expression (6.13) should be rewritten as a linear restriction, as shown in (6.14) :

$$u_r \bar{y}_{r_k} - \phi_{r_k} \sum_{r=1}^{s} u_r \bar{y}_r \geqslant 0, \quad r_k = 1,\ldots,s \tag{6.14}$$

By limiting negligible weights and avoiding the disregard of one or more output indicators, the application of weight limitations mitigates a problem associated with total freedom in the definition of weights in DEA models (Lavigne et al., 2019). Furthermore, as stated by Zanella et al. (2015), the specification of ARI weight restrictions implemented in this study ensures that all DMUs in the sample share the same weight restrictions and are assessed against a single frontier. Is is noteworthy that as these restrictions are ratios of virtual weights, the bounds ϕ_{r_k} are expressed in percentage, and consequently are independent of the measurement scale of the outputs.

6.4 Sample and Variable selection

6.4.1 Sample studied

The data of operational and financial variables on water supply and sanitation services used in this study were obtained from the National Sanitation Information System (SNIS).

The sample used is a balanced panel of 283 large municipalities from all Brazilian macro-regions. The data was collected for the period 2012-2019. The municipalities assessed were selected to ensure homogeneity in terms of scale size, such that only those with more than 50,000 inhabitants were included in the sample (government agencies use this value to characterize large municipalities). Table 6.2 shows the number of municipalities from each macro-region included in the sample studied. The total number of municipalities in each macro-region is also reported, to reveal the representativeness of the sample in the Brazilian context.

Table 6.2: Number of large municipalities per Brazilian macro-region.

	Brazilian Macro-Region					
	North	Northeast	Southeast	South	Center-West	Total
Sample (no. municipalities)	5	91	81	73	33	283
Total (in the macro-region)	63	174	241	99	35	612

The sample used in this study represents 46% of the large Brazilian municipalities and contains more than half of the Brazilian population (52%). Some municipalities could not be included in this study due to the unavailability of data for the entire period studied. The Center-West region is the best represented in the sample, with 94% of its large municipalities analysed in this study, covering 85% of its population. On the other hand, the North region is the least represented in the sample, containing only 8% of its large municipalities. The population representativeness of the Northern region is approximately 37%.

6.4.2 Variable selection for the efficiency assessment

The selection of input and output variables is a critical step in an efficiency analysis study, as noted in recent literature reviews in the water industry (Goh and See, 2021; Cetrulo et al., 2019). The variables should be selected to reflect the objectives of the studies. Table 6.3 shows the inputs and outputs of the models specified in the selected literature previously reported in Table 6.1.

Table 6.3: Overview of the inputs and outputs used in the previous studies.

Reference	Inputs	Outputs
Maziotis et al. (2021)	Total operating costs (Chilean Pesos/year); total network length	Adjusted volume of water delivered (1,000 m^3/year); number of customers receiving wastewater treatment. Undesirable: Volume of leaked water (1,000 m^3/year); water supply unplanned interruptions (h/year)
Mocholi-Arce et al. (2021)	Annual total expenditure (M£/year)	Volume of water distributed (1,000 m^3/year); number of water connections (1,000/year). Undesirable: Volume of leaked water (1,000 m^3/year); number of bursts per km of main
Molinos-Senante et al. (2020a)	Length mains (km); operation expenditure (Chilean pesos/year); number of employees	Drinking water delivered (m^3/year); customers with access to wastewater treatment
Sala-Garrido et al. (2019)	Operating costs (Chilean Pesos/year); number of employees	Adjusted volume of water distributed; adjusted number of customers with access to wastewater treatment. Undesirable: Non-revenue water; unplanned interruptions
Ananda and Pawsey (2019)	Network length (km); operating costs	Total urban water supplied; total connections. Undesirable: Water main breaks; total water and sanitation complaints and water quality complaints
Guerrini et al. (2018)	Operating expenditures; capital expenditure; fixed assets	Net profit (%); revenues (1,000 EUR)
See and Ma (2018)	Network length; number of employees; other operating inputs	Total water delivered; total connections. Undesirable: Water losses in distribution (Mm^3/year)
Sala-Garrido et al. (2018)	Operating costs; number of employees; network length	Adjusted volume of water distributed; adjusted number of customers with access to wastewater treatment
Molinos-Senante and Maziotis (2018)	Capital costs; other costs	Water distributed; water connections

Continued on next page

Table 6.3 - Continuation

Reference	Inputs	Outputs
Molinos-Senante et al. (2017b)	Capital stock; operating expenditure; labor (full-time equivalent employee number)	Volume of drinking water distributed (1,000 m^3/year); number of connections
Molinos-Senante et al. (2017a)	Operating costs; capital stock	Volume of water distributed (1,000 m^3/day); number of connections
Maziotis et al. (2017)	Operating costs; capital stock	Volume of water distributed (1,000 m^3/day); number of water connections. Undesirable: Total number of written complaints; total number of more than 12 h and 24 h of unplanned interruptions; properties below the reference level at the end of year
Molinos-Senante and Sala-Garrido (2015)	Operating costs (1,000 Chilean Pesos); number of employees; network length	Water distributed (1,000 m^3/year); customers with access to wastewater treatment
Carvalho and Sampaio (2015)	Operation expenditure; gross index of linear losses	Billed water volume; active water connections; active wastewater connections
Molinos-Senante et al. (2014)	Operating costs; capital stock	Water distributed (1,000 m^3/day); number of connections
De Witte and Marques (2012)	Number of employees; network length (km)	Number of connections; volume of water delivered
Portela et al. (2011)	Operation expenditure	Number of billed properties; adjusted distribution input surface water; adjusted distribution non-surface water; number of sources; number of adjusted billed properties

Most of the selected studies use the volume of water distributed or delivered as output. This strategy reflects one of the main objectives of the services, which is to provide water to customers. Another indicator common to the studies is the number of water or sanitation connections, usually associated with the installed infrastructure and investments. Both indicators have also been used in this work.

This study will use a model with one input and seven outputs. The efficiency analysis model is based on the expansion of outputs, which depends on the resources used to provide the services (*e.g.*, maintenance and repair of existing infrastructure) and capital investments (*e.g.*, for infrastructure expansion). The input representing total expenses (TOTEX) comprises the operational expenses (OPEX) and the investments (or capital expenses, CAPEX). It is noteworthy that the regulator of water services in England, OFWAT, has used the TOTEX indicator for the efficiency analysis in the price review of English water providers since 2014, in line with the methodology used in electricity services.

In this study, the TOTEX values were deflated to the base year 2012 using the broad consumer price index (IPCA), which is the official index used in Brazil to measure national inflation (Table 6.4).

Table 6.4: Inflationary indices used to adjust the data.

Year	2012*	2013	2014	2015	2016	2017	2018	2019
Price index	1	1,067	1,136	1,257	1,336	1,376	1,427	1,489

*Base year.
Source: Instituto Brasileiro de Geografia e Estatística (IBGE)

Regarding the outputs, this study considered the following variables: i) the volume of water consumed (VWCons); ii) the number of water connections (NWConn) (See and Ma, 2018; See, 2015; De Witte and Marques, 2010a); iii) the water supply network length (Wnet) (Lombardi et al., 2019; Guerrini et al., 2018); iv) the volume of sewage collected (VSCol) (Walker et al., 2019); v) the volume of sewage treated (VSTreat); vi) the number of sewage connections (NSConn) (da Motta and Moreira, 2006); and vii) the sewage network length (Snet).

The variable 'volume of water consumed' was chosen instead of the conventional 'volume of water produced' since its value discounts water losses. This strategy aligns with the best regulatory practices, to reflect aspects related to service quality and sustainability in the analysis.

Concerning sanitation services, this study simultaneously considered the variables 'volume of wastewater collected' and 'volume of wastewater treated'. This strategy reflects the Brazilian reality, in which more than half of the municipalities do not have public sanitation services. Of those that do, approximately 30% do not provide adequate treatment. Thus, the adoption of these two variables allows favoring the municipalities that collect sewage and treat it.

Table 6.5 shows the descriptive statistics of the variables used in the model.

Table 6.5: Variables' statistics.

		Input	Outputs						
		TOTEX (R$)	VWCons (1,000m^3)	NWConn (x1000)	Wnet (km)	VSCol (1,000m^3)	VSTreat (1,000m^3)	NSConn (x1000)	Snet (km)
2012	Average	55,647.24	15,513.90	60.417	730.95	8,660.11	6,963.89	33.917	365.66
	Std. Dev.	155,551.84	45,695.40	99.587	1,211.13	29,874.82	25,139.63	76.248	725.34
	Min	1,052.41	325.00	2.868	39.74	27.00	21.49	0.002	1.28
	Max	1,895,974.29	660,085.00	918.132	10,112.00	414,798.20	330,157.72	723.946	5,602.81
2013	Average	59,787.31	15,608.95	62.485	758.23	8,830.44	6,963.09	35.602	382.26
	Std. Dev.	165,830.72	47,616.25	103.868	1,221.89	31,638.31	24,552.57	78.613	737.11
	Min	1,350.20	365.83	3.068	40.00	26.64	9.55	0.002	1.28
	Max	2,002,081.90	704,077.00	992.693	10,210.69	461,896.83	332,189.48	739.072	5,813.60
2014	Average	62,882.39	15,952.52	64.169	772.80	9,041.95	7,269.98	37.636	404.89
	Std. Dev.	165,363.82	47,998.06	104.589	1,202.19	32,164.11	25,004.53	81.911	778.37
	Min	1,588.81	300.98	3.184	44.00	27.27	8.00	0.062	1.00
	Max	1,931,720.53	708,874.68	972.569	10,290.60	469,285.69	334,572.81	786.727	6,148.67
2015	Average	61,427.28	15,881.17	66.154	786.38	8,972.38	7,462.41	39.584	424.36
	Std. Dev.	156,807.86	50,206.53	108.866	1,187.15	31,350.33	25,214.78	84.270	802.30
	Min	1,372.74	339.64	3.237	44.42	27.50	7.00	0.061	1.28
	Max	1,716,216.73	760,232.00	1067.360	10,352.52	455,815.22	338,008.67	796.590	6,254.23
2016	Average	61,544.61	15,641.64	67.312	805.20	9,220.05	7,747.78	41.262	441.15
	Std. Dev.	157,168.49	50,305.27	109.937	1,223.35	31,202.85	25,708.82	86.557	822.71
	Min	1,330.23	287.20	3.403	46.49	25.58	7.20	0.111	1.28
	Max	1,775,618.15	768,528.00	1073.813	10,891.20	449,063.98	342,099.71	819.368	6,665.05
2017	Average	62,962.58	15,913.46	67.893	832.51	9,209.26	7,825.92	42.750	459.68
	Std. Dev.	168,837.40	50,964.86	110.511	1,233.75	31,132.47	26,207.20	88.549	853.21
	Min	1,522.05	296.04	3.450	48.82	26.09	7.60	0.166	1.28
	Max	2,123,819.15	771,976.00	1077.384	10,710.21	449,781.11	355,103.17	832.277	6,972.69
2018	Average	61,378.88	16,197.96	69.083	854.10	9,525.10	7,986.41	44.381	479.98
	Std. Dev.	142,178.03	51,734.26	111.679	1,260.44	31,451.83	25,248.37	90.654	869.48
	Min	1,491.69	292.62	3.325	52.03	23.67	6.20	0.244	1.97
	Max	1,341,391.01	777,585.00	1086.868	10,736.86	455,922.73	333,335.09	847.533	6,924.00
2019	Average	64,090.42	15,649.19	71.074	877.25	9,638.84	8,242.25	46.086	503.93
	Std. Dev.	138,544.70	39,175.23	122.335	1,275.89	29,925.11	25,735.61	95.642	891.98
	Min	1,779.24	299.75	3.369	54.40	25.22	5.20	0.246	1.97
	Max	1,284,647.10	527,345.13	1357.211	10,839.45	427,367.57	346,019.45	965.444	7,286.00

From a national perspective, there was no significant increase in TOTEX between 2012 and 2019. It is noteworthy that the relative percentage of TOTEX components (OPEX and CAPEX) remained relatively stable over the period. OPEX was the most relevant expense in the provision of Brazilian water services throughout the period studied, ranging from 70% (in 2014) to 77% (in 2018).

The volume of water consumed also remained relatively stable in the 2012-2019 period. On the other hand, the variables 'number of connections' and 'water network length' increased significantly in the same period. An increase in the number of connections and network extension indicates an increase in service coverage. The stable level of consumption over the years, despite the increase in coverage, may indicate the adoption of consumption reduction practices associated with the increase in the size of the infrastructure.

Regarding sanitation services, the number of sewage connections and the extension of the sewage network also had a significant increase. In addition, the volume of treated sewage increased from 70% to 85% of the total volume of collected sewage.

Table 6.6 shows the average annual variation of the variables used in this chapter for the Brazilian macro-regions.

Table 6.6: Average annual variation of the variables in the Brazilian macro-regions.

	Input	Outputs						
	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	Snet
North	▲ 2.6%	▼ 2.8%	▲ 2.3%	▲ 1.4%	▲ 4.9%	▲ 1.2%	▲ 11.7%	▲ 6.3%
Northeast	▲ 3.3%	▼ 0.5%	▲ 1.9%	▲ 1.3%	■ 0.0%	▲ 0.4%	▲ 5.4%	▲ 4.5%
Southeast	▼ 0.7%	▼ 0.8%	▲ 2.2%	▲ 3.4%	▲ 1.2%	▲ 1.9%	▲ 3.0%	▲ 4.3%
South	▲ 5.0%	▲ 3.5%	▲ 1.7%	▲ 1.9%	▲ 2.2%	▲ 5.0%	▲ 4.7%	▲ 4.5%
Center-West	▲ 2.1%	▲ 0.2%	▲ 3.5%	▲ 3.9%	▲ 3.3%	▲ 3.6%	▲ 7.1%	▲ 6.3%

The North and Center-West region municipalities stood out in the increase in the volume of sewage collected, the number of sewage connections and sewage networks, revealing a significant effort to improve access. It is noteworthy that these two regions were the ones that most expanded access to sanitation services in the period studied. The Center-West region increased its coverage from 39 to 61% and the North region from 29 to 39%.

The Southeast region was the only one that presented a systematic reduction in TOTEX. The SNIS data show that the CAPEX component (*i.e.*, investments) was the main responsible for reducing TOTEX in recent years.

6.4.3 Specification of weights

Following Tourinho et al. (2021), we considered a value of total virtual weight restricted equal to 30% for the efficiency assessment. The minimum virtual weight bounds ϕ_r were specified to ensure that the weights are balanced among the seven output indicators, whilst keeping a substantial proportion of the total virtual weight (70%) with a flexible assignment among all output variables. This approach was ratified and validated by experts from the Brazilian water sector. The values used in the empirical analysis are shown in Table 6.7.

The total virtual weight of the variables associated with water supply (O_1, O_2, and O_3) must be greater or equal to 15% ($\phi_1 + \phi_2 + \phi_3 = 15\%$). Similarly, the virtual weight of the variables associated with sanitation (O_4, O_5, O_6 and O_7) must be greater or equal to 15% ($\phi_4+\phi_5+\phi_6+\phi_7 = 15\%$).

Table 6.7: Lower bound of the virtual weight restrictions specified for the output indicators.

Indicator	**Value of ϕ_r (%)**
Volume of water consumed (VWCons)	10
Number of water connections (NWConn)	2,5
Water network length (Wnet)	2,5
Volume of sewage collected (VSCol)	5
Volume of sewage treated (VSTreat)	5
Number of sewage connections (NSConn)	2,5
Sewage network length (Snet)	2,5

6.5 Results and discussion

6.5.1 Evolution of water supply and sanitation services at national level

Table 6.8 shows the average efficiency values of all municipalities in the sample, considering as reference the national metafrontier $E^M(X^{g,t}, Y^{g,t})$. The average within-year efficiency scores $E^t(X^{g,t}, Y^{g,t})$ are also provided, considering as reference the technology in the period under analysis T^t. With these two efficiency scores, it is also possible to estimate the Best Practice Gap, given by $BPG^{t,M}(X^{g,t}, Y^{g,t}) = \frac{E^M(X^{g,t}, Y^{g,t})}{E^t(X^{g,t}, Y^{g,t})}$, which indicates the average distance between the annual frontier and the metafrontier considering all years.

Table 6.8: Average efficiency estimates and average Best Parctice Gap (in %)

Year	2012	2013	2014	2015	2016	2017	2018	2019
$E^M(X^{g,t}, Y^{g,t})$	26.70	25.74	24.76	26.37	26.66	26.62	26.88	25.60
$E^t(X^{g,t}, Y^{g,t})$	29.68	30.37	31.86	32.72	34.76	33.45	29.76	28.51
$BPG^{t,M}(X^{g,t}, Y^{g,t})$	89.98	84.76	77.72	80.59	76.69	79.60	90.34	89.82

The average $BPG^{t,M}(X^{g,t}, Y^{g,t})$ values are much closer to one (100%) than the average within-year efficiency values $E^t(X^{g,t}, Y^{g,t})$, which suggests that the under performance of Brazilian municipalities is primarily attributable to the dispersion of DMUs in relation to the annual frontiers than due to the distance between the annual frontier and the best-practices observed in the decade studied (corresponding to the analysis using the metafrontier).

This means that contemporaneous inefficiency is the major source of productivity loss in the Brazilian water sector, rather than an effect of not having the technology with the highest observed productivity available in the period under assessment. The average annual efficiency scores $E^t(X^{g,t}, Y^{g,t})$ have a magnitude around 30%. This relatively low score signalls high heterogeneity in municipalities performance (ie., municipalities could not follow the best-practice levels observed in contemporaneous peers). However, this distance to best practice may be either attributable to managerial problems/inefficiency or to non-discretionary contextual conditions of the operation, as noted in Tourinho et al. (2021). This motivated a more detailed analysis at macroregion level that is presented in the next section.

It is noteworthy that the highest value of the average BPG corresponds to the years 2012, 2018, and 2019, suggesting that the annual frontiers were closer to the maximum productivity levels at the beginning and the end of the decade studied. The productivity losses at the frontier occurred until 2016 (with has the lowest value of BPG, equal to 76,69%), with improvements in frontier productivity in subsequent years.

Table 6.9 shows the average values obtained for the Global Malmquist Productivity index $GMI^{t,t+1}(X^{g,t},Y^{g,t})$ and its components $EC^{t,t+1}(X^{g,t},Y^{g,t})$ and $BPC^{t,t+1}(X^{g,t},Y^{g,t})$, for all Brazilian municipalities in the sample studied.

Table 6.9: Average results for the Global Malmquist index and its components

Period	12/13	13/14	14/15	15/16	16/17	17/18	18/19	12/19
$GMI^{t,t+1}(X^{g,t},Y^{g,t})$	0.964	0.962	1.065	1.011	0.998	1.009	0.952	0.959
$EC^{t,t+1}(X^{g,t},Y^{g,t})$	1.023	1.049	1.027	1.062	0.962	0.890	0.958	0.961
$BPC^{t,t+1}(X^{g,t},Y^{g,t})$	0,942	0,917	1,037	0,952	1,038	1,135	0,994	0.998

The results reported in Table 6.9 show a productivity loss of approximately 4% in the period studied (see the value of GMI equal to 0,959 in the last column, corresponding to the change between 2012 and 2019). This decline in productivity is mostly attributable to an increase in the average distance to the frontier, as revealed by the efficiency change score 0,961 between 2012 and 2019. The average distance between the anual frontier and the metafrontier remained approximately unchanged between the first and the last year considered (BPC=0,998).

Figure 6.1 summarises the results reported in Tables 6.8 and 6.9 for the meta-efficiency scores of Brazilian municipalities and the evolution of the GMI.

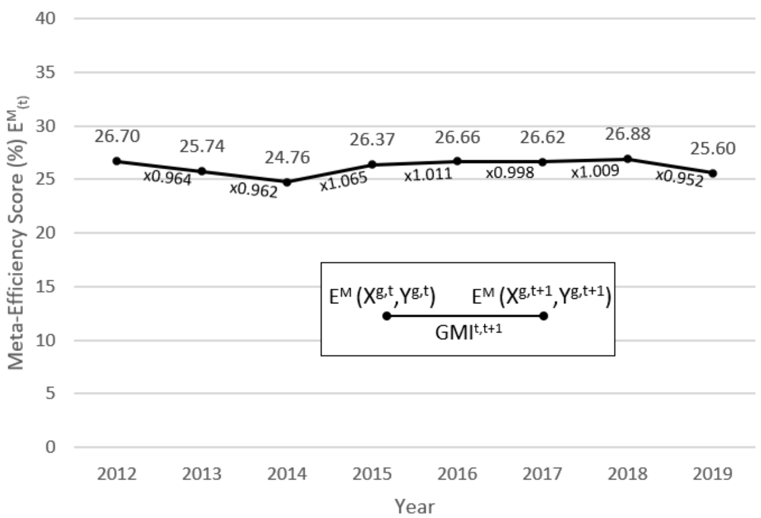


Figure 6.1: Annual average meta-efficiency values and GMI estimates at national level.

Each point associated to the years considered in Figure 6.1 represents the average distance of Brazilian municipalities from the maximum productivity level achieved in the period 2012-2019 (*i.e.*, the values reported on Table 6.8 for average $E^M(X^{g,t},Y^{g,t})$, estimated with model (6.5)). The slope of the segment joining the points of consecutive years reflects the value of the $GMI^{t,t+1}(X^{g,t},Y^{g,t})$ (*i.e.*, the values reported on Table 6.9). For values of the GMI greater than one, the line goes up, and for values of GMI smaller than one, the line goes down, representing productivity improvement and productivity decline, respectively.

The trend in Figure 6.1 show that the average meta-efficiency of the Brazilian municipalities has remained relatively stable throughout the studied period. This result highlights that there has been no significant change in WSS productivity over the past few years, which indicates that there is still a great need for improvement of water supply and sanitation services in the country to enable meeting the objectives of Agenda 2030.

Next we explore in more detail the components of the GMI representing Efficiency Change and Best Practice Gap.

Figure 6.2 shows the evolution of the average within-period efficiency of water services in the municipalities, represented by the Efficiency Change. This score represents heterogeneity in performance when compared with the best-practices observed in the same year in other Brazilian municipalities. The average within-year efficiency of water services in Brazilian municipalities in 2012 was 29.68% (as shown in Table 6.8). It should be noted that the low values of average relative efficiency score may be more a consequence of heterogeneity in the exogenous conditions associated with the provision of services rather than sub-optimal use of resources due to departure from best-practice adoption (Tourinho et al., 2021).

Figure 6.2 also shows that from 2012 to 2016 there was a noticeable approximation of the performance of Brazilian water services to the best-practice frontier for each year, signaling an effort by providers to improve services and bring service delivery closer to the best observed annual standards. Nevertheless, there was a significant worsening in average efficiency levels in the following years, ending the study period with a value below the initial average score of 2012.

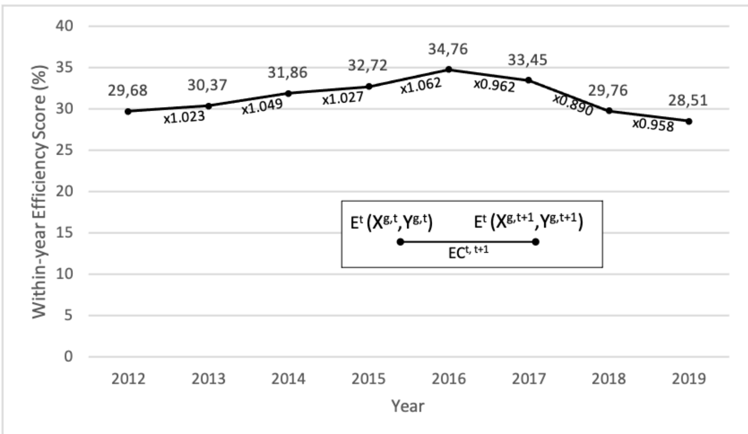


Figure 6.2: Annual average within year efficiency values and EC component of the GMI.

Figure 6.3 shows the evolution of the second component of the GMI of Brazilian water services (BPC), representing the change in the Best Practice Gap (BPG). The Best-Practice Gap represents the distance between each year's best-practice frontiers relative to the maximum productivity frontier (metafrontier) for 2012-2019. Note the downward slope in the 2012-2016 period indicating that the frontier declined (*i.e.*, the gap between the within-year best-practice frontier and the metafrontier increased). This trend was only interrupted between 2014 and 2015, with a BPC higher than one. We can observe an increasing trend of BPC between 2016 and 2018, followed by a stagnation of productivity (BPC approximately equal to one) in the last period analysed (between 2018 and 2019).

It is noteworthy the opposite behaviour of BPC and EC, pictorially illustrated in Figures 6.2 and 6.3, that is typical of productivity change components. As the frontier productivity declines, which is reflected by BPG lower than one, the average distance of the DMUs to the frontier reduces, which is reflected by EC higher than one.

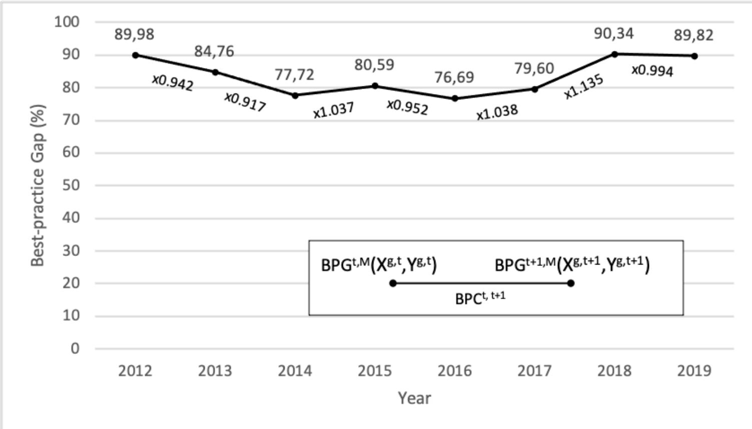


Figure 6.3: Annual average best-practice gap change.

The unusual behavior of the best-practices gap curve may result from the tumultuous macroeconomic scenario observed in Brazil in this period. The country has been facing a severe economic crisis since 2011, with an intensifying devaluation of the national currency against the US Dollar and the prices of major export commodities falling. In addition, there is a well-known lack of control of the public accounts, with consecutive primary deficits due to high expenses with public payrolls. Even with recovery since 2018, it is already perceived that the last decade (2011-2020) was the worst decade for the economy in 120 years. Given this scenario of uncertainties, investment plans were reviewed and usually reduced.

Since the benchmark is a metafrontier of all years, the divergence seen between the years 2012 and 2016 (Figure 6.3) may suggest that the metafrontier is formed by parts of the 2012 frontiers (initial year and beginning of the economic crisis) and the final years (2018 and 2019, with the economy already recovering).

6.5.2 Evolution of water supply and sanitation services within the macro-regions

This section, instead of using a single national metafrontier as a benchmark, considers separate metafrontiers calculated for each of the three most populous Brazilian macro-regions (*i.e.*, Northeast, Southeast, and South). The Production Possibility Set delimited by these metafrontiers contains all observations from a given municipality in all years studied (2012-2019). With this procedure, we are able to make comparisons with a greater degree of homogeneity in terms of exogenous conditions that are non-discretionary for the managers of municipal WWS. Consequently, the results obtained are better approximations to what could in fact be considered as potential for improvement in each municipality, as it is compared with peers in the same macro-regions. However, it prevents comparisons across regions, as the relative position of the reference macro-regional frontiers is not taken into account in assessments considering separate regional frontiers.

Table 6.10 shows the average efficiency values of the municipalities in the sample (DMUs in a given macro-region) considering the regional metafrontiers for the Northeast $(E^{NE}(X^{NE,t},Y^{NE,t}))$, Southeast $(E^{SE}(X^{SE,t},Y^{SE,t}))$ and South $(E^{S}(X^{S,t},Y^{S,t}))$. The average within-year efficiency scores $(E^{t}(X^{g,t},Y^{g,t}))$ and the average Best Practice Gap $(BPG^{t,g}(X^{g,t},Y^{g,t}))$ are also reported.

Table 6.10: Average efficiency estimates (in %) and BPG for separate samples of municipalities in the NE, SE and S.

Year	2012	2013	2014	2015	2016	2017	2018	2019
$E^{NE}(X^{NE,t},Y^{NE,t})$	26.45	26.77	24.11	26.75	26.47	25.03	25.19	24.20
$E^{t}(X^{NE,t},Y^{NE,t})$	28.84	31.36	34.71	37.14	39.31	33.92	28.89	27.42
$BPG^{t,NE}(X^{NE,t},Y^{NE,t})$	91.71	85.37	69.48	72.02	67.33	73.78	87.21	88.25
$E^{SE}(X^{SE,t},Y^{SE,t})$	33.83	35.30	35.08	35.08	36.51	37.85	38.64	37.03
$E^{t}(X^{SE,t},Y^{SE,t})$	41.70	40.02	40.10	42.35	43.58	44.05	42.58	39.88
$BPG^{t,SE}(X^{SE,t},Y^{SE,t})$	81.13	88.21	87.49	82.83	83.78	85.93	90.76	92.85
$E^{S}(X^{S,t},Y^{S,t})$	53.26	45.99	45.87	46.29	46.79	46.10	45.16	43.64
$E^{t}(X^{S,t},Y^{S,t})$	56.94	52.47	51.98	53.84	55.79	50.95	49.56	49.01
$BPG^{t,S}(X^{S,t},Y^{S,t})$	93.52	87.66	88.24	85.98	83.86	90.48	91.13	89.04

The values of $E^{g}(X^{g,t},Y^{g,t})$ reported on Table 6.10 show that, on average, the productivity of water services in the municipalities of the South region are closer to the maximum productivity levels observed within the same region. The higher average scores obtained in the South represents more homogeneity of productivity levels across municipalities.

On the other hand, the Northeast region presents the lowest average meta-efficiency scores among the regions, representing heterogeneity in terms of productivity levels of the services provided in the different municipalities.

Table 6.11 complements this information with the average values obtained for the Global Malmquist Productivity index and its components considering the analysis with separate within-region metafrontiers.

Table 6.11: Average results for the Global Malmquist index and its components within regions

Period	12/13	13/14	14/15	15/16	16/17	17/18	18/19	12/19
$GMI^{t,t+1}(X^{NE,t},Y^{NE,t})$	1.012	0.901	1.109	0.990	0.946	1.006	0.961	0.915
$EC^{t,t+1}(X^{NE,t},Y^{NE,t})$	1.088	1.107	1.070	1.059	0.863	0.852	0.949	0.951
$BPC^{t,t+1}(X^{NE,t},Y^{NE,t})$	0.931	0.814	1.036	0.935	1.096	1.182	1.012	0.962
$GMI^{t,t+1}(X^{SE,t},Y^{SE,t})$	1.043	0.994	1.000	1.041	1.037	1.021	0.958	1.095
$EC^{t,t+1}(X^{SE,t},Y^{SE,t})$	0.960	1.002	1.056	1.029	1.011	0.966	0.937	0.956
$BPC^{t,t+1}(X^{SE,t},Y^{SE,t})$	1.087	0.992	0.947	1.011	1.026	1.056	1.023	1.144
$GMI^{t,t+1}(X^{S,t},Y^{S,t})$	0.864	0.997	1.009	1.011	0.985	0.980	0.966	0.819
$EC^{t,t+1}(X^{S,t},Y^{S,t})$	0.921	0.991	1.036	1.036	0.913	0.973	0.989	0.861
$BPC^{t,t+1}(X^{S,t},Y^{S,t})$	0.937	1.007	0.974	0.975	1.079	1.007	0.977	0.952

Figure 6.4 pictorially illustrates the results reported in these two tables concerning productivity change. Each point represents an average efficiency value of the municipalities in each region relative to their respective regional metafrontier, *i.e.*, $E^{g}(X^{g,t},Y^{g,t})$ (see Table 6.10). The line connecting two points represents the $GMI^{t,t+1}(X^{g,t},Y^{g,t})$ (see Table 6.11). An upward slope in

the trendline (*i.e.*, $GMI^{t,t+1} > 1$) means that the average productivity of the municipalities in that region improved between the years t and $t+1$.

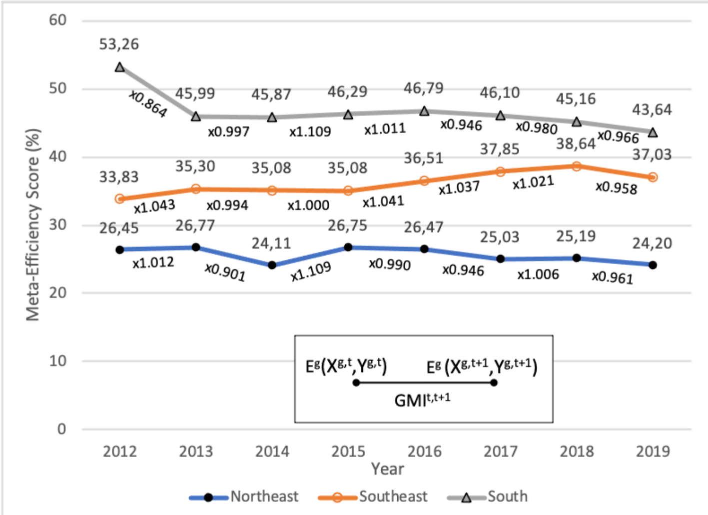


Figure 6.4: Annual average meta-efficiency values and GMI estimates at regional level.

Regarding productivity change trends, the South region exhibits a productivity decline of 18,1% in the period 2012-2019 (=1-81,9%), as reported by the GMI score in the last column of Table 6.11. This decline was mostly caused by the productivity decline of 13,6% registered between 2012 and 2013 (=1-86,4%), as reported in the first column of table 6.11.

The Northeast also shows a productivity decline trend, with a reduction of productivity of 8,5% in the decade analysed.

The Southeast is the only region with productivity improvement trend, balanced over the years, with an overall productivity improvement of 9,5% in the decade analysed. The productivity gains were only interrupted in the final year studied, with a productivity decline of 4,2% between 2018 and 2019.

This shows that the SE macro-region, where the two most developed Brazilian cities are located (São Paulo and Rio de Janeiro) is the only one with a positive trajectory towards the SDG 6 of the United nations' Agenda 2030, through the productivity gains.

Note that as the values of efficiency are estimated using separate metafrontiers, the productivity levels across regions cannot be compared. Water supply and sanitation are public services whose expenses (both operating and capital) depend on various factors, such as geographic factors (*e.g.*, topography and water availability), economic factors (*e.g.*, interest and access to credit), and social factors (*e.g.*, water consumption, household income). For instance, high terrain slopes require higher pressure in the water supply network, more powerful pumps (with higher electricity consumption), and stronger pipes. On the other hand, municipal areas or even municipalities with many low-income customers require service providers to reduce their profit margins for reinvestment.

Figure 6.5 shows the evolution of the components of the Malmquist index for the three regions analysed. For the efficiency change component, each point represents an average value of the efficiency of the sample municipalities from each region relative to the regional frontier for each year (*i.e.*, $E^t(X^{g,t}, Y^{g,t})$, see Table 6.10). The line connecting two dots represents the value of $EC^{t,t+1}(X^{g,t}, Y^{g,t})$ (see Table 6.11).

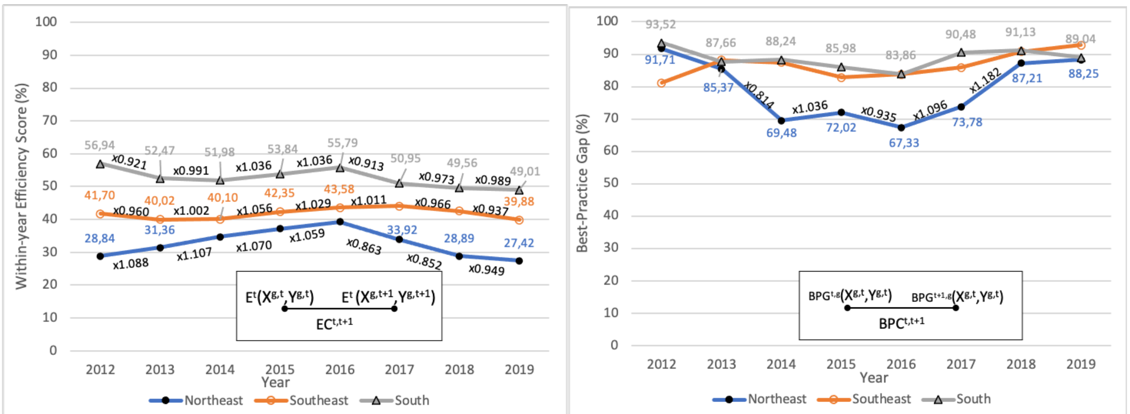


Figure 6.5: Trends in the evolution of the within-year efficiency and BPG in Brazilian macro-regions.

Although the efficiency levels of Northeast and Southeast exhibit modest declines around 5% in the decade analysed, the Southeast should a relatively stable trend, with a greater efficiency decline (around 6%) in the last year analysed. Conversely, in the Northeast we observe efficiency improvements until 2016, and declines in the following years. The South shows the largest efficiency decline (13,9%), with deterioration in efficiency levels in all years except between 2014/15 and 2015/16.

Regarding the Best-Practice Change component, we can see that the Southeast frontier moved closer to the metafrontier in more recent years, signalling annual productivity gains in the frontier, as the frontiers of each year are progressively approaching the regional metafrontier. The South exhibited productivity losses at the frontier only between 2012 and 2013 and the final year considered (from 2018 to 2019). However, the Northeast showed a more step decline in frontier productivity between 2012 and 2014, mostly recovered between 2016 and 2018. This trend resembles the one observed in the national analysis (see Figure 6.3) and suggests that the results obtained for the Northeast region significantly influence the global national result. The frontier dominance by the Northeast region can be explained, in part, by the low level of expenditures of some municipalities in the region, which end up forming both the regional and national frontier.

6.5.3 Comparison of productivity levels among regions

Table 6.12 shows the results of the Group Comparison index and its components, for the Southeast, Northeast and South macro-regions.

Table 6.12: Results of the GCI and its components

	2012	2013	2014	2015	2016	2017	2018	2019	average
$GCI^{SE,NE}$	0.92	0.89	0.80	0.89	0.85	0.77	0.76	0.76	0.83
$GCI^{SE,S}$	0.92	0.76	0.77	0.78	0.76	0.73	0.70	0.72	0.77
$ESG^{SE,NE}$	0.70	0.79	0.89	0.90	0.93	0.80	0.70	0.71	0.80
$ESG^{SE,S}$	1.38	1.32	1.31	1.29	1.30	1.18	1.20	1.26	1.28
$BPG^{SE,NE}$	1.32	1.13	0.90	0.98	0.91	0.97	1.07	1.07	1.04
$BPG^{SE,S}$	0.67	0.58	0.59	0.61	0.59	0.62	0.58	0.58	0.60

Figure 6.6 illustrates the comparison of the Brazilian regions in terms of CGI and its components.

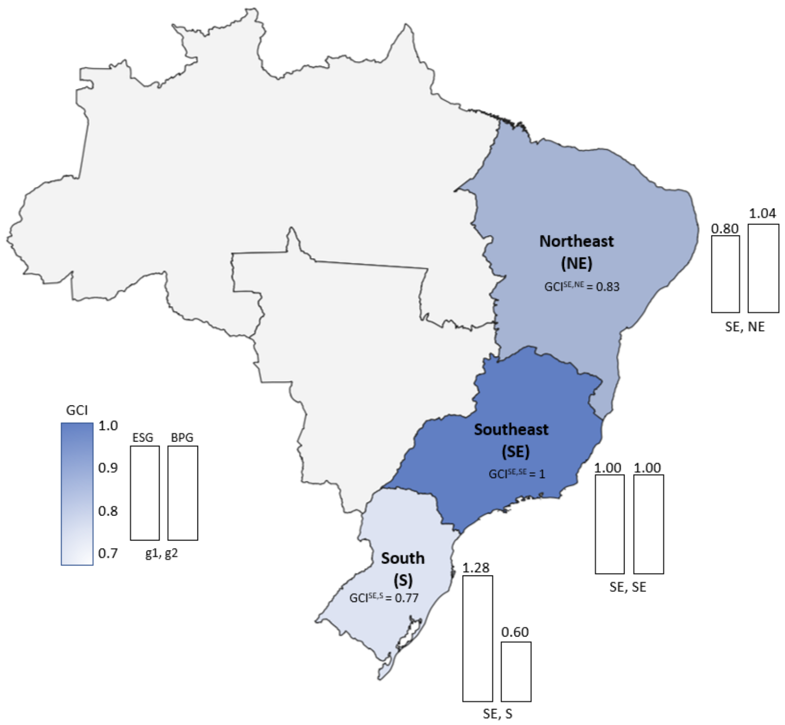


Figure 6.6: Average of Group Comparison index and its components in Brazilian macro-regions.

Municipalities in the Southeast region were the closest to the maximum productivity observed in the 2012-2019 period among the Brazilian macro-regions. The Southeast is the most economically developed region, which may explain part of the superiority in their productivity. The Gross Domestic Product (GDP) of the region's states represents more than 50% of the national GDP. Moreover, its regional providers (namely SABESP in São Paulo and COPASA in Minas Gerais) are internationally recognized for their high standard of performance.

Regarding the South region, even though it presents the lowest GCI compared to the Southeast region, it stands out for its high ESG value. The performance of the municipalities in the South region is 26% closer to the best regional practices than the municipalities in the Southeast region.

The region presents higher values in TOTEX, which can harm the region in the productivity analysis, compared to other regions with lower expenses. It turns out that these expenses are directly associated with the investment in sewage treatment infrastructure, which enabled the increase in treatment volume by 13.7% in 2014 and 12% in 2015. In this case, despite not having an extraordinary level of productivity, the South region is improving the national coverage indicators, which improves the well-being of the population and helps the country to achieve the Agenda 2030 goals.

Finally, the Northeast region presents lower average productivity than the Southeast region during the studied period. On the other hand, the superiority of the BPG index reinforces the dominance of the Northeast region frontier (*i.e.*, it is closer to the national frontier than the Southeast region frontier).

6.6 Conclusions

This study showed the evolution of the productivity of water supply and sanitation services from the national and regional perspectives, using the respective metafrontiers as benchmarks. It also compared the productivity levels across the Brazilian regions.

The relative stability of the national productivity averages, even in face of international development agendas, shows the need for Brazil to direct efforts to address the crucial challenges of water supply and sanitation services. In fact, considering that the 2030 Agenda was adopted internationally at the end of 2015, the impact of this commitment on the productivity of Brazilian water services is not yet visible. Even considering that investments on infrastructure works require some time to produce measurable results, it seems evident that the country's subscription to the 2030 Agenda did not cause any significant improvement to the productivity levels of water supply and sanitation services in the following years.

Concerning the differences in the regional trends, the Southeast region presents the highest level of productivity growth among the Brazilian macro-regions. In addition, the region stood out for the trend of bringing its regional border closer to national best practices. Conversely, both South and Northeast region has lost productivity in the decade studied. The South region has stood out in investments in sanitation in recent years, especially in sewage treatment, which may have undermined its performance in the productivity analysis, but eventually helped the country to improve its operational levels. The Northeast region best-practice frontier had a significant productivity loss between 2012 and 2014, that despite the recovery observed since 2016, finished the decade studies with a productivity decline of approximately 5% compared with the standard observed in 2012.

The strategy of using the Southeast region as a reference to compare the performance of the South and Northeast regions allowed us to see that although the former has a better global performance index (*i.e.*, the GCI), the other regions stand out each in one of the index components.

The result of this work emphasized the regional difference in the provision of water supply and sanitation services, both from a purely operational point of view and in the trend of productivity gains.

From the economic perspective, it was evident that a scenario of turbulence such as the one the country is going through causes a general concern among providers and sub-national governments to make new investments, given the future uncertainties, which impacts all Brazilian regions.

From the perspective of improving quality of life through best practices in service delivery, the results showed that Brazil needs to invest in infrastructure to expand service coverage and promote efforts to expand public services' productivity and reduce regional differences through balanced and egalitarian policies.

CHAPTER 7

A Non-Convex Global Malmquist index to Compare the Performance of Water Services among Brazilian Macro-Regions

Water supply and sanitation are public services fundamental to human well-being. Nevertheless, approximately 2 billion people still do not have access to safe drinking water worldwide. There will have to be a significant global effort to expand coverage and improve service performance in the coming years to cope with this issue. Notably, service performance is usually influenced by the environment in which it is provided. Factors such as topography and climate tend to affect the type of infrastructure used and the water consumption habits of customers. Understanding regional differences are, therefore, a necessity for both providers and regulators. This chapter proposes an innovative framework based on optimization techniques to compare the performance of water supply and sanitation services in the three most populated regions of Brazil (Northeast, Southeast, and South). The proposed models estimate a Best-Practice frontier recurring to a 'Benefit-of-the-Doubt' formulation that can support decision-making in water services. The framework's relevance is illustrated using the Brazilian water and sanitation regulator data collected at the municipality level for 2019. The results revealed that the performance of water supply and sanitation services in the Southeast region is closer to best practice when compared to the metafrontier. In turn, the performance of services in municipalities in the South region are more homogeneous and closer to their regional frontier.

7.1 Introduction

Camp (1989) defines benchmarking as the ongoing measuring of products, services, and activities against similar leading companies. It is a learning process in which a company discovers and analyzes the "competing" companies with the best performance and uses this knowledge to raise its performance. According to Alegre et al. (2016), benchmarking in the water sector consists of six stages: i) planning; ii) research; iii) observation; iv) analysis; v) adaptation; and vi) development. These steps are based on existing knowledge, strategic planning tools, analysis of procedure improvement, development, team building, data collection, and management change.

Given the natural monopoly condition of the water sector, benchmarking studies enable indirect competition among providers. In this case, although it is not usually possible for users to choose which company will be responsible for providing the services needed, the regulator can evaluate the efficiency of the services provided using benchmarking exercises, and consequently trigger improvements. Based on this information, the user can demand better quality of services or adequate tariffs for the services actually provided.

In the last 20 years, the number of studies on the performance evaluation of water supply and sanitation services has increased significantly (Goh and See, 2021). Despite the rapid growth in recent years in the number of publications exploring water services in developing countries, studies conducted in developed countries still predominate in the literature (Cetrulo et al., 2019).

The literature on water services performance typically presents two strands: the analysis of efficiency in a given year and the impact of contextual variables (Tourinho et al., 2021; Sala-Garrido et al., 2021; Salazar-Adams, 2021; Maziotis et al., 2020b); and studies on productivity changes over time, to explore if specific actions or public policies (*e.g.*, regulatory reforms) have caused any change in the evolution of performance (Maziotis et al., 2021; Mocholi-Arce et al., 2021; Molinos-Senante et al., 2020a; Sala-Garrido et al., 2019). The present chapter is framed in the first strand, as it explores the performance of water services provided at municipality level in Brazil, and explores the differences among macro-regions.

For the water industry, efficiency analysis among management entities can be an effective way to identify the margin of efficiency gains through infrastructure investments and operational improvements. In addition, benchmarking is considered a valuable tool to increase efficiency as it can be used to evaluate companies' comparative performance, underpinning effective regulation (Marques et al., 2011).

There are several methodologies available for efficiency assessment of the WSS (See, 2015; Marques et al., 2014; Berg and Marques, 2011), being the Data Envelopment Analysis the most used one (Cetrulo et al., 2019; Cabrera Jr et al., 2018; Molinos-Senante et al., 2016a). The estimation of the efficiency frontier, particularly in the WSS sector, is often used as a basis to assess how and to what degree external factors influence the achievement of efficiency. The main objective of benchmarking in the water sector has been to determine the source of operations' inefficiencies (Walter et al., 2009). For this objective, the analysis is usually divided into two stages: in the first step, the analysis determines the most efficient companies through efficiency assessment, followed by some regression technique with explanatory variables (which refer to contextual issues affecting efficiency, but outside the scope of action of the operators, *e.g.*, the scope of operation – local or regional, and private participation). The second stage analysis is applied to understand the influence of these factors on the efficiency score (Cetrulo et al., 2019).

Therefore, the literature includes the efficiency assessment carried out in the first stage of the analysis (Mellah and Amor, 2016; Byrnes et al., 2010) as the main subject. Additionally, on the second stage, the most frequently analyzed factors are: the scale of service (Guerrini et al., 2018; Worthington and Higgs, 2014); the aggregation of entities (Carvalho and Marques, 2016; Guerrini et al., 2015b); the density of connections per meter of network (Guerrini et al., 2018, 2015a; Nauges and Van den Berg, 2008); and ownership (Romano et al., 2017; Buafua, 2015). More recently, the quality of service factor has been included in the efficiency analysis framework

(Pinto et al., 2017a; Molinos-Senante et al., 2017b; Romano et al., 2017), as well as environmental aspects (Dong et al., 2018; Ananda, 2014) and how these factors influence the WSS performance.

In the framework of the water industry, previous studies (*e.g.*, (Walker et al., 2019; Ananda and Pawsey, 2019; Molinos-Senante and Sala-Garrido, 2016; Guerrini et al., 2015b)) have adopted the input orientation since the aim of the WSS is to provide water and sewerage services minimizing the use of inputs. Moreover, it is assumed that the utilities only have a limited choice in the amount of produced outputs but can control the inputs used to produce a given amount (Ananda and Pawsey, 2019). Thus, considering this background, the present study adopts the input-orientated (IO) DEA model.

However, it is noteworthy that the DEA methodology is based on analyzing the composition of inputs and outputs, which implies the variables chosen is a significant step to obtain reliable results (Thanassoulis, 2000). Consequently, the variables should adequately characterize the operation of the entities being analyzed. The use of information with inherent inaccuracies is an obstacle to obtaining good results (Cabrera Jr et al., 2018).

A major issue in benchmarking, particularly in the DEA (due to its sensibility to the data), is the definition of the entity that will be considered the benchmark (*i.e.*, the reference) for the others, particularly concerning the characteristics that define it as efficient. Moreover, applying benchmarking methods without considering the specificities of the systems (even with reliable data) and without realizing that there are aspects that influence them can lead to inaccurate results (Molinos-Senante et al., 2016a).

Furthermore, studies on the efficiency of water services tend to focus on the overall assessment of services in a given country (*e.g.*, Salazar-Adams (2021) in Mexico; lo Storto (2020) in Italy; Liu and Fukushige (2020) in China; and Maziotis et al. (2020b) in Chile), without distinguishing regional specificity, even though it is well known that geographic factors greatly influence the operation and performance of water supply and sanitation services, Tourinho et al. (2021). The study of the impact of regional differences on service performance is particularly relevant in Brazil, considering its continental dimension. Most studies exploring the Brazilian water and wastewater sector considered this aspect. For example, Carvalho and Sampaio (2015), Ferro et al. (2014) and Faria et al. (2008) found heterogeneity in efficiency levels among Brazilian macro-regions. By contrast, Barbosa et al. (2016) and Faria et al. (2005) found no statistical difference in the efficiency levels of water services among regions. It is noteworthy that worldwide the issue was also addressed. In Italy (Lombardi et al., 2019) and Japan (Marques et al., 2014), the geographical differences within the country had a significant impact on water services' performance.

This chapter aims to benchmark the performance of water supply and sanitation services among Brazilian macro-regions using an innovative Global pseudo-Malmquist index, that is used for group comparisons considering a non-convex metafrontier. The group comparison index used in this chapter results from an adaptation of the index proposed by Camanho et al. (2021). The main difference is that in this chapter a non-convex metafrontier is constructed. Additionally, a Mixed Integer Linear Programming (MILP) model is presented, allowing estimating a non-convex frontier for evaluations involving BoD composite indicators.

This research provides the basis for the development of Decision Support Systems, which can contribute to the improvement of water services in Brazil using optimisation techniques.

7.2 Methodology

7.2.1 A Global Malmquist index with a non-convex metafrontier for Benefit-of-the-Doubt formulations

The analysis of performance of water services described in this study involves the estimation of a composite indicator, according to the Benefit-of-the-Doubt (BoD) framework proposed by Cherchye et al. (2007). The composite indicator aggregates several individual indicators into a summary measure of performance that provides an overall perspective of achievements.

The BoD formulation is equivalent to a DEA CRS formulation with a dummy input equal to one. Following Koopmans (1951), this dummy input can be interpreted as an “helmsman” attempting to steer the unit under assessment towards better performance. Therefore, the set of input variables of a standard DEA model is replaced by a dummy input equal to one to obtain a BoD composite indicator model, as shown in (7.1).

$$
\begin{aligned}
&\frac{1}{CI^g(\mathbb{1},Y^g)} = \text{Max } \theta_k && (7.1)\\
&s.t. \sum_{j=1}^{n_g} y_{rj}\ \lambda_j \geq \theta_k y_{rk} \qquad r = 1,\ldots,s\\
&\sum_{j=1}^{n} \lambda_j \leq 1\\
&\lambda_j \geq 0 \qquad\qquad j = 1,\ldots,n_g
\end{aligned}
$$

The assessment of water services performance reported in this chapter requires a comparison of DMUs (municipalities) from different groups (macro-regions) in the same period of time, against a non-convex metafrontier. To illustrate the derivation of a new index for the comparison of groups’ performance, consider G groups $(g = g_1, g_2, ..., g_G)$ whose performance needs to be compared considering data from j DMUs that belong to each group. The number of DMUs in each of the groups can vary, and it is denoted for group g as n_g. The technology of production (or Production Possibility Set - PPS) for group g is denoted as T^g. The production possibility set T^g contains all feasible output combinations corresponding to a certain production process that is specific to group g.

The formulation of a BoD composite indicator evaluated against a non-convex metafrontier is shown in (7.2):

$$
\begin{aligned}
&\frac{1}{CI^M(\mathbb{1},Y)} = \max\theta && (7.2)\\
&s.t\sum_{j=1}^{n_g}\lambda_j^g y_{rj}^g \geq \theta y_{rk} - M(1-z_g) \quad r=1,\ldots,s \quad g=1,\ldots,G\\
&\sum_{g=1}^{G} z_g = 1\\
&\sum_{j=1}^{n_g}\lambda_j^g \leq z_g \qquad g=1,\ldots,G\\
&\lambda_j^g \geq 0 \qquad j=1,\ldots,n_g, g=1,\ldots,G\\
&z_g \in \{0,1\} \qquad g=1,\ldots,G
\end{aligned}
$$

The resulting Global Malmquist index to evaluate the gap in performance between two groups (A and B), based on the estimation of Composite Indicators' scores, is presented in expression (7.3). To distinguish this index from the standard formulation of the Global Malmquist index to assess productivity change over time, this index is named global Group performance Comparison Index (GCI).

$$
GCI^{AB} = \frac{\left[\prod_{j=1}^{n_B} CI^M(\mathbb{1},Y^B)\right]^{1/n_B}}{\left[\prod_{j=1}^{n_A} CI^M(\mathbb{1},Y^A)\right]^{1/n_A}} \tag{7.3}
$$

A value of $GCI > 1$ means that the performance of Group B is better than the performance of Group A. This index can also be decomposed in the components of Efficiency Spread Gap (ESG) and Best-Practice Gap (BPG), as shown in (7.4):

$$
\begin{aligned}
GCI^{AB} &= \frac{\left[\prod_{j=1}^{n_B} CI^B(\mathbb{1},Y^B)\right]^{1/n_B}}{\left[\prod_{j=1}^{n_A} CI^A(\mathbb{1},Y^A)\right]^{1/n_A}} \times \left(\frac{\left[\prod_{j=1}^{n_B} CI^M(\mathbb{1},Y^B)\right]^{1/n_B}}{\left[\prod_{j=1}^{n_B} CI^B(\mathbb{1},Y^B)\right]^{1/n_B}} \times \frac{\left[\prod_{j=1}^{n_A} CI^A(\mathbb{1},Y^A)\right]^{1/n_A}}{\left[\prod_{j=1}^{n_A} CI^M(\mathbb{1},Y^A)\right]^{1/n_A}}\right)\\
&= \frac{\left[\prod_{j=1}^{n_B} CI^B(\mathbb{1},Y^B)\right]^{1/n_B}}{\left[\prod_{j=1}^{n_A} CI^A(\mathbb{1},Y^A)\right]^{1/n_A}} \times \left(\frac{\frac{\left[\prod_{j=1}^{n_B} CI^M(\mathbb{1},Y^B)\right]^{1/n_B}}{\left[\prod_{j=1}^{n_B} CI^B(\mathbb{1},Y^B)\right]^{1/n_B}}}{\frac{\left[\prod_{j=1}^{n_A} CI^M(\mathbb{1},Y^A)\right]^{1/n_A}}{\left[\prod_{j=1}^{n_A} CI^A(\mathbb{1},Y^A)\right]^{1/n_A}}}\right)\\
&= ESG^{AB} \times \left(\frac{BPG^{BM}}{BPG^{AM}}\right)\\
&= ESG^{AB} \times BPG^{AB}
\end{aligned} \tag{7.4}
$$

7.2.2 An illustrative application

This section illustrates the estimation of a Global Group comparison index considering three DMUs (1, 2 and 3) observed in three groups (A, B and C). In the context of the empirical application presented in this chapter, this could correspond to the Brazilian municipalities (*i.e.*, 9 different municipalities observed in 3 macro-regions). Each DMU is evaluated considering a dummy input (equal to one) and two outputs. Table 7.1 shows the data used in the illustrative example.

Table 7.1: Data used in the illustrative application.

Group A			Group B			Group C		
DMUs	output 1	output 2	DMUs	output 1	output 2	DMUs	output 1	output 2
a_1	2.4	9.6	b_1	5.5	12.2	c_1	8.7	14.4
a_2	5.2	5.9	b_2	4.4	4.8	c_2	7.1	5.7
a_3	10.8	6.7	b_3	16.5	7.2	c_3	13.1	4.4

Figure 7.1 provides a pictorial representation of data and shows the metafrontier consisting of a non-convex envelopment of the group-specific frontiers. a_j is the observed value of DMU j in group A, b_j is the observed value of DMU j in group B and c_j is the observed value for DMU j in group C. Note that the non-convexification of observations from different groups in the construction of the metafrontier can play a crucial role in identifying superior technologies that envelop the data as closely as possible.

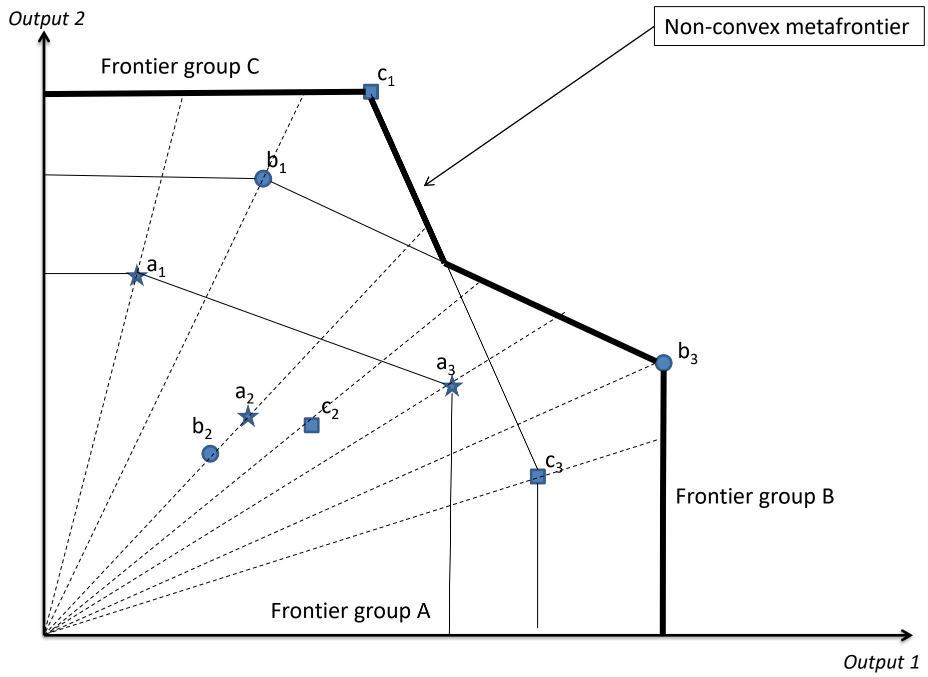


Figure 7.1: Illustration of the non-convex metafrontier.

Table 7.2 shows the results of the computation of the BoD composite indicator score $CI^M(\mathbb{1},Y)$ considering as reference the non-convex metatechnology set $T^M = T^A \cup T^B \cup T^C$. The within group composite indicator scores computed in relation to technology sets T^A, T^B and T^C are also shown ($CI^A(\mathbb{1},Y^A)$, $CI^B(\mathbb{1},Y^B)$ and $CI^C(\mathbb{1},Y^C)$).

Table 7.2: Composite indicator results.

DMU i	$CI^A(\mathbb{1},Y^A)$	$CI^B(\mathbb{1},Y^B)$	$CI^C(\mathbb{1},Y^C)$	$CI^M(\mathbb{1},Y^A)$	$CI^M(\mathbb{1},Y^B)$	$CI^M(\mathbb{1},Y^C)$
DMU 1	1	1	1	0.67	0.85	1
DMU 2	0.74	0.46	0.64	0.52	0.43	0.61
DMU 3	1	1	1	0.79	1	0.79
Geometric average	0.90	0.77	0.86	0.65	0.71	0.78

Table 7.3 shows the results of the Global Group Performance Comparison index and its components.

Table 7.3: Results of the GPI and its components.

g_1, g_2	GCI^{g_1,g_2}	ESG^{g_1,g_2}	BPG^{g_1,g_2}
A,B	1,10	0,85	1,29
B,C	1,10	1,12	0,98
A,C	1,21	0,95	1,27
C,M	–	–	0,91
B,M	–	–	0,93
A,M	–	–	0,72

For example, comparing groups A and B, it can be observed that the performance of group B is better than the performance of group A ($GCI^{AB} = 1.10 \geq 1$). When exploring the components of the index, it is observed that although group B is worst in terms of efficiency spread ($ESG^{AB} = 0.85 \leq 1$), it has a more productive frontier than group A ($BPG^{A,B} = 1.29 \geq 1$).

The circularity of the index and its components can also be verified: $GCI^{AC} = GCI^{AB} \times GCI^{BC}$ ($1.21 = 1.10 \times 1.10$), $ESG^{AC} = ESG^{AB} \times ESG^{BC}$ ($0.95 = 0.85 \times 1.12$), and $BPG^{AC} = BPG^{AB} \times BPG^{BC}$ ($1.27 = 1.29 \times 0.98$).

7.3 Empirical analysis

7.3.1 Sample studied

The study of Brazilian Municipalities is based on data collected from the National Sanitation Information System (SNIS), corresponding to the most recent year available (2019). The SNIS is an official database of the Brazilian federal government that annually collects information on water supply and sanitation services.

The sample studied includes 390 municipalities with more than 50,000 inhabitants, all located in the three most populous macro-regions in the country (186 municipalities from the Southeast (SE), 125 from the Northeast (NE), and 79 from the South (S) macro-region). These municipalities comprise 38% of the country's population.

Seven outputs related to operational aspects were used in this study. The outputs were constructed based on seven key activity indicators related to water and wastewater services, normalised by the operating expenses (OPEX) incurred in providing the services. This strategy allows financial aspects to be integrated into the performance analysis.

The seven key activity indicators used in the BoD model are: i) the number of water connections; ii) the number of wastewater connections; iii) the volume of water consumed; iv) the volume of wastewater collected; v) the volume of wastewater treated; vi) the water supply network length; vii) the wastewater network length.

Table 7.4 shows the descriptive statistics of the variables used in this study.

Table 7.4: Output variables statistics.

Outputs	Description	Mean	St.Dev.	Min	Max
O_1	Number of water connections/OPEX	1.39	0.65	0.32	7.34
O_2	Number of wastewater connections/OPEX	0.79	0.52	0.01	2.95
O_3	Volume of water consumed/OPEX	0.24	0.21	0.08	3.01
O_4	Volume of wastewater collected/OPEX	0.13	0.10	0.00	0.79
O_5	Volume of wastewater treated/OPEX	0.10	0.08	0.00	0.72
O_6	Water supply network length/OPEX	0.02	0.03	0.00	0.65
O_7	Wastewater network length/OPEX	0.01	0.01	0.00	0.08

7.3.2 Results and Discussion

The results of the geometric average of the BoD composite indicators required for the estimation of the Global GCI are shown in Table 7.5.

Table 7.5: Composite indicator results (geometric average for the sample under study).

$CI^S(\mathbb{1},Y^S)$	$CI^{NE}(\mathbb{1},Y^{NE})$	$CI^{SE}(\mathbb{1},Y^{SE})$	$CI^M(\mathbb{1},Y^S)$	$CI^M(\mathbb{1},Y^{NE})$	$CI^M(\mathbb{1},Y^{SE})$
0.555	0.263	0.514	0.226	0.262	0.357

Additionally, Figure 7.2 shows the distribution of Composite indicator values across the three macro-regions compared to the within-group frontier. The Kruskal-Wallis test showed that only the distribution of CI scores from the Northeast region is statistically different from the others (p-value < 0.05). Notably, almost 75% of the Northeast municipalities have CI scores below 0.3. On the other hand, almost all municipalities in the South are above this value.

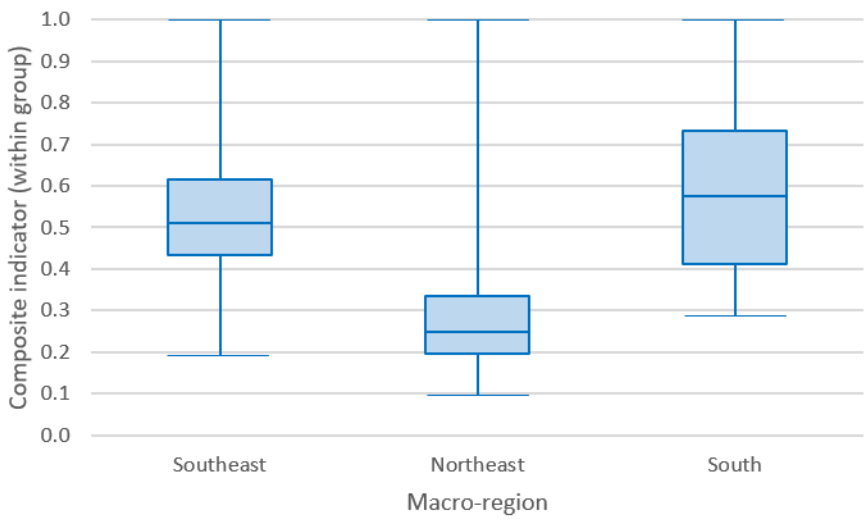


Figure 7.2: Within-group CI scores.

This analysis suggests that the heterogeneity in performance levels is more problematic in the Northeast than in the other regions.

In turn, Figure 7.3 shows the distribution of CI scores in the municipalities of the three Brazilian macro-regions compared to the metafrontier. In this case, the Kruskal-Wallis test showed that only the Southeast region's scores are statistically different from the others. The superiority of the Southeast region is noticeable, where almost 75% of the municipalities are above 0.3 while most of the municipalities in the Northeast and South are below this value. This means that the performance of Southeast municipalities is superior to the performance levels observed in the other regions.

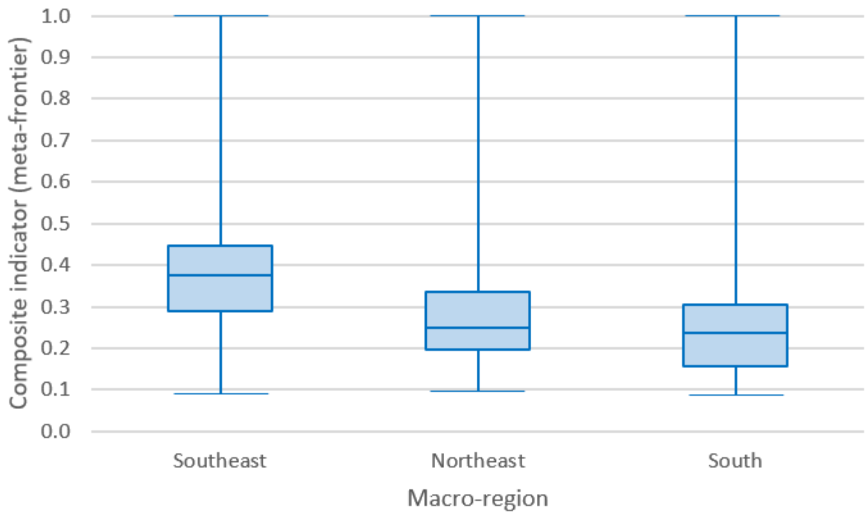


Figure 7.3: Metafrontier CI scores.

Note that, within its group, the South region has the highest average value for the composite indicator (0.555), which means that the region's municipalities are closer to the best practices observed in their own region. On the other hand, when considering the metafrontier as a benchmark, the municipalities in the South region have the worst average (0.226). This result indicates that the municipalities in the South region have a similar performance within the region, but that from a national perspective there is considerable potential for improvement.

In turn, the municipalities of the Northeast region present a similar average compared to the regional frontier and the metafrontier. The municipalities will have a significant challenge to improve the overall performance of water supply and sanitation services even within the region.

Finally, the municipalities of the Southeast region present the highest average Composite indicator value among the regions compared to the metafrontier (0.357), besides presenting a slightly lower average than the South region when compared to the regional frontier. This result suggests that the services of municipalities in the Southeast region are closer to the best practices in the global context, which justifies its use as a reference region for benchmarking at a national level.

The values obtained for GCI and its components are shown on Table 7.6 and depicted in Figure 7.4. Note that all values are reported considering the most populous macro-region (SE) as the reference for the comparisons.

Table 7.6: Results of the global non-convex index and its components

g_1, g_2	GCI^{g_1,g_2}	ESG^{g_1,g_2}	BPG^{g_1,g_2}
SE,NE	0.735	0.511	1.440
SE,S	0.633	1.080	0.586
NE, Meta	–	–	0.999
S, Meta	–	–	0.407
SE, Meta	–	–	0.694

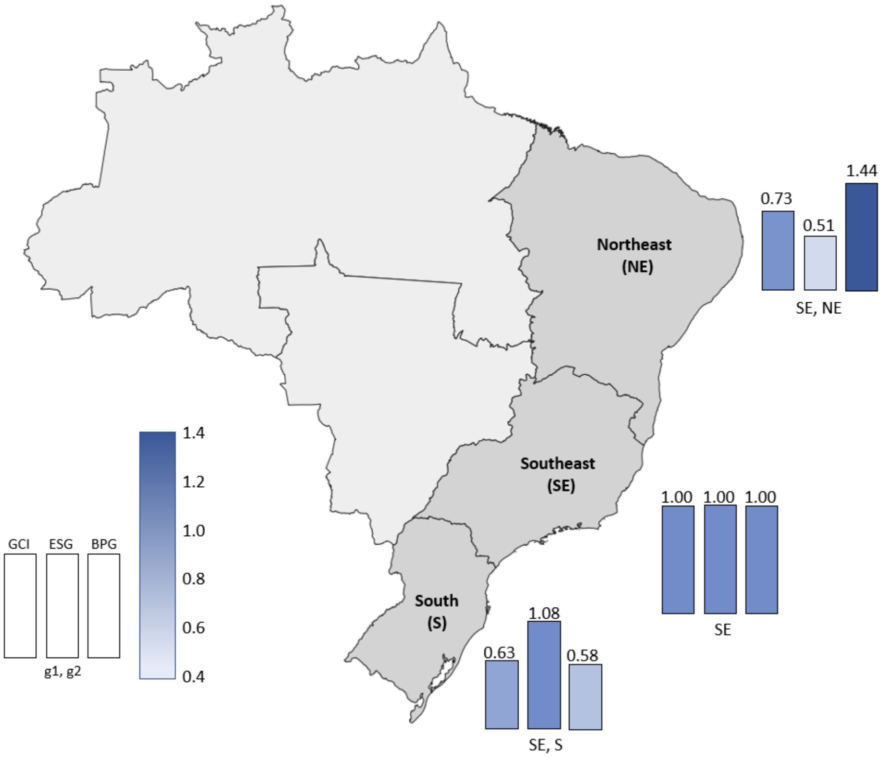


Figure 7.4: Illustration of the Group Comparison Index and its components.

The values of $GCI^{SE,NE} \leq 1$ and $GCI^{SE,S} \leq 1$ reported in Table 7.6 and Figure 7.4 show that the SE macro-region, where the main Brazilian cities of Rio de Janeiro and São Paulo are located, has better performance than NE and S. However, the components of the index reveal different causes for the performance differences among regions. The NE macro-region has a few municipalities with very good performance, that set the golden standard for the metafrontier, and thus the frontier of NE dominates the frontier of SE (as revealed by the value of $BPG^{SE,NE} \geq 1$). However, most municipalities cannot keep up with the regional best practice, so the dispersion of efficiency levels is very large (as revealed by the value of $ESG^{SE,NE} \leq 1$). The opposite is observed in the South. Although one municipality from the South is located in the metafrontier, the regional frontier is significantly below the metafrontier (as revealed by the value of $BPG^{S,Meta} \leq 1$). The regional frontier of the South is also dominated by the SE frontier (as revealed by the value of $BPG^{SE,S} \leq 1$), but there is more homogeneous performance among municipalities in the South than in the Southeast ($ESG^{SE,S} \geq 1$).

7.4 Conclusions

This chapter proposed a new pseudo-Malmquist index to compare the performance of Brazilian municipalities in three macro-regions, considering the water distribution and wastewater services provided to the population given the operational costs incurred. The analysis was conducted for 2019 and revealed that the best performing region is the Southeast. Concerning the Northeast region, it was concluded that despite having few municipalities operating with the best practices at the National level, there are significant levels of heterogeneity in the performance, with several municipalities exhibiting low-performance levels. Conversely, although the best municipalities in the South have worst performance than those located in the frontier of the SE region, there is more homogeneity in performance levels among municipalities in the South than in the Southeast.

This chapter opens new possibilities for developing Decision Support Systems to manage and improve performance in the water sector. The index developed in this chapter and illustrated with a real-world case study can open new possibilities to guide decision-making in the public sector.

CHAPTER 8
Conclusions

This chapter presents the main conclusions derived from this Thesis. Section 8.1 discusses the fulfillment of the research objectives as well as the main contributions delivered by this doctoral research. Section 8.2 acknowledges the limitations of this research. Section 8.3 presents directions for future research.

8.1 Fulfillment of the Research Objectives

This Thesis focused on investigating the best practices for water supply and sanitation services in Brazilian municipalities, as well as on developing innovative models, based on optimization techniques, for quantifying the Brazilian water sector performance. The Thesis includes methodological developments and illustrative applications using real data of water supply and sanitation services in Brazilian large municipalities. The studies conducted are aligned with the specific objectives proposed for this Thesis. The Data Envelopment Analysis technique was used to explore efficiency from different perspectives.

Firstly, in the exploratory analysis of service expenditures (Chapter 4), it was found that OPEX usually represents a large part of the total expenditures in service provision. This scenario may suggest a lack of investments in the sector (low CAPEX share). Furthermore, it was found that the most representative components in operating expenses are those related to labor and electricity. This result is significant from a public policy point of view. It indicates that any government or regulatory action to stimulate the reduction of expenses in the water sector should consider labor optimization and energy efficiency.

Chapter 5 explores an innovative benchmarking approach to assess water supply and sanitation services' performance in Brazilian municipalities. The first contribution of this chapter is to propose a benchmarking approach from an integrated perspective of efficiency and access. Benchmarking projects can help decision-makers to develop strategies that disseminate good practices. It was concluded that this type of approach could bring critical insights into the quality of services provided to the population and design performance improvement strategies for the water sector. The results revealed significant heterogeneity in the level of efficiency of water supply and sanitation services in the country, which makes explicit the need for non-standardized actions focused on the specificities of each region. The second contribution of this chapter was to explore the main contextual variables related to the provision of water supply and sanitation services, considering the Brazilian regional differences and the different types of providers. The results of this study are relevant for regulators in characterising the current state of performance of water supply and sanitation services in all Brazilian macro-regions.

Chapter 6 extended the efficiency analysis performed in the previous chapter to assess the evolution of productivity in the 2012-2019 period. The chapter showed the evolution of the productivity of water supply and sanitation services from the national and regional perspectives, using the respective metafrontiers as benchmarks. The main contribution of this chapter was to show that even in a scenario of international pressure for the improvement and expansion of water supply services, productivity in the provision of water supply and sanitation services in Brazil has remained relatively stable over the past years. The slow growth in service coverage is associated with the stagnation in productivity and the instability in the economic and political scenario, which shows that for Brazil to achieve the goals proposed in the 2030 Agenda, a paradigm shift is necessary. Concerning regional differences, the Southeast region presented the highest level of productivity among the Brazilian macro-regions. The South region showed a greater homogeneity in performance among its municipalities, and the Northeast region presented the most significant heterogeneity among its municipal services during the period studied.

Finally, chapter 7 used an innovative approach to compare service efficiency considering regional differences. The main contribution of this chapter is to present a new perspective for analyzing the performance of water supply and sanitation services in Brazilian municipalities. To achieve this goal, the innovative pseudo-Mamquist index methodology was used to define the non-convex best practice frontier. The analysis also involves the estimation of a composite indicator, according to the Benefit-of-the-Doubt (BoD) framework, which aggregates several individual indicators into a summary measure of performance that provides an overall perspective of achievements. The study conducted in this chapter identified the Southeast region with the best performance among the regions. Nevertheless, the components of the index reveal different causes for the performance differences among regions. The Northeast macro-region has a few municipalities with outstanding performance, setting the golden standard for the metafrontier, and thus the frontier of Northeast dominates the frontier of Southeast. However, most municipalities cannot keep up with the regional best practice, so the dispersion of efficiency levels is substantial. The opposite is observed in the South macro-region. Although one of its municipality is located in the metafrontier, the regional frontier is significantly below. The Southeast frontier also dominates the regional frontier of the South, but there is more homogeneous performance among municipalities in the South than in the Southeast.

Overall, the results obtained in this Thesis suggest that government investments and actions in the water sector in Brazil may be being made in an unbalanced way, often favoring the Southeast region, which already has satisfactory levels of efficiency and service coverage. This picture is even more worrisome when it is assumed that only the part of the population that has more capacity to pay for the services is favored to the detriment of the poorest.

8.2 Limitations of the Research

Although the research described in this Thesis reached all the objectives proposed, there are a few limitations in the empirical part of the analysis carried out in the scope of this Thesis. The limitations concerning the data and the possibility of errors in the information are noteworthy.

The limited regularity with which providers deliver the data also concerns its availability. Because submission of SNIS information is voluntary, there is no annual information on water supply and sanitation services for all municipalities. Each provider chooses whether or not to report its information each year. Although submitting the information is required to obtain federal resources, there is no effective control of this restriction.

On the other hand, although the information used in this work comes from the Brazilian government's official database, which perform some tests to control inconsistencies, the information submitted does not go through audit processes. The lack of audited data questions their reliability since a provider can report (and justify) values that are accepted.

As a consequence of these limitations, the models used in this Thesis suffered some restrictions in the sample size. In Chapter 5, the sample was 448 municipalities in a universe of 612 municipalities with more than 50,000 inhabitants. In Chapter 6, where it was proposed to use panel data, which requires information for all years of the study, only 283 were part of the sample (out of 612 municipalities with more than 50,000 inhabitants), mainly due to lack of information.

8.3 Directions to Further Research

The performance assessment models developed in this Thesis were illustrated in the context of water supply and sanitation on a municipality level. However, the approaches proposed to assess efficiency and productivity are versatile and can be generalized to other contexts. For instance, the analysis of the evolution of the performance of the State Sanitation Entities (CESBs) would be of great value to the sector. Furthermore, this Thesis used a provider-oriented approach. Thus, future studies could compare service performance from the provider and regulator perspectives, exploring their different roles and objectives with the adoption of different weights for the analysis variables, according to the importance given by each entity.

From a methodological point of view, further studies could complement the DEA results with statistical analysis of data, enhancing the robustness of the results obtained. The use of approaches to address extreme values and outliers in DEA assessments, especially in evaluations involving data on severe drought events, deserves attention in the future.

Additionally, considering the potential of the DEA technique, the availability of data in Brazil, and the specificities of water supply services, future studies should consider aggregating the information in ways different from those performed in this Thesis. Factors such as water availability, topography, and age of infrastructure are examples of clustering that can help define strategies to improve service performance.

APPENDIX A

Data for Chapters 5, 6 and 7

A.1 Information and indicators used in Chapter 5

Table A.1: Data used in Chapter 5

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U001	Ariquemes	RO	9465.35	23313	683	3214.42	241.08	241.08	165.28	9.06
U002	Cacoal	RO	17095.89	25078	17498	4519.97	1777.47	1777.47	439.35	104.00
U003	Porto Velho	RO	118209.39	42533	6083	7740.82	736.00	140.00	943.02	70.17
U004	Rio Branco	AC	45262.23	62898	23075	13230.70	4472.62	4472.62	1148.66	548.34
U005	Manaus	AM	251610.15	443131	64786	61492.28	19544.57	19544.57	3865.45	579.11
U006	Boa Vista	RR	88223.20	93821	84662	17806.20	16025.58	16025.58	1411.26	970.68
U007	Altamira	PA	6977.77	9277	9277	6307.20	5045.76	5045.76	195.92	192.92
U008	Ananindeua	PA	28270.31	40920	2945	9104.37	622.68	622.68	442.00	87.94
U009	Barcarena	PA	4501.69	9969	3315	1317.00	15.70	15.70	203.00	52.27
U010	Belém	PA	208721.89	221347	40655	47503.60	14505.44	1337.72	2127.00	548.75
U011	Itupiranga	PA	737.27	1200	142	115.00	51.00	51.00	20.00	12.00
U012	Marabá	PA	24454.99	22074	572	4861.51	164.12	164.12	235.00	16.50
U013	Marituba	PA	4566.21	9240	3602	1267.20	538.71	239.76	116.00	4.00
U014	Paragominas	PA	8841.12	24538	6057	4309.76	534.89	534.89	257.05	44.86
U015	Parauapebas	PA	52758.17	37563	7992	10841.00	1635.86	1558.44	990.00	69.30
U016	Redenção	PA	6074.82	11233	1325	1404.89	99.20	99.20	367.95	27.53
U017	Santarém	PA	29296.36	35604	3100	6236.47	533.63	533.63	361.00	26.50
U018	Macapá	AP	47449.90	45157	12545	10888.59	2725.82	2725.82	714.61	95.61
U019	Araguaína	TO	40882.57	63977	16864	7881.81	1883.37	1883.37	1299.08	353.41
U020	Gurupi	TO	21215.40	32318	8304	4043.43	1003.08	1003.08	529.62	126.92
U021	Paraíso do Tocantins	TO	12778.75	18752	4226	2250.98	284.20	284.20	383.41	104.19
U022	Palmas	TO	86844.38	110296	78939	15562.27	10003.94	10003.94	1762.43	1113.82
U023	Barreirinhas	MA	4203.66	4445	1196	728.81	619.49	619.49	46.40	22.75
U024	Caxias	MA	21063.83	42096	2214	8783.53	433.00	433.00	430.50	59.05
U025	Coroatá	MA	8999.80	13613	1000	2539.24	166.52	166.52	180.15	6.00
U026	Imperatriz	MA	41215.84	65453	21841	12107.55	4566.37	4566.37	595.33	136.50
U027	São José de Ribamar	MA	21993.84	59455	18956	8470.00	5845.00	5382.00	566.00	119.00
U028	São Luís	MA	260701.08	191209	90191	40849.05	32679.24	8090.04	1980.48	923.68
U029	Floriano	PI	18847.04	20117	641	3073.81	80.79	80.79	225.40	6.86
U030	Parnaíba	PI	43288.78	48593	17132	6331.86	1766.06	1766.06	623.51	171.32
U031	Picos	PI	20500.21	23697	12042	3174.58	1196.19	1196.19	120.00	120.42
U032	Acaraú	CE	4056.47	7445	1045	898.02	103.16	103.16	102.81	21.53
U033	Acopiara	CE	6103.52	8464	1756	710.30	124.57	124.57	54.40	23.81

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U034	Aquiraz	CE	5218.07	6558	3023	665.94	319.20	319.20	147.09	37.53
U035	Aracati	CE	12331.21	15363	4485	1766.45	466.09	466.09	164.57	52.54
U036	Barbalha	CE	6753.57	12944	1884	1634.63	182.54	182.54	98.55	44.06
U037	Beberibe	CE	2844.92	3369	1345	299.75	107.71	107.71	58.45	15.71
U038	Camocim	CE	3284.72	18010	4982	5550.00	1845.00	1363.00	155.00	87.00
U039	Canindé	CE	4506.71	14665	3021	1851.00	404.00	404.00	109.30	23.00
U040	Cascavel	CE	6531.29	12822	508	1049.78	25.22	25.22	148.39	4.53
U041	Caucaia	CE	47403.33	89933	43407	9339.07	3719.76	3719.76	636.91	280.19
U042	Crateús	CE	16155.86	18650	10083	1631.27	655.52	655.52	204.23	130.70
U043	Crato	CE	12920.53	36782	10641	10164.84	3058.00	107.28	320.63	106.28
U044	Eusébio	CE	8627.92	16159	1865	1996.86	219.34	219.34	249.40	25.43
U045	Fortaleza	CE	507689.46	662869	406645	101925.15	56427.95	56427.95	4176.65	2633.42
U046	Granja	CE	2491.36	5711	250	2505.00	36.00	36.00	52.30	1.86
U047	Horizonte	CE	9893.10	18033	1750	1490.31	356.97	356.97	150.97	12.73
U048	Icó	CE	4628.48	13661	4623	3325.00	1406.00	1338.00	140.00	49.00
U049	Iguatu	CE	17465.65	31130	3969	3487.34	518.05	518.05	414.33	31.00
U050	Itapipoca	CE	16907.49	24423	11260	2896.29	1238.60	1238.60	313.16	51.57
U051	Juazeiro do Norte	CE	54168.90	87800	24545	10501.73	2384.93	2384.93	723.34	170.42
U052	Limoeiro do Norte	CE	11300.94	21310	5638	6274.05	1451.60	1451.60	201.39	71.35
U053	Maracanaú	CE	47762.37	74193	36560	7981.82	4981.98	4981.98	584.83	227.28
U054	Maranguape	CE	14165.12	26831	4250	2553.91	312.69	312.69	275.71	65.41
U055	Morada Nova	CE	6955.95	18291	334	2546.00	61.00	61.00	633.00	4.00
U056	Pacajus	CE	6696.20	14965	731	1242.06	227.77	227.77	152.03	3.10
U057	Pacatuba	CE	10604.77	20401	12071	2060.44	943.56	943.56	170.49	42.05
U058	Quixadá	CE	16406.78	19694	5179	2053.95	357.84	357.84	190.88	83.56
U059	Russas	CE	13402.07	17248	5565	1672.79	462.98	462.98	163.60	55.70
U060	Tauá	CE	5632.35	11398	1605	1103.40	106.09	106.09	103.87	19.09
U061	Tianguá	CE	14598.80	21429	7399	2052.33	531.79	531.79	288.84	68.93
U062	Trairi	CE	2378.23	3942	593	305.29	42.58	42.58	55.53	7.00
U063	Caicó	RN	12323.83	20320	4079	2364.37	386.41	386.41	309.06	59.00
U064	Parnamirim	RN	47850.17	67729	3452	10647.53	641.83	641.83	444.67	69.00
U065	Macaíba	RN	11775.43	14489	754	1546.60	253.55	253.55	200.21	21.53
U066	Mossoró	RN	71821.29	74815	37228	11177.95	6310.28	6310.28	1200.62	255.00

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U067	Natal	RN	214565.42	212709	84457	36795.85	20170.12	20170.12	1674.70	1056.04
U068	São Gonçalo do Amarante	RN	583.84	4284	1722	545.66	419.87	419.87	380.00	48.00
U069	Bayeux	PB	5592.78	20915	2697	2751.96	362.66	362.66	105.86	19.80
U070	Cabedelo	PB	6181.42	15598	1890	3574.51	879.65	879.65	78.98	8.75
U071	Cajazeiras	PB	17440.13	20146	3136	2251.45	354.56	354.56	186.60	23.92
U072	Campina Grande	PB	122144.48	128255	106481	17175.04	12519.84	12519.84	763.74	430.28
U073	Guarabira	PB	25406.90	18139	11137	2239.47	1234.37	1234.37	135.16	57.04
U074	João Pessoa	PB	316055.53	209441	149174	42796.93	31025.97	31025.97	1032.76	654.28
U075	Patos	PB	35556.32	34220	4571	4186.84	533.98	533.98	217.40	14.57
U076	Santa Rita	PB	12263.34	34006	1767	5406.41	240.94	240.94	131.04	21.83
U077	Sapé	PB	5552.20	10020	3525	1062.94	288.09	288.09	89.05	18.39
U078	Abreu e Lima	PE	6828.80	25180	6362	2692.33	936.55	936.55	225.07	90.03
U079	Arcoverde	PE	16402.57	22470	1110	2384.03	154.23	154.23	193.57	13.06
U080	Cabo de Santo Agostinho	PE	45746.02	46998	5618	22824.61	888.04	888.04	578.10	194.29
U081	Camaragibe	PE	9650.90	30338	561	3806.46	160.27	160.27	344.17	7.53
U082	Caruaru	PE	47510.34	109874	50529	12194.98	5818.18	5818.18	1070.40	431.17
U083	Garanhuns	PE	26784.33	45344	5153	5200.17	554.13	554.13	470.88	129.72
U084	Gravatá	PE	17541.84	30305	340	4133.23	83.09	83.09	348.12	6.52
U085	Igarassu	PE	21040.70	24843	999	2838.07	193.34	193.34	317.37	18.93
U086	Ipojuca	PE	16675.39	14327	3053	2016.82	408.88	408.88	215.38	117.65
U087	Jaboatão dos Guararapes	PE	52361.39	118891	21775	22155.53	3391.44	3391.44	1156.34	360.45
U088	Moreno	PE	4603.39	14815	5263	1313.70	442.51	442.51	141.29	84.15
U089	Olinda	PE	56567.50	93870	35776	12217.17	6437.59	6437.59	840.58	470.64
U090	Paulista	PE	36967.13	82307	36671	9834.44	4490.16	4490.16	1262.13	623.44
U091	Petrolina	PE	52566.09	93571	69547	13214.11	9746.85	9746.85	970.74	669.01
U092	Recife	PE	650917.18	297810	99179	63462.11	47526.41	47402.84	3578.36	1742.51
U093	Salgueiro	PE	15293.26	20963	6855	2190.09	757.33	757.33	267.90	94.54
U094	São Lourenço da Mata	PE	8953.67	21137	6793	2539.33	619.97	619.97	228.99	70.13
U095	Surubim	PE	6579.44	19404	2380	1629.16	57.22	57.22	166.26	25.85
U096	Vitória de Santo Antão	PE	22641.00	33653	12639	4435.00	1380.15	1380.15	319.91	159.80
U097	Arapiraca	AL	25572.36	56801	1070	7378.20	109.49	109.49	640.78	36.64
U098	Coruripe	AL	5510.35	15586	3333	7080.10	578.89	578.89	252.00	25.13
U099	Maceió	AL	276113.63	155000	59401	33351.20	13183.00	13183.00	1616.41	403.03

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U100	Marechal Deodoro	AL	13781.54	21401	5967	4715.45	1430.89	1430.89	157.20	44.60
U101	Palmeira dos Índios	AL	11145.38	18679	837	2181.43	88.34	88.34	313.16	4.91
U102	Rio Largo	AL	14051.34	15901	6132	1607.93	585.96	585.96	193.00	25.00
U103	São Miguel dos Campos	AL	7424.56	17600	9823	2089.00	1652.60	315.46	195.00	109.75
U104	União dos Palmares	AL	9740.89	18310	15855	1967.98	806.20	672.10	136.30	70.34
U105	Aracaju	SE	296220.02	218515	115959	40496.27	21492.74	21492.74	1785.93	1070.06
U106	Estância	SE	7981.39	19365	1916	2598.10	89.30	89.30	168.18	10.38
U107	Lagarto	SE	23283.65	27887	2123	3631.60	322.29	322.29	290.92	25.20
U108	Nossa Senhora do Socorro	SE	48633.84	45267	15185	8057.87	2161.71	2161.71	412.84	165.09
U109	Alagoinhas	BA	31248.82	51317	13111	5145.00	1738.00	1318.00	626.30	100.18
U110	Barreiras	BA	37321.30	52677	37460	6564.40	4528.46	4528.46	670.10	298.93
U111	Bom Jesus da Lapa	BA	11775.07	18639	9039	2941.00	1833.56	1493.24	222.00	179.00
U112	Brumado	BA	12059.60	21717	1743	2548.44	157.45	157.45	468.22	11.39
U113	Camaçari	BA	88658.17	81491	33978	13545.79	5049.11	3212.38	1142.12	181.93
U114	Campo Formoso	BA	4999.49	10370	858	885.03	56.48	56.48	51.25	2.69
U115	Candeias	BA	32390.24	25826	12923	2717.03	1231.31	1219.37	299.96	176.47
U116	Conceição do Coité	BA	10058.13	19094	1025	1944.15	67.59	67.59	240.90	6.72
U117	Cruz das Almas	BA	11067.36	19171	8104	1879.30	785.45	785.45	383.12	152.40
U118	Dias D'Ávila	BA	21984.38	16991	11060	1771.42	1388.78	1388.78	220.00	93.48
U119	Euclides da Cunha	BA	7117.05	15411	3656	1465.68	353.82	353.82	373.26	46.60
U120	Eunápolis	BA	16970.46	34078	4375	3756.40	376.65	376.65	301.77	23.73
U121	Feira de Santana	BA	131955.34	174078	117291	19787.22	14752.28	14752.28	2357.88	678.22
U122	Guanambi	BA	20213.21	27090	16212	3366.06	2104.42	2104.42	674.58	238.73
U123	Ilhéus	BA	40848.77	48341	31630	5977.27	4064.51	4064.51	596.56	152.92
U124	Ipirá	BA	9152.94	16306	1086	1421.22	83.88	83.88	154.37	9.97
U125	Irecê	BA	19609.47	28138	4394	2746.15	373.73	373.73	408.40	25.42
U126	Itaberaba	BA	12479.87	23251	4088	2087.66	277.83	277.83	243.08	23.76
U127	Itabuna	BA	39737.29	50686	40114	18457.29	14396.69	4606.93	441.00	353.00
U128	Itamaraju	BA	12041.31	18737	14835	1827.38	1431.63	1431.63	174.48	29.67
U129	Itapetinga	BA	9188.96	23501	22160	3515.61	2381.50	503.09	189.90	140.10
U130	Jacobina	BA	13905.83	25673	1871	2436.34	155.29	155.29	375.16	3.30
U131	Jaguaquara	BA	8250.87	14073	5533	1347.32	500.20	500.02	122.10	88.52
U132	Jequié	BA	35317.41	52517	47775	5321.45	4855.08	4855.08	496.65	461.97

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U133	Juazeiro	BA	33674.99	66430	58180	20653.00	6460.00	5679.00	514.00	444.00
U134	Lauro de Freitas	BA	51214.27	43732	20586	10506.74	4057.10	3974.46	575.99	140.56
U135	Luís Eduardo Magalhães	BA	15322.26	29096	16056	3771.38	2004.10	2004.10	268.41	237.60
U136	Paulo Afonso	BA	20784.59	33878	12834	4619.38	1520.88	1520.88	286.96	148.16
U137	Porto Seguro	BA	31199.40	33551	30817	4009.88	4782.55	4782.55	368.46	345.35
U138	Salvador	BA	793821.74	489845	526876	121417.93	128009.58	125423.29	4580.11	4088.85
U139	Santo Amaro	BA	14455.01	17241	8270	2658.77	804.38	804.38	122.89	71.91
U140	Santo Antônio de Jesus	BA	20186.80	35987	8728	3675.08	837.78	831.47	384.56	49.41
U141	Santo Estêvão	BA	8066.94	14542	1804	1392.67	165.66	165.66	192.20	3.43
U142	Senhor do Bonfim	BA	14876.75	27493	2068	3628.06	142.71	142.71	216.45	13.56
U143	Serrinha	BA	14835.00	27388	3189	5097.98	269.64	269.64	303.45	18.99
U144	Simões Filho	BA	27210.47	25262	14112	5084.61	1792.07	1755.59	436.70	76.82
U145	Teixeira de Freitas	BA	24628.28	40364	24256	4298.16	2768.12	2768.12	442.95	248.64
U146	Tucano	BA	4699.72	9729	4457	906.39	428.36	428.36	83.72	28.66
U147	Vitória da Conquista	BA	80642.68	99302	88189	11895.89	10876.36	10876.36	1252.33	777.59
U148	Alfenas	MG	21494.63	31819	31605	4144.98	3221.44	3219.26	322.38	314.87
U149	Araguari	MG	16875.50	46165	45190	16739.30	13391.44	5801.33	505.00	490.55
U150	Araxá	MG	26817.92	41389	41315	5518.33	4314.41	4314.41	694.55	542.07
U151	Belo Horizonte	MG	721027.29	602243	614720	139031.11	108635.54	108635.54	6935.52	4464.32
U152	Betim	MG	98435.34	127157	107478	17679.22	11861.23	11861.23	1521.35	1062.73
U153	Bom Despacho	MG	16842.96	20287	20027	2355.34	1762.07	1762.07	279.68	206.41
U154	Caratinga	MG	18869.05	25702	21058	3302.01	2141.10	1236.88	206.85	116.72
U155	Conselheiro Lafaiete	MG	31631.75	48002	42983	5605.10	3902.07	3176.52	446.42	362.32
U156	Contagem	MG	155888.79	185179	175948	29707.66	21840.40	21840.40	1970.66	1287.09
U157	Curvelo	MG	24496.41	30241	25628	3355.60	2250.50	2250.50	321.78	196.22
U158	Divinópolis	MG	57796.94	78329	68072	12338.73	8568.76	287.43	1175.34	831.52
U159	Esmeraldas	MG	14161.91	24183	5006	2449.32	382.35	382.35	427.47	39.12
U160	Frutal	MG	13772.75	22643	23079	2671.47	2138.84	2138.84	195.39	171.54
U161	Ibirité	MG	36500.44	51926	43868	6334.39	4170.99	2534.98	511.53	247.48
U162	Ipatinga	MG	58064.91	71692	76035	10225.72	8770.89	8770.89	691.21	558.92
U163	Itabira	MG	23785.89	32824	30644	6725.16	6523.41	2338.15	423.62	323.03
U164	Itabirito	MG	20138.07	18233	15791	3781.85	2376.34	1998.44	440.84	219.08
U165	Itajubá	MG	22852.82	32530	30962	4934.71	3633.70	3294.46	814.24	343.16

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U166	Ituiutaba	MG	27964.20	40406	39912	6949.00	5941.85	5745.78	565.34	543.47
U167	Janaúba	MG	12491.11	25503	7051	2950.58	630.40	630.40	406.32	102.44
U168	Januária	MG	12361.50	17704	4579	1988.08	371.36	371.36	237.09	67.29
U169	Juiz de Fora	MG	145784.18	140190	137807	31157.93	23327.26	1487.67	1865.82	1365.70
U170	Lagoa da Prata	MG	12495.84	18707	18525	3112.12	2649.00	2649.00	314.67	272.33
U171	Lagoa Santa	MG	19704.76	25555	13096	4210.59	1777.28	1777.28	586.22	259.21
U172	Lavras	MG	28047.65	38449	37568	4930.08	3729.94	3729.94	482.23	389.53
U173	Manhuaçu	MG	14151.72	21320	16244	4816.65	4345.32	5.20	260.40	173.20
U174	Montes Claros	MG	99368.37	136665	137767	14353.73	11482.64	11482.64	1805.91	1278.74
U175	Muriaé	MG	26933.21	35751	35660	5832.77	4957.85	1668.30	476.73	477.65
U176	Nova Lima	MG	25725.01	30628	3112	6017.94	1030.53	1030.53	504.26	72.60
U177	Paracatu	MG	21951.15	28626	26423	3339.10	2380.75	2380.75	311.27	266.89
U178	Pará de Minas	MG	32309.80	36425	34572	4725.52	3919.46	3919.46	507.31	330.23
U179	Passos	MG	21230.85	39378	39078	7495.51	5996.41	3036.12	535.92	480.87
U180	Patos de Minas	MG	35260.84	59244	58222	8758.87	6837.18	4040.54	883.86	668.71
U181	Patrocínio	MG	16991.46	29160	28634	3938.00	3150.00	3072.00	469.00	410.00
U182	Pedro Leopoldo	MG	17210.80	22210	15391	2987.65	1628.14	1023.94	361.52	115.25
U183	Pirapora	MG	14685.58	18476	7949	3680.36	1160.09	1160.09	289.37	86.29
U184	Poços de Caldas	MG	49718.65	56688	56152	10107.54	8589.40	2576.82	1087.65	973.04
U185	Pouso Alegre	MG	36605.32	51922	52568	7016.43	5485.37	5485.37	668.63	545.11
U186	Ribeirão das Neves	MG	62921.92	94332	81448	12273.32	8074.55	6159.45	1095.09	817.18
U187	Santa Luzia	MG	48723.67	59176	51096	8124.01	5497.17	5497.17	785.54	470.01
U188	São Francisco	MG	7793.01	12838	6706	1459.86	607.20	607.20	173.87	92.93
U189	São Sebastião do Paraíso	MG	17432.52	27226	26234	3494.41	2663.02	1967.59	308.09	247.49
U190	Sete Lagoas	MG	70676.87	74371	70751	11562.94	9250.35	2775.10	1172.84	949.57
U191	Timóteo	MG	20994.85	24604	24579	3544.09	2800.09	1372.52	275.06	196.28
U192	Três Corações	MG	16403.14	26188	25809	3429.49	2597.86	664.41	360.34	292.64
U193	Três Pontas	MG	6732.34	19138	19067	3007.46	2405.97	48.44	255.13	222.64
U194	Uberaba	MG	134337.11	112913	112268	26064.06	26064.06	25933.74	1902.74	1869.51
U195	Uberlândia	MG	172750.38	194497	192710	60043.19	50217.05	50217.05	3438.60	2808.90
U196	Unaí	MG	19508.75	23462	20605	5006.86	3435.43	2828.95	339.79	248.80
U197	Varginha	MG	39967.43	50268	50841	6711.36	5218.11	5218.11	664.43	555.39
U198	Vespasiano	MG	31736.65	31706	29459	4375.83	3085.83	3085.83	540.50	316.94

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U199	Viçosa	MG	11179.88	21183	19287	4181.00	3345.00	33.45	285.60	219.40
U200	Aracruz	ES	22897.49	31355	23559	5191.45	3557.92	1601.06	390.88	248.93
U201	Cachoeiro de Itapemirim	ES	56922.88	61745	56995	9637.20	7226.49	7092.80	659.02	544.92
U202	Cariacica	ES	69535.72	85616	32321	16345.25	5307.98	4382.97	1297.73	391.76
U203	Colatina	ES	25511.99	28330	25287	6545.00	8419.00	44.00	340.00	210.00
U204	Guarapari	ES	32373.16	30682	14213	7609.72	5148.05	5148.00	539.88	229.05
U205	Linhares	ES	20191.63	36448	26762	8124.40	6455.87	5487.49	506.48	294.16
U206	Nova Venécia	ES	7806.64	12107	1723	1835.05	172.52	172.52	196.77	72.44
U207	São Mateus	ES	11516.09	29553	19641	4211.90	3094.82	216.64	480.00	138.00
U208	Serra	ES	158194.90	106079	77277	37033.71	14675.96	14675.96	1844.55	1018.15
U209	Viana	ES	13558.85	14902	7119	3187.18	1126.27	885.66	272.11	90.14
U210	Vila Velha	ES	122950.47	94664	33947	28901.06	15918.70	15915.55	1369.92	408.31
U211	Vitória	ES	114017.02	56373	41909	26801.14	20007.03	20007.03	864.14	481.08
U212	Belford Roxo	RJ	49148.02	77888	41800	27782.52	12673.53	1016.00	563.33	418.00
U213	Cabo Frio	RJ	51603.26	80913	80913	9996.00	12024.00	12024.00	1317.00	39.00
U214	Duque de Caxias	RJ	55560.73	137973	67500	70908.29	28652.03	2397.00	1311.43	675.00
U215	Maricá	RJ	8962.34	23911	2300	3270.64	267.42	184.00	160.00	23.00
U216	Niterói	RJ	278605.26	88704	82494	36818.40	42824.06	42824.06	1314.98	785.83
U217	São Gonçalo	RJ	158557.14	135191	72100	138997.51	35719.65	11550.00	1692.00	721.00
U218	São Pedro da Aldeia	RJ	21494.92	40759	40759	4609.00	3340.00	3340.00	701.00	56.00
U219	Seropédica	RJ	8336.28	12801	5300	4533.29	1595.39	168.00	301.11	53.00
U220	Americana	SP	70848.98	82979	81662	15296.61	14321.63	7722.53	2162.50	2331.54
U221	Amparo	SP	17398.63	24577	21987	3790.29	3032.23	1767.17	326.40	228.96
U222	Andradina	SP	13758.73	22467	22750	3642.23	3537.00	3537.00	293.26	322.46
U223	Araçatuba	SP	63466.18	75497	74440	14799.77	15323.01	15323.01	745.33	848.34
U224	Araraquara	SP	96086.36	99189	99449	17716.29	18963.41	18963.41	1440.71	1202.06
U225	Artur Nogueira	SP	14654.30	16614	16176	2676.31	1803.92	595.29	175.66	167.47
U226	Arujá	SP	27957.74	27919	18850	4882.96	2457.08	2457.08	401.24	201.78
U227	Assis	SP	27124.64	39862	39738	6367.79	6320.21	6320.21	498.14	402.98
U228	Atibaia	SP	68111.29	42770	26483	7248.31	9735.37	5657.04	604.74	404.70
U229	Avaré	SP	24436.47	34959	33785	5109.56	5049.85	5049.85	421.20	343.31
U230	Barretos	SP	48349.13	51174	50307	7778.36	6781.11	6781.11	700.00	650.00
U231	Barueri	SP	90311.34	82488	64333	19163.92	12168.16	6224.09	747.72	428.62

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U232	Batatais	SP	16046.64	23796	23000	8300.00	6640.00	5046.00	300.00	280.00
U233	Bebedouro	SP	21291.60	30694	30670	7101.75	4617.30	2615.17	731.00	729.00
U234	Bertioga	SP	51507.04	25825	13208	4571.76	2762.79	2762.79	357.62	244.95
U235	Birigui	SP	19472.29	48894	47529	11346.22	11200.00	11200.00	470.50	459.50
U236	Boituva	SP	18478.57	20538	17692	3286.03	2416.46	2416.46	153.28	69.58
U237	Botucatu	SP	45780.41	57606	54716	9145.55	8426.19	8426.19	659.23	477.63
U238	Bragança Paulista	SP	38013.08	54803	48864	9239.94	6512.89	6512.89	859.42	529.69
U239	Caçapava	SP	32399.05	35205	29824	5413.66	4528.85	4497.51	489.91	293.45
U240	Campinas	SP	708092.80	356746	331899	80797.22	63678.82	56832.33	4730.69	4464.89
U241	Campo Limpo Paulista	SP	15602.16	23199	18595	3760.52	2935.99	2883.55	295.45	179.75
U242	Campos do Jordão	SP	25655.56	16287	13985	3445.52	2690.34	2690.34	321.14	124.36
U243	Capivari	SP	17744.62	18895	17867	3270.70	2833.14	1085.09	309.72	276.00
U244	Caraguatatuba	SP	54901.43	57828	47975	8713.74	7453.41	7453.41	633.90	508.20
U245	Carapicuíba	SP	63800.52	101763	72087	18545.88	10519.10	5423.95	647.90	434.83
U246	Catanduva	SP	38593.39	51436	49333	10257.23	10053.42	8125.76	500.00	500.00
U247	Cotia	SP	69536.90	71765	33220	13751.10	5183.02	2331.99	1158.18	391.60
U248	Cruzeiro	SP	12600.14	27665	26440	4289.87	4286.40	3.10	315.00	295.80
U249	Cubatão	SP	37066.79	29947	17067	7111.18	3619.13	3619.13	255.22	148.35
U250	Diadema	SP	87015.82	112643	106053	20865.76	15805.45	8328.54	824.67	495.07
U251	Embu	SP	51205.29	80225	52756	12060.80	6682.92	3675.61	641.57	313.29
U252	Embu-Guaçu	SP	16201.11	17801	8273	2398.31	910.72	910.72	258.48	126.72
U253	Fernandópolis	SP	21170.60	30777	30627	5048.94	4866.66	4866.66	335.38	283.52
U254	Ferraz de Vasconcelos	SP	31765.87	47769	40533	7774.34	5300.77	2968.44	322.62	262.19
U255	Franca	SP	108034.65	133372	131789	20549.69	20304.87	20304.87	1518.36	1253.35
U256	Guaratinguetá	SP	40508.60	42966	39795	8216.34	6572.77	1617.93	630.00	338.81
U257	Guarujá	SP	154679.31	68841	50759	18527.20	12807.42	12807.42	841.24	446.04
U258	Hortolândia	SP	43959.59	72587	68886	12699.44	11374.10	11374.10	602.44	358.46
U259	Ibiúna	SP	13507.64	14426	5827	2195.76	802.70	802.70	147.13	28.61
U260	Indaiatuba	SP	100654.18	84602	83984	17226.95	14642.91	10069.20	1104.87	985.89
U261	Itanhaém	SP	50139.79	72414	33469	7889.10	4317.58	4317.58	962.06	429.88
U262	Itapecerica da Serra	SP	22454.93	48306	23410	6798.61	2532.25	2481.60	450.70	216.48
U263	Itapetininga	SP	40670.18	54574	51149	7949.59	7287.53	7287.53	643.31	458.86
U264	Itapeva	SP	23596.06	30394	26649	4170.36	3634.70	3547.05	395.70	250.27

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U265	Itapevi	SP	32151.28	60906	40321	9272.78	4855.79	2668.15	498.07	273.38
U266	Itapira	SP	22334.49	27552	26516	4398.75	4398.75	4398.75	351.54	315.25
U267	Itaquaquecetuba	SP	56959.32	97711	65552	15053.40	8047.96	1319.71	915.10	469.45
U268	Itararé	SP	12937.60	16999	15516	2196.96	2013.83	2013.83	212.36	140.58
U269	Itatiba	SP	36356.64	31424	29364	5902.70	5156.62	5156.62	235.51	159.07
U270	Itu	SP	52874.20	55318	53081	9157.99	8453.71	8453.71	831.70	597.24
U271	Itupeva	SP	22475.40	17344	15214	3265.64	2345.15	2345.15	87.54	36.43
U272	Jaboticabal	SP	19382.04	29114	31098	5241.25	6739.00	5241.25	365.66	250.91
U273	Jacareí	SP	74838.01	73918	73634	13389.01	10480.06	8189.75	801.06	620.16
U274	Jaguariúna	SP	12942.87	20146	18691	3744.79	3690.37	3101.98	212.00	207.00
U275	Jandira	SP	23227.12	34896	25686	5571.82	3222.86	1468.92	249.07	157.87
U276	Jaú	SP	67830.92	53337	56420	9363.83	10125.20	433.00	897.00	736.70
U277	Jundiaí	SP	276320.31	109452	105671	31216.37	36079.34	37156.75	1942.56	998.74
U278	Leme	SP	26912.13	37434	37181	6074.78	5972.85	5972.85	460.00	440.00
U279	Lençóis Paulista	SP	20590.21	24476	24081	7978.99	7200.01	7145.78	337.10	277.97
U280	Limeira	SP	114628.90	101730	100962	20655.00	16932.00	16932.00	1198.66	1048.88
U281	Lins	SP	24096.82	31027	30817	5695.56	5173.17	5173.17	238.11	214.04
U282	Lorena	SP	25479.95	31442	30984	4833.66	4479.42	4479.42	267.61	208.09
U283	Mairiporã	SP	22668.88	18712	7182	2588.70	849.97	611.75	367.68	74.32
U284	Mirassol	SP	17622.61	23347	23943	3854.00	4000.00	3000.00	475.00	492.00
U285	Mococa	SP	21286.65	25436	25104	3886.20	3593.46	3593.46	405.60	172.16
U286	Mogi das Cruzes	SP	154133.86	134769	121033	24274.67	18733.64	5885.88	1151.00	829.00
U287	Mogi Guaçu	SP	44961.71	58868	57766	9988.35	7743.65	5807.74	645.95	576.67
U288	Mogi Mirim	SP	43370.30	34602	32636	5745.41	5221.07	4744.49	496.00	400.00
U289	Mongaguá	SP	31194.55	39325	31672	4305.79	3767.18	3767.18	425.56	321.17
U290	Monte Alto	SP	17800.31	19787	19631	3166.18	3166.18	3166.18	278.96	260.92
U291	Monte Mor	SP	23905.52	23201	18896	3452.18	2507.31	2507.31	248.61	91.65
U292	Nova Odessa	SP	27363.14	25263	24661	3764.88	3764.88	3764.88	282.76	273.59
U293	Olímpia	SP	15306.50	23100	23094	4804.16	3531.51	1059.44	246.38	236.44
U294	Osasco	SP	135405.00	189018	143652	40569.65	24537.78	13684.55	1281.87	823.17
U295	Ourinhos	SP	28019.25	41468	41126	6572.21	5119.11	4312.85	643.70	525.75
U296	Paulínia	SP	35934.01	36674	34646	7513.22	6113.79	6113.79	492.84	232.22
U297	Peruíbe	SP	36117.91	44733	34725	5397.35	4842.84	4842.84	541.80	473.77

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U298	Piedade	SP	10839.61	11462	7165	1646.19	1029.41	1016.93	178.33	63.21
U299	Pindamonhangaba	SP	48371.92	57396	55158	9078.22	8469.86	8469.86	608.17	446.89
U300	Piracicaba	SP	207959.65	155758	150884	29364.47	29364.47	29364.47	1708.76	1441.49
U301	Pirassununga	SP	25820.77	31551	31530	5206.69	4295.35	4201.30	524.00	441.00
U302	Poá	SP	27061.31	34158	32497	5417.45	4746.67	4090.50	302.54	253.72
U303	Porto Feliz	SP	15803.05	16114	15871	2816.39	2814.21	2550.80	205.01	151.31
U304	Porto Ferreira	SP	18987.75	21632	21082	4195.00	2975.00	2443.00	338.00	313.00
U305	Praia Grande	SP	100739.09	109892	65625	23245.95	16066.86	16066.86	1004.27	640.46
U306	Presidente Prudente	SP	79808.63	87433	87097	15408.62	15408.62	15408.62	1117.90	951.83
U307	Registro	SP	15918.13	20526	18643	3029.43	2776.25	2776.25	225.18	219.32
U308	Ribeirão Pires	SP	28159.60	31745	26059	5058.88	3312.15	2318.51	570.62	362.59
U309	Ribeirão Preto	SP	236476.62	203466	202623	58536.74	58536.74	58536.74	2338.52	1990.07
U310	Rio Claro	SP	94289.57	75004	73911	14753.27	17789.00	16366.00	925.57	738.00
U311	Rio Grande da Serra	SP	8883.34	12538	7762	1725.25	963.87	819.29	168.37	85.12
U312	Santa Bárbara D'Oeste	SP	68448.73	67227	66621	11313.00	10102.88	7819.01	831.86	713.74
U313	Santa Isabel	SP	11689.89	12103	8143	1994.60	1331.24	103.03	120.18	78.83
U314	Santana de Parnaíba	SP	39190.22	41550	17305	8837.57	2964.52	772.47	707.36	311.90
U315	Santo André	SP	78233.83	203247	199545	14004.29	11044.05	5080.26	39.95	68.51
U316	Santos	SP	129936.42	68044	64473	37392.24	36505.49	36505.49	1404.05	549.99
U317	São Bernardo do Campo	SP	237277.06	195456	172403	48370.47	35289.39	9760.01	2028.09	1288.10
U318	São Carlos	SP	103872.47	109121	108303	20475.77	17600.63	16720.60	1056.13	989.00
U319	São João da Boa Vista	SP	27662.05	37661	36843	6202.05	5914.76	5914.76	562.74	364.69
U320	São José do Rio Pardo	SP	11900.50	21036	20925	3900.00	3000.00	420.00	270.00	250.00
U321	São José do Rio Preto	SP	167251.41	173862	173862	40062.92	37653.98	37653.98	2055.00	1987.40
U322	São José dos Campos	SP	190907.82	188077	177408	39970.83	37693.19	37693.19	1841.68	1260.56
U323	Sertãozinho	SP	40007.99	46153	45791	11573.49	9258.79	9258.79	540.00	440.00
U324	Sorocaba	SP	170963.14	231585	220705	45313.00	38407.29	37447.10	2094.64	1451.54
U325	Sumaré	SP	68018.38	89462	85068	15504.00	12103.00	3315.00	795.00	678.00
U326	Taboão da Serra	SP	43468.89	76736	66385	14220.79	10001.10	5422.05	420.30	322.47
U327	Taquaritinga	SP	13710.94	23905	23905	3548.74	2778.71	2778.71	276.00	274.00
U328	Valinhos	SP	40955.67	38051	36272	7696.52	7104.35	7104.35	672.45	629.54
U329	Vargem Grande Paulista	SP	7405.83	12625	4849	2119.92	559.93	178.98	326.26	78.17
U330	Várzea Paulista	SP	33359.02	32740	31286	5283.72	5242.83	5242.83	300.60	222.59

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U331	Vinhedo	SP	33096.03	25525	21309	5292.17	4498.34	4498.34	562.90	352.26
U332	Votorantim	SP	35986.05	35951	34959	7602.81	6054.07	5726.88	571.70	421.26
U333	Votuporanga	SP	21786.97	40449	40040	6634.79	5305.97	5305.97	522.11	502.68
U334	Almirante Tamandaré	PR	24681.75	30834	17237	4467.49	1892.12	1892.12	488.27	242.59
U335	Apucarana	PR	41533.95	47175	36300	6713.50	5278.18	5278.18	621.44	667.80
U336	Arapongas	PR	34283.97	44089	28302	5793.07	3916.66	3916.66	628.83	486.35
U337	Araucária	PR	40336.71	40129	30845	7051.41	4486.81	4486.81	680.06	519.54
U338	Cambé	PR	27634.98	37820	35483	5872.22	5268.79	5268.79	379.49	520.52
U339	Campo Largo	PR	32768.20	36298	24658	5405.58	3509.32	3509.32	676.92	566.69
U340	Campo Mourão	PR	29149.32	36304	31187	5267.97	4617.44	4617.44	500.83	537.20
U341	Cascavel	PR	85713.86	100613	92686	15452.06	16083.60	16083.60	1468.06	1458.46
U342	Castro	PR	13491.87	19717	15848	2498.54	2005.94	2005.94	288.37	246.76
U343	Cianorte	PR	30420.68	26892	16011	4190.43	2792.37	2792.37	673.83	253.94
U344	Colombo	PR	43627.72	66641	44239	10274.28	6267.30	6267.30	950.93	596.61
U345	Curitiba	PR	624406.48	491362	456696	200555.45	104925.19	104925.19	7418.84	6331.21
U346	Fazenda Rio Grande	PR	24071.12	47048	38350	5316.76	4293.84	4293.84	608.56	528.92
U347	Foz do Iguaçu	PR	79962.35	90150	67416	17575.18	14417.13	14417.13	1535.89	1232.98
U348	Francisco Beltrão	PR	26415.89	26059	19063	4324.16	3489.20	3489.20	569.27	409.15
U349	Guarapuava	PR	41519.26	54090	44389	8149.95	6628.65	6628.65	1063.81	818.48
U350	Ibiporã	PR	13567.43	20975	19178	3361.57	2989.63	2989.63	459.78	299.57
U351	Irati	PR	15690.40	17728	15470	2183.19	1859.52	1859.52	398.31	300.73
U352	Londrina	PR	222094.44	164582	150930	45073.40	33184.45	33184.45	2018.43	1874.96
U353	Marechal Cândido Rondon	PR	13847.13	18552	5085	3721.55	694.46	694.46	600.23	159.45
U354	Maringá	PR	119957.18	131071	119052	23496.12	24885.08	24885.08	1967.58	1773.54
U355	Palmas	PR	8614.44	13017	9890	1705.09	1338.05	1338.05	239.04	151.75
U356	Paranaguá	PR	43579.98	35929	31325	5335.28	4416.50	4416.50	653.77	579.55
U357	Paranavaí	PR	32821.62	35869	28718	5009.30	4207.96	4207.96	749.65	552.43
U358	Pato Branco	PR	29235.01	27856	21058	4623.03	3755.16	3755.16	669.09	409.12
U359	Pinhais	PR	25659.82	38168	31289	77158.44	5216.54	5216.54	617.68	482.54
U360	Piraquara	PR	21431.32	32175	28931	4625.91	3981.22	3981.22	567.38	441.93
U361	Ponta Grossa	PR	94227.57	116530	104300	16857.28	14821.55	14821.55	1465.40	1604.09
U362	Prudentópolis	PR	7142.82	9768	7978	1087.20	867.75	867.75	186.60	177.20
U363	Rolândia	PR	16875.87	24663	11839	3414.91	1735.58	1735.58	350.85	239.64

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U364	São José dos Pinhais	PR	69111.68	82705	56616	29495.85	10579.26	10579.26	1414.20	859.17
U365	Telêmaco Borba	PR	24513.52	25554	20710	3620.92	2934.28	2934.28	341.86	256.28
U366	Toledo	PR	38635.74	45132	34630	7249.67	5715.18	5715.18	810.83	731.48
U367	Umuarama	PR	39207.30	42292	35607	6248.01	5755.27	5755.27	503.78	561.02
U368	União da Vitória	PR	16427.92	17375	4727	4570.84	905.73	905.73	353.92	89.31
U369	Ararangué	SC	6570.96	16400	2160	3308.69	473.04	473.04	593.46	63.18
U370	Balneário Camboriú	SC	48188.15	30318	28121	21370.37	17424.32	17404.92	381.00	310.00
U371	Canoinhas	SC	12317.24	15227	2191	2721.82	259.75	259.75	377.93	51.17
U372	Chapecó	SC	50469.90	46503	12798	8443.29	5021.47	5021.47	687.13	242.21
U373	Concórdia	SC	22136.94	19233	1012	3044.48	39.54	39.54	309.37	3.81
U374	Criciúma	SC	65547.70	53448	7470	19826.33	2809.86	2809.86	1137.96	157.80
U375	Florianópolis	SC	201794.91	108634	43749	60396.81	14553.44	10390.32	1485.27	660.72
U376	Gaspar	SC	14081.18	17760	240	3759.97	44.18	44.18	418.81	1.90
U377	Içara	SC	14559.55	15570	3257	2206.33	135.91	135.91	215.63	48.11
U378	Indaial	SC	15924.60	18260	2647	3180.49	455.67	455.67	388.02	20.04
U379	Itajaí	SC	62357.11	55387	6559	23510.05	3173.27	3173.27	709.81	163.26
U380	Itapema	SC	25739.04	14911	6787	5399.00	3042.59	3042.59	291.17	175.90
U381	Jaraguá do Sul	SC	51442.19	42158	32539	8916.69	6355.52	6355.52	892.60	590.80
U382	Joinville	SC	146657.34	154098	41510	35597.00	9072.00	9072.00	2252.34	553.57
U383	Lages	SC	50978.27	50193	11812	9876.99	2043.01	1778.87	783.13	156.25
U384	Palhoça	SC	28242.92	50504	8737	11495.00	1324.03	1297.55	715.00	85.00
U385	São Bento do Sul	SC	17251.35	27175	6579	3983.00	933.98	933.98	606.00	155.00
U386	São José	SC	56683.94	52251	11469	14227.24	9134.09	9134.09	608.90	98.73
U387	Videira	SC	12748.33	14696	78	2495.04	10.10	10.10	276.12	1.43
U388	Alegrete	RS	24297.43	22559	3976	3031.77	600.20	938.50	281.11	70.82
U389	Alvorada	RS	61643.56	52084	14881	26385.01	1467.06	1310.70	599.95	250.20
U390	Bagé	RS	32027.71	40329	28019	4776.20	4040.89	1037.32	482.00	319.92
U391	Cachoeira do Sul	RS	26797.11	26716	8243	3615.11	1058.97	1459.96	250.94	168.02
U392	Cachoeirinha	RS	52529.11	37533	23034	17020.67	2627.49	7307.44	398.91	368.74
U393	Canoas	RS	145038.40	79269	20120	17342.67	4587.69	8827.08	844.88	752.48
U394	Capão da Canoa	RS	29497.24	18926	3583	6132.67	1500.95	2494.91	360.60	80.80
U395	Cruz Alta	RS	22036.39	20386	2886	2821.20	440.78	428.47	224.31	59.06
U396	Estância Velha	RS	11874.41	12131	418	2684.23	48.14	26.04	162.98	7.20

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U397	Esteio	RS	32267.81	20343	1327	17323.53	254.36	126.68	204.91	4.10
U398	Gravataí	RS	106399.34	63703	23507	9697.95	2716.50	1639.85	700.62	614.58
U399	Guaíba	RS	26795.95	28154	1806	6984.25	204.82	513.65	589.98	110.54
U400	Ijuí	RS	28287.14	23921	1799	4350.80	398.65	353.40	299.42	44.64
U401	Lajeado	RS	22457.78	19476	238	4520.17	30.77	33.00	344.62	6.46
U402	Novo Hamburgo	RS	53536.19	52763	2892	10508.74	791.11	791.11	896.42	73.07
U403	Passo Fundo	RS	66736.21	54876	10021	10588.28	2237.89	2868.65	798.91	317.22
U404	Porto Alegre	RS	398825.24	302579	252412	117241.29	74788.30	60373.99	4170.02	2022.88
U405	Santa Cruz do Sul	RS	50438.57	37457	5731	6258.85	829.93	446.90	598.01	161.72
U406	Santa Rosa	RS	27244.66	21470	5162	3751.18	949.46	442.12	253.31	98.25
U407	Santo Ângelo	RS	38830.88	23778	3762	3897.41	733.88	1593.10	435.17	68.34
U408	São Borja	RS	16003.80	16474	2639	2305.44	357.36	958.41	197.93	49.64
U409	São Gabriel	RS	11803.72	19361	2844	2672.21	507.94	507.94	209.00	27.00
U410	São Leopoldo	RS	80389.94	64741	5086	10999.42	1453.70	180.09	773.00	131.50
U411	Sapucaia do Sul	RS	41850.64	34895	246	6041.72	258.53	235.39	346.30	1.97
U412	Tramandaí	RS	23091.84	27060	3319	2985.50	586.25	676.06	398.83	54.91
U413	Naviraí	MS	13588.09	19076	6321	2761.01	764.26	764.26	234.62	96.47
U414	Alta Floresta	MT	6912.03	14916	6307	2337.00	915.00	915.00	221.48	117.51
U415	Barra do Garças	MT	11690.15	25798	14122	3903.36	2145.13	2145.13	403.21	190.00
U416	Cáceres	MT	12468.68	24043	2098	3355.35	208.29	208.29	282.42	39.50
U417	Cuiabá	MT	148424.23	164109	86396	35536.89	23891.35	18779.99	2623.00	1100.00
U418	Lucas do Rio Verde	MT	8293.76	23032	7063	5039.21	1346.20	1346.20	436.50	108.50
U419	Primavera do Leste	MT	11822.63	21529	15964	3471.86	2673.52	2673.52	348.21	320.18
U420	Rondonópolis	MT	55048.19	78588	69818	10860.13	9991.00	9781.00	1136.07	704.23
U421	Sinop	MT	20379.26	50911	12419	8233.26	1570.00	1570.00	952.56	225.61
U422	Sorriso	MT	8584.55	27696	8387	5709.11	1233.23	1233.23	462.89	311.28
U423	Tangará da Serra	MT	11398.06	30953	7248	4696.60	3974.00	3974.00	355.15	138.34
U424	Várzea Grande	MT	45786.44	74169	21471	15625.99	9460.00	6046.70	1250.45	187.67
U425	Águas Lindas de Goiás	GO	37988.46	70305	22380	7317.70	1954.58	1634.42	223.94	430.15
U426	Anápolis	GO	135405.64	141863	87866	16711.62	11123.20	11123.20	2044.43	730.77
U427	Aparecida de Goiânia	GO	112282.92	134878	80160	16186.30	9149.64	8548.94	2996.94	937.17
U428	Caldas Novas	GO	29841.61	40145	17034	7253.00	5165.00	5165.00	200.00	80.00
U429	Catalão	GO	20401.24	43100	27802	4814.26	3034.19	2414.86	502.32	360.69

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Table A.1 - Continuation

DMU	Municipality	State	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
U430	Cidade Ocidental	GO	20273.15	32365	10280	3003.06	1039.09	1039.09	294.74	52.55
U431	Cristalina	GO	10288.78	13396	5986	1712.15	755.84	755.84	143.63	80.45
U432	Formosa	GO	34652.35	38474	32717	4444.16	3836.93	3836.93	365.90	404.99
U433	Goianésia	GO	19051.39	21228	19899	2504.82	2524.55	2524.55	303.98	161.17
U434	Goiânia	GO	542814.82	565143	437939	97544.88	68784.88	58857.85	7650.59	4376.88
U435	Inhumas	GO	18852.76	19715	14027	2477.95	1876.67	1876.67	256.84	99.98
U436	Itumbiara	GO	36955.78	39177	39494	5639.41	6146.74	5690.46	594.37	266.44
U437	Jaraguá	GO	11393.43	16197	4441	1864.57	505.73	505.66	227.79	62.32
U438	Jataí	GO	38549.60	38093	30521	5302.62	4295.27	4295.27	558.78	503.80
U439	Luziânia	GO	36542.42	54623	12088	5924.51	1633.76	1633.76	881.03	100.81
U440	Novo Gama	GO	22293.89	29643	10273	3589.65	1245.04	1245.04	351.34	101.96
U441	Planaltina	GO	28816.81	36777	17885	3657.25	1656.02	1656.02	236.65	233.93
U442	Quirinópolis	GO	14655.71	16124	16763	1915.77	2245.62	2245.62	204.60	132.45
U443	Rio Verde	GO	64414.82	69442	45225	9852.05	6649.56	6649.56	728.50	458.42
U444	Santo Antônio do Descoberto	GO	14823.14	19883	11505	2222.10	1296.48	1296.48	204.70	62.80
U445	Senador Canedo	GO	20027.75	40267	1700	5874.27	650.10	162.52	787.57	22.90
U446	Trindade	GO	38426.35	48773	26215	5287.40	3003.50	3003.50	1331.29	335.72
U447	Valparaíso de Goiás	GO	40731.79	64081	21434	6841.33	2771.70	2771.70	345.31	108.76
U448	Brasília	DF	1427447.35	688562	591150	158200.00	129923.00	129923.00	9269.00	7286.00

A.2 Information and indicators used in Chapter 6

Table A.2: Data used in Chapter 6

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU001	North	2012	5969.80	3894.91	18976	425	1324.12	1324.12	10126	160
DMU002	North	2012	60758.97	9859	50116	820.08	3644.85	3644.85	18400	324.88
DMU003	North	2012	274470.98	102271	348580	3447.61	24886.41	24886.41	40820	470.13
DMU004	North	2012	60597.02	16421.6	74558	1310.6	8258.14	8258.14	34843	488.51
DMU005	North	2012	191654.75	53830.15	223081	2058	2417	1208	14763	381
DMU006	Northeast	2012	6728.30	8291.84	34969	650	42.26	42.26	289	49.17
DMU007	Northeast	2012	7809.82	10207.41	53997.00	543.22	9822.32	9822.22	15265.00	112.94
DMU008	Northeast	2012	104274.90	130041.14	199624	5887.49	39897.6	5234.69	92173	932
DMU009	Northeast	2012	174223.37	41557.57	234681	1515.24	6120.03	6120.03	32393	478.8
DMU010	Northeast	2012	2489.87	803.00	5947.00	86.79	84.00	84.00	736.00	21.08
DMU011	Northeast	2012	3345.83	953.00	7783.00	40.05	153.00	153.00	1512.00	23.81
DMU012	Northeast	2012	2889.73	669.00	4885.00	112.23	257.00	257.00	2181.00	36.23
DMU013	Northeast	2012	5284.18	1800.00	13597.00	95.48	49.00	49.00	389.00	9.29
DMU014	Northeast	2012	4425.46	1566.00	9918.00	52.72	149.00	149.00	1186.00	46.33
DMU015	Northeast	2012	1630.80	365.00	2986.00	43.30	118.00	118.00	1281.00	18.41
DMU016	Northeast	2012	2629.63	2235.1	14054.0	118.0	280.5	280.5	3746.0	81.2
DMU017	Northeast	2012	3432.74	1185.80	14945.00	109.30	371.28	371.28	2999.00	23.00
DMU018	Northeast	2012	3450.94	1285.00	10891.00	115.22	27.00	27.00	342.00	4.97
DMU019	Northeast	2012	15912.13	8999.00	67226.00	387.90	3074.00	3074.00	27312.00	247.04
DMU020	Northeast	2012	7590.89	2103.00	16912.00	151.75	655.00	655.00	6990.00	132.47
DMU021	Northeast	2012	4082.81	1732.00	10576.00	133.56	145.00	145.00	1141.00	34.80
DMU022	Northeast	2012	337841.43	115124.00	608101.00	4604.09	54771.00	54771.00	308818.00	2260.16
DMU023	Northeast	2012	5437.61	1565.00	14497.00	161.40	272.00	272.00	1559.00	3.62
DMU024	Northeast	2012	2827.93	3210.00	12433.00	129.00	1352.00	1352.00	4702.00	45.00
DMU025	Northeast	2012	5654.48	3890.92	26159.00	261.31	832.20	832.20	4003.00	31.00
DMU026	Northeast	2012	12080.52	3087.00	19995.00	214.60	1244.00	1244.00	8638.00	49.95
DMU027	Northeast	2012	28332.88	10764.00	76678.00	946.99	2254.00	2254.00	20195.00	149.22
DMU028	Northeast	2012	3801.01	3851.47	17278.00	130.00	873.81	873.81	3279.00	70.00
DMU029	Northeast	2012	12386.13	8578.00	61503.00	106.62	4590.00	4590.00	26783.00	191.47
DMU030	Northeast	2012	8381.62	3145.00	23896.00	235.40	116.00	116.00	1154.00	9.61
DMU031	Northeast	2012	3949.38	2319.00	15298.00	479.00	48.50	48.50	350.00	4.00
DMU032	Northeast	2012	4111.02	1488.00	13371.00	132.64	332.00	332.00	2.00	9.11
DMU033	Northeast	2012	4563.65	1590.00	14193.00	111.36	957.00	957.00	9949.00	18.90

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU034	Northeast	2012	9261.76	2209	16581	139.5	204	204	2877	15.78
DMU035	Northeast	2012	6942.46	1789	14618	129.64	467	467	3859	51.42
DMU036	Northeast	2012	19084.34	9554	55945	381.22	5494.2	5494.2	36991	280
DMU037	Northeast	2012	3781.42	1175	10059	70.23	81	81	1040	19.09
DMU038	Northeast	2012	9945.54	2048	17136	178.28	482	482	4958	70.27
DMU039	Northeast	2012	1052.41	325	2868	39.74	45	45	437	7
DMU040	Northeast	2012	8783.98	2410.91	18645	110.15	151.23	151.23	1479	10.23
DMU041	Northeast	2012	4059.34	2721.84	14834	170.98	720.86	598	4044	42.8
DMU042	Northeast	2012	5492.59	1252.18	10270	191.25	77.01	77.01	328	21.53
DMU043	Northeast	2012	39428.78	9848.12	64149	390.91	3709.08	3709.08	25757	208.67
DMU044	Northeast	2012	139388.05	35760.29	188309	1578.71	13195.4	9606.25	65329	519.04
DMU045	Northeast	2012	6360.94	3698.14	13683	73.72	663.86	663.86	482	5.48
DMU046	Northeast	2012	12054.27	3154.19	16748	123.81	731.23	731.23	2721	22.3
DMU047	Northeast	2012	84058.99	20689.57	111768	561.96	19071.79	19071.79	77030	302.2
DMU048	Northeast	2012	16323.91	2330.21	16536	114.32	1900.04	1900.04	8895	35.11
DMU049	Northeast	2012	187430.61	41684.86	177516	1004.1	27055.97	27055.97	77085	511.78
DMU050	Northeast	2012	26651.39	5442.07	30187	164.23	543.97	543.97	1508	11.12
DMU051	Northeast	2012	5011.38	924.4	9308	85.75	665.93	665.93	2704	17.19
DMU052	Northeast	2012	2016.09	2351.2	21335.0	191.8	466.8	466.8	6211.0	73.0
DMU053	Northeast	2012	11047.30	2102.56	17354	149.24	43.56	43.56	744	6.54
DMU054	Northeast	2012	59558.55	12013.33	42974	374.8	129.48	129.48	4540	38.96
DMU055	Northeast	2012	6857.12	4143.62	31900	305.81	71.38	71	549	5.61
DMU056	Northeast	2012	49295.06	12112.45	85730	745.87	5024.4	5024	36419	332.07
DMU057	Northeast	2012	14359.65	4716.28	36341	296.42	278.66	278.66	2843	26.19
DMU058	Northeast	2012	13568.83	3864.02	23242	288.52	67.28	67	349	5.96
DMU059	Northeast	2012	28619.77	2565.62	20812	213.23	53.43	53	449	5.2
DMU060	Northeast	2012	66842.68	15087.9	94549	1009.28	1361.91	1361	11410	161.7
DMU061	Northeast	2012	2110.91	1386.22	12879	121.21	257.78	257.78	3524	53.38
DMU062	Northeast	2012	28262.86	12300.6	84888	761.36	5341.9	5341	31749	435.21
DMU063	Northeast	2012	21670.04	9245.61	76047	666.83	3384.2	3248	31352	471.92
DMU064	Northeast	2012	21008.23	9849.65	62971	665.5	6667.72	6667.72	43374	455.75
DMU065	Northeast	2012	409558.22	59551.84	304216	3035.91	36564.2	35754	94696	1302.35
DMU066	Northeast	2012	4725.42	2469.74	18725	182.72	274.15	274	2581	23.36

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU067	Northeast	2012	14400.89	3404.59	29247	270.13	831.75	831.75	10064	86.91
DMU068	Northeast	2012	136648.74	25886.71	133159	1430	25524.29	25524.29	40325	316.4
DMU069	Northeast	2012	248938.58	36585	164863	2251	13386	13386	57048	687
DMU070	Northeast	2012	31484.96	4836	35710	482	1873	1873	12536	173
DMU071	Northeast	2012	17697.40	6670.22	40457	289.41	498.08	498.08	3669	30.75
DMU072	Northeast	2012	4142.77	2040	14691	145	313	313	5692	119
DMU073	Northeast	2012	7931.45	2307.4	17481	229.87	85.87	85.87	741	3.57
DMU074	Northeast	2012	47598.61	10412.67	61848	989.12	2239.36	1163.66	12037	32.02
DMU075	Northeast	2012	60342.97	3098.73	23492	291.25	759.36	759.36	6562	50.31
DMU076	Northeast	2012	11201.79	1970.61	14697	209.67	1137.24	1137.24	7005	49.28
DMU077	Northeast	2012	10068.90	3492.57	27153	278.2	226	226	2540	5.88
DMU078	Northeast	2012	78847.28	18803.67	141474	2005.41	11907	11907	75638	501.51
DMU079	Northeast	2012	28618.04	6194.83	39576	550.04	3774.31	3774.31	21676	137.01
DMU080	Northeast	2012	7138.80	1446.13	13136	129.79	39.84	39.84	495	2.78
DMU081	Northeast	2012	7665.38	2413.04	22498	338.24	285.86	285.86	3047	12.67
DMU082	Northeast	2012	8075.96	2136.26	18905	217.7	159.05	159.05	1521	7.34
DMU083	Northeast	2012	33989.21	18008.05	49053	419.64	13866	1932	32623	328
DMU084	Northeast	2012	4081.96	3619.2	21016.0	171.6	3100.0	514.7	19537.0	130.9
DMU085	Northeast	2012	27253.84	5728.37	45982	488.18	5040.66	5040.66	39431	264.76
DMU086	Northeast	2012	15185.66	8754	41809	375	3366	3166	28094	210
DMU087	Northeast	2012	30794.62	8778.39	42274	459.28	4187.64	4166.24	14619	135.19
DMU088	Northeast	2012	12807.31	4218.85	29105	261	267.64	267.64	1472	10.3
DMU089	Northeast	2012	21187.30	3454.54	24912	342.25	3992.58	3992.58	21127	147.8
DMU090	Northeast	2012	722552.56	135977.7	493551	4875.24	172660.58	171777.11	423081	3906.08
DMU091	Northeast	2012	12430.11	2147.34	15274	92.72	871.37	871.37	7210	54.64
DMU092	Northeast	2012	10780.12	3402.59	26968	176.92	248.92	248.92	2426	8.81
DMU093	Northeast	2012	10102.89	2435.71	20904	204.36	223.67	223.67	1944	7
DMU094	Northeast	2012	43054.02	4213.25	19666	211.34	1825.14	1815.79	5604	52.42
DMU095	Northeast	2012	11746.08	4669.01	34621	417.51	254.88	254.88	3622	6.72
DMU096	Northeast	2012	49150.95	10658.54	79957	817.15	6885.66	6885.66	44627	356.06
DMU097	Southeast	2012	23557.95	4421.9	27751	309.52	3394.3	2633.78	27083	243.54
DMU098	Southeast	2012	8029.79	11117	36700	387.75	8894	158	34889	396.65
DMU099	Southeast	2012	28162.84	5413.32	33053	232.97	4175.89	875.73	32542	316.8

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU100	Southeast	2012	16798.35	4464.94	31341	265.6	3320.56	322.06	26954	242.14
DMU101	Southeast	2012	790137.25	158532.21	566326	6719.04	119057.53	102219.64	546027	4026.39
DMU102	Southeast	2012	103581.37	20572.46	112289	1353.32	12813.86	11488.6	88692	637.89
DMU103	Southeast	2012	28359.94	5717.21	40665	438.67	3895.34	658.65	35484	354.05
DMU104	Southeast	2012	159587.05	33335	169562	1752.83	22525.88	19450.99	144462	1019.43
DMU105	Southeast	2012	12647.87	2429.8	17907	154.94	1937.23	1873.91	18303	131.05
DMU106	Southeast	2012	63332.52	10909.41	64807	678.07	9226.38	9226.38	67526	337.14
DMU107	Southeast	2012	17088.71	6414.91	28922	365.06	5131.93	1617.6	28250	228.8
DMU108	Southeast	2012	29624.31	5369.57	28946	433.21	3929.26	3344.82	27150	306.43
DMU109	Southeast	2012	17707.49	6761.26	34114	472.75	5398.2	4219.86	33373	463.64
DMU110	Southeast	2012	12385.51	2887.05	21710	379.27	387.58	387.58	3813	83.56
DMU111	Southeast	2012	106056.74	29575.57	121971	937.5	23660.45	2124.36	120058	681.56
DMU112	Southeast	2012	16762.43	3838.86	20141	353.44	1126.66	1126.66	7899	166.06
DMU113	Southeast	2012	28555.96	5009.57	32148	413.96	3743.65	3026.52	30664	292.52
DMU114	Southeast	2012	5891.54	4540	20408	204	3620	33	15250	203
DMU115	Southeast	2012	99031.10	14969.69	112380	946.46	11519.47	11519.47	110542	654.61
DMU116	Southeast	2012	10644.99	5683.24	31201	430.5	4830.75	1639.9	31034	444
DMU117	Southeast	2012	22701.60	5870.47	25785	269.17	599.76	599.76	2366	51.45
DMU118	Southeast	2012	18474.35	3437.96	24161	261.8	2343.84	2109.53	21233	244.29
DMU119	Southeast	2012	13082.82	7159.27	33465	443.57	5668.41	2692.77	33092	412.27
DMU120	Southeast	2012	9523.93	3360	24229	389	2688	2150	23930	344
DMU121	Southeast	2012	7870.10	4776.38	16930	268	746.5	672	5114	78
DMU122	Southeast	2012	29375.95	9903.77	50672	1055.35	8418.2	2104	50282	942.36
DMU123	Southeast	2012	35839.13	7079.9	42028	581.39	5456.89	2702.86	41755	471.74
DMU124	Southeast	2012	67001.01	12387.04	81981	832.82	7058.43	442.92	60830	385.11
DMU125	Southeast	2012	48212.88	8943.77	54308	670.51	5528.11	1121.2	42419	255.45
DMU126	Southeast	2012	6971.63	1399.41	10713	147.27	274	274	2437	87.61
DMU127	Southeast	2012	4837.48	434.69	3725	49.13	298.73	298.73	3399	42.87
DMU128	Southeast	2012	4645.69	2765.05	16404	204.04	2765.05	22.41	16322	191.62
DMU129	Southeast	2012	57241.09	21741.87	99608	1022.9	17393.49	12871.18	98988	959.37
DMU130	Southeast	2012	84603.61	51090.9	171030	2997	42086	42086	168237	2456
DMU131	Southeast	2012	8957.44	4118.25	19768	253	3464.68	2260.66	17109	148
DMU132	Southeast	2012	55889.49	6812.18	41854	434.74	5254.81	4391.78	41831	395.9

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU133	Southeast	2012	27731.37	4190.5	28578	379.17	2558.04	2558.04	22165	134.6
DMU134	Southeast	2012	8146.50	4922.99	18816	265	4147.62	39.02	15963	209
DMU135	Southeast	2012	11336.38	4064	24079	347.83	3081.1	400.53	17587	227.26
DMU136	Southeast	2012	47946.57	10158.95	51722	570.86	7514.17	7196.18	47151	446.18
DMU137	Southeast	2012	76523.86	19795.49	86084	1040.78	4148.24	4148.24	19398	328
DMU138	Southeast	2012	11514.42	6619	24295	338	5030	276	21225	208
DMU139	Southeast	2012	20823.16	7766.45	28561	474.02	3433.44	3433.44	6606	114.48
DMU140	Southeast	2012	10680.74	7274.05	31452	444	5222.82	4232.37	20234	234.13
DMU141	Southeast	2012	9725.69	4035	30453	317.62	2009.47	21.49	17592	172.83
DMU142	Southeast	2012	121634.81	41295.75	105287	1387.36	8496.75	8094.04	43055	612.71
DMU143	Southeast	2012	14949.53	3409.47	14801	193.49	968.12	968.12	5285	36.31
DMU144	Southeast	2012	69643.50	27862.55	90209	1116.99	10991.38	10991.38	14507	352.8
DMU145	Southeast	2012	76246.67	30723	56369	561.19	14031.27	14031.27	20438	363.5
DMU146	Southeast	2012	27755.94	15621.92	42626	468.29	3995	2866	15921	157.35
DMU147	Southeast	2012	27211.24	8394.39	40496	610	8199	300	34751	303.74
DMU148	Southeast	2012	79047.10	30460	82672	553	12054	7280	41827	418
DMU149	Southeast	2012	35489.51	7332.65	44824	515.49	10975.39	10975.39	44824	37.66
DMU150	Southeast	2012	80806.77	19165.17	86736	1232.86	10011.52	7518.15	41405	568
DMU151	Southeast	2012	127830.60	60797	151085	1265	21667	6381	74687	675
DMU152	Southeast	2012	11113.09	4225	22036	87	703	480	4770	23
DMU153	Southeast	2012	235116.80	40018.8	86667	1282.1	40018	40018	55910	690.5
DMU154	Southeast	2012	45880.94	8811.3	35602	727.2	7583.34	4417.72	33625	440.6
DMU155	Southeast	2012	56651.23	8899	48034	645	8416	8416	40903	255
DMU156	Southeast	2012	28896.95	8422	31746	462.6	5760	3460	31211	361
DMU157	Southeast	2012	41368.24	6460	34117	109	1853.82	1853.82	10624	230
DMU158	Southeast	2012	1895974.29	660085	918132	10112	414798.2	330157.72	723946	5394
DMU159	Southeast	2012	201022.45	134529	177555	1544	44142	7776	77195	707
DMU160	Southeast	2012	16518.62	3612.38	28507	411.9	3581	3581	28507	52.99
DMU161	Southeast	2012	15676.74	6062.48	21418	221.1	5153.11	1929.11	13740	182.1
DMU162	Southeast	2012	38856.44	21219.78	73927	875.77	16975.92	4867	66779	713.37
DMU163	Southeast	2012	50410.12	20893.98	75483	1178	10820.07	9207.11	80852	1320
DMU164	Southeast	2012	10199.88	3478	21815	326.4	2956.3	426	18588	228.96
DMU165	Southeast	2012	7577.55	3566.27	20231	227.32	3155.86	2138.33	18205	192.11

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU166	Southeast	2012	39991.57	14755.95	68042	603.03	13550.46	13550.46	73509	597.06
DMU167	Southeast	2012	55015.10	19054.49	85694	1294.28	16042.74	16042.74	85985	1084.61
DMU168	Southeast	2012	23522.93	4619.33	23627	330.18	1649.4	1599.91	12345	154.12
DMU169	Southeast	2012	26927.30	6007.61	35209	391.84	4777.49	4777.48	34931	352.94
DMU170	Southeast	2012	25428.56	6265.69	36508	381	3441.37	2584.12	23250	198
DMU171	Southeast	2012	20980.21	4621.68	29929	375.04	3690.12	3690.11	28494	344.39
DMU172	Southeast	2012	20358.10	8989.69	41559	543	8989.69	8989.69	41216	541
DMU173	Southeast	2012	83953.73	18096.89	68012	682	9532.18	2859.65	45417	358.41
DMU174	Southeast	2012	8797.03	5787.2	27002.0	521.2	5787.2	1909.8	27002.0	477.9
DMU175	Southeast	2012	23485.61	3949.41	22333	267.52	1149.76	1149.75	8009	129.37
DMU176	Southeast	2012	12896.09	2932.66	15611	150.46	1857.55	1504.61	12978	68.39
DMU177	Southeast	2012	40434.52	8415.1	48748	546.41	6145.11	6145.1	45420	396.7
DMU178	South	2012	11599.81	4137.44	27518	453.51	861.2	861.2	7548	175.51
DMU179	South	2012	20898.58	6282.45	39733	492.23	2781.43	2781.43	18189	368.08
DMU180	South	2012	15804.12	5379.08	36137	530.74	2554.21	2554.21	16872	286.65
DMU181	South	2012	17147.23	6659.97	34465	590.53	2089.57	2043.85	12529	214.92
DMU182	South	2012	11757.64	5417.19	32709	269.35	3858.7	3858.7	25944	392.67
DMU183	South	2012	13250.39	4593.76	31593	580.12	1981.62	1981.62	12821	292.21
DMU184	South	2012	13087.97	4685.45	29422	377.05	3365.55	3365.55	20389	364.75
DMU185	South	2012	44341.17	13860	82366	1162.63	10085.09	10085.09	52948	877.98
DMU186	South	2012	6096.04	2209.15	16470	243.69	1642.79	1642.79	11839	198.94
DMU187	South	2012	13723.79	3809.37	22229	529.01	2553.39	2553.39	13478	232.98
DMU188	South	2012	22095.56	9351.21	60042	869.48	3644.34	3644.34	27114	421.39
DMU189	South	2012	338201.00	108047.38	455354	7082.24	96187.56	95359.99	392481	5602.81
DMU190	South	2012	11599.57	3668.73	28084	418.06	1413.96	1413.96	11063	205.26
DMU191	South	2012	43453.76	15377.59	75983	1082.24	11449.78	11449.78	48643	860.24
DMU192	South	2012	11146.53	3576.95	21588	348.68	2525.75	2525.75	13054	247.42
DMU193	South	2012	25080.41	7195.83	47088	804.05	4686.54	4686.54	29436	537.97
DMU194	South	2012	7027.91	2744.13	17927	324.15	2408.38	2408.38	15905	228.06
DMU195	South	2012	7641.23	1957.03	15430	357.1	1640.39	1640.39	12926	265.11
DMU196	South	2012	116179.51	33901.84	150967	1797.36	28553.54	28553.54	121395	1626.23
DMU197	South	2012	7000.12	3502.18	15194	463.8	37.6	37.6	328	16.31
DMU198	South	2012	67570.70	22274.7	116411	1741.93	20664.87	20664.87	93638	1590.36

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU199	South	2012	4178.42	1486.06	10908	153.81	932.13	932.13	6782	121.9
DMU200	South	2012	59862.00	5601.12	34894	553.18	4335.4	1398.59	15372	383.19
DMU201	South	2012	14043.06	4622.94	29025	582.67	3740.68	3740.68	23062	431.96
DMU202	South	2012	12684.60	3831.36	21857	436.9	2989.29	2989.29	15627	313.25
DMU203	South	2012	14455.89	6053.25	34832	457.49	4359.7	4359.7	26573	357.37
DMU204	South	2012	12187.74	3824.23	26084	569.75	2752.38	2752.38	18591	384.94
DMU205	South	2012	51973.20	15547.21	96775	1316.5	12433.05	12433.05	80940	1332.53
DMU206	South	2012	3056.99	957.62	8291	151.87	695.09	695.09	5884	150.54
DMU207	South	2012	7848.60	3073.38	19505	268.39	1159.04	1159.04	9078	139.2
DMU208	South	2012	45603.25	13065.98	72041	1185.48	7301.04	6441.35	41296	663.29
DMU209	South	2012	10734.65	3230.17	21894	232.72	2220.78	2220.78	14932	202.43
DMU210	South	2012	17252.52	5820.57	36239	546.57	4264.17	4264.17	26029	523.52
DMU211	South	2012	18653.40	5720.37	33250	448.79	4667.48	4667.48	24783	456.32
DMU212	South	2012	7005.76	2282.94	15390	283.46	654.76	637.43	3432	86.64
DMU213	South	2012	22222.61	16897.8	18310	300	11926.32	11926.32	13732	300
DMU214	South	2012	45542.67	18187.3	82097	1531.83	1148	996.9	4702	193
DMU215	South	2012	34164.77	6751.16	41348	656.9	2342.07	2342.07	10322	214.59
DMU216	South	2012	11739.60	2483.05	16475	229.82	124.23	124.23	959	3.5
DMU217	South	2012	152955.44	42353.11	90530	1402.44	12070.66	12070.66	30703	557.75
DMU218	South	2012	21243.34	3672.29	12871	220.23	1707.84	1707.84	4179	62.64
DMU219	South	2012	23580.71	7682	36746	680	2791	2791	18050	362
DMU220	South	2012	108093.06	31111.69	134709	2017.49	2364.01	2364.01	14319	229.17
DMU221	South	2012	21419.48	9161.73	45114	761.14	1155.63	1142.63	8003	113.1
DMU222	South	2012	25953.85	7561.2	39417	700	455.5	455.5	2830	39.3
DMU223	South	2012	20529.46	2907.88	23710	570.26	495.34	495.34	4450	107.85
DMU224	South	2012	41726.45	11617.27	45918	321.24	3089.07	3089.07	7266	134.4
DMU225	South	2012	22134.18	2879.41	19992	162.06	2303.53	692.18	3141	24.49
DMU226	South	2012	62882.64	24764.81	48393	721.35	2193.3	877.32	10431	87
DMU227	South	2012	23984.10	8707.59	38653	472.44	3305.13	968.79	20619	294.41
DMU228	South	2012	28758.06	3572.72	24623	372.88	2858.18	1336.17	6890	81.36
DMU229	South	2012	45295.11	17491.63	30137	301.87	3478.79	3478.79	14327	176.33
DMU230	South	2012	5804.27	755.66	6873	67.65	980	362	8930	56
DMU231	South	2012	85237.51	16573.29	74308	793.5	4015	2279.67	12172	135.84

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU232	South	2012	22420.70	3716.17	13276	215.36	1639.04	1416.5	2474	39.18
DMU233	South	2012	89794.30	23376.04	120053	1478	15328.55	6496.42	100166	1533.31
DMU234	South	2012	15346.11	2657.88	19088	224.56	749	747.07	2536	33
DMU235	South	2012	8606.55	1633.4	10038	145.99	61	60.86	424	7.2
DMU236	South	2012	38026.43	24747.63	19363	174.04	231	231	63	1.28
DMU237	South	2012	67005.22	9092.37	54639	698.81	4292	4292	15589	244.8
DMU238	South	2012	37379.71	10780.48	51929	803	243.51	243.51	758	24
DMU239	South	2012	70277.80	9202.32	48266	688.85	7361.86	2823.78	4302	33.61
DMU240	South	2012	57815.72	16436.48	83023	923	7626.53	3050.61	40862	406.27
DMU241	South	2012	306361.75	118224.59	280811	3929.24	75140.88	18678.85	217514	1809.98
DMU242	South	2012	63853.91	12138.94	55633	637.96	3819	3819	11437	110
DMU243	South	2012	29918.64	5536.17	31944	446.71	1161.69	1161.69	1809	50.71
DMU244	South	2012	66062.72	15119.48	59747	820.6	12095.58	8378.38	21098	240.34
DMU245	South	2012	11888.53	7466.31	22402	275.5	1655	1655	8599	97.24
DMU246	South	2012	40131.32	3241.8	18703	263.48	661	661	2259	41.57
DMU247	South	2012	16599.00	2205.55	15114	192.83	469	469	2250	49.64
DMU248	South	2012	55799.33	12760.95	58245	736.13	5112.37	5112.37	4098	99
DMU249	South	2012	25643.07	6178.62	31787	253.62	410.81	410.81	158	1.97
DMU250	South	2012	17363.76	2706	21857	250.25	811	811	3104	46.7
DMU251	Center-West	2012	181800.78	47055.76	237390	3551	22853.24	22853.24	118808	1601.24
DMU252	Center-West	2012	38242.18	9727	56165	826.88	3238.99	3238.99	19887	294.92
DMU253	Center-West	2012	7255.83	2508.49	15403	211.65	354.02	354.02	2252	43.89
DMU254	Center-West	2012	7137.15	2250.53	13532	182.33	172.99	172.99	1286	32.73
DMU255	Center-West	2012	11133.18	3010.31	18256	304.17	576.66	576.66	3811	114.15
DMU256	Center-West	2012	17375.22	6786.72	37841	456.92	1801.12	1801.12	11767	89.13
DMU257	Center-West	2012	6695.20	1583.92	11102	190.5	741.29	741.29	3341	75.89
DMU258	Center-West	2012	4731.97	2555.13	15993	231	528.7	528.7	4626	72
DMU259	Center-West	2012	6782.86	2031.95	13511	276.49	390.53	390.53	4891	136.92
DMU260	Center-West	2012	18437.82	12651.66	60735	57.14	5007.85	4139.19	17975	56.97
DMU261	Center-West	2012	5383.41	4764	24794	415	1197	1197	6649	81
DMU262	Center-West	2012	24167.34	11578.1	68651	1123.71	2411.25	2411.25	14286	120.36
DMU263	Center-West	2012	78677.18	15675.44	107593	1374.53	8766.02	8766.02	53934	658.22
DMU264	Center-West	2012	56605.95	13989.79	92156	1288.98	4364.52	3083.54	26501	449.63

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU265	Center-West	2012	10385.77	5024.23	34072	378.14	3627	3627	17802	230
DMU266	Center-West	2012	10011.56	2466.27	19698	275.26	1112.15	1112.15	8276	51.57
DMU267	Center-West	2012	5364.65	1473.54	10274	125.79	492.26	492.26	3299	80.45
DMU268	Center-West	2012	18941.37	4142.13	30353	348.94	1911.89	1911.89	12863	235.26
DMU269	Center-West	2012	12179.24	2205.46	16283	227.14	1575.97	1575.97	11488	161.18
DMU270	Center-West	2012	487925.30	96707.57	436354	5854.14	64960.54	50526.31	309873	3504.24
DMU271	Center-West	2012	10553.16	2186.14	15399	233.36	1057.71	1057.71	7668	90.86
DMU272	Center-West	2012	23079.43	5283.79	29513	494.23	4450.09	4418.94	24492	266.42
DMU273	Center-West	2012	8002.03	1863.54	13228	116.57	257.22	257.06	1863	62.32
DMU274	Center-West	2012	18743.24	4629.25	29494	417.58	2949.65	2824.59	17742	152.58
DMU275	Center-West	2012	33460.30	5126.43	35939	713.92	1091.5	1091.5	6046	100.77
DMU276	Center-West	2012	14029.58	3860.82	23501	250.46	864.82	864.82	5383	28.04
DMU277	Center-West	2012	12002.23	3370.69	25118	220.05	850.59	850.59	6240	69.04
DMU278	Center-West	2012	8464.93	1909.66	12828	201.75	1976.86	1976.86	12574	128.39
DMU279	Center-West	2012	30921.48	8751.8	53855	604.58	4648.98	4648.98	25698	252.1
DMU280	Center-West	2012	6639.01	2095.67	13598	187.39	716.97	716.97	5046	61.87
DMU281	Center-West	2012	17674.92	4307.66	31319	351.72	1870.94	1870.94	13080	219.64
DMU282	Center-West	2012	18106.40	5048.01	36535	287.5	1827.17	1827.17	11552	99.22
DMU283	Center-West	2012	1190629.05	179577	599810	8897.77	118808.52	118808.52	481051	5176.21
DMU001	North	2013	8462.70	3973.89	19637	428	1350.75	1350.75	10268	170
DMU002	North	2013	35802.61	10766.74	46139	1074.72	3728.55	3728.55	18893	438.97
DMU003	North	2013	271923.39	104043	360249	3546.11	25784.04	25784.04	43075	478.16
DMU004	North	2013	70104.40	15600.31	77567	1379.42	8904.02	8904.02	33398	579.57
DMU005	North	2013	189266.62	54414	224303	2112.37	2824	1018	18900	381
DMU006	Northeast	2013	6670.08	3388.46	35773	130	44.4	44.4	1289	49.17
DMU007	Northeast	2013	11561.72	10731.04	56315.00	843.22	8932.21	8932.21	15978.00	112.94
DMU008	Northeast	2013	101923.80	45369.91	201350	5897.49	48982.36	3848	118320	935.65
DMU009	Northeast	2013	206144.66	43224.81	241618	1529.01	6310.33	6310.33	33959	477.13
DMU010	Northeast	2013	2437.48	884.25	6396.00	107.00	105.00	105.00	736.00	21.00
DMU011	Northeast	2013	3092.13	868.77	7998.00	40.00	145.00	145.00	1512.00	24.00
DMU012	Northeast	2013	3357.33	788.63	5511.00	116.00	268.00	268.00	2181.00	37.00
DMU013	Northeast	2013	6382.34	2097.18	14287.00	102.00	209.00	209.00	389.00	57.00
DMU014	Northeast	2013	4285.29	1559.12	10415.00	53.00	154.00	154.00	1186.00	46.00

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU015	Northeast	2013	1719.29	375.46	3257.00	43.00	115.00	115.00	1281.00	18.00
DMU016	Northeast	2013	2151.52	3285.0	14606.0	120.9	985.0	292.9	3963.0	82.3
DMU017	Northeast	2013	3360.94	2172.20	15602.00	109.30	337.70	337.70	3745.00	23.00
DMU018	Northeast	2013	3796.50	1375.50	11519.00	115.00	27.00	27.00	342.00	5.00
DMU019	Northeast	2013	31548.96	10024.98	74004.00	574.00	3325.00	3325.00	27567.00	455.00
DMU020	Northeast	2013	9147.16	1960.85	17231.00	136.00	630.00	630.00	6990.00	132.00
DMU021	Northeast	2013	4792.76	2192.07	11941.00	183.00	157.00	157.00	1219.00	51.00
DMU022	Northeast	2013	325369.61	115039.59	632789.00	3931.00	56894.00	56894.00	309454.00	1986.00
DMU023	Northeast	2013	5789.12	1909.77	16004.00	163.00	345.00	345.00	1559.00	4.00
DMU024	Northeast	2013	2785.89	3290.00	13017.00	135.00	1420.00	1380.00	4819.00	48.00
DMU025	Northeast	2013	6235.99	3890.92	26884.00	313.57	876.65	876.65	4111.00	31.00
DMU026	Northeast	2013	10817.42	2973.73	20928.00	215.00	1271.00	1271.00	8638.00	50.00
DMU027	Northeast	2013	31539.48	10835.90	79148.00	962.00	2288.00	2288.00	20195.00	149.00
DMU028	Northeast	2013	3489.64	4011.94	18187.00	138.00	882.54	882.54	3540.00	70.00
DMU029	Northeast	2013	34384.37	8997.54	65591.00	523.00	4775.00	4775.00	26779.00	369.00
DMU030	Northeast	2013	9506.19	3115.56	24237.00	235.00	115.00	115.00	1154.00	10.00
DMU031	Northeast	2013	3001.38	2235.00	15899.00	489.00	49.00	49.00	338.00	4.00
DMU032	Northeast	2013	4775.00	1674.94	14691.00	137.00	361.00	361.00	2.00	12.00
DMU033	Northeast	2013	7320.97	1652.98	19006.00	192.00	985.00	985.00	9940.00	92.00
DMU034	Northeast	2013	9750.86	2261.66	17090	140	287	287	2877	16
DMU035	Northeast	2013	7647.93	1920.85	15143	130	466	466	3859	51
DMU036	Northeast	2013	19720.78	10230.82	57931	489	3680.3	3680.3	39063	340
DMU037	Northeast	2013	4077.37	1058.8	10371	74	81	81	1040	19
DMU038	Northeast	2013	10158.51	2108.53	17994	178	477	477	4958	70
DMU039	Northeast	2013	1350.20	365.83	3068	40	44	44	437	7
DMU040	Northeast	2013	8768.80	2465.36	19060	110.16	166.53	166.53	1580	10.37
DMU041	Northeast	2013	4301.15	3162.11	16685	174.4	450.68	449.8	4098	42.8
DMU042	Northeast	2013	4684.00	1374.12	10640	191.25	46.23	46.23	333	21.53
DMU043	Northeast	2013	38831.74	10368.37	66894	390.91	3949.74	3949.74	26600	211.22
DMU044	Northeast	2013	131103.09	37628.24	196424	1578.71	14128.95	10285.88	67281	541.61
DMU045	Northeast	2013	5993.19	4362.27	14234	74.53	611.27	611.27	492	5.48
DMU046	Northeast	2013	10497.67	3028.73	17426	142.7	667.56	667.56	2706	22.92
DMU047	Northeast	2013	78870.27	21306.71	115933	578.97	17213.13	17213.13	79594	314.91

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU048	Northeast	2013	10498.21	2325.45	16848	123.31	1805.28	1805.28	9012	35.11
DMU049	Northeast	2013	229852.66	40706.03	185689	1006.94	24064.17	24064.17	78717	512.01
DMU050	Northeast	2013	22219.20	5132.43	31375	190.67	463.56	463.56	1559	11.12
DMU051	Northeast	2013	5179.62	924.4	9423	87.7	672.57	672.57	2644	17.27
DMU052	Northeast	2013	2167.53	2496.8	21441.0	191.9	546.9	546.9	6246.0	73.9
DMU053	Northeast	2013	8387.86	1869.31	18016	149.35	55.32	55.32	893	7.28
DMU054	Northeast	2013	27029.12	17102.12	42974	377.1	235.58	235.58	5488	42.59
DMU055	Northeast	2013	7061.77	3871.8	32130	307.09	67.38	67.38	683	6.68
DMU056	Northeast	2013	40447.57	12292.72	85730	784.15	5284.81	5284.81	39384	346.5
DMU057	Northeast	2013	12240.25	4943.51	37376	308.75	426.93	426.93	2939	29.34
DMU058	Northeast	2013	9881.04	3789.45	24727	288.52	59.82	59.82	349	6.02
DMU059	Northeast	2013	14270.64	2644.77	21015	220.88	49.55	49.55	449	5.28
DMU060	Northeast	2013	40378.85	13967.18	94824	1011.82	1239.12	1239.12	12367	176.44
DMU061	Northeast	2013	2184.17	1270.03	13555	132.56	221.04	221.04	4091	62.37
DMU062	Northeast	2013	26307.75	12022.93	87528	761.47	5485.73	5485.73	32290	447.48
DMU063	Northeast	2013	18386.43	8924.48	77881	682.83	3746.45	3746.45	33018	472.85
DMU064	Northeast	2013	22274.66	10408.05	65747	668.64	7101.09	7101.09	46136	477.68
DMU065	Northeast	2013	481088.88	57637.42	306103	3051.15	36293.9	35629	96219	1318.28
DMU066	Northeast	2013	6230.22	2268.89	19307	192.94	301.17	301.17	2582	23.62
DMU067	Northeast	2013	12533.01	3452.7	29249	276.85	811.03	811.03	10963	93.1
DMU068	Northeast	2013	154007.39	28256.42	134839	1444	11540.5	11540.5	40656	318.4
DMU069	Northeast	2013	247641.57	38283	174192	2277.25	13621.5	13621.5	61418	687.7
DMU070	Northeast	2013	31472.56	4836	36906	482.92	1963.82	1963.82	13085	173.09
DMU071	Northeast	2013	22256.06	6802.66	43384	297.37	682.17	682.17	5083	33.46
DMU072	Northeast	2013	4391.60	2438	15629	156	357	357	6750	125
DMU073	Northeast	2013	8403.19	2415.73	18269	290.25	86.72	86.72	769	3.57
DMU074	Northeast	2013	60989.67	10672.08	63939	995.46	2600.67	1463.43	12739	39.4
DMU075	Northeast	2013	27873.12	3702.88	23832	164.21	857.29	857.29	7361	50.31
DMU076	Northeast	2013	14441.89	1910.83	15298	209.41	1239.11	1239.11	7847	49.28
DMU077	Northeast	2013	11438.59	3487.76	28363	301.77	251.84	251.84	2595	10.8
DMU078	Northeast	2013	100851.60	17586.98	148857	2078.41	13167.78	13167.78	84858	515.68
DMU079	Northeast	2013	35581.62	6220.87	41723	550.04	3922.53	3922.53	23587	137.02
DMU080	Northeast	2013	7140.27	1467.52	14022	131.64	26.64	26.64	1000	2.78

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU081	Northeast	2013	12965.25	2884.8	23398	404.26	292.46	292.46	3296	12.67
DMU082	Northeast	2013	8711.54	2338.11	19507	234.76	170.56	170.56	1514	7.34
DMU083	Northeast	2013	30174.06	18331.46	49677	428.1	14533.65	2180.05	34369	331.5
DMU084	Northeast	2013	4240.50	3514.3	21186.0	175.5	3092.3	511.6	19751.0	132.1
DMU085	Northeast	2013	31869.69	5623.98	47674	975.57	6544.45	5292.36	41927	379.47
DMU086	Northeast	2013	18989.48	8754	42562	387	3475	3268	28705	213
DMU087	Northeast	2013	45554.28	9501.48	42128	399.66	8689.93	8689.93	14928	510.61
DMU088	Northeast	2013	15987.00	4848.95	30409	268.96	276.5	274.69	1689	10.3
DMU089	Northeast	2013	25157.13	3449.06	26665	352.69	3449.06	3449.06	23048	147.8
DMU090	Northeast	2013	833402.85	138893.25	502455	5243	128246.87	128246.87	446867	3623.9
DMU091	Northeast	2013	15261.53	1666.14	16029	152.63	868.59	868.59	7402	54.64
DMU092	Northeast	2013	12772.68	3591.18	28813	224.52	304.58	304.58	3161	11.81
DMU093	Northeast	2013	15110.47	4952.03	21726	206.73	250.61	250.61	2415	6.1
DMU094	Northeast	2013	23945.26	4007.35	19063	166.68	3022.41	3022.41	5795	83.12
DMU095	Northeast	2013	15421.25	4813.44	35679	427.78	520.69	520.69	4097	14.72
DMU096	Northeast	2013	53136.91	10602.37	84657	901.24	7054.66	7054.66	52321	356.06
DMU097	Southeast	2013	22590.66	4429.71	28454	311.05	3413.12	3291.84	27858	243.99
DMU098	Southeast	2013	7845.74	11812	37937	393.13	9450	160	36360	408.91
DMU099	Southeast	2013	25925.34	5425.37	34525	234.77	4182.19	3287.41	34023	316.99
DMU100	Southeast	2013	17084.18	6211.76	32238	267.23	3407.35	322.06	27880	245.27
DMU101	Southeast	2013	740818.19	159363.07	578160	6744.89	120242.67	107399.7	561095	4071.37
DMU102	Southeast	2013	100077.02	20724.8	116169	1400.88	13099.66	11955.63	93879	731.38
DMU103	Southeast	2013	26529.58	5869.22	42134	440.2	3993.39	1671.84	36788	354.86
DMU104	Southeast	2013	154579.58	34346.46	174793	1769.7	23454.13	20408.81	151160	1053.21
DMU105	Southeast	2013	11692.10	2498.66	18896	160.81	2001.98	2001.98	19307	137.08
DMU106	Southeast	2013	59367.54	10861.52	66213	685.46	9192.61	9192.61	68887	338.21
DMU107	Southeast	2013	15732.24	6689	31232	370.68	5369.26	2358.79	30287	229.62
DMU108	Southeast	2013	28199.56	5344.82	29582	561.23	3924.13	3888	27895	314.93
DMU109	Southeast	2013	19210.66	6928.63	35247	479.05	5522.28	4516.78	34698	464.91
DMU110	Southeast	2013	11477.77	2871.94	22365	385.92	439.94	439.94	4810	87.31
DMU111	Southeast	2013	110676.16	29752.9	125808	948.49	23802.32	2156.81	123808	685.61
DMU112	Southeast	2013	17545.78	3999.57	21110	358.43	1219.04	1219.04	8517	173.68
DMU113	Southeast	2013	26587.86	5102.62	33300	422.49	3820.53	3820.53	31894	313.11

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU114	Southeast	2013	6340.36	4238	19215	210	4048.38	18	14503	215
DMU115	Southeast	2013	92562.04	15467.66	117729	1577.88	12020.3	11609.52	116438	1124.81
DMU116	Southeast	2013	11162.35	5782.1	32078	434.18	4914.79	1639.9	31895	449.07
DMU117	Southeast	2013	21966.67	6160.32	26802	397.18	761.89	761.89	2540	51.45
DMU118	Southeast	2013	17656.88	3534.92	25212	268.91	2431.01	2387.75	22428	246.81
DMU119	Southeast	2013	11967.84	7152.25	34176	455.21	5685.83	2930.19	33940	422.52
DMU120	Southeast	2013	10092.89	3550	25414	393	2840	2754	25121	347
DMU121	Southeast	2013	8320.10	4891.46	17134	268.5	796	796	5676	78
DMU122	Southeast	2013	30994.54	10236.44	51753	1067.68	8700.98	2044.29	51348	961.86
DMU123	Southeast	2013	34754.09	7103.98	43157	581.39	5506.11	4682.19	43130	485.29
DMU124	Southeast	2013	69256.54	12932.83	86986	839.98	7553.48	655.26	66221	509.55
DMU125	Southeast	2013	44523.76	9167.76	55920	725.89	5666.01	2920.41	43355	256.63
DMU126	Southeast	2013	6502.19	1462.03	11085	150.24	338.57	328.54	3838	87.99
DMU127	Southeast	2013	4020.40	463.33	3995	49.04	327.58	327.58	3672	43.1
DMU128	Southeast	2013	4431.74	2982.05	16743	207.72	2946.74	22.68	16650	191.62
DMU129	Southeast	2013	60061.84	22059.66	100871	1125.2	17647.72	13059.31	100350	1055.3
DMU130	Southeast	2013	83353.74	54211.98	175331	3019	50354.99	50354.99	172265	2469
DMU131	Southeast	2013	10083.84	4317.06	20309	268	3757.01	2550.17	17896	170.2
DMU132	Southeast	2013	39216.79	6877.78	43273	439.49	5322.15	5135.01	43235	399.38
DMU133	Southeast	2013	27980.09	4352.88	29765	397.14	2630.54	2630.54	23032	138.6
DMU134	Southeast	2013	7960.75	4537.75	19201	266	3259.77	32.6	16406	209.32
DMU135	Southeast	2013	11744.05	4388.03	24873	354.16	3347.76	432.97	18578	229.73
DMU136	Southeast	2013	55020.77	10265.9	52931	589.86	7621	7302	48411	464.1
DMU137	Southeast	2013	78916.88	19666.13	87352	1058.02	3130.95	3130.95	22395	329.68
DMU138	Southeast	2013	12355.13	7009	25586	338	5641	316	22719	208
DMU139	Southeast	2013	21662.58	8040	29383	474.02	3418.41	3418.41	8138	115.26
DMU140	Southeast	2013	11519.44	7810.71	32214	448	5679.02	4486.43	21422	241.56
DMU141	Southeast	2013	9697.44	3283	32565	321.22	3448	21.49	18700	176.63
DMU142	Southeast	2013	117812.83	43143.89	106097	1367.78	8534.97	8534.97	45156	592.09
DMU143	Southeast	2013	12264.80	3507.1	15101	196.87	887.24	887.24	5745	36.6
DMU144	Southeast	2013	71733.34	28893.87	91891	1135.22	12124.78	12124.78	20915	358.26
DMU145	Southeast	2013	78727.14	30332.32	56897	572.94	17618.81	17618.81	22256	365.61
DMU146	Southeast	2013	27854.98	17051.2	43255	471.7	3995	3129.9	5782	160.31

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU147	Southeast	2013	36232.14	8424.96	42200	610	8362.17	300	36121	303.74
DMU148	Southeast	2013	64854.85	30717	82911	553	12107	10447	42012	418
DMU149	Southeast	2013	44629.44	8003	55426	807	10591	10591	55426	38
DMU150	Southeast	2013	88453.60	19922.67	88793	1252.6	10356.2	10356.2	48118	692
DMU151	Southeast	2013	108856.09	61065	151369	1265	21710	4381	74819	675
DMU152	Southeast	2013	11875.98	4247	22036	88	704	481	4784	23
DMU153	Southeast	2013	250839.73	40939	87540	1293.7	40927.7	40927.7	56705	710.6
DMU154	Southeast	2013	47930.97	8857	36997	734	7677	4990	34585	452.23
DMU155	Southeast	2013	63969.15	10067	51423	667	11902	9521	42199	260
DMU156	Southeast	2013	31324.44	8780	33020	463	6118	3671	31508	362
DMU157	Southeast	2013	41767.76	6493	34117	110	2454.92	2454.92	15304	230
DMU158	Southeast	2013	2002081.90	704077	992693	10210.69	461896.83	332189.48	739072	5396
DMU159	Southeast	2013	215809.53	135202	177555	1558	44230	7783	77427	710
DMU160	Southeast	2013	19383.57	3776	30712	412	3430	3430	30712	53
DMU161	Southeast	2013	13362.49	6799.16	22315	234.13	5388.8	2357.96	14511	194.83
DMU162	Southeast	2013	40018.43	20674.97	75266	877.56	16539.98	2480.89	68179	718.7
DMU163	Southeast	2013	51337.94	21388.34	76636	1179.92	9416.97	8836.24	82055	1321.92
DMU164	Southeast	2013	10291.10	3506.92	22239	326.4	2981	890	18900	228.96
DMU165	Southeast	2013	6589.42	3759.24	20124	230.47	2827.11	2827.11	18180	193.7
DMU166	Southeast	2013	44574.90	15211.01	68961	603.67	15211	15211	67911	598.4
DMU167	Southeast	2013	56023.34	19296.94	89267	1306.66	19251.95	19251.95	89655	1092.74
DMU168	Southeast	2013	24221.12	4723.61	24485	347.62	1858.7	1802.94	13873	156.21
DMU169	Southeast	2013	23736.00	6145.5	35924	395.21	4886.79	4886.79	35609	355.48
DMU170	Southeast	2013	30785.89	6197.78	37504	382	4041	3031	23724	198
DMU171	Southeast	2013	22917.01	4848.32	31151	376.99	3846.84	3846.84	29739	346.73
DMU172	Southeast	2013	20353.50	8889.73	42242	561	8889.73	8889.73	41989	559.7
DMU173	Southeast	2013	87139.22	18741.15	69974	714.51	10083.76	2722.9	47492	372.96
DMU174	Southeast	2013	9538.37	6005.5	27596.0	650.0	6005.5	1981.8	27596.0	600.0
DMU175	Southeast	2013	25876.20	3980.51	22739	274.07	1212.68	1212.68	8665	129.57
DMU176	Southeast	2013	13522.99	2885.6	16483	151.1	1869.53	803.9	13954	68.41
DMU177	Southeast	2013	38822.03	8296.93	50500	599.12	6090.95	6090.95	46886	422.64
DMU178	South	2013	16711.42	4246.49	28402	454.67	1252.98	1252.98	9385	182.17
DMU179	South	2013	30837.94	6303.33	41023	515.88	3354.58	3354.58	21200	447.07

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU180	South	2013	23524.70	5562.9	37902	538.48	3270.19	3270.19	22433	396.97
DMU181	South	2013	26429.61	6845	35661	602.69	2066.21	2022.01	12711	222.42
DMU182	South	2013	20312.35	5397.97	33995	301.1	4248.95	4248.95	27068	401.14
DMU183	South	2013	19914.87	4666.61	33052	585.4	2049.12	2049.12	13322	295.12
DMU184	South	2013	20905.76	4710.5	30532	384.3	3566.6	3566.6	22233	368.21
DMU185	South	2013	66215.70	14012.89	85956	1167.43	11185.28	11185.28	60122	955.93
DMU186	South	2013	9658.93	2290.82	17017	245.92	1710.71	1710.71	12472	198.99
DMU187	South	2013	19565.86	3877.5	23030	529.72	2612.81	2612.81	13793	233.54
DMU188	South	2013	33937.27	9662.35	61917	881.81	4042.81	4042.81	28907	433.6
DMU189	South	2013	495860.69	108479.78	464179	7199.72	97463.49	95938.39	405197	5813.6
DMU190	South	2013	17784.76	3907.63	30913	427.44	1575.85	1575.85	13245	240.94
DMU191	South	2013	67377.43	15219.88	78083	1098.01	11739.02	11739.02	53169	902.76
DMU192	South	2013	16523.91	3641.66	22473	371.08	2617.65	2617.65	13379	258.1
DMU193	South	2013	31281.54	7254.72	48002	832.61	4813.24	4813.24	30634	576.23
DMU194	South	2013	7054.19	2780.9	18423	324.25	2154.34	2154.34	16218	228.09
DMU195	South	2013	10782.77	1988.66	15856	365.57	1670.91	1670.91	13385	274.32
DMU196	South	2013	166763.96	33733	154945	1810.74	29008.37	29008.37	127235	1638.07
DMU197	South	2013	7062.85	3581.9	15686	508.57	47.24	47.24	533	81.87
DMU198	South	2013	106671.22	22681.63	120139	1800.04	21225.51	21225.51	96916	1640.91
DMU199	South	2013	6317.45	1522.22	11237	159.87	969.08	969.08	6940	128.39
DMU200	South	2013	42689.52	5678.83	35224	556.93	4604.48	1678.96	15496	434.97
DMU201	South	2013	22115.92	4607.61	29963	590.33	3814.63	3814.63	24282	443.47
DMU202	South	2013	18096.31	3898.69	22916	455.44	3092.93	3092.93	16948	315.1
DMU203	South	2013	23343.18	6118.16	35802	465.07	4593.61	4593.61	27594	417.36
DMU204	South	2013	18958.84	4008.14	28216	590.79	3046.67	3046.67	20643	406.14
DMU205	South	2013	79958.93	15510.86	101479	1324.74	12994.09	12994.09	87292	1379.31
DMU206	South	2013	4909.66	981.19	8633	154.63	714.99	714.99	6124	152.47
DMU207	South	2013	11902.46	3128.4	20562	299.46	1653.96	1653.96	10889	213.99
DMU208	South	2013	66142.25	13650.67	74397	1195.86	7713.5	7000.11	42737	669.05
DMU209	South	2013	15208.08	3143.61	22431	233.46	2257.6	2257.6	16028	230.73
DMU210	South	2013	26536.69	5958.49	37661	579.35	4583.23	4583.23	27732	547.82
DMU211	South	2013	26977.46	5731.43	34329	449.34	4695.94	4695.94	25913	458.09
DMU212	South	2013	10150.18	2317.27	15972	283.46	658.65	640.5	3426	86.64

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU213	South	2013	24094.13	17134.15	18485	300	4556.13	4556.13	13437	300
DMU214	South	2013	45027.43	18129.06	83165	1535.3	1771	1608	6894	284
DMU215	South	2013	35326.96	7184.26	42388	673.11	2452.71	2452.71	10455	214.59
DMU216	South	2013	12181.64	2640.22	17174	229.82	128.9	128.9	965	3.5
DMU217	South	2013	162834.91	40807.6	95104	1402.44	13341.19	13341.19	34551	557.75
DMU218	South	2013	21254.77	3747.66	13169	235.27	1929.82	1929.82	4260	63.4
DMU219	South	2013	23662.22	8176	37679	680	2710	2710	18694	366
DMU220	South	2013	114440.90	31876.85	137832	2107.07	4792	4792	18127	272
DMU221	South	2013	20635.28	9164.21	45934	762.47	2309.77	2012.56	9608	143.52
DMU222	South	2013	22975.10	8014.2	41545	703.6	461.95	461.95	3501	39.5
DMU223	South	2013	10439.32	2733.53	24249	574.6	433.17	433.17	4692	114
DMU224	South	2013	49308.83	11927.55	46922	321.24	3205.39	3205.39	7184	134.4
DMU225	South	2013	20305.51	2776.26	20738	152.97	435.4	223.14	3142	24.5
DMU226	South	2013	62693.17	24843.57	49130	1184.55	4095.67	716.86	10746	160
DMU227	South	2013	42041.73	8470.81	39478	476.52	3515.5	968.79	21435	294.41
DMU228	South	2013	27826.50	3475.01	24983	227.83	865.85	117.5	6974	81.36
DMU229	South	2013	45830.53	17963.38	31571	325.9	7593.08	993.88	15872	176.33
DMU230	South	2013	6411.59	752.57	6974	77.32	980	362	8971	57.5
DMU231	South	2013	87977.64	16381.99	75430	837.99	2910.37	2727.9	12652	135.84
DMU232	South	2013	21456.08	3629.13	13666	219.51	1751.89	875.91	2487	39.18
DMU233	South	2013	89803.01	24112.45	122461	1505.86	15184.22	6622.56	112948	1610.25
DMU234	South	2013	14930.23	2628.81	19740	214.5	355.44	398.34	2561	33.01
DMU235	South	2013	8651.31	2105.53	10420	145.99	71.39	9.55	423	7.2
DMU236	South	2013	40673.69	24984.54	19917	198.26	1007.74	134.06	63	1.28
DMU237	South	2013	63017.35	9069.49	56250	697.62	2375.22	1278.89	16240	244.8
DMU238	South	2013	35274.25	10458.25	52643	830	630.72	630.72	1711	32.12
DMU239	South	2013	55740.23	9388.56	49233	851.89	1704.79	1587.82	5300	33.62
DMU240	South	2013	59757.82	16685.43	88302	931.05	8009.01	3203.6	42903	407.53
DMU241	South	2013	303590.18	117414.67	284582	4000.22	74796.57	18181.27	227405	1868
DMU242	South	2013	60147.68	11856.38	56736	393.9	2646.12	1766.86	11910	100
DMU243	South	2013	28075.69	5483.6	32977	598.01	434.14	560.08	2428	50.71
DMU244	South	2013	68377.27	15128.23	60978	731.53	6488.4	8159.48	22181	236.6
DMU245	South	2013	11953.70	7992.1	22779	275.5	1655	648	8684	97.24

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU246	South	2013	33124.51	3258.55	19108	248	498.81	46.01	2817	41.57
DMU247	South	2013	12282.26	2153.94	15420	215.54	354.09	749.32	2296	49.64
DMU248	South	2013	52901.11	12286.52	59043	737.2	3859.61	3859.61	4080	99
DMU249	South	2013	29486.50	6144.95	32377	253.62	269.45	253.56	161	1.97
DMU250	South	2013	21124.50	2684.99	23128	375.24	620.92	881.02	3138	46.71
DMU251	Center-West	2013	231071.07	48858.14	245317	3583	25253.36	25253.36	131263	1675
DMU252	Center-West	2013	39858.47	9520.55	59532	839.1	3680.26	3680.26	25393	298.04
DMU253	Center-West	2013	7703.95	2540.75	16086	219.12	355.64	355.64	2377	44.3
DMU254	Center-West	2013	7273.69	2251.47	14002	184.56	191.53	191.53	1396	32.73
DMU255	Center-West	2013	11555.69	2991.73	19428	310.52	617.3	617.3	4445	114.21
DMU256	Center-West	2013	19591.94	6638.74	41294	462.96	1905.63	1905.63	14495	90.02
DMU257	Center-West	2013	7621.48	1969.9	11812	192.93	689.26	689.26	3582	86.72
DMU258	Center-West	2013	5529.84	2505.9	17210	262	545.39	545.39	4772	77
DMU259	Center-West	2013	7326.99	2173.12	14874	272.73	445.5	445.5	4318	135.37
DMU260	Center-West	2013	24987.39	14713.4	61572	1237.39	5474.98	5013.54	25460	298
DMU261	Center-West	2013	5332.79	5322	26194	417	1300	1300	6700	86
DMU262	Center-West	2013	23107.25	10757.42	63002	1135.28	5378.71	1613.61	16321	120.36
DMU263	Center-West	2013	94647.86	16353.22	113737	1973.77	9372.18	9372.18	60507	658.8
DMU264	Center-West	2013	62738.25	14873.64	99535	1374.49	4624.16	3221.65	28911	449.68
DMU265	Center-West	2013	10098.79	5024.23	35244	386.24	3808	3808	18581	251
DMU266	Center-West	2013	12473.17	2605.3	21757	285.98	1090.91	1090.91	8411	51.57
DMU267	Center-West	2013	6143.33	1545.79	10664	125.91	529.23	529.23	3550	80.45
DMU268	Center-West	2013	36215.24	4214.56	31706	362.17	2030.44	2030.44	14851	235.26
DMU269	Center-West	2013	12669.93	2257.13	17184	227.29	1748.93	1748.93	14135	161.18
DMU270	Center-West	2013	669004.17	99691.1	461086	5931.1	66959.85	53574.58	326253	3540.76
DMU271	Center-West	2013	16008.52	2319.56	16079	233.54	1442.1	1442.1	10323	90.86
DMU272	Center-West	2013	46753.12	5397.88	30741	494.37	4677.44	4641.42	26513	266.44
DMU273	Center-West	2013	11130.29	1967.36	13939	116.57	378.42	378.04	2970	62.32
DMU274	Center-West	2013	26207.15	4822.75	30652	419.72	3109.75	3109.75	18806	152.69
DMU275	Center-West	2013	35580.94	5361.75	38530	713.92	1205.85	1205.85	8340	100.77
DMU276	Center-West	2013	19373.44	3997.83	25162	295.62	911.65	911.65	5465	28.04
DMU277	Center-West	2013	14951.02	3546.18	27194	236.66	880.76	880.76	6590	69.04
DMU278	Center-West	2013	10148.11	1992.68	13541	204.28	2034.4	1752.76	13209	131.42

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU279	Center-West	2013	38480.82	9174.14	56604	612.83	4734.05	4734.05	26545	260.08
DMU280	Center-West	2013	13496.39	2175.26	14624	187.45	983.13	983.13	6556	61.87
DMU281	Center-West	2013	18008.15	4492.1	34736	352.85	1939.38	1939.38	14571	220.12
DMU282	Center-West	2013	23619.03	5298.21	40610	287.65	1886.13	1886.13	11794	99.13
DMU283	Center-West	2013	1214891.91	185916	616298	8978	122309	122309	493762	5531
DMU001	North	2014	7981.39	5400	21069	448	1365.75	1365.75	11072	180
DMU002	North	2014	24370.03	11320.98	47428	1116.21	3880.14	3880.14	19134	467.27
DMU003	North	2014	275053.20	109602.8	372175	3594.78	27217.1	27217.1	49125	479.05
DMU004	North	2014	84352.43	16826.85	80674	1403.64	6856.27	6856.27	33953	644.05
DMU005	North	2014	221309.85	55673.69	219653	2255.18	2922.41	1250.53	32635	381
DMU006	Northeast	2014	8868.95	4557.75	36681	150	44.4	44.4	1289	49.17
DMU007	Northeast	2014	12850.05	10835.18	54879.00	543.22	9538.56	9538.56	15986.00	112.98
DMU008	Northeast	2014	301499.07	44300.3	178262	1959	30772.44	3574	83407	875
DMU009	Northeast	2014	221175.07	43216.82	243229	1529.01	6714.08	6714.08	35011	477.13
DMU010	Northeast	2014	3398.38	840.53	6820.00	107.00	99.14	99.14	893.00	21.08
DMU011	Northeast	2014	4304.09	854.79	8316.00	55.00	155.78	155.78	1768.00	23.81
DMU012	Northeast	2014	5512.52	911.41	5974.00	121.00	303.21	303.21	2603.00	36.90
DMU013	Northeast	2014	9244.40	2091.95	14886.00	103.00	333.04	333.04	3248.00	57.13
DMU014	Northeast	2014	5128.91	1392.63	10722.00	53.00	153.58	153.58	1250.00	46.34
DMU015	Northeast	2014	2264.20	397.22	3478.00	44.00	120.48	120.48	1374.00	18.41
DMU016	Northeast	2014	2447.08	3285.0	15379.0	124.9	985.0	366.2	4326.0	83.5
DMU017	Northeast	2014	3249.47	1591.36	14563.00	109.30	194.74	194.74	2779.00	23.00
DMU018	Northeast	2014	4873.50	1367.03	12067.00	115.00	27.27	27.27	349.00	4.97
DMU019	Northeast	2014	53447.69	9772.76	76190.00	557.19	3406.58	3406.58	31636.00	298.13
DMU020	Northeast	2014	13331.07	1971.68	17765.00	160.00	647.16	647.16	8008.00	132.47
DMU021	Northeast	2014	7774.99	2681.10	13145.00	197.12	178.43	178.43	1459.00	51.16
DMU022	Northeast	2014	559059.47	112003.87	643158.00	3986.68	57491.28	57491.28	330199.00	2383.29
DMU023	Northeast	2014	8088.62	2021.45	17302.00	165.00	378.76	378.76	1855.00	14.80
DMU024	Northeast	2014	3004.78	3303.00	13483.00	135.00	1456.00	1387.00	4853.00	48.00
DMU025	Northeast	2014	6934.75	4204.00	28248.00	344.50	725.44	725.44	4139.00	31.00
DMU026	Northeast	2014	14282.05	2530.72	21697.00	225.00	1067.65	1067.65	10507.00	49.95
DMU027	Northeast	2014	41931.78	9327.75	81430.00	985.00	2222.96	2222.96	20443.00	149.22
DMU028	Northeast	2014	6101.93	4261.56	18184.00	144.00	915.31	915.31	3900.00	70.00

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU029	Northeast	2014	62751.83	8805.46	68583.00	558.28	5149.97	5149.97	28726.00	151.99
DMU030	Northeast	2014	11716.68	3067.17	25037.00	239.00	110.67	110.67	1237.00	9.61
DMU031	Northeast	2014	3042.18	2506.00	16512.00	492.00	62.00	62.00	349.00	4.00
DMU032	Northeast	2014	6116.36	1783.33	15918.00	137.00	393.97	393.97	767.00	11.94
DMU033	Northeast	2014	13836.79	1628.98	20188.00	192.10	972.56	972.56	10346.00	71.96
DMU034	Northeast	2014	12517.48	2193.74	17688	141	291.48	291.48	3469	74.2
DMU035	Northeast	2014	11198.02	2265.8	15860	134	495.03	495.03	4484	52.71
DMU036	Northeast	2014	23104.48	10872.2	58972	526	3582.36	3582.36	39757	408
DMU037	Northeast	2014	5484.91	909.85	10639	82	84.31	84.31	1185	19.09
DMU038	Northeast	2014	12086.20	2026.58	18792	178	451.77	451.77	5237	70.44
DMU039	Northeast	2014	1588.81	300.98	3184	45	41.18	41.18	499	7
DMU040	Northeast	2014	9243.63	2497.2	19310	114.01	176.04	176.04	1665	10.37
DMU041	Northeast	2014	5421.93	2666	18091	176.88	420.88	418.6	4161	42.8
DMU042	Northeast	2014	5294.29	1379.63	11088	191.25	47.26	47.26	335	21.53
DMU043	Northeast	2014	43548.08	10698.97	68892	390.91	4310.46	4310.46	31460	211.22
DMU044	Northeast	2014	132708.85	38017.52	200671	1587.07	13585.95	9890.57	69000	541.9
DMU045	Northeast	2014	6456.06	4960	14807	75.31	704.45	704.45	585	6.02
DMU046	Northeast	2014	10964.36	2950	18390	161.47	729.75	729.75	3075	22.92
DMU047	Northeast	2014	83081.00	20997	121737	625.2	20069.11	20069.11	92959	316.21
DMU048	Northeast	2014	13278.43	2289	17314	123.61	1937.45	1937.45	10246	35.11
DMU049	Northeast	2014	203959.01	43465	196638	1008.99	29061.36	29061.36	121192	525.84
DMU050	Northeast	2014	22078.13	5044	32210	195.1	570.83	570.83	1983	11.12
DMU051	Northeast	2014	4461.48	1240	9777	87.7	671.4	671.4	3458	17.27
DMU052	Northeast	2014	4577.84	2576.0	23731.0	212.8	640.0	640.0	6248.0	82.1
DMU053	Northeast	2014	10702.82	1508.31	18889	163.06	71	71	1069	10.66
DMU054	Northeast	2014	42410.45	21202.78	44353	392.36	229	229	5615	42.6
DMU055	Northeast	2014	9375.48	3740.61	32087	307.11	65	65	682	7.26
DMU056	Northeast	2014	46313.87	12226.42	89961	854.75	5496	5496	41450	369.16
DMU057	Northeast	2014	14897.90	4892.38	39223	316.15	323	323	3707	35.35
DMU058	Northeast	2014	11613.23	4079.96	26267	323.36	56	56	347	6.31
DMU059	Northeast	2014	20197.33	2630.33	21615	222.26	49	49	471	5.32
DMU060	Northeast	2014	51900.21	20312.93	129360	1107.14	1277	1277	12047	177.62
DMU061	Northeast	2014	2470.63	1372.73	13905	132.57	223	223	4271	63.18

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU062	Northeast	2014	39183.31	12423.42	86727	761.78	5693	5693	32852	464.49
DMU063	Northeast	2014	20171.13	8654.49	77972	1218.4	3866	3248	33624	483.92
DMU064	Northeast	2014	25978.33	10467.82	72833	669.93	7049	7049	48008	515.35
DMU065	Northeast	2014	417828.43	60790.76	304900	3323.56	38847	38847	102963	1528.68
DMU066	Northeast	2014	7551.71	2238.87	19684	198.76	277	277	2566	24
DMU067	Northeast	2014	15299.56	3583.79	30358	283.97	877	877	11823	99.58
DMU068	Northeast	2014	158629.51	30083.32	137571	1444	11185.2	10694.17	40786	407.53
DMU069	Northeast	2014	236025.43	36383	181895	2288	14156	14156	68433	688
DMU070	Northeast	2014	31469.71	5208	39199	483	2089	2089	14379	173
DMU071	Northeast	2014	22983.35	7033.26	44953	631.08	1149.63	1149.63	9247	98.06
DMU072	Northeast	2014	4628.60	2720	16541	160	1300	1300	7399	145
DMU073	Northeast	2014	9288.61	2567.97	19363	340.94	90.32	90.32	808	9.1
DMU074	Northeast	2014	49479.61	11990.66	67625	1022.21	3012.35	1768.91	16988	118.94
DMU075	Northeast	2014	22203.01	4164.4	24500	165.63	1005	1005	9159	50.31
DMU076	Northeast	2014	11542.14	2014.14	16761	209.67	1369.05	1369.05	8978	59.43
DMU077	Northeast	2014	10880.25	3646.78	29399	301.77	259.1	259.1	2598	13.33
DMU078	Northeast	2014	105304.39	18876.95	156304	2129.09	14339.49	14339.49	93370	548.6
DMU079	Northeast	2014	30147.16	6323	42610	556.83	3999.35	3999.35	24318	137.26
DMU080	Northeast	2014	6394.82	1459.19	14616	135.13	92.15	92.15	1089	9.9
DMU081	Northeast	2014	11417.05	2650.07	24338	405.22	330.04	330.04	3397	18.88
DMU082	Northeast	2014	8073.17	2138.66	20390	230.82	156.08	156.08	1537	14.7
DMU083	Northeast	2014	27494.25	15575.73	50551	430.2	12965.01	3145.5	35239	333
DMU084	Northeast	2014	5179.48	3598.0	23573.0	178.9	3185.5	523.4	20708.0	136.5
DMU085	Northeast	2014	29928.14	5792.26	50433	484.48	5461.66	5461.66	45782	453.79
DMU086	Northeast	2014	20927.48	8814	44620	407	3657	3439	31372	213
DMU087	Northeast	2014	49648.43	4416.9	44013	400.82	3936.87	3919.02	16325	459.62
DMU088	Northeast	2014	11794.21	4862.07	30913	270.03	561.32	561.32	7959	144.5
DMU089	Northeast	2014	25167.76	3756.31	27966	356.93	2875.15	2875.15	24696	180
DMU090	Northeast	2014	741840.17	150874.89	519038	5352.53	134477.66	133868.06	468164	3517.63
DMU091	Northeast	2014	11469.20	1645	16507	145.79	858.21	858.21	7714	54.64
DMU092	Northeast	2014	12562.64	3619.96	30856	239.48	428.24	428.24	4419	42.73
DMU093	Northeast	2014	14175.72	6835.28	22463	206.59	272.22	272.22	2429	19
DMU094	Northeast	2014	21811.87	1970.73	25672	188.3	1756.55	1748.58	7178	204.93

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU095	Northeast	2014	15456.94	4896.27	36534	430.29	733.62	733.62	6589	25.48
DMU096	Northeast	2014	56410.74	11501.92	90141	1143.69	8517.15	8517.15	62572	665.05
DMU097	Southeast	2014	22666.44	4373.4	29435	311.05	3377.89	3356.64	28839	243.99
DMU098	Southeast	2014	8085.81	14253.00	37687.00	401.36	11402.00	175.00	36388.00	411.92
DMU099	Southeast	2014	26176.31	5472.03	36414	235.75	4203.52	4203.52	35807	317.16
DMU100	Southeast	2014	21939.42	6334.24	32770	272.53	3974.46	875.48	28680	247.72
DMU101	Southeast	2014	732024.08	155415.07	589109	6775.99	117816.25	106392.68	574936	4186.36
DMU102	Southeast	2014	102679.28	20990.71	119875	1426.68	13443.74	13443.74	96910	838.67
DMU103	Southeast	2014	26812.93	5864.6	43778	442.44	3998.65	1370.88	38357	357.91
DMU104	Southeast	2014	152030.86	33258.63	178485	1958.59	23013.49	20606.5	157967	1054.93
DMU105	Southeast	2014	12057.73	2622.19	19486	164.46	2102.92	2102.92	19923	140.81
DMU106	Southeast	2014	58244.02	10908.11	66784	690.4	9236.83	9236.83	69662	338.58
DMU107	Southeast	2014	16035.84	6736.2	32261	374	5388.96	2703.01	30990	231.3
DMU108	Southeast	2014	27460.90	5275.01	30267	722.54	3883.15	3620.51	28588	325.13
DMU109	Southeast	2014	19657.35	7154.32	37012	505.95	5704.02	5058.27	36493	492.22
DMU110	Southeast	2014	12109.81	2936.17	23609	389.92	542.64	542.64	6059	92.61
DMU111	Southeast	2014	111632.32	29481.87	129365	1840.43	23585.49	1933.38	127313	1340.79
DMU112	Southeast	2014	18153.32	4054.39	22759	363.61	1372.02	1372.02	9715	174.01
DMU113	Southeast	2014	27527.13	5049.38	34512	434.17	3774.47	3774.47	33046	321.28
DMU114	Southeast	2014	8426.11	5016	19562	212	5176	10	14908	217
DMU115	Southeast	2014	91950.48	15804.82	122730	1773.07	12307.08	11640.15	122360	1243.02
DMU116	Southeast	2014	11846.85	5803.87	33200	438.72	4933.29	1617.4	33024	454.56
DMU117	Southeast	2014	22986.59	6307.6	27807	439.82	931.46	931.46	2628	52.19
DMU118	Southeast	2014	17880.26	3561.81	25702	270.66	2478.42	2478.42	23153	248.57
DMU119	Southeast	2014	12513.27	6875.49	35353	454.76	5500.39	3039.44	35091	423.53
DMU120	Southeast	2014	10099.85	4142	26004	396	3316	3216	25503	378
DMU121	Southeast	2014	8428.52	3644	17957	273	821	821	7214	84
DMU122	Southeast	2014	32205.83	9972.83	52948	1070	8476.93	1581.24	52497	962.57
DMU123	Southeast	2014	34849.22	7041.28	44573	602.99	5475.83	5360.26	44716	498.62
DMU124	Southeast	2014	72151.65	12958.52	90590	950.31	7792.77	1545.19	69857	510.06
DMU125	Southeast	2014	43960.27	8931.04	57515	736.28	5493.46	4799.94	44726	347.3
DMU126	Southeast	2014	6714.31	1473.12	11827	153.68	486.26	479.11	5090	89.39
DMU127	Southeast	2014	4130.54	514.93	4391	49.86	358.42	358.42	3880	43.59

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU128	Southeast	2014	5202.72	2989.3	17068	208	2953.42	17.42	17028	206.8
DMU129	Southeast	2014	57599.33	21751.18	102884	1237.72	17400.94	12876.69	102369	1160.83
DMU130	Southeast	2014	90811.47	53723.27	178505	3083	50016.36	50016.36	175635	2484
DMU131	Southeast	2014	13523.30	4752.58	20933	315.21	3408.01	2410.8	18502	236.59
DMU132	Southeast	2014	34742.07	6821.62	44828	453.53	5271.82	5271.82	44818	412.24
DMU133	Southeast	2014	28251.99	4297.29	30622	463.8	2654.49	2654.49	24136	153.45
DMU134	Southeast	2014	8869.56	4548.79	19618	267	3639.04	36.39	16858	210
DMU135	Southeast	2014	12080.17	4587.38	25768	355.21	2802.18	364.28	19746	230.7
DMU136	Southeast	2014	57666.66	11999.07	54564	606.62	8958.75	8805.33	50228	475.82
DMU137	Southeast	2014	82551.43	20423.93	88618	1227.94	5026.78	3479.24	26155	390.19
DMU138	Southeast	2014	13387.20	7603	26111	338	5859	328	23133	208
DMU139	Southeast	2014	23132.16	8367.83	30326	479.76	3550.06	3255.52	8906	116.43
DMU140	Southeast	2014	12385.20	7835	32969	448	5773.89	4561.35	21968	241.56
DMU141	Southeast	2014	10214.04	5276	33638	328.52	3950	21.49	19280	186.13
DMU142	Southeast	2014	127089.50	46843.72	107402	1596.7	9707.49	8250.42	47123	690.22
DMU143	Southeast	2014	12925.49	3563.48	15406	255.42	1026.44	1026.44	6218	80.54
DMU144	Southeast	2014	84144.75	29849.72	93379	1293.79	12708.99	12708.99	23833	390.67
DMU145	Southeast	2014	84294.51	30723.64	57293	827.89	16747.17	16747.17	25522	352.16
DMU146	Southeast	2014	30614.57	16233.25	43701	604.4	6210.26	1055.74	21268	262
DMU147	Southeast	2014	38145.33	8701.97	43326	646.5	9736	300	37116	303.74
DMU148	Southeast	2014	61587.53	31391	83146	554	12142	10775	42133	418
DMU149	Southeast	2014	57823.13	9180.75	62329	1098.29	9802	9802	62329	38
DMU150	Southeast	2014	104165.33	20916.43	91649	1285.31	14583.2	14583.2	51227	734.53
DMU151	Southeast	2014	100671.71	61065	152952	1275	21934	2934	75590	675
DMU152	Southeast	2014	9656.07	4251	22051	90	705	243	4784	23
DMU153	Southeast	2014	267801.82	45219.7	88717	1303.3	42920.4	42920.4	57875	724.3
DMU154	Southeast	2014	45191.49	8395.14	38691	734	8554.44	5642.28	36467	452.23
DMU155	Southeast	2014	68539.92	10101	52737	700	12401	9943	43824	269
DMU156	Southeast	2014	32697.33	7674.6	33844	484.9	7010.8	4206.5	32248	379.4
DMU157	Southeast	2014	76484.72	6499	34124	113	2531	2531	15445	230
DMU158	Southeast	2014	1931720.53	708874.68	972569	10290.6	469285.69	334572.81	786727	5982
DMU159	Southeast	2014	222467.95	135337	177573	1558	44684	7863	77427	710
DMU160	Southeast	2014	24945.54	4200.73	33040	446.28	3608	3608	33040	53

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU161	Southeast	2014	15060.33	6512.18	23238	242.73	8372.81	283.82	16936	196.22
DMU162	Southeast	2014	37820.28	21051.4	77800	881.2	16535.5	2811.03	69362	719.2
DMU163	Southeast	2014	44387.65	24057.38	77855	1181.55	10880.09	9863.91	83212	1323.2
DMU164	Southeast	2014	12904.42	3444.85	22764	326.4	3827.1	1062.08	20290	228.96
DMU165	Southeast	2014	6191.16	3690.17	20646	254.56	2952.09	2952.09	18609	200.06
DMU166	Southeast	2014	33983.42	13997.41	71140	646.52	13997.41	13997.41	71507	635.55
DMU167	Southeast	2014	58467.67	18060.19	92179	1345.03	15336.32	15336.32	92567	1123.3
DMU168	Southeast	2014	25164.21	4602.04	25312	356.86	1929.9	1872	14940	162.63
DMU169	Southeast	2014	28482.16	6262.57	37006	404.06	5183.55	5183.55	36682	364.33
DMU170	Southeast	2014	34148.50	5946.35	38590	391	5054.4	2929	24144	198.5
DMU171	Southeast	2014	19384.30	4964.55	32198	377.88	4133.45	4133.45	30746	347.31
DMU172	Southeast	2014	21449.31	9049.76	43292	572	9049.75	9049.75	42969	569.7
DMU173	Southeast	2014	85076.62	18003.14	72032	718.71	9997.66	2499.41	49964	386.61
DMU174	Southeast	2014	11055.99	5771.3	28298.0	680.0	5771.4	1904.6	28298.0	680.0
DMU175	Southeast	2014	28529.70	4172.55	23490	282.34	1752.68	1752.68	9804	131.43
DMU176	Southeast	2014	14042.40	2951.51	17010	151.37	1977.89	874.28	14475	68.41
DMU177	Southeast	2014	41434.77	8741.06	53037	607.35	6704.62	6704.62	49264	425.48
DMU178	South	2014	17782.77	4564.6	29041	457.16	1465.64	1465.64	10145	182.31
DMU179	South	2014	33004.83	6458.04	42598	535.49	3750.35	3750.35	22834	462.14
DMU180	South	2014	26270.17	5698.33	39248	558.72	3561.64	3561.64	23374	418.42
DMU181	South	2014	27429.56	7109.62	36841	621.67	2082.73	1807.76	13069	236.13
DMU182	South	2014	21724.73	5614.62	35243	319.31	4453.82	4453.82	28616	420.18
DMU183	South	2014	21174.73	4904.4	34193	603.9	2119.77	2119.77	14156	299.11
DMU184	South	2014	22174.44	4908.39	31571	403.17	3774.77	3774.77	23705	408.05
DMU185	South	2014	68967.33	14629.62	88776	1201.86	12143.55	12143.55	66095	968.24
DMU186	South	2014	10455.17	2372.09	17595	246.58	1788.06	1788.06	12774	199.84
DMU187	South	2014	20003.33	3986.12	23991	532.04	2665.86	2665.86	14084	236.92
DMU188	South	2014	34863.68	10235.96	63322	884.55	4431.45	4431.45	30230	435.09
DMU189	South	2014	506529.26	110984.1	471172	7259.35	100855.56	99564.53	418123	5880.17
DMU190	South	2014	19090.73	4290.68	33839	483.39	1953.5	1953.5	16911	256.44
DMU191	South	2014	65217.94	15812.94	80777	1379.25	12475.53	12475.53	55900	959.35
DMU192	South	2014	17779.96	3817.85	23208	379.05	2754.38	2754.38	14010	268.1
DMU193	South	2014	32276.69	7357.51	49032	848.37	5041.59	5041.59	33345	591.7

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU194	South	2014	7616.44	3044.99	19220	360.78	2290.93	2290.93	17294	255.07
DMU195	South	2014	11753.16	2088.12	16269	368.03	1763.45	1763.45	13755	275.73
DMU196	South	2014	172059.66	35052.86	157812	1868.95	30650.87	30650.87	132185	1729.16
DMU197	South	2014	7141.21	3740.75	16289	516.1	133.99	133.99	1423	89
DMU198	South	2014	107783.69	23387.83	122960	1882.69	21913.63	21913.63	101121	1657.89
DMU199	South	2014	6601.46	1591.3	11522	165.28	1042.67	1042.67	7820	132.48
DMU200	South	2014	47035.03	5593.61	35672	562.75	4543.43	2993.21	17714	528.57
DMU201	South	2014	23122.93	4793.03	31185	627.87	4025.18	4025.18	25431	478.92
DMU202	South	2014	19182.41	4073.33	23921	462.71	3293.82	3293.82	17703	343.58
DMU203	South	2014	24347.17	6514.13	36492	466.73	4774.45	4774.45	28847	419.92
DMU204	South	2014	19411.90	4178.83	29390	602.2	3230.13	3230.13	22063	414.11
DMU205	South	2014	79000.96	16042.28	104690	1339.78	13678.74	13678.74	90986	1449.59
DMU206	South	2014	4697.81	1006.83	8969	158.03	751.84	751.84	6686	157.03
DMU207	South	2014	13398.31	3265.34	21759	319.84	1770.89	1770.89	11039	215.74
DMU208	South	2014	66509.65	13952.52	76128	1214.34	7926.16	7913.41	44445	698.39
DMU209	South	2014	16176.24	3290.63	23007	235.61	2394.41	2394.41	16964	241.79
DMU210	South	2014	27552.03	6212.43	39177	618.34	4813.25	4813.25	29260	587.24
DMU211	South	2014	28196.56	5903.18	36285	475.91	4877.11	4877.11	27468	476.03
DMU212	South	2014	11468.16	2450.09	16357	289.01	700.73	682.66	3519	87.51
DMU213	South	2014	27575.07	15160.75	18706	300	7568.45	7568.45	13045	300
DMU214	South	2014	69832.72	18335.31	86740	1559	3437	3259	15440	288
DMU215	South	2014	37452.41	7354.6	43489	673.11	2482.91	2482.91	10970	214.59
DMU216	South	2014	12408.34	2749.22	17710	229.83	132.34	132.34	972	3.5
DMU217	South	2014	193041.50	43070.03	97532	1402.45	15683.55	15683.55	35807	557.75
DMU218	South	2014	23178.87	3990.81	13471	236.74	1546.24	1546.24	4281	64.2
DMU219	South	2014	26563.61	8359	38640	685	2739	2739	20640	379
DMU220	South	2014	122167.99	32823.81	141262	2126.2	5964.81	5964.81	23391	538.76
DMU221	South	2014	27024.37	9644.52	46703	772.44	2410.66	2033.52	9893	145.53
DMU222	South	2014	24963.30	8469.47	43232	707	554.4	554.4	4310	70.2
DMU223	South	2014	12378.42	3601.68	24881	577.5	672.9	672.9	4837	126.1
DMU224	South	2014	57896.97	12939.72	48074	322.6	3796.49	3796.49	9088	134.41
DMU225	South	2014	20712.54	3388	21255	153	526	525	3144	24
DMU226	South	2014	47755.65	27108	49554	1185	1613	1379	11021	160

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU227	South	2014	31177.75	5809.08	39713	476.52	3515.5	968.79	21599	294.41
DMU228	South	2014	22758.80	4015	25326	232	997	561	7029	81
DMU229	South	2014	46700.30	19419	32558	326	3229	3228	16870	176
DMU230	South	2014	6571.88	856	7133	78	1200	362	9300	57.5
DMU231	South	2014	85274.69	19418	76203	840	3462	3461	12867	136
DMU232	South	2014	24542.27	4029	14079	225	1574	1573	2505	39
DMU233	South	2014	92731.98	24580.7	125080	1606.06	19644.56	7785.19	115115	1621.27
DMU234	South	2014	17742.20	3260	19990	220	441	440	2565	33
DMU235	South	2014	8922.84	2716	10866	147	61	8	424	7
DMU236	South	2014	20908.61	23602	20139	198	177	151	62	1
DMU237	South	2014	78589.40	11580	57825	698	3154	1872	17329	245
DMU238	South	2014	38673.08	10633.93	53020	854	645.78	645.78	1880	35.7
DMU239	South	2014	55518.24	11231	50630	796	2147	2146	5548	34
DMU240	South	2014	55437.23	16112.69	89233	933.55	7734.09	3093.64	43797	408
DMU241	South	2014	307255.29	120492.4	288472	4052.2	76100.72	33666.87	230764	1907.03
DMU242	South	2014	65333.17	13910	57345	518	2742	2741	13063	110
DMU243	South	2014	36445.69	6341	33821	598	544	543	2691	51
DMU244	South	2014	69578.02	17968	62300	867	6364	6363	24641	240
DMU245	South	2014	13500.49	5292.2	23147	279	1820.5	712.8	8866	97.24
DMU246	South	2014	22016.25	3717	19665	253	568	541	2882	42
DMU247	South	2014	13219.25	2570	15657	199	415	414	2317	50
DMU248	South	2014	56984.67	12317.17	60140	739.2	2634.99	2634.99	4223	99.9
DMU249	South	2014	25899.64	7006	33055	254	301	238	161	2
DMU250	South	2014	19899.18	3715	24362	389	835	834	3146	47
DMU251	Center-West	2014	222103.34	49803.41	261035	3634	27321.9	27321.9	144364	1781
DMU252	Center-West	2014	44862.99	9688	62627	1047.95	4480	4480	32173	307.41
DMU253	Center-West	2014	8319.72	2619	16829	321.58	365	365	2474	44.31
DMU254	Center-West	2014	7781.41	2305	14358	240.3	201	201	1476	32.73
DMU255	Center-West	2014	12738.39	3139	20152	362.38	712	712	5417	114.56
DMU256	Center-West	2014	23621.37	6779	42983	726.99	2277	2277	18024	99.28
DMU257	Center-West	2014	5994.05	2124.11	12601	194.18	736.56	736.56	3762	99.05
DMU258	Center-West	2014	5208.02	3400	19930	295	817	817	5913	78
DMU259	Center-West	2014	7808.54	2563.66	16445	282.51	614.84	614.84	6263	137.52

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU260	Center-West	2014	35284.00	13813.1	63776	948.85	5504.64	4743.68	25460	443.67
DMU261	Center-West	2014	4573.46	8437	27899	420	856	856	5870	90.9
DMU262	Center-West	2014	22008.07	11924	67306	1148.73	5378.71	1613.61	18331	133.29
DMU263	Center-West	2014	97598.21	16776.55	118812	2006.73	9941.41	9941.41	64148	658.8
DMU264	Center-West	2014	107716.97	15800.88	106804	1410.56	4855	4612	31080	400
DMU265	Center-West	2014	16362.60	5044.16	37782	395	2122.5	2122.5	21989	260
DMU266	Center-West	2014	12829.42	2811.83	23788	288.17	1109.63	1109.63	8554	51.83
DMU267	Center-West	2014	7151.08	1595.84	11112	125.9	543.29	543.29	3615	80.45
DMU268	Center-West	2014	42799.84	4439.47	33472	362.51	2387.19	2387.19	17313	235.26
DMU269	Center-West	2014	22349.35	2391.17	17681	227.3	2133.35	2133.35	15770	161.17
DMU270	Center-West	2014	692572.34	102393.83	487489	5986.06	67514.35	55909.32	353868	3552.96
DMU271	Center-West	2014	16421.42	2353.93	16713	246.24	1660.07	1660.07	11509	99.98
DMU272	Center-West	2014	39484.54	5596.33	32595	494.37	5350.92	5237.39	31639	266.44
DMU273	Center-West	2014	10435.06	2047.73	14976	226.32	486.05	485.92	3530	62.32
DMU274	Center-West	2014	38932.26	4882.14	31772	422.51	3307	3141	20385	290
DMU275	Center-West	2014	51597.07	5720.73	41425	718.55	1566.06	1566.06	8966	100.76
DMU276	Center-West	2014	17534.60	4014.72	26507	298.17	904.42	904.42	5539	36.56
DMU277	Center-West	2014	14868.17	3715.96	29267	236.65	911.71	911.71	6790	69.04
DMU278	Center-West	2014	8546.50	2045.35	14123	204.4	2064.58	1526.14	13679	132.25
DMU279	Center-West	2014	57567.31	9473.64	59730	618.24	4951	4704	28841	340
DMU280	Center-West	2014	13188.55	2249.03	15684	188.15	1182.36	1182.36	8780	62.02
DMU281	Center-West	2014	30876.18	4816.81	36836	362.65	2122	2016	15284	215
DMU282	Center-West	2014	25109.11	5594.6	44633	292.42	2075.93	2075.93	15455	99.21
DMU283	Center-West	2014	1274050.28	182959	615776	9072.85	128352	128352	493429	6148.67
DMU001	North	2015	9012.98	4289.85	22012	455	1364.02	1364.02	11744	182
DMU002	North	2015	25203.46	12121.59	52570	1139.44	4083.41	4083.41	21857	533.47
DMU003	North	2015	275402.53	111868	382100	3625.08	26753.51	26753.51	52212	480.07
DMU004	North	2015	72667.82	18646.62	84557	1395.21	13787.74	13645.17	49776	712.26
DMU005	North	2015	205931.35	61051.16	220795	2255.18	2970.2	888.39	32635	381
DMU006	Northeast	2015	10643.11	5835.19	37693	366	162.71	162.71	2248	59.05
DMU007	Northeast	2015	11665.50	11240.74	62239.00	543.22	9538.56	9538.56	15983.00	112.98
DMU008	Northeast	2015	291571.47	42300.04	189495	1962	26431.31	3711	97499	875
DMU009	Northeast	2015	183806.83	43628.12	255278	1619.1	6542.61	6542.61	36976	481.57

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU010	Northeast	2015	1763.05	785.81	7005.00	96.96	92.30	92.30	953.00	21.30
DMU011	Northeast	2015	3840.65	817.37	8482.00	44.42	144.55	144.55	1790.00	23.81
DMU012	Northeast	2015	3375.32	765.87	6227.00	131.27	305.63	305.63	2982.00	37.35
DMU013	Northeast	2015	8204.92	1877.57	15245.00	162.49	387.68	387.68	3889.00	57.13
DMU014	Northeast	2015	4258.12	1448.90	11126.00	98.54	157.01	157.01	1326.00	46.33
DMU015	Northeast	2015	1578.25	340.61	3547.00	57.30	107.17	107.17	1367.00	18.47
DMU016	Northeast	2015	2424.96	4212.0	15904.0	129.0	985.0	618.3	4454.0	84.0
DMU017	Northeast	2015	2719.45	1667.57	14093.00	109.30	155.36	155.36	2663.00	23.00
DMU018	Northeast	2015	3520.59	1322.80	12480.00	134.65	27.50	27.50	362.00	4.97
DMU019	Northeast	2015	35168.20	9829.76	81587.00	600.29	3359.04	3359.04	34084.00	305.06
DMU020	Northeast	2015	9624.10	1529.76	17879.00	151.55	538.77	538.77	8181.00	132.47
DMU021	Northeast	2015	5117.96	2394.91	13872.00	238.32	204.25	204.25	1720.00	35.56
DMU022	Northeast	2015	417470.21	107328.80	655434.00	4042.94	56150.27	56150.27	350274.00	2399.69
DMU023	Northeast	2015	6651.12	1935.24	19113.00	148.16	295.93	295.93	1900.00	14.80
DMU024	Northeast	2015	2987.44	3369.00	13760.00	138.00	1465.00	1395.00	4855.00	49.00
DMU025	Northeast	2015	7345.37	4204.00	28818.00	378.95	821.05	821.05	4586.00	31.00
DMU026	Northeast	2015	12105.45	2599.10	22191.00	310.22	1213.63	1213.63	10599.00	49.95
DMU027	Northeast	2015	34405.55	9646.43	84500.00	673.73	2246.32	2246.32	21828.00	167.72
DMU028	Northeast	2015	4646.51	4593.96	19148.00	144.60	979.38	979.38	4192.00	70.00
DMU029	Northeast	2015	22631.38	8754.92	71879.00	565.03	5270.93	5270.93	31330.00	228.43
DMU030	Northeast	2015	7877.21	3124.80	26613.00	268.97	238.60	238.60	2573.00	24.96
DMU031	Northeast	2015	4409.60	2487.00	16866.00	500.00	60.00	60.00	336.00	4.00
DMU032	Northeast	2015	3720.15	1627.90	16911.00	152.03	327.17	327.17	768.00	11.94
DMU033	Northeast	2015	8639.04	2025.11	20896.00	193.13	937.96	937.96	11128.00	42.04
DMU034	Northeast	2015	11318.95	2158.01	18198	170.63	307.19	307.19	3606	74.2
DMU035	Northeast	2015	9056.90	1951.7	16540	147.87	476.52	476.52	4639	52.71
DMU036	Northeast	2015	21532.31	11176.41	60137	576.4	3734.61	3734.61	40351	420
DMU037	Northeast	2015	7866.22	904.34	10876	89.79	89.76	89.76	1362	19.09
DMU038	Northeast	2015	10666.89	1876.8	19547	178.28	410.1	410.1	5410	70.44
DMU039	Northeast	2015	1372.74	339.64	3237	47.6	39.76	39.76	515	7
DMU040	Northeast	2015	8729.72	2377.26	19633	135.73	169.97	169.97	1677	10.37
DMU041	Northeast	2015	5083.36	3370.78	19019	179.9	462.96	418.6	4179	42.8
DMU042	Northeast	2015	7396.25	1466.44	12144	191.25	60.88	60.88	733	21.53

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU043	Northeast	2015	47416.44	10985.17	71850	397.91	4701.19	4701.19	31745	211.22
DMU044	Northeast	2015	143645.19	38239.57	206392	1604.08	14266.36	10385.91	73310	788.99
DMU045	Northeast	2015	6651.60	4672.31	14962	76.06	716.72	716.72	578	6.02
DMU046	Northeast	2015	11586.36	2055.01	19044	167.77	731.43	731.43	3086	22.92
DMU047	Northeast	2015	85798.86	15434.99	125763	679.35	20696.03	15434.99	98449	352.78
DMU048	Northeast	2015	15582.15	2422.04	17725	129.76	1942.29	1942.29	10628	35.37
DMU049	Northeast	2015	205959.94	43710.53	202191	1012.22	29733.76	29733.76	123425	525.84
DMU050	Northeast	2015	24679.73	4058.52	32926	200.58	575.21	575.21	2008	11.12
DMU051	Northeast	2015	4707.21	1266.71	10220	88.29	670.42	670.42	3471	17.27
DMU052	Northeast	2015	4729.32	2728.6	23961.0	212.9	745.8	745.8	6389.0	82.1
DMU053	Northeast	2015	9940.64	1535.19	19434	163.21	82.49	82.49	1095	10.66
DMU054	Northeast	2015	39436.10	21967.97	44945	460.69	376.42	376.42	5701	48.4
DMU055	Northeast	2015	7733.49	3719.55	32132	323.43	67.4	67.4	710	7.26
DMU056	Northeast	2015	45660.47	11340.92	94618	883.9	5027.29	5027.29	41896	369.16
DMU057	Northeast	2015	11644.62	4857.58	40358	326.12	377.1	377.1	3925	35.35
DMU058	Northeast	2015	11479.04	4056.05	27595	323.36	55.9	55.9	347	6.31
DMU059	Northeast	2015	19453.61	2510.79	22870	239.7	54.1	54.1	724	5.32
DMU060	Northeast	2015	51705.48	20220.69	130549	1129.16	1261.43	1261.43	12192	227.49
DMU061	Northeast	2015	2614.87	1297.98	13994	132.62	280.99	280.99	5060	63.18
DMU062	Northeast	2015	37862.35	12246.9	89333	780.24	5896.54	5896.54	35222	464.49
DMU063	Northeast	2015	19539.78	8238.85	78066	1245.01	3521.17	3248	34155	544.25
DMU064	Northeast	2015	27284.00	10645.52	78644	672.31	7042.36	7042.36	51869	535.35
DMU065	Northeast	2015	439691.40	60075.97	307333	3346.07	39532.18	39400	105169	1528.68
DMU066	Northeast	2015	9407.87	2340.6	19902	211.01	323.99	323.99	2689	24
DMU067	Northeast	2015	11562.45	3609.71	31120	294.88	924.09	924.09	11970	99.58
DMU068	Northeast	2015	207638.42	29635.75	137699	1444	10549	10549	34097	407.53
DMU069	Northeast	2015	209921.17	36065.8	189149	2491.5	15238.9	15238.9	76335	687.7
DMU070	Northeast	2015	26547.24	5249.02	40210	503.12	2155.86	2155.86	14422	173.09
DMU071	Northeast	2015	22887.34	6751.46	47304	639.21	1807.08	1807.08	16391	176.76
DMU072	Northeast	2015	4928.54	2183	17501	169	1450	1450	7800	150
DMU073	Northeast	2015	9461.22	2539	20062	311.32	134.43	134.43	1388	9.1
DMU074	Northeast	2015	52407.58	11221.46	68413	1027.95	3150.03	1901.08	17512	138.96
DMU075	Northeast	2015	24818.73	3704.88	24687	167.22	1158.71	1158.71	10216	51.59

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU076	Northeast	2015	13649.64	1975.77	16909	209.67	1477.6	1477.6	9221	69.85
DMU077	Northeast	2015	11118.18	3765.93	30209	301.77	261.69	261.69	2606	13.33
DMU078	Northeast	2015	98212.63	17596.87	163048	2161.73	14518.52	14518.52	100744	578.57
DMU079	Northeast	2015	31518.40	6268.96	43815	556.83	4033.26	4033.26	25494	137.26
DMU080	Northeast	2015	6864.42	1463.82	14915	135.1	97.15	97.15	1092	9.9
DMU081	Northeast	2015	11358.87	2965.38	25730	406.65	364.37	364.37	4417	18.88
DMU082	Northeast	2015	9823.56	2346.76	21845	234.53	229.85	229.85	2680	14.7
DMU083	Northeast	2015	28499.67	16813.4	50775	431.5	13275	3302.4	35381	334.5
DMU084	Northeast	2015	5518.29	3972.7	22465.0	179.4	2138.3	522.2	21044.0	137.3
DMU085	Northeast	2015	28366.08	5563.17	50977	486.79	5550.36	5550.36	46455	453.79
DMU086	Northeast	2015	22585.90	20993	47409	422	4644	4141	35106	213
DMU087	Northeast	2015	40580.29	11920.81	44495	413.53	4206.83	4188.37	18375	459.62
DMU088	Northeast	2015	14596.96	4717.13	31559	270.69	1322.54	1322.54	10079	146.06
DMU089	Northeast	2015	24851.93	3855.5	30102	357.37	2862.84	2862.84	26583	180
DMU090	Northeast	2015	738230.85	150177.24	502681	5365.69	137227.12	136625.08	485133	4029.11
DMU091	Northeast	2015	13272.21	1695.09	16654	110.56	867.34	867.34	7879	54.64
DMU092	Northeast	2015	13095.15	3761.1	32581	259.18	573.89	573.89	5407	42.73
DMU093	Northeast	2015	10012.49	6633.91	23826	227.1	273.57	273.57	2420	19
DMU094	Northeast	2015	23690.52	5409.96	25117	188.67	1905.4	1897.04	8226	204.93
DMU095	Northeast	2015	15116.97	4714.56	37781	430.29	1135.93	1135.93	10024	30.94
DMU096	Northeast	2015	52384.06	11600.41	93189	1176.48	9346.16	9346.16	70702	665.05
DMU097	Southeast	2015	22484.90	3957.04	29884	311.05	3054.44	3054.44	29469	243.99
DMU098	Southeast	2015	9232.13	15100.2	40326	466.34	12080.16	393	39186	457.47
DMU099	Southeast	2015	27642.99	5264.57	37388	235.76	4049.69	4049.69	36845	317.16
DMU100	Southeast	2015	22814.30	7218.11	33504	275.03	4323.12	881.18	29564	248.87
DMU101	Southeast	2015	761638.92	138464.62	601090	6825.48	105201.19	97281.05	588294	4299.97
DMU102	Southeast	2015	104324.38	18235.75	123741	1460.28	11706.98	11706.98	100064	924.18
DMU103	Southeast	2015	26485.93	5367.24	44904	443.2	3674.6	1453.1	39628	359.68
DMU104	Southeast	2015	160453.32	28996.49	181404	1962.07	20368.74	19018.02	163621	1145.86
DMU105	Southeast	2015	12606.19	2524.15	20500	164.65	2022.95	2022.95	20962	141.11
DMU106	Southeast	2015	57217.35	10215.65	67532	690.46	8658.89	8658.89	70765	338.9
DMU107	Southeast	2015	16752.52	6115.77	31466	378.95	4848.12	1832	28920	298.06
DMU108	Southeast	2015	26666.88	4926.33	31136	784.25	3617.32	3213.04	29387	329.88

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU109	Southeast	2015	19076.41	6679.81	38487	535.52	5333.16	4653.5	37978	515.7
DMU110	Southeast	2015	12191.38	2889.14	24292	394.96	579.83	579.83	6450	95.79
DMU111	Southeast	2015	113992.21	27800.72	131129	1846.14	22240.58	1689.49	129015	1349.96
DMU112	Southeast	2015	18518.34	3734.35	23414	364.37	1298.26	1298.26	10159	178.2
DMU113	Southeast	2015	20860.10	4775.02	35383	476.31	3552.28	3552.28	33665	331.3
DMU114	Southeast	2015	6336.75	6530	19767	215	5367	7	15014	225
DMU115	Southeast	2015	92404.72	15261.38	127051	1779.46	11914.52	10978.73	126480	1252.88
DMU116	Southeast	2015	12192.88	5574.73	33885	443.39	4738.52	1617.4	33786	460.96
DMU117	Southeast	2015	24349.11	5733.87	28809	465.18	896	896	2680	52.22
DMU118	Southeast	2015	18488.05	3433.95	26403	275.19	2402.45	2325.96	24015	252.63
DMU119	Southeast	2015	12270.46	6283.01	36390	467.93	4994.05	3298.73	36128	429.41
DMU120	Southeast	2015	10134.06	3388	26672	431	2710	2628	26239	397
DMU121	Southeast	2015	8285.92	3102	17928	273.3	870	870	7900	85.5
DMU122	Southeast	2015	32314.98	9343	53690	1071.46	7942	1862.88	53248	965.35
DMU123	Southeast	2015	35962.85	6461.31	45831	632.77	5036.23	5036.23	46067	517.43
DMU124	Southeast	2015	75627.90	11944.74	94014	1009.2	7242.31	3974.18	73480	556.73
DMU125	Southeast	2015	45107.14	8033.18	58793	753.46	5007.59	3176.13	46284	350.01
DMU126	Southeast	2015	7007.94	1444.09	12153	158.2	541.81	541.81	6002	91.33
DMU127	Southeast	2015	15404.47	10734.24	38072	209.91	8919.59	347.59	33186	174.29
DMU128	Southeast	2015	5798.19	3874.44	17266	208.8	3099.55	15.92	17212	208
DMU129	Southeast	2015	62296.80	23952.81	104665	1299.61	19162.24	14563.3	104189	1276.91
DMU130	Southeast	2015	102071.49	50265.39	180899	3143	40815.49	40815.49	180899	2518
DMU131	Southeast	2015	11969.37	4548.54	21335	320.22	3548.2	2459.86	18895	260.58
DMU132	Southeast	2015	34767.23	6272.41	46223	454.8	4849.84	4599.53	46368	413.16
DMU133	Southeast	2015	29306.87	4029.12	31591	466.93	2508.9	2508.9	25182	158.24
DMU134	Southeast	2015	10469.74	3839	19995	270	3071.2	30.71	17163	219
DMU135	Southeast	2015	14181.88	4490	26332	367.17	3525	494	20490	234.06
DMU136	Southeast	2015	58212.54	11358.6	55285	622.26	8019.86	7897.15	50835	490.44
DMU137	Southeast	2015	81155.93	18255.41	90252	1241.97	4893.77	4172.71	28335	391.33
DMU138	Southeast	2015	13807.39	6730	26716	338	6175	334	23656	208
DMU139	Southeast	2015	22092.28	7466.97	30995	482.96	3326.71	3306.79	10250	264.24
DMU140	Southeast	2015	12657.81	7446.41	33454	460	5421.65	5152.36	22844	241.56
DMU141	Southeast	2015	10220.38	4681	36395	338.52	3506	21.49	21261	188.13

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU142	Southeast	2015	120787.87	41607.76	109894	1601.69	9596.15	7788.28	55313	772.74
DMU143	Southeast	2015	12389.50	3455.48	15753	258.9	1032.47	1032.47	6475	82.41
DMU144	Southeast	2015	82048.55	27051.61	94451	1321.3	12330.04	12330.04	25152	403.36
DMU145	Southeast	2015	80712.94	27732.18	57663	842.57	14408.59	14408.59	28127	369.12
DMU146	Southeast	2015	26400.66	18254	42518	389.83	6322.24	1074.78	21651	232
DMU147	Southeast	2015	64526.12	9795.25	43624	646.5	9737	300	37319	303.74
DMU148	Southeast	2015	56565.27	31607	83309	555.48	12166	10780.59	42215	418
DMU149	Southeast	2015	81706.00	9666.32	67976	1104	10952.52	10952.52	67976	44
DMU150	Southeast	2015	115401.19	16436.7	95991	1300.2	10885.96	10885.96	55452	751.4
DMU151	Southeast	2015	86635.39	61344	153394	1277.92	25447	4345	75820	675
DMU152	Southeast	2015	8467.21	4250	23566	90	680	232	4831	23
DMU153	Southeast	2015	250475.32	37951.8	88508	1305.7	42757.87	42757.87	69410	738.3
DMU154	Southeast	2015	57341.91	8650.8	39316	675.6	8174.38	7386.42	36570	417.7
DMU155	Southeast	2015	67814.80	12173	53825	732.2	12527.84	10052	44009	273.9
DMU156	Southeast	2015	30152.37	7088.4	34557	486	7088.39	4394.8	32657	383
DMU157	Southeast	2015	72347.93	6498	34305	121	1324.58	1324.58	15531	231
DMU158	Southeast	2015	1716216.73	760232	1067360	10352.52	455815.22	338008.67	796590	6254.23
DMU159	Southeast	2015	195888.55	135336	178048	1583	44451	8264	77736	711
DMU160	Southeast	2015	34638.11	4403.33	35140	449	3724.43	3724.43	35140	54
DMU161	Southeast	2015	14400.34	6725.11	23737	266.82	9115.3	292.15	17227	225.35
DMU162	Southeast	2015	41259.24	17882.3	78544	1018.37	14305.84	3147.74	71018	887.51
DMU163	Southeast	2015	35394.51	18517.78	79995	1470.5	15281.64	14336.47	77965	1353.95
DMU164	Southeast	2015	13713.09	3432.86	23500	326.4	3623.97	1627.05	20859	228.96
DMU165	Southeast	2015	7416.17	3388.73	21368	257.35	3320.96	3320.96	19759	207.69
DMU166	Southeast	2015	36788.47	13294.93	71166	673.29	13294.93	13294.93	78514	645.5
DMU167	Southeast	2015	61314.98	15793.32	96293	1380.32	20919.02	20919.02	96681	1152.13
DMU168	Southeast	2015	28782.04	4029.13	26080	375.6	1809.29	1755.01	15708	168.79
DMU169	Southeast	2015	25592.83	5798.05	37729	422.86	4853.91	4853.91	37464	379.33
DMU170	Southeast	2015	33382.71	5171.48	39936	397.27	3692.78	3224.36	25446	210.83
DMU171	Southeast	2015	19927.37	4679.03	32420	378.54	3909.72	3909.72	30983	347.92
DMU172	Southeast	2015	23270.08	8512.23	45132	580	8512.23	8512.23	45276	577.3
DMU173	Southeast	2015	85411.17	15769.99	74413	730.86	9033.68	3130.06	52627	390.79
DMU174	Southeast	2015	10724.53	5493.9	28779.0	705.0	5493.9	1813.0	28729.0	705.0

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU175	Southeast	2015	39281.84	4082.53	23968	290.87	1869.13	1869.13	10201	132.41
DMU176	Southeast	2015	16476.65	2790.56	17408	151.64	1877.52	1877.52	14932	68.41
DMU177	Southeast	2015	39450.77	8214.6	53780	608.02	6358.06	6358.06	50117	429.98
DMU178	South	2015	18932.78	4321.84	29690	464.96	1483.23	1483.23	10823	183.14
DMU179	South	2015	39447.63	6345.23	43957	560.45	3923.85	3923.85	28158	627.63
DMU180	South	2015	27682.21	5528.02	40708	616.52	3493.79	3493.79	24535	448.4
DMU181	South	2015	32729.77	6905.11	37610	637.07	2733.76	2733.76	20534	366.88
DMU182	South	2015	26564.19	5386.38	35720	347.8	4357.41	4357.41	29408	450.11
DMU183	South	2015	23562.75	4770.05	34917	639.8	2154.84	2154.84	16811	346.52
DMU184	South	2015	22538.63	4803.24	32362	412.06	3874.47	3874.47	25873	455.03
DMU185	South	2015	75813.59	14541.24	90338	1279.5	13018.19	13018.19	73469	1121.81
DMU186	South	2015	11241.63	2304.4	17912	255.53	1748.39	1748.39	13208	219.3
DMU187	South	2015	22313.57	3820.23	24447	592.59	2510.63	2510.63	14206	240.12
DMU188	South	2015	38051.05	9689.49	64298	893.45	4353.16	4353.16	32893	452.35
DMU189	South	2015	531578.98	106830.88	476452	7295.81	98016.24	97499.13	427283	6054.47
DMU190	South	2015	22230.70	4382.21	37089	528.74	2181.8	2181.8	19735	303.15
DMU191	South	2015	57031.72	15524.96	82884	1408.33	12366.03	12366.03	58680	1044.65
DMU192	South	2015	18456.23	3813.83	23839	484.74	2734.58	2734.58	14410	287.21
DMU193	South	2015	33829.57	7229.11	49968	871.97	5326.63	5326.63	37282	739.12
DMU194	South	2015	8335.11	3080.56	19909	360.78	2748.13	2748.13	17892	255.07
DMU195	South	2015	12328.86	2078.24	16738	368.6	1734.2	1734.2	14314	279.84
DMU196	South	2015	175918.51	40312.09	158328	1899.17	29766.48	29766.48	134334	1749.46
DMU197	South	2015	8149.56	3677.27	16866	543.68	270.52	270.52	2570	91.72
DMU198	South	2015	112645.75	22353.89	124877	1900.63	21527.84	21527.84	105052	1685.49
DMU199	South	2015	6960.70	1603.83	11987	208.72	1108.73	1108.73	8374	134.71
DMU200	South	2015	46872.99	5152	34744	628.36	3864	3246	17959	532.65
DMU201	South	2015	23606.41	4601.64	32632	686.3	3892.08	3892.08	26272	499.59
DMU202	South	2015	20457.97	4127.99	24803	534.51	3331.74	3331.74	18535	354.97
DMU203	South	2015	28334.73	6131.59	36783	591.46	4821.06	4821.06	29562	456.35
DMU204	South	2015	21297.42	4110.86	30225	499.02	3238.02	3238.02	23426	387.05
DMU205	South	2015	83468.95	15599.83	107065	1344.03	13403.34	13403.34	93856	1492.44
DMU206	South	2015	5551.82	989.67	9099	163.35	763.48	763.48	7016	165.79
DMU207	South	2015	13818.75	3162.29	22604	326.36	1691.7	1691.7	11215	217.19

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU208	South	2015	66559.91	13479.17	76878	1240.17	8134.35	8134.35	48273	718.29
DMU209	South	2015	17770.26	3568.87	23850	310.28	2674.72	2674.72	17771	243.93
DMU210	South	2015	28855.23	6209.44	40538	667.66	4845.91	4845.91	30238	609.97
DMU211	South	2015	29651.59	5722.58	37271	492.57	4831.05	4831.05	29232	503.58
DMU212	South	2015	11718.91	4310.26	16481	335.78	676.3	659.39	3542	89.05
DMU213	South	2015	32516.76	15967.36	24504	300	8564.21	8564.21	12114	300
DMU214	South	2015	87757.42	17064.11	86060	1564.5	4490	4304	20195	321
DMU215	South	2015	36883.31	7262.16	44331	673.11	2686.92	2686.92	12360	238.33
DMU216	South	2015	14205.45	2732.74	18128	281.82	135.35	135.35	975	3.8
DMU217	South	2015	183400.96	42619.95	100612	1374.35	16150	16150	37279	557.75
DMU218	South	2015	19248.20	4160.01	13785	266	1929.09	1929.09	4320	95.31
DMU219	South	2015	30275.90	8359.68	39607	696.36	3677.95	3677.95	21903	410.96
DMU220	South	2015	116744.35	32336.48	144165	2140	7223.7	7223.7	32489	538.8
DMU221	South	2015	23236.39	8221.33	47408	773.17	2825.7	2332.8	11266	147.92
DMU222	South	2015	16894.46	8810.81	43370	710	615.97	615.97	4980	71
DMU223	South	2015	15401.62	3708.61	25274	583	776.09	776.09	5877	137
DMU224	South	2015	50529.28	12550.96	49123	333.96	3962.48	3962.48	9257	152.45
DMU225	South	2015	20552.65	3272.07	22009	153.07	518.9	581.66	3644	24.49
DMU226	South	2015	44836.80	25780.32	50429	1185.45	1260.49	1484.87	11262	89.58
DMU227	South	2015	32677.61	8778.4	40343	476.52	3515.5	968.79	22019	294.41
DMU228	South	2015	21354.94	3856.91	25520	250.94	997.06	1304.03	7186	81.36
DMU229	South	2015	46020.45	18794	33300	328.68	2078.4	7855.81	17566	176.33
DMU230	South	2015	5882.66	867.47	7227	78.21	1400	368	10200	78
DMU231	South	2015	90323.52	18749.36	76907	844.88	2964.77	4781.8	13472	135.84
DMU232	South	2015	22327.59	4681.32	17481	290.11	1081.89	1713.89	2524	39.18
DMU233	South	2015	94909.90	24774.89	129827	1652.75	19819.91	9177.94	117247	1656.53
DMU234	South	2015	17441.73	3141.81	20141	224.31	406.09	438.92	2560	33
DMU235	South	2015	9290.98	2613.5	11131	167.58	50.6	8.89	421	7.2
DMU236	South	2015	19160.63	23544.22	20141	204.91	105.93	127.01	61	1.28
DMU237	South	2015	79423.19	10880.47	58774	697.62	2203.26	1720.98	18234	244.8
DMU238	South	2015	35978.09	10070.03	52978	863.22	749.28	749.28	1968	39.15
DMU239	South	2015	50318.04	10986.21	51572	797.99	1584.68	3373.65	5816	33.61
DMU240	South	2015	61003.35	16060.37	90226	938.84	7708.98	3083.59	48880	409.05

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU241	South	2015	313867.79	128661.85	292295	4095.73	78509.31	66395.08	234940	1926.51
DMU242	South	2015	66563.50	14145.85	57425	547.58	2265.55	3428.33	13279	110
DMU243	South	2015	32592.75	6178.9	34786	598.01	569.21	811.79	3336	50.71
DMU244	South	2015	67852.83	17951.53	62916	867.4	4865.82	7080.88	26609	240.34
DMU245	South	2015	14266.78	4800.57	23141	279.13	823.33	247	8862	97.24
DMU246	South	2015	20482.95	3581.82	20004	253.31	569.87	450.04	3053	41.57
DMU247	South	2015	12986.54	2474.43	15823	199.34	335.3	740.38	2321	49.64
DMU248	South	2015	51446.84	11409.96	61571	740	2634.99	2634.99	5334	100
DMU249	South	2015	26089.03	6750.17	33698	346.3	201.38	241.24	161	1.97
DMU250	South	2015	17867.33	3601.5	25058	390.4	551.13	1129.53	3154	46.87
DMU251	Center-West	2015	222211.23	52426.41	270628	3663	29163.37	29163.37	153570	1848
DMU252	Center-West	2015	45665.46	9651.73	64238	1185.43	4869.55	4869.55	34958	684.44
DMU253	Center-West	2015	8307.91	2613.43	17120	229.62	394.07	394.07	3660	53.7
DMU254	Center-West	2015	7829.19	2294.16	14668	244.63	205.32	205.32	1531	32.99
DMU255	Center-West	2015	13181.66	3151.14	21149	366.2	875.01	875.01	7893	214.53
DMU256	Center-West	2015	23441.67	6298.66	43748	731.03	2405.87	2405.87	19710	141.93
DMU257	Center-West	2015	6300.31	2138.51	13173	194.68	1013	1013	4100	101.61
DMU258	Center-West	2015	3864.54	3400	19782	297.8	860	860	6010	78
DMU259	Center-West	2015	8102.07	2650.27	17323	289.5	1706.91	1706.91	11641	194.75
DMU260	Center-West	2015	25205.74	13542.88	69053	954.37	5775.24	5105.42	39302	462.57
DMU261	Center-West	2015	4630.14	9978	28962	422.5	857	857	5900	90.9
DMU262	Center-West	2015	18595.52	11924	65435	1152.03	5613.91	2806.95	19381	136.5
DMU263	Center-West	2015	95716.15	16367.85	123227	2007.75	9890.09	9890.09	67347	658.8
DMU264	Center-West	2015	85174.49	15823.26	112958	1412.68	4281	3425	34040	528
DMU265	Center-West	2015	22238.99	4787.46	39643	454	2697.51	2697.51	21994	299
DMU266	Center-West	2015	12203.97	2824.15	26146	292.32	1088.75	1088.75	9433	52.55
DMU267	Center-West	2015	5785.84	1583.12	11582	129.82	509.8	509.8	3706	80.45
DMU268	Center-West	2015	22690.45	4413.09	34789	365.9	2515.23	2515.23	19290	235.26
DMU269	Center-West	2015	15117.90	2409.5	18233	292.43	2317.14	2317.14	17628	161.17
DMU270	Center-West	2015	742646.99	98674.29	508551	6025.02	67769.38	53482.85	381658	3567.72
DMU271	Center-West	2015	13072.19	2247.84	17393	246.38	1729.28	1729.28	12734	99.98
DMU272	Center-West	2015	24849.64	5424.5	33742	494.37	5632.66	5424.5	34018	266.44
DMU273	Center-West	2015	10001.58	1993.01	15375	228.08	480.61	480.37	3852	62.32

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU274	Center-West	2015	30892.69	4728.08	32929	422.63	3020	2949	21293	326
DMU275	Center-West	2015	27254.41	5740.59	45099	818.94	1513.44	1513.44	9246	100.76
DMU276	Center-West	2015	18408.88	3897.97	27327	307.23	866.64	866.64	5880	36.56
DMU277	Center-West	2015	16374.75	3684.87	31075	236.65	950.44	950.44	8856	69.04
DMU278	Center-West	2015	9528.33	1986.07	15012	204.4	2002.42	1975.22	14636	132.25
DMU279	Center-West	2015	51501.35	9188.75	62188	619.58	4233	3756	30722	337
DMU280	Center-West	2015	8542.63	2186.63	16612	192.98	1331.06	1331.06	9711	62.06
DMU281	Center-West	2015	26110.90	4860.17	39475	366.08	2085	2067	15724	218
DMU282	Center-West	2015	22826.18	5794.05	49341	294.5	2319.15	2319.15	16506	99.21
DMU283	Center-West	2015	1266624.45	160072	634092	8173.86	130577	130577	514281	6112.83
DMU001	North	2016	8858.04	4268.56	22443	525	1302.14	1302.14	11942	204
DMU002	North	2016	33011.44	12712.53	53323	1139.44	4354.32	4354.32	21851	533.47
DMU003	North	2016	269083.88	112534	400039	3712.81	26779.35	26779.35	52275	524.41
DMU004	North	2016	86465.83	17863.79	90043	1400.23	14500	12380	53299	794.93
DMU005	North	2016	204084.28	49097.02	221666	2027.21	2620.8	1310	30849	328
DMU006	Northeast	2016	9027.01	5924.8	39368	393.84	162.71	162.71	2252	59.05
DMU007	Northeast	2016	10975.36	12091.29	61662.00	543.22	9614.00	9114.00	15991.00	129.80
DMU008	Northeast	2016	303574.14	43955.83	193533	1962	30528.66	4852.22	101097	875
DMU009	Northeast	2016	195298.05	44020.69	263399	1619.1	6439.77	6439.77	44812	481.57
DMU010	Northeast	2016	2495.67	892.19	7119.00	98.89	106.54	106.54	1033.00	21.31
DMU011	Northeast	2016	3609.28	795.12	8439.00	46.49	140.33	140.33	1764.00	23.81
DMU012	Northeast	2016	3996.22	737.64	6392.00	131.89	341.22	341.22	3028.00	37.49
DMU013	Northeast	2016	4057.61	1820.82	15235.00	163.17	446.75	446.75	4279.00	57.13
DMU014	Northeast	2016	4297.14	1568.98	11290.00	98.54	158.39	158.39	1263.00	46.34
DMU015	Northeast	2016	1880.70	287.20	3487.00	57.88	103.89	103.89	1342.00	18.51
DMU016	Northeast	2016	2667.99	4212.0	15904.0	133.0	985.0	679.0	4572.0	85.0
DMU017	Northeast	2016	2336.23	1327.57	13269.00	109.30	151.64	151.64	2700.00	23.00
DMU018	Northeast	2016	4112.80	1240.16	12781.00	134.92	25.58	25.58	354.00	4.97
DMU019	Northeast	2016	31168.21	9639.87	88477.00	619.84	3424.30	3424.30	38989.00	306.08
DMU020	Northeast	2016	8964.86	1615.43	17860.00	151.55	601.60	601.60	8470.00	132.47
DMU021	Northeast	2016	5879.51	2137.20	14664.00	238.70	226.59	226.59	1761.00	35.56
DMU022	Northeast	2016	322257.80	102156.82	659630.00	4112.66	54337.36	54337.36	365267.00	2442.27
DMU023	Northeast	2016	6696.81	1755.66	19963.00	149.86	333.28	333.28	1840.00	12.73

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU024	Northeast	2016	2985.48	3402.00	13918.00	138.00	1479.00	1408.00	4851.00	49.00
DMU025	Northeast	2016	7950.20	4018.46	29020.00	386.52	948.43	948.43	4587.00	31.00
DMU026	Northeast	2016	12080.07	2899.12	23091.00	310.48	1286.58	1286.58	11334.00	56.91
DMU027	Northeast	2016	33389.19	11128.39	86260.00	688.77	2341.43	2341.43	22962.00	185.01
DMU028	Northeast	2016	6057.47	4093.74	20249.00	146.10	1039.39	1039.39	4323.00	70.30
DMU029	Northeast	2016	31747.32	8305.60	73675.00	571.33	4936.15	4936.15	31936.00	235.32
DMU030	Northeast	2016	8369.05	2764.32	27002.00	275.24	272.55	272.55	3681.00	71.67
DMU031	Northeast	2016	4741.53	2442.00	17124.00	506.00	60.00	60.00	337.00	4.00
DMU032	Northeast	2016	5245.46	1537.06	16986.00	152.03	321.17	321.17	766.00	2.83
DMU033	Northeast	2016	8587.22	2210.51	21523.00	193.58	904.64	904.64	11144.00	42.05
DMU034	Northeast	2016	9695.36	2145.78	18228	178.13	314.12	314.12	3771	74.2
DMU035	Northeast	2016	8709.86	1693.65	16499	153.82	448.91	448.91	4703	53.19
DMU036	Northeast	2016	25933.26	9127.48	61256	602.53	4413.34	4413.34	41728	420
DMU037	Northeast	2016	4090.97	1084.67	11110	90.4	103.49	103.49	1571	19.09
DMU038	Northeast	2016	9837.16	1852.95	20008	185.19	403.92	403.92	5850	70.44
DMU039	Northeast	2016	1330.23	309.52	3403	47.6	45.57	45.57	592	6.1
DMU040	Northeast	2016	10829.03	2303.15	20298	180.71	165.86	165.86	1685	10.37
DMU041	Northeast	2016	4321.73	3427.82	19468	185.5	420.58	418.87	4150	42.8
DMU042	Northeast	2016	7625.17	1787.72	12005	191.81	105.31	105.31	742	21.53
DMU043	Northeast	2016	48557.03	11404.65	75649	400.09	4885.11	4885.11	31939	211.67
DMU044	Northeast	2016	139580.62	38347.1	212362	1611.47	15273.98	11119.46	74518	869.38
DMU045	Northeast	2016	7866.93	3879.08	15135	77.06	874.07	874.07	1035	8.75
DMU046	Northeast	2016	12235.49	2081.01	18516	168.94	499.61	499.61	3298	23.92
DMU047	Northeast	2016	88321.04	14401.36	122247	681.82	14385.65	14385.65	101299	353.52
DMU048	Northeast	2016	15334.05	2465.29	17508	130.7	1528.93	1528.93	10677	56.35
DMU049	Northeast	2016	217805.12	43292.68	248597	1020.22	34105.61	34105.61	130246	638.14
DMU050	Northeast	2016	25583.86	4542.41	32096	204.28	411.05	411.05	2746	11.12
DMU051	Northeast	2016	5687.40	1073.67	10008	88.29	403.75	403.75	3478	17.27
DMU052	Northeast	2016	5136.08	2440.8	24293.0	215.4	888.3	888.3	6400.0	82.1
DMU053	Northeast	2016	8492.69	1568.47	19877	164.03	91.81	91.81	1123	10.66
DMU054	Northeast	2016	24283.59	20962.45	43388	467.49	751.92	751.92	5344	49
DMU055	Northeast	2016	7283.43	3398.04	29607	323.68	72.26	72.26	629	7.26
DMU056	Northeast	2016	48281.45	10076.55	99843	886.4	4702.07	4702.07	44158	369.17

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU057	Northeast	2016	13256.13	4950.42	42054	336.41	400.25	400.25	4052	35.35
DMU058	Northeast	2016	11049.67	3620.91	28499	323.36	44.21	44.21	347	6.31
DMU059	Northeast	2016	16146.91	2240.58	23505	264.33	84.24	84.24	1062	7.25
DMU060	Northeast	2016	54659.36	20745.07	114106	1130.72	2824.91	2824.91	22304	227.49
DMU061	Northeast	2016	3065.83	1186.79	14527	136.15	384.34	384.34	5352	75.11
DMU062	Northeast	2016	44177.70	9956.85	88090	787.27	5133.01	5133.01	34507	464.49
DMU063	Northeast	2016	24000.50	7824.6	78277	1260.57	3483.99	3212.24	34935	544.39
DMU064	Northeast	2016	33046.52	11232.92	85902	734.35	7617.4	7617.4	58837	535.35
DMU065	Northeast	2016	441760.81	54432.24	283914	3363.01	40264.56	40143.77	97601	1528.68
DMU066	Northeast	2016	6602.61	2179.51	20501	220.15	353.67	353.67	2760	24
DMU067	Northeast	2016	14665.45	3575.01	31897	301.12	990.93	990.93	11991	99.58
DMU068	Northeast	2016	211525.57	28771.59	135319	1444	26496.56	26496.56	41159	407.53
DMU069	Northeast	2016	250583.37	35690.76	191285	1573.07	18221.59	18221.59	93332	687.7
DMU070	Northeast	2016	31374.22	5150.25	40540	413.43	2131.54	2131.54	14370	173.09
DMU071	Northeast	2016	25935.78	6573.27	47776	647.27	2780.65	2780.65	25658	256.65
DMU072	Northeast	2016	5030.32	2236	17809	185	1186	1186	8025	165
DMU073	Northeast	2016	10541.65	2647.88	20684	380.36	170.9	170.9	1785	9.1
DMU074	Northeast	2016	58282.49	12648.95	76449	1069.92	2130.38	2130.38	24060	138.96
DMU075	Northeast	2016	26835.10	3819.56	25415	166.77	1221.01	1221.01	10687	53.87
DMU076	Northeast	2016	14351.95	2002.86	17075	211.22	1507.54	1507.54	9289	75.08
DMU077	Northeast	2016	12452.18	3929.71	31212	315.97	257.38	257.38	2616	13.33
DMU078	Northeast	2016	106033.65	19215.58	168322	2205.65	15433.36	15433.36	109398	596.85
DMU079	Northeast	2016	34024.57	5874.72	44612	596.56	3772.06	3772.06	25955	137.26
DMU080	Northeast	2016	7087.75	1442.73	15221	133.85	99.45	99.45	1089	10.5
DMU081	Northeast	2016	14034.93	2843.99	26328	413.95	434.48	434.48	4461	18.88
DMU082	Northeast	2016	10440.26	2217.2	21936	236.63	253.19	253.19	2609	17.3
DMU083	Northeast	2016	26321.88	11576.42	52588	434	9410	3042	36294	339
DMU084	Northeast	2016	6117.53	3856.4	22453.0	183.1	2019.2	493.1	21050.0	137.7
DMU085	Northeast	2016	31842.99	5440.98	50883	489.18	5102.01	5102.01	46402	453.79
DMU086	Northeast	2016	22696.45	21250.57	60569	482	5379	4796	40781	219
DMU087	Northeast	2016	42553.99	10663.43	45704	431.2	9980.74	9980.74	19105	493.07
DMU088	Northeast	2016	17517.78	4726.98	31860	272.58	1436.24	1436.24	10850	147.64
DMU089	Northeast	2016	24778.21	4057.21	31731	359.21	4012.2	4012.2	28988	180

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU090	Northeast	2016	775925.15	129195.22	499119	5358.67	144408.03	144408.03	496948	3506.06
DMU091	Northeast	2016	14485.54	1590.31	16933	110.6	830.74	830.74	7929	54.64
DMU092	Northeast	2016	15574.18	3770.36	34194	291.9	631.4	631.4	6746	42.73
DMU093	Northeast	2016	12844.68	6745.93	24344	227.44	249.24	249.24	2336	19
DMU094	Northeast	2016	24874.22	4970.19	26583	203.15	4520.19	4520	10543	233.2
DMU095	Northeast	2016	19156.86	4719.23	38443	430.43	1510.1	1510.1	14870	207
DMU096	Northeast	2016	56652.35	11395.38	94166	1187.65	9599.04	9599.04	75568	665.05
DMU097	Southeast	2016	22061.59	4076.09	30480	321.38	3157.89	3125.95	30177	313.81
DMU098	Southeast	2016	9304.39	15305.7	40906	482.89	12244.54	449	40018	471.91
DMU099	Southeast	2016	27801.48	5471.32	39122	644.57	4213.89	4213.89	38781	317.16
DMU100	Southeast	2016	25426.12	6411.86	32628	280.61	4506.73	1045.32	29072	250.76
DMU101	Southeast	2016	732874.91	139616.94	602825	6837.51	106553.41	100743.42	601081	4393.25
DMU102	Southeast	2016	105254.95	17848.54	124572	1479.32	11533.36	11533.36	103068	1003.69
DMU103	Southeast	2016	28958.85	5449.35	46078	444.08	3733.41	1987.42	40726	359.94
DMU104	Southeast	2016	161421.78	29589.32	182675	1966.34	21018.66	19117.04	167359	1214.61
DMU105	Southeast	2016	13060.54	2542.93	21183	164.96	2031.32	2031.32	21840	141.2
DMU106	Southeast	2016	58160.69	10187.72	68793	691.2	8602.49	8602.49	72845	558.92
DMU107	Southeast	2016	15874.73	4908.17	31330	384.2	4171.94	1588.03	28740	308.44
DMU108	Southeast	2016	25182.68	4964.31	31742	787.83	3618.38	3226.78	29888	333.09
DMU109	Southeast	2016	20815.55	6706.38	38603	536.95	5354.37	4309.74	38115	517.76
DMU110	Southeast	2016	12145.77	2938.45	24655	398.86	615.13	615.13	6672	101.67
DMU111	Southeast	2016	116678.23	28249.51	133103	1850.89	22599.6	1943.65	130937	1355.87
DMU112	Southeast	2016	17744.48	3710.53	24096	491.55	1323.99	1323.99	10765	207.96
DMU113	Southeast	2016	26454.23	4916.94	36336	505.79	3674.32	3674.32	35013	368.3
DMU114	Southeast	2016	7640.96	5194.36	20113	220	4465	7.2	15308	220
DMU115	Southeast	2016	96488.88	15135.28	130342	1786.24	11763.71	11763.71	130807	1260.6
DMU116	Southeast	2016	14511.96	5632.23	34134	452.84	4787.4	1624.1	34062	470.45
DMU117	Southeast	2016	23193.39	5830.92	29197	469.86	956.16	956.16	2921	62.16
DMU118	Southeast	2016	17908.61	3491.94	27123	280.3	2460.4	2392.68	24906	263.56
DMU119	Southeast	2016	13744.72	6515.02	37038	487.34	5212.01	3583.22	36781	443.58
DMU120	Southeast	2016	9951.53	3566	27286	448	2853	2767	26991	398
DMU121	Southeast	2016	9035.94	3372	18002	279.2	1140	1140	6940	85.5
DMU122	Southeast	2016	32320.54	9830.81	54550	1072.27	8356.18	1960.03	53831	967

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU123	Southeast	2016	37600.22	6563.41	47443	637.36	5094.01	4377.11	47622	521.14
DMU124	Southeast	2016	72973.98	12230.56	94356	1054.22	7549.17	2369.35	75938	639.04
DMU125	Southeast	2016	46538.54	8206.71	59521	764.19	5159.82	4367.52	47626	351.74
DMU126	Southeast	2016	7486.98	1457.92	12451	159.35	575.4	575.4	6221	91.6
DMU127	Southeast	2016	14661.43	10741.96	38277	209.95	8926.35	354.35	33405	174.81
DMU128	Southeast	2016	5325.58	4046.79	17922	254.01	3526.22	11.09	17861	219.76
DMU129	Southeast	2016	59303.22	24259.92	104881	1429.57	19405.48	14748.16	104427	1404.6
DMU130	Southeast	2016	107101.43	55101.39	181704	3206	42119.52	42119.52	178797	2571
DMU131	Southeast	2016	11831.13	4170.91	21858	433.66	3565.01	2465.21	19317	273.93
DMU132	Southeast	2016	35278.26	6478.71	47545	456.69	4999.53	4999.53	47728	413.4
DMU133	Southeast	2016	30175.54	4140.74	31803	499.78	2657.84	2657.84	26221	226.71
DMU134	Southeast	2016	7243.21	3972	20128	273	3178	31.78	18418	209
DMU135	Southeast	2016	14843.39	4123.17	28807	374.3	3298.53	461	21720	236.06
DMU136	Southeast	2016	58971.04	11106.57	55777	633.71	6963.47	6856.93	51285	500.94
DMU137	Southeast	2016	80774.52	17357.61	90303	1255.22	5005.62	3974.68	29593	382.99
DMU138	Southeast	2016	14262.82	5762	27353	338	6594	356	24310	208
DMU139	Southeast	2016	23829.59	7338.02	31103	486.3	3668.59	3668.59	12919	264.62
DMU140	Southeast	2016	12645.38	7422.44	34189	460	5601.81	5321.72	23882	241.56
DMU141	Southeast	2016	9865.94	3484.36	35692	341.42	2489	21.49	20402	188.23
DMU142	Southeast	2016	117112.77	37655.4	110586	1691.45	11666.58	9894.37	67048	848
DMU143	Southeast	2016	13792.59	3379.33	15784	261.66	1079.98	1079.98	6337	96.82
DMU144	Southeast	2016	88121.06	26405.4	96081	1339.08	12195.5	12195.41	28876	398.57
DMU145	Southeast	2016	77642.62	25655.35	57683	850.89	17106.76	17106.76	32127	456.38
DMU146	Southeast	2016	25210.67	18104.75	42356	460.37	5961.54	598.57	20416	232
DMU147	Southeast	2016	35175.64	7609.06	45770	648.35	9900	300	38161	674
DMU148	Southeast	2016	56790.94	31798	83309	557.97	12183	10782	42274	418
DMU149	Southeast	2016	79448.51	9554.59	71326	1122	8816.18	8816.18	71326	38
DMU150	Southeast	2016	105906.01	17529.2	97901	1315	10864.74	10864.74	56151	776
DMU151	Southeast	2016	92081.72	61851	153467	1299.9	25577	2404	76208	675
DMU152	Southeast	2016	8090.55	4038	23581	95.04	681	236	4841	23
DMU153	Southeast	2016	241313.31	37561.81	88730	1308.6	41846.4	41846.4	70667	748.4
DMU154	Southeast	2016	54107.77	8034.4	40859	695.7	7124.9	6673.8	37871	421.2
DMU155	Southeast	2016	59568.92	9522.05	56764	765	12575.14	10099.3	44104	277

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU156	Southeast	2016	32345.18	7082.1	35926	487	7077.7	4390.82	33979	390
DMU157	Southeast	2016	41034.18	5968	34630	119.88	1587.39	1587.39	15581	232
DMU158	Southeast	2016	1775618.15	768528	1073813	10891.2	449063.98	342099.71	819368	6665.05
DMU159	Southeast	2016	193253.61	128570	178451	1677.24	44540	9295	77891	720
DMU160	Southeast	2016	33164.34	4337.38	36586	452	3308.22	3308.22	36586	54
DMU161	Southeast	2016	16016.38	6725.11	23968	400.3	9230	292.15	17277	411.3
DMU162	Southeast	2016	44076.05	18669.62	77900	1038.08	14935.7	2789.1	69856	898
DMU163	Southeast	2016	49621.12	18465.74	80690	1472	15435.14	6399.42	78708	1356.4
DMU164	Southeast	2016	13735.15	3441.76	23546	326.4	2982.01	2069.27	21129	228.96
DMU165	Southeast	2016	8292.38	3335.55	21426	258.86	4185.24	4185.24	20082	209.59
DMU166	Southeast	2016	33822.49	13732.25	72368	695.7	13732.25	13732.25	80122	664.52
DMU167	Southeast	2016	62827.40	16191.75	98725	1412.93	14898.1	14898.1	99113	1178.67
DMU168	Southeast	2016	22874.47	4323.01	26577	385.57	1982.6	1982.6	16684	178.6
DMU169	Southeast	2016	22751.42	5961.57	38088	432.38	5919.74	5919.74	37841	382.15
DMU170	Southeast	2016	32076.86	5653.57	40360	403.41	5034.89	3714.91	25523	222.86
DMU171	Southeast	2016	19825.14	4823.36	33001	379.29	4814.16	4814.16	31723	348.64
DMU172	Southeast	2016	23361.24	8376.53	47167	598	8376.53	8356.53	46642	595.2
DMU173	Southeast	2016	79288.27	16896.02	77424	745.85	9964.92	3786.67	57277	407.82
DMU174	Southeast	2016	12671.42	5488.5	29714.0	716.0	5488.5	2085.6	29679.0	716.0
DMU175	Southeast	2016	23544.99	4219.84	24756	323.08	2320.14	2320.14	10952	220.48
DMU176	Southeast	2016	16558.95	2821.14	17972	153.06	2066.23	2066.23	15388	69.53
DMU177	Southeast	2016	37427.60	8368.33	54251	636.14	7646.36	7646.36	50632	455.85
DMU178	South	2016	20475.35	4265.98	29730	472.57	1546.58	1546.58	12443	238.83
DMU179	South	2016	37387.28	6315.06	44474	590.66	4511.81	4511.81	32133	645.72
DMU180	South	2016	29389.18	5508.19	41166	619.34	3547.93	3547.93	24976	452.24
DMU181	South	2016	31423.45	6912.56	38119	652.29	3303.45	3303.45	22280	393.66
DMU182	South	2016	28489.75	5422.5	36207	358.95	4476.09	4476.09	31104	474.08
DMU183	South	2016	27184.11	4807.18	35280	647.4	2502.05	2502.05	19450	462.99
DMU184	South	2016	23980.21	4846.74	34010	430.61	4082.12	4082.12	27885	482.66
DMU185	South	2016	78654.84	14764.59	91881	1348.38	13961.16	13961.16	80889	1336.88
DMU186	South	2016	11533.86	2327.58	18899	275.59	1790.18	1790.18	14312	231.06
DMU187	South	2016	21558.77	3857.42	24514	601.76	2531.83	2531.83	14315	240.37
DMU188	South	2016	39661.04	9813.81	64391	930.61	5009.17	5009.17	38258	534.31

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU189	South	2016	535926.18	107527.42	478832	7327.52	99922.61	99922.61	434683	6131.34
DMU190	South	2016	22368.69	4616.44	39624	541.27	2413.31	2413.31	21625	322.86
DMU191	South	2016	70626.26	15809.27	84092	1423.97	12456.83	12456.83	59699	1072.1
DMU192	South	2016	20116.98	3938.14	24398	504.12	2803.42	2803.42	14654	296.96
DMU193	South	2016	36710.59	7379.64	50875	925.19	5704.46	5704.46	39025	749.09
DMU194	South	2016	8700.41	3082.81	20080	367.78	2737.63	2737.63	17988	262.07
DMU195	South	2016	12631.78	2096.4	16992	375.43	1754.07	1754.07	14727	294.11
DMU196	South	2016	192029.29	41357.54	159139	1970.87	30365.35	30365.35	137232	1778.24
DMU197	South	2016	9378.77	3787.02	17220	568.52	405.66	405.66	3486	105.16
DMU198	South	2016	129108.76	21959.58	125622	1912.21	21756.63	21756.63	107324	1723.66
DMU199	South	2016	7540.86	1649.78	12351	221.6	1155.48	1155.48	8518	139.47
DMU200	South	2016	49514.33	4924.49	34463	631.84	3693	3102	19471	534.14
DMU201	South	2016	26454.11	4736.14	33388	705.03	3934.62	3934.62	26600	517.15
DMU202	South	2016	22909.50	4278.49	25406	576.7	3477.26	3477.26	19156	373.72
DMU203	South	2016	27108.34	6133.71	37021	604.82	4915.1	4915.1	30004	459.76
DMU204	South	2016	21654.40	4249.49	30663	514.18	3420.52	3420.52	24005	397.69
DMU205	South	2016	85056.25	15896.57	110029	1415.93	13783.55	13783.55	97328	1535.96
DMU206	South	2016	5653.56	1025.91	9299	172.7	797.39	797.39	7157	167.29
DMU207	South	2016	14727.78	3118.9	22914	336.97	1659.61	1659.61	11357	226.35
DMU208	South	2016	65077.36	13591.73	77628	1285.01	8692.98	8692.98	49714	758.23
DMU209	South	2016	18877.80	3505.4	24111	323.09	2701.11	2701.11	18796	254.99
DMU210	South	2016	29311.23	6375.28	41560	723.42	4988.6	4988.6	31104	648.05
DMU211	South	2016	32193.73	5780.69	38288	494.19	5118.19	5118.19	31911	529.63
DMU212	South	2016	12760.16	4350.95	16721	337.14	701.3	701.3	3905	89.12
DMU213	South	2016	40939.14	19069	26428	300	12909.6	12909.6	21922	300
DMU214	South	2016	84241.82	18870.01	88818	1562.5	5403	5073	23810	367
DMU215	South	2016	43676.72	7727.57	44690	684.5	3118.09	3118.09	12454	239.49
DMU216	South	2016	14369.63	2847.84	18443	293.39	67.18	67.18	1001	3.8
DMU217	South	2016	208164.35	45537.33	103675	1378.61	13972.38	13972.38	40063	647.17
DMU218	South	2016	20815.09	4349.31	14088	281.97	1985.29	1985.29	4688	105.6
DMU219	South	2016	32154.51	8422.22	40226	703.5	4752.36	4752.36	27569	423.3
DMU220	South	2016	115759.34	33053.83	146447	2148.61	7420.58	7420.58	33045	542.3
DMU221	South	2016	31664.42	8688.54	47705	778.88	2913.38	1146.21	10615	149.72

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU222	South	2016	16665.44	8845.5	45750	710	778.6	778.6	5326	71
DMU223	South	2016	15562.43	3826.6	25716	587	851.23	851.23	6087	137
DMU224	South	2016	58456.40	13320.32	50059	334.68	8652.92	8652.92	9670	97.95
DMU225	South	2016	17796.16	2976.26	22110	153.08	576.33	574.46	3881	24.49
DMU226	South	2016	41488.79	26529.44	50539	599.95	1360.89	1185.12	13469	89.58
DMU227	South	2016	41262.84	7075.94	40577	476.52	3687.9	1141.19	22246	297.27
DMU228	South	2016	18578.17	3529.84	25741	250.95	1003.44	1169.8	7313	81.36
DMU229	South	2016	33530.91	18289.54	33851	329.54	2250.68	8110.66	19008	176.33
DMU230	South	2016	5642.73	792.23	7285	78.21	1400	368	10300	80
DMU231	South	2016	79522.49	16696.52	77290	844.89	3326.06	6043.02	14933	135.84
DMU232	South	2016	19515.53	4729.28	17922	359.65	1166.47	1782.74	2753	39.18
DMU233	South	2016	95043.27	25357.7	132102	1718.58	20286.16	9726.8	118855	1710.13
DMU234	South	2016	14577.45	2803.12	20232	224.32	419.61	447.49	2733	33
DMU235	South	2016	9095.12	2400.79	11416	167.59	50.35	12.36	412	7.2
DMU236	South	2016	17839.74	22269.81	20088	204.91	107	85.11	111	1.28
DMU237	South	2016	63887.89	9312.48	59057	700.62	2338.28	1265.39	19349	244.8
DMU238	South	2016	35016.89	10290.13	52956	867.2	708.9	708.9	2002	39.15
DMU239	South	2016	45415.62	9923.2	52262	798.91	1712.89	3362.28	6668	33.61
DMU240	South	2016	61881.49	19626.09	86958	941.64	9420.52	3768.21	48570	414.85
DMU241	South	2016	320837.50	119131.19	295810	4119.17	75296.6	63675.47	240231	1947.9
DMU242	South	2016	54611.23	11256.29	57639	547.58	2288.44	3085.88	13796	110
DMU243	South	2016	30828.17	5799.6	35984	598.02	673.75	811.59	4395	50.71
DMU244	South	2016	57474.25	14323.08	63115	876.46	4956.35	7401.36	27729	240.34
DMU245	South	2016	14823.86	3435.04	23364	280.15	853.56	256.07	8942	98.53
DMU246	South	2016	18430.74	3391.35	20303	253.31	611.16	412.93	3384	41.57
DMU247	South	2016	10570.71	2222.13	15979	199.35	340.46	627.86	2427	49.64
DMU248	South	2016	52053.23	11461	61633	745.17	2640.66	2640.66	5438	122.33
DMU249	South	2016	26564.98	6116.95	33487	346.3	236.72	231.89	241	1.97
DMU250	South	2016	16853.07	2910.83	25696	394.7	576.43	1376.97	3277	46.87
DMU251	Center-West	2016	211002.52	51305.71	275124	3906	29952.57	29952.57	161476	2111
DMU252	Center-West	2016	54619.21	10120.69	66515	1194.65	5640.18	5640.18	39695	684.6
DMU253	Center-West	2016	9794.49	2597.08	17568	230.12	565.42	565.42	4447	95.82
DMU254	Center-West	2016	8891.50	2387.6	15836	301.67	214.83	214.83	1555	32.99

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU255	Center-West	2016	15334.60	3197.52	22636	369.07	1275.56	1275.56	10553	214.53
DMU256	Center-West	2016	27396.28	6652.74	46186	733.79	2775.61	2775.61	22534	142.14
DMU257	Center-West	2016	7143.74	2187.45	13664	203.73	1154.74	1154.74	4286	107.55
DMU258	Center-West	2016	3948.15	3252.19	20621	329	1016	1016	6025	80
DMU259	Center-West	2016	9571.84	3197.76	17605	295.72	2543.07	2543.07	11988	202.19
DMU260	Center-West	2016	30347.01	13542.88	70566	1056.61	5728.43	5459.79	48673	567.84
DMU261	Center-West	2016	5681.16	10548	30877	355.15	968	968	7383	95.82
DMU262	Center-West	2016	20889.19	10464.66	68604	1163.1	5703.14	3703.24	19420	136.5
DMU263	Center-West	2016	97939.10	16448.74	127569	2008.89	9967.46	9967.46	70293	661.54
DMU264	Center-West	2016	75874.48	16135.56	120022	2280.26	5114.21	4328.68	37471	449.68
DMU265	Center-West	2016	25182.29	4452	40697	456	3931.64	3931.64	22422	300
DMU266	Center-West	2016	13626.44	2862.88	27634	294.03	1068.98	1068.98	9590	52.55
DMU267	Center-West	2016	6836.58	1592.64	11936	131.96	516.33	516.33	3838	80.45
DMU268	Center-West	2016	25507.64	4385.35	35971	365.9	3009.97	3009.96	26882	235.26
DMU269	Center-West	2016	15135.99	2452.19	19318	292.6	2440.14	2440.14	18505	161.17
DMU270	Center-West	2016	629062.55	97233.6	525742	6638.65	67341.71	55125.91	401500	3690.67
DMU271	Center-West	2016	13437.20	2261.42	18286	246.38	1754.87	1754.87	13380	99.98
DMU272	Center-West	2016	24845.76	5620	35055	594.37	5881.07	5609.95	35679	266.44
DMU273	Center-West	2016	8838.29	1929.91	15538	227.35	480.64	480.51	4028	62.32
DMU274	Center-West	2016	31130.20	4858.22	35131	541.76	3492.37	3492.37	24212	318.2
DMU275	Center-West	2016	31112.72	5828.69	47692	872.87	1501.26	1501.26	9539	100.81
DMU276	Center-West	2016	19033.10	3792.73	27997	310	875.86	875.86	5970	36.56
DMU277	Center-West	2016	18187.17	3677.15	33238	236.65	1302.96	1302.95	14121	69.04
DMU278	Center-West	2016	10326.91	2088	15409	204.6	2087.62	2087.62	16030	132.45
DMU279	Center-West	2016	50181.88	9254	64017	620.27	5185.9	5182.91	33421	273.77
DMU280	Center-West	2016	10426.85	2141.74	17822	200.71	1266.37	1266.37	10274	62.54
DMU281	Center-West	2016	26208.95	4967.6	41867	369.76	2188.36	2188.36	19018	220.11
DMU282	Center-West	2016	26787.49	6136.04	54189	326.13	2471.4	2471.4	18171	106.92
DMU283	Center-West	2016	1262676.00	161595	643032	8534.49	135296	135296	529358	6377.11
DMU001	North	2017	9347.04	4349.05	23706	528	1483.76	1483.76	15621	228
DMU002	North	2017	33159.77	12864.51	54358	1139.57	4329.95	4329.95	21693	534.32
DMU003	North	2017	297077.84	53152	415934	3765.78	25286.8	25286.8	63604	529.2
DMU004	North	2017	92163.05	19590.91	91017	1403.96	14776	14776	59847	882.83

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU005	North	2017	230097.78	52264.66	224020	2127	2004.75	405.22	31773	294
DMU006	Northeast	2017	14050.96	6789	40035	395.65	396.28	396.28	2234	59.05
DMU007	Northeast	2017	13994.21	12041.36	63719.00	581.32	4364.55	4364.55	20875.00	136.50
DMU008	Northeast	2017	291779.97	42827.21	194561	1777.32	30666.26	6753.04	90162	788.76
DMU009	Northeast	2017	213960.51	47033.83	264862	2498	7454.18	7454.18	48719	499
DMU010	Northeast	2017	2892.74	875.33	7191.00	100.32	104.69	104.69	1015.00	21.38
DMU011	Northeast	2017	4178.18	730.53	8449.00	48.82	129.59	129.59	1767.00	23.81
DMU012	Northeast	2017	4450.58	688.77	6333.00	144.15	316.38	316.38	3014.00	37.53
DMU013	Northeast	2017	9304.94	1675.22	15162.00	163.20	444.45	444.45	4321.00	57.13
DMU014	Northeast	2017	4538.52	1521.55	11794.00	98.54	160.57	160.57	1853.00	46.34
DMU015	Northeast	2017	2170.70	296.04	3450.00	58.45	103.18	103.18	1342.00	18.51
DMU016	Northeast	2017	2538.16	5020.0	17160.0	145.0	1506.0	1003.5	4646.0	85.5
DMU017	Northeast	2017	2558.23	1477.60	14042.00	109.30	153.13	153.13	2721.00	23.00
DMU018	Northeast	2017	4355.77	1160.45	12656.00	136.31	26.09	26.09	348.00	4.98
DMU019	Northeast	2017	29676.36	9599.19	88905.00	623.59	3585.73	3585.73	40251.00	306.76
DMU020	Northeast	2017	11892.35	1499.60	17849.00	176.00	593.73	593.73	8956.00	132.47
DMU021	Northeast	2017	6909.17	2054.49	14773.00	242.83	208.44	208.44	1782.00	34.92
DMU022	Northeast	2017	384162.55	96248.77	654835.00	4135.68	53941.02	53941.02	379091.00	2531.39
DMU023	Northeast	2017	7468.21	1583.83	18660.00	150.96	358.42	358.42	1903.00	12.73
DMU024	Northeast	2017	3039.65	3500.00	13865.00	138.00	1480.00	1409.00	4733.00	49.00
DMU025	Northeast	2017	8986.52	3806.70	29868.00	394.25	495.29	495.29	4559.00	31.00
DMU026	Northeast	2017	13902.49	2922.71	23294.00	310.48	1292.41	1292.41	11248.00	56.91
DMU027	Northeast	2017	37651.98	10754.47	87362.00	709.24	2341.61	2341.61	24234.00	185.01
DMU028	Northeast	2017	5583.94	5117.31	20074.00	176.80	1268.06	1268.06	5394.00	70.30
DMU029	Northeast	2017	35941.39	7970.32	73137.00	577.92	4927.88	4927.88	34638.00	235.32
DMU030	Northeast	2017	15382.86	2568.05	27157.00	275.71	311.10	311.10	3882.00	73.55
DMU031	Northeast	2017	5221.77	2600.00	17490.00	515.00	60.00	60.00	335.00	4.00
DMU032	Northeast	2017	5374.84	1393.10	15772.00	152.03	317.60	317.60	766.00	2.84
DMU033	Northeast	2017	8409.88	2158.12	19828.00	198.75	901.02	901.02	11344.00	42.05
DMU034	Northeast	2017	12258.68	1958.32	18224	190.87	304.73	304.73	3763	83.56
DMU035	Northeast	2017	9542.58	1627.65	16864	158.32	431.58	431.58	5317	53.19
DMU036	Northeast	2017	20410.89	8778.13	63069	656.43	4343.99	4343.99	43694	462
DMU037	Northeast	2017	4377.29	1133.57	11238	97.21	117.76	117.76	1639	19.09

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU038	Northeast	2017	10367.53	1875.38	20283	191.09	423.91	423.91	5818	70.44
DMU039	Northeast	2017	1522.05	338.1	3768	52.55	46.09	46.09	561	6.1
DMU040	Northeast	2017	9584.60	1995.05	14981	244.1	148.1	148.1	1656	10.5
DMU041	Northeast	2017	4754.24	5294	19954	191.5	377.16	372.54	4079	42.8
DMU042	Northeast	2017	8593.97	1942.45	14402	195.21	248.75	248.75	738	21.53
DMU043	Northeast	2017	53433.46	11233.66	68597	900	4961.04	4961.04	30789	211.67
DMU044	Northeast	2017	182337.41	36379.86	201930	1601.67	15107.81	15107.81	71892	964.01
DMU045	Northeast	2017	6885.44	4838.74	15473	77.65	761.85	761.85	1047	8.75
DMU046	Northeast	2017	11923.02	1953.97	19379	169.29	315.89	315.89	3097	23.92
DMU047	Northeast	2017	86412.80	14940.78	124707	701.12	10448.03	10448.03	103131	372.11
DMU048	Northeast	2017	14863.74	2447.63	17810	130.84	1129.85	1129.85	10820	56.5
DMU049	Northeast	2017	201201.64	45885.28	205030	1024.74	29903.07	29903.07	134582	645.14
DMU050	Northeast	2017	24796.97	4279.93	33576	209.67	390.56	390.56	4494	14.31
DMU051	Northeast	2017	4841.59	1078.73	9915	88.29	263.88	263.88	3478	17.27
DMU052	Northeast	2017	5282.08	2577.1	24530.0	220.3	946.9	946.9	6386.0	83.0
DMU053	Northeast	2017	9895.07	2002.24	21000	193.57	131.78	131.78	1113	11.26
DMU054	Northeast	2017	25902.11	21157.53	45202	532.66	811.35	811.35	5340	49
DMU055	Northeast	2017	7356.20	3759.66	29684	339.09	133.81	133.81	595	7.34
DMU056	Northeast	2017	47852.21	10160.43	105215	948.62	4818.86	4818.86	48422	431.17
DMU057	Northeast	2017	14593.13	5124.59	43233	406.81	525.74	525.74	5115	47.09
DMU058	Northeast	2017	13333.45	3829.86	29024	323.36	74.17	74.17	346	6.52
DMU059	Northeast	2017	22144.94	2447.75	24063	293.6	160.07	160.07	1027	17.12
DMU060	Northeast	2017	51662.85	20754.02	115302	1156.34	3096.23	3096.23	22159	360.45
DMU061	Northeast	2017	3372.25	1198.33	14552	138.78	405.61	405.61	5329	75.11
DMU062	Northeast	2017	38696.61	10425.26	89068	814.87	5475.89	5475.89	34833	470.64
DMU063	Northeast	2017	26675.10	8324.59	79516	1260.57	3780.34	3780.34	36060	588.6
DMU064	Northeast	2017	33870.16	11819.22	87786	756.14	8200.74	8200.74	65274	669.01
DMU065	Northeast	2017	418463.69	58350.8	286949	3520.91	43539.66	43419.07	97698	1543.03
DMU066	Northeast	2017	8355.36	2449.27	20679	228.01	420.38	420.38	2748	25.57
DMU067	Northeast	2017	13844.43	4562.92	33109	315.7	1317.53	1317.53	12805	110.05
DMU068	Northeast	2017	154489.85	30436.47	144853	1444	9531.96	9531.96	48336	385.33
DMU069	Northeast	2017	251781.39	34359.68	192569	1573.08	18705.58	18705.58	93989	687.7
DMU070	Northeast	2017	30315.21	4860.01	39624	413.43	2118.76	2118.76	14966	173.09

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU071	Northeast	2017	31997.38	6359.84	50129	661.28	3766.36	3766.36	31396	276.13
DMU072	Northeast	2017	5652.13	2250	17775	180	1428	1428	8642	165
DMU073	Northeast	2017	11486.66	2589.01	20838	463.44	169.02	169.02	1678	11.39
DMU074	Northeast	2017	72618.28	12795.82	76268	1093.02	4136.92	2549.64	27189	157.35
DMU075	Northeast	2017	27072.26	2645.62	25612	293.11	1203.75	1203.75	11511	53.87
DMU076	Northeast	2017	17056.29	1832.22	16082	211.08	1677.75	1677.75	10716	75.39
DMU077	Northeast	2017	12930.05	3785.94	32906	301.77	257.66	257.66	3752	13.33
DMU078	Northeast	2017	117134.92	18673.68	170460	2272.24	16153.38	16153.38	116773	612.2
DMU079	Northeast	2017	37778.55	5774.49	46983	596.56	4115.3	4115.3	30099	137.26
DMU080	Northeast	2017	7364.34	1459.17	15507	144.1	100.01	100.01	1073	10.5
DMU081	Northeast	2017	13239.53	2835.89	26946	403.2	411.63	411.63	4378	25.42
DMU082	Northeast	2017	10737.45	2208.55	22592	243.06	240.27	240.27	2564	17.3
DMU083	Northeast	2017	29840.90	18253.56	50614	435	13507.63	3303.05	42750	342
DMU084	Northeast	2017	6188.83	3867.1	23068.0	184.4	2010.4	491.0	21811.0	138.5
DMU085	Northeast	2017	32787.33	5147.13	50914	493.06	3705.93	3705.93	46541	453.79
DMU086	Northeast	2017	19522.77	21099.82	62861	489	6036	5381	45240	227
DMU087	Northeast	2017	45312.39	10250.56	44420	424.65	4790.28	4774.25	19968	205.43
DMU088	Northeast	2017	16454.34	4609.05	32747	284.2	1484.94	1484.86	12411	147.75
DMU089	Northeast	2017	27367.29	3844.69	31829	358.48	3075.75	3075.75	30042	180
DMU090	Northeast	2017	804464.84	124000.37	493116	5145.06	147205.9	146711.4	512896	3899.44
DMU091	Northeast	2017	16132.25	1941.51	17005	121.55	807.96	807.96	8128	54.64
DMU092	Northeast	2017	15711.76	3672.15	34530	320.23	806.69	806.69	8097	42.73
DMU093	Northeast	2017	13379.35	5987.32	25777	223.37	294.58	294.58	3111	19
DMU094	Northeast	2017	28529.51	4943.61	27607	204.38	2780.25	2770.99	13722	147.73
DMU095	Northeast	2017	21871.96	4626.76	38872	430.44	2513.99	2513.99	21087	86.05
DMU096	Northeast	2017	64972.55	10577.4	94025	1224.11	9657.33	9657.33	80603	665.05
DMU097	Southeast	2017	17384.59	4069.24	30855	321.38	3159.93	2226.53	30600	313.81
DMU098	Southeast	2017	9483.98	15602.70	44127.00	488.69	12485.04	1623.05	43248.00	477.68
DMU099	Southeast	2017	22361.01	5528.36	39903	644.61	4280.77	4280.77	39644	317.24
DMU100	Southeast	2017	24115.82	6378.36	34004	289.02	3444.61	1099.75	30262	257.17
DMU101	Southeast	2017	588099.92	138756.55	599787	6858.36	107176.61	105954.69	608167	4416.35
DMU102	Southeast	2017	81672.57	17369.12	124953	1507.48	11548.24	10622.77	105127	1182.27
DMU103	Southeast	2017	23376.78	5483.76	46500	445.47	3788.47	1570.16	41435	360.39

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU104	Southeast	2017	129533.73	29462.98	183637	1973.12	21185.5	20282.63	169875	1218.35
DMU105	Southeast	2017	10531.75	2604.25	21597	195.2	2091.54	2091.54	22143	171.36
DMU106	Southeast	2017	45773.74	9916.75	69630	691.2	8425.89	8425.89	73260	558.92
DMU107	Southeast	2017	15444.14	6018.78	31978	386.76	4815.03	2493.84	29395	310.16
DMU108	Southeast	2017	20058.60	4925.43	32086	807.81	3605.42	3079.3	30317	339.31
DMU109	Southeast	2017	18253.42	6717.61	39019	545.73	5363.35	5275.19	38542	526.53
DMU110	Southeast	2017	9601.30	2867.48	24708	401.29	601.73	601.73	6720	101.71
DMU111	Southeast	2017	116390.69	29706.47	136054	1854.06	23765.18	1657.13	133782	1359.59
DMU112	Southeast	2017	14815.84	3813.38	24167	517.6	1453.8	1453.8	11777	208.03
DMU113	Southeast	2017	21069.98	4939.93	37226	522.22	3724.39	3724.39	36053	384.21
DMU114	Southeast	2017	7681.96	6085.33	20606	245	5213.29	7.6	15738	245
DMU115	Southeast	2017	74536.08	14172.44	131578	1796.15	11117.37	9780.91	131918	1272.56
DMU116	Southeast	2017	14070.31	5673.76	34653	454.15	4822.7	1592.6	34551	472.23
DMU117	Southeast	2017	18691.07	5877.49	29541	476.06	991.91	991.91	2957	55
DMU118	Southeast	2017	14955.12	3285.38	27832	290.83	2311.62	2044.57	25367	266.58
DMU119	Southeast	2017	14754.24	6989.62	37963	501.85	5591.7	3275.2	37706	458.81
DMU120	Southeast	2017	11518.12	3741	27856	452	2993	2873	27500	400
DMU121	Southeast	2017	9556.64	3519.25	18054	289.37	1141.6	1141.6	7251	85.5
DMU122	Southeast	2017	33307.89	10316.7	55237	1082.03	8760.51	2207.52	55275	968.92
DMU123	Southeast	2017	30654.64	6702.49	49451	646.73	5213.37	5146.93	49490	527.54
DMU124	Southeast	2017	58059.41	12145.15	94442	1067.12	7679.42	3263.2	77849	642.2
DMU125	Southeast	2017	38589.39	8130.28	59289	772.93	5268.89	5268.89	48985	459.73
DMU126	Southeast	2017	6243.55	1451.95	12658	171.01	582.27	582.27	6381	92
DMU127	Southeast	2017	3296.16	535.68	4939	50.28	370.4	370.4	4445	44.88
DMU128	Southeast	2017	4864.73	4166.47	18362	254.8	3952.32	48.07	18301	222.37
DMU129	Southeast	2017	83485.63	19909.02	107104	1572.52	15927.21	12104.67	106570	1545.06
DMU130	Southeast	2017	106651.87	58913.6	188973	3211	48261.3	48261.3	185861	2576
DMU131	Southeast	2017	12419.23	4565.07	22263	466.13	3637.99	2542.45	19675	298.41
DMU132	Southeast	2017	30356.74	6627.23	48824	637.21	5144.39	5144.39	49174	534.9
DMU133	Southeast	2017	25326.72	4191.26	31994	500.25	2790.65	2790.65	27483	227
DMU134	Southeast	2017	7856.61	4130	20308	282.4	3304	33.04	18533	214
DMU135	Southeast	2017	16169.98	4138.44	29284	378.36	3269.95	689.88	22159	259.66
DMU136	Southeast	2017	60596.90	9033.48	55978	637.23	7152.86	7026.44	51503	511.48

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU137	Southeast	2017	83649.26	16061.88	85073	1263.58	4883.43	3887.79	30659	374.93
DMU138	Southeast	2017	16088.71	5865	27640	340	7073	375	24596	208
DMU139	Southeast	2017	24295.80	7106.16	29537	490.45	3850	3768.69	13488	207.51
DMU140	Southeast	2017	14242.69	7703.95	34810	460	6069.66	6069.66	25091	241.56
DMU141	Southeast	2017	8651.56	3087.94	29653	348.22	3010.55	210.74	19834	195.27
DMU142	Southeast	2017	110484.94	34679.41	105131	1825.71	11800.3	11511.98	68221	915.08
DMU143	Southeast	2017	13232.13	3188.98	14639	264.19	1054.75	1043.52	6470	88.37
DMU144	Southeast	2017	93568.09	25648.63	92909	1361.09	13025.34	13024.77	31205	405.09
DMU145	Southeast	2017	77902.23	24818.34	55725	855.86	18547.42	18547.42	38151	475.61
DMU146	Southeast	2017	28829.99	18076.49	42292	487.3	5211.44	892.43	22309	238.57
DMU147	Southeast	2017	31773.22	7603.19	46576	2127	9956.84	300	38746	796
DMU148	Southeast	2017	80819.47	31959	83374	562.59	12194	1444	42312	418
DMU149	Southeast	2017	74971.56	9682.77	73866	1121.98	10592.99	10592.99	73866	37.56
DMU150	Southeast	2017	119549.82	18964.49	100375	1332.2	11557.56	11557.56	74691	779.5
DMU151	Southeast	2017	104111.34	62184	153718	1306.65	25635	3944	76381	675
DMU152	Southeast	2017	16923.14	4041	23588	143	632	196	4832	23
DMU153	Southeast	2017	244021.65	37025.3	88611	1312	41139.6	41139.6	81222	758.3
DMU154	Southeast	2017	55384.27	8138.8	41898	704.4	7928.9	7928.9	38821	427.8
DMU155	Southeast	2017	64550.53	9991	58502	784	12678.23	10202	44198	280
DMU156	Southeast	2017	32553.02	7112	36464	489.17	7105	5000.87	34820	393.23
DMU157	Southeast	2017	47079.88	5951	35191	139	2023.93	2023.93	16060	223
DMU158	Southeast	2017	2123819.15	771976	1077384	10710.21	449781.11	355103.17	832277	6428.24
DMU159	Southeast	2017	230123.92	129100	178502	1687	45008	10704	77932	720
DMU160	Southeast	2017	31642.63	4449.61	38249	452.47	3270.93	3270.93	38249	56.19
DMU161	Southeast	2017	20787.24	10463.82	30090	400.4	11328.94	339.32	20180	445
DMU162	Southeast	2017	45002.31	17161.55	78238	1039.59	13729.24	3609.84	70357	901.99
DMU163	Southeast	2017	48541.54	13930.79	81326	1928	7618.41	5681.12	79727	2329.4
DMU164	Southeast	2017	9900.83	3462.45	23833	326.4	2816.69	2205.57	21294	228.96
DMU165	Southeast	2017	11310.87	3367	21627	259.01	4204.03	4204.03	22122	211.59
DMU166	Southeast	2017	54044.99	13852.27	76729	697.3	13852.27	13852.27	81848	665.1
DMU167	Southeast	2017	61437.84	16918.19	100826	1417.39	18221.95	18221.95	101214	1184.29
DMU168	Southeast	2017	23314.74	4641.02	26897	386.98	2206.83	2206.83	17212	191.88
DMU169	Southeast	2017	24327.68	6041.7	38373	441.66	5999.23	5999.23	38186	385.49

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU170	Southeast	2017	37213.58	6701.45	41799	404.02	4942.79	3753.41	26406	236.26
DMU171	Southeast	2017	20179.69	4888.33	34288	380.52	4874.56	4874.56	33064	349.11
DMU172	Southeast	2017	30951.36	6502.51	47621	604	6502.51	6502.51	47650	602.95
DMU173	Southeast	2017	84619.03	17740.87	80555	728.9	10824.63	4113.36	60813	398.84
DMU174	Southeast	2017	13209.49	7206.2	29796.0	716.0	7206.2	2491.1	29771.0	716.0
DMU175	Southeast	2017	29799.13	4436.77	25174	327.12	2468.86	2468.86	11608	223.31
DMU176	Southeast	2017	12397.00	2981.99	18264	153.26	2179.87	2179.87	15683	69.58
DMU177	Southeast	2017	38857.07	8531.05	55006	655.66	7845.37	7845.37	51640	475.24
DMU178	South	2017	24127.93	4397.24	30554	481.34	1754.39	1754.39	12659	239.97
DMU179	South	2017	42546.89	6465.8	45220	597.29	4943.81	4943.81	34426	657.83
DMU180	South	2017	32324.91	5656.83	42278	624.75	3682.48	3682.48	26596	482.27
DMU181	South	2017	34858.63	7031.54	38847	663.11	3601.21	3601.21	25076	495.4
DMU182	South	2017	29435.91	5555.13	36681	360.24	4750.06	4750.06	32689	479.17
DMU183	South	2017	28931.08	5277.43	35524	655.53	2776.22	2776.22	20955	466.37
DMU184	South	2017	27350.63	4984.02	34537	477.48	4301.32	4301.32	29244	521.56
DMU185	South	2017	83491.30	15103.57	96157	1389.55	14992.41	14992.41	85788	1390.38
DMU186	South	2017	12476.47	2413.82	19035	284.29	1903.95	1903.95	14664	239.1
DMU187	South	2017	23714.28	3986.39	25119	633.68	2650.89	2650.89	14869	242.52
DMU188	South	2017	48457.18	10089.78	65737	938.84	5741.97	5741.97	39693	582.88
DMU189	South	2017	515213.58	198129.7	483791	7360.79	102672.21	102672.21	443282	6281.35
DMU190	South	2017	23370.71	4847.14	41973	581.95	2731.23	2731.23	25380	354.68
DMU191	South	2017	76949.77	16502.65	86047	1455.92	13230.99	13230.99	62930	1142.45
DMU192	South	2017	22598.78	4101.1	24987	517.46	2973.96	2973.96	16249	366.37
DMU193	South	2017	40945.34	7705.46	51827	943.37	6062.68	6062.68	40150	784.87
DMU194	South	2017	8475.61	3125.59	20498	369.06	2754.19	2754.19	18339	263.19
DMU195	South	2017	13682.68	2136.48	17262	382.73	1807.99	1807.99	14999	295.61
DMU196	South	2017	189018.50	43014.53	161595	1984.08	31339.38	31339.38	141258	1831.72
DMU197	South	2017	7851.26	3509.37	17701	577.05	545.56	545.56	4061	114.35
DMU198	South	2017	125669.58	22424.12	127196	1952.55	22733.6	22733.6	109873	1740.45
DMU199	South	2017	8054.88	1716.06	12669	227.28	1262.09	1262.09	9675	146
DMU200	South	2017	52449.63	4921.13	34534	640.07	4721.45	3100.3	21969	535.07
DMU201	South	2017	30016.29	4861.55	34318	719.34	4058.76	4058.76	27525	524.12
DMU202	South	2017	25376.83	4391.89	26138	600.15	3571.09	3571.09	19758	380.11

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU203	South	2017	27229.57	76996.45	37373	612.06	5075.92	5075.92	30320	478.75
DMU204	South	2017	21953.75	4463.47	31079	518.79	3624.61	3624.61	24719	407.76
DMU205	South	2017	89682.40	16494.04	111619	1429.34	14417.34	14417.34	99012	1547.91
DMU206	South	2017	6635.12	1067.24	9437	173.99	819.64	819.64	7288	167.67
DMU207	South	2017	15512.23	3269.29	23718	346.76	1717.26	1717.26	11494	234.68
DMU208	South	2017	65860.44	28276.88	79763	1313.41	9285.48	9285.48	51692	837.76
DMU209	South	2017	23080.44	3475.43	24321	338.22	2757.14	2757.14	19183	252.24
DMU210	South	2017	33042.80	6709.84	42724	759.73	5269.19	5269.19	32169	679.32
DMU211	South	2017	34415.94	6019.14	39907	503.78	5472.41	5472.41	33801	560.48
DMU212	South	2017	16472.68	4426.63	17010	349.24	776.71	776.71	4448	89.31
DMU213	South	2017	41187.60	19306	28545	381	14118.62	14118.62	23761	300
DMU214	South	2017	86286.98	17392.01	89664	1572	6101	5755	25610	386
DMU215	South	2017	49949.69	8138.85	45208	685.4	4224.68	4224.68	12598	239.8
DMU216	South	2017	16644.59	2959.93	18668	296.06	52.52	52.52	1009	3.8
DMU217	South	2017	219882.23	31622.57	105809	1445.21	14644.61	14644.61	42470	778.56
DMU218	South	2017	25193.46	4425.61	14424	283.38	2609	2609	4679	105.6
DMU219	South	2017	35369.98	8277.99	40478	857	4844.3	4844.3	29772	564
DMU220	South	2017	95239.62	33911.48	149093	2161.99	8395	8395	34743	547.1
DMU221	South	2017	34698.26	8677.43	48616	785.69	2796.84	1102.32	11143	154.94
DMU222	South	2017	17660.71	10219.58	47299	712	858.5	858.5	5997	71
DMU223	South	2017	13626.01	3918.18	26130	591	887.11	887.11	6258	140
DMU224	South	2017	70102.98	13786.77	51244	340.08	8544.84	8544.84	9806	97.95
DMU225	South	2017	17351.14	3023.69	22350	153.07	590.72	637.73	3880	24.49
DMU226	South	2017	45519.70	26326.7	52130	599.95	1488.57	1448	13652	89.58
DMU227	South	2017	38110.17	3267.45	40853	476.52	2515.9	686.2	23825	297.27
DMU228	South	2017	18641.15	3587.34	26096	250.94	1018.97	1181.81	7408	81.36
DMU229	South	2017	33335.00	18272.26	34641	329.54	2351.45	10112.61	19867	176.33
DMU230	South	2017	6018.93	885.05	7276	78.21	1540.44	100.37	10348	56
DMU231	South	2017	83229.99	17044.2	78170	844.88	3637.99	6205.45	16003	135.84
DMU232	South	2017	21014.81	4941.42	18125	359.78	1315.69	1863.57	3410	39.18
DMU233	South	2017	87025.75	25495.24	133717	1743.13	20396.19	9410.15	120185	1723.15
DMU234	South	2017	14590.05	2832.52	20277	224.31	436.82	416.07	2812	33
DMU235	South	2017	9630.48	2389.49	11665	167.58	49.4	18.95	416	7.2

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU236	South	2017	18215.98	17690.21	20135	204.91	113.78	118.92	166	1.28
DMU237	South	2017	63732.95	9469.14	60271	700.62	2450.08	1507.93	19720	244.8
DMU238	South	2017	36757.16	10169.1	52944	870.48	662.57	662.57	2132	51.34
DMU239	South	2017	46331.15	10195.07	53065	798.91	1832.67	2630.87	7029	33.61
DMU240	South	2017	67795.11	16547.03	87735	947.7	7942.58	3177.03	48957	416.54
DMU241	South	2017	292168.70	116783.81	298539	4142.64	74767.17	58713.37	243280	1962.72
DMU242	South	2017	59239.21	10008.96	58224	547.58	2367.4	3023.1	14021	110
DMU243	South	2017	29666.65	5999.71	36463	598.01	701.81	462.89	4558	50.71
DMU244	South	2017	62066.17	12230.54	63518	740.58	5163.56	6828.29	27672	240.34
DMU245	South	2017	14566.41	3694.66	24049	281.2	1795.8	912.5	9029	98.67
DMU246	South	2017	18810.59	3464.23	20688	253.31	677.41	613.37	4099	41.57
DMU247	South	2017	11392.53	2264.42	16094	199.34	359.14	687.76	2455	49.64
DMU248	South	2017	46311.17	11203.88	62292	764.81	3734.23	3734.23	5538	124.93
DMU249	South	2017	27556.47	6151.75	34026	346.3	257.13	232.86	238	1.97
DMU250	South	2017	18054.17	2965.24	26166	396.88	565.68	1076.43	3294	46.87
DMU251	Center-West	2017	201504.18	52158	282039	3952	31215	31215	167063	2139
DMU252	Center-West	2017	60070.83	10501.51	68924	1293.52	6275.29	6275.29	42128	721.16
DMU253	Center-West	2017	10373.11	2654.19	17822	231.56	615.76	615.76	4725	95.82
DMU254	Center-West	2017	9257.19	2542.73	16018	329.76	225.72	225.72	1678	47.24
DMU255	Center-West	2017	16077.37	3319.52	23259	372.44	1406.08	1406.08	11531	214.53
DMU256	Center-West	2017	29376.65	6851.81	46276	736.14	3050.52	3050.52	23716	142.47
DMU257	Center-West	2017	6898.42	2177	14024	220	880	880	4357	117
DMU258	Center-West	2017	4464.06	3368.21	21544	429	1023.93	1023.93	6540	100
DMU259	Center-West	2017	11173.78	3131.11	18966	295.72	2315.6	2315.6	13464	202.19
DMU260	Center-West	2017	30627.06	12362.8	74177	1057.87	9423	9126	55305	567.84
DMU261	Center-West	2017	6761.08	4323	31410	355.15	829	829	7368	95.82
DMU262	Center-West	2017	22573.11	11456.18	70716	1185.28	5812.65	4858.23	20672	165.4
DMU263	Center-West	2017	91392.19	16608.42	131798	2036.95	10130.63	10130.63	74263	720.41
DMU264	Center-West	2017	61194.28	16355.2	126122	2284.36	6131.84	5300.23	50350	1016.46
DMU265	Center-West	2017	9259.09	4971.68	41588	470	3977.34	3977.34	24698	320
DMU266	Center-West	2017	11906.47	2799.84	29312	294.74	1007.1	1007.1	9762	52.55
DMU267	Center-West	2017	6550.74	1628.08	12683	134.81	517.89	517.89	4006	80.45
DMU268	Center-West	2017	25580.51	4263.3	37055	365.9	3219.99	3219.99	27420	235.26

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU269	Center-West	2017	14231.11	2475.69	19968	292.6	2460.34	2460.34	19050	161.17
DMU270	Center-West	2017	676134.66	96485.92	540692	6712.64	67351.85	55171.4	416671	3745.46
DMU271	Center-West	2017	13066.48	2271.54	18770	246.38	1765.45	1765.45	13757	99.98
DMU272	Center-West	2017	28458.78	5611.55	36528	594.37	5876.74	5611.55	36926	266.44
DMU273	Center-West	2017	7267.16	1899.99	15036	227.35	490.32	490.2	4269	62.32
DMU274	Center-West	2017	27952.01	5027.16	36042	544.14	3882.5	3882.5	27415	397.13
DMU275	Center-West	2017	26356.24	5790.22	49767	874.04	1490.48	1490.48	9918	100.81
DMU276	Center-West	2017	16349.17	3617.41	28446	310	797.08	797.08	6066	36.56
DMU277	Center-West	2017	18322.31	3531.86	34287	236.65	1586.56	1586.56	15484	69.04
DMU278	Center-West	2017	10193.23	2156.16	15766	204.6	2156.16	2156.16	16275	132.45
DMU279	Center-West	2017	51454.07	9433.72	65201	621.15	5765.87	5765.87	37904	273.77
DMU280	Center-West	2017	11611.92	2112.07	18487	201.93	1259.39	1259.39	10925	62.67
DMU281	Center-West	2017	19232.64	5033.33	45023	1331.29	2525.39	2525.39	22749	335.72
DMU282	Center-West	2017	22908.76	6185.02	57893	327.34	2499.08	2499.08	18460	108.51
DMU283	Center-West	2017	1193987.45	144867	658704	8855.32	121354	121354	549172	6972.69
DMU001	North	2018	9519.99	4408.36	24228	530	1717.35	1717.35	16565	228
DMU002	North	2018	40781.69	12713.72	54519	1147.91	4201.92	4201.92	21544	546.27
DMU003	North	2018	222034.73	55492	432637	3812.23	17227.5	17227.5	65104	550.51
DMU004	North	2018	109271.54	16485.85	92675	1408.05	15088.01	15088.01	78922	948.21
DMU005	North	2018	241146.14	48161.06	224037	2127	12375.63	1120.04	34298	548.75
DMU006	Northeast	2018	14953.57	9231.58	40964	419	432	432	2244	59.05
DMU007	Northeast	2018	13869.65	11970.91	65325.00	595.33	4335.84	4335.84	20860.00	136.50
DMU008	Northeast	2018	218568.09	42378	189816	1924.83	30633.32	7545.85	88562	874.83
DMU009	Northeast	2018	187921.94	42217.1	244658	2476.45	8212.87	8212.87	48458	505
DMU010	Northeast	2018	2972.40	890.52	7296.00	101.72	107.03	107.03	1020.00	21.38
DMU011	Northeast	2018	3504.68	736.42	8435.00	52.03	130.15	130.15	1760.00	23.81
DMU012	Northeast	2018	4521.51	674.30	6160.00	144.16	333.67	333.67	3030.00	37.53
DMU013	Northeast	2018	12776.48	1784.72	15145.00	163.49	468.57	468.57	4447.00	57.13
DMU014	Northeast	2018	4480.16	1621.20	12639.00	98.55	186.87	186.87	1863.00	46.34
DMU015	Northeast	2018	2042.21	292.62	3325.00	58.45	105.80	105.80	1353.00	18.51
DMU016	Northeast	2018	2234.27	5320.0	17430.0	150.0	1800.0	1330.0	4822.0	85.5
DMU017	Northeast	2018	2946.59	1589.07	14593.00	109.30	170.94	170.94	3115.00	23.00
DMU018	Northeast	2018	4224.90	1125.69	12537.00	147.91	23.67	23.67	344.00	4.98

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU019	Northeast	2018	36430.02	9584.99	88431.00	632.50	3674.53	3674.53	41383.00	307.20
DMU020	Northeast	2018	12274.47	1544.34	18403.00	202.06	624.50	624.50	9624.00	132.47
DMU021	Northeast	2018	7263.62	2032.57	15328.00	248.66	214.76	214.76	1892.00	35.56
DMU022	Northeast	2018	401900.25	99093.15	659495.00	4187.35	55280.97	55280.97	395565.00	2536.13
DMU023	Northeast	2018	7698.73	1500.81	17719.00	150.97	363.34	363.34	1740.00	12.73
DMU024	Northeast	2018	2906.21	3325.00	13870.00	140.00	1406.00	1338.00	4750.00	49.00
DMU025	Northeast	2018	11770.60	3380.93	30436.00	399.17	502.47	502.47	3898.00	31.00
DMU026	Northeast	2018	13313.00	2880.40	23900.00	312.17	1264.31	1264.31	11369.00	57.98
DMU027	Northeast	2018	37982.97	10721.39	86902.00	723.34	2390.63	2390.63	24533.00	185.01
DMU028	Northeast	2018	6289.15	5475.00	21214.00	191.80	1369.50	1369.50	5474.00	70.90
DMU029	Northeast	2018	36869.28	7997.41	73980.00	580.58	5188.54	5188.54	35794.00	235.32
DMU030	Northeast	2018	25293.78	2560.23	26724.00	275.71	308.62	308.62	4202.00	73.55
DMU031	Northeast	2018	5676.33	2510.00	17702.00	630.00	60.00	60.00	330.00	4.00
DMU032	Northeast	2018	5075.34	1283.21	15080.00	152.03	245.51	245.51	743.00	2.84
DMU033	Northeast	2018	8432.29	2095.81	19549.00	168.91	930.18	930.18	11828.00	42.05
DMU034	Northeast	2018	12113.18	1985.73	19323	190.88	348.77	348.77	5137	83.56
DMU035	Northeast	2018	9639.85	1665.05	17066	160.78	465.43	465.43	5457	53.19
DMU036	Northeast	2018	19751.12	8996.56	62856	685.83	4438.99	4343.99	43620	485
DMU037	Northeast	2018	4222.31	1134.21	11303	97.37	109.33	109.33	1638	19.09
DMU038	Northeast	2018	10974.57	2187.69	20769	252.04	444.67	444.67	6991	70.44
DMU039	Northeast	2018	1491.69	321.07	3756	54.54	43.69	43.69	534	6.1
DMU040	Northeast	2018	10021.84	2050.4	20131	244.1	190.26	190.26	1695	10.5
DMU041	Northeast	2018	5117.66	3481.9	20405	191.5	378.18	378.18	4273	42.8
DMU042	Northeast	2018	8012.87	1691.35	14998	200.21	311.09	311.09	751	21.53
DMU043	Northeast	2018	60196.78	11404.25	73994	900	5904.98	5904.98	34254	211.67
DMU044	Northeast	2018	167951.51	38248.9	213714	1601.67	19243.32	19243.32	77867	1056.04
DMU045	Northeast	2018	5350.53	3784.78	15503	78.86	790.1	790.1	1129	8.75
DMU046	Northeast	2018	13886.56	2129.2	19936	178.85	448.5	448.5	3117	23.92
DMU047	Northeast	2018	91365.45	18198.6	136260	719.9	14236.3	14236.3	105446	385.08
DMU048	Northeast	2018	18050.18	2227.88	18006	134.1	1354.6	1354.6	11059	56.61
DMU049	Northeast	2018	222603.60	42796.93	206994	1030.55	35808.4	35629.36	148614	649.53
DMU050	Northeast	2018	27181.05	4097.29	34026	216.31	668.5	668.5	4539	14.57
DMU051	Northeast	2018	4598.53	1783.39	9993	89.05	322.8	322.8	3493	18.1

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU052	Northeast	2018	5493.18	2526.5	24935.0	220.3	919.7	919.7	6370.0	83.0
DMU053	Northeast	2018	8429.78	1950.58	21608	193.57	111.75	111.75	1104	11.26
DMU054	Northeast	2018	30241.26	21950.9	45901	543.43	837.52	837.52	5376	72.48
DMU055	Northeast	2018	11192.77	3626.69	30206	344.17	133.94	133.94	591	7.34
DMU056	Northeast	2018	31796.46	10805.76	107459	948.62	5137.11	5137.11	49662	431.17
DMU057	Northeast	2018	18883.44	4721.28	44319	417.37	494.04	494.04	5003	129.67
DMU058	Northeast	2018	11698.01	3953.18	29679	329.53	71.5	71.5	344	6.52
DMU059	Northeast	2018	15704.04	2524.98	24495	296.99	157.78	157.78	1009	17.12
DMU060	Northeast	2018	55365.57	22200.91	117503	1156.34	3316.02	3316.02	21890	360.45
DMU061	Northeast	2018	4098.62	1187.6	14750	138.78	398.55	398.55	5286	84.15
DMU062	Northeast	2018	46288.54	11201.2	91624	814.87	5900.27	5900.27	34565	470.64
DMU063	Northeast	2018	31339.94	8745.68	80788	1262.13	3991.42	3991.42	36538	623.44
DMU064	Northeast	2018	32583.67	12118.82	90799	813.07	8913.6	8913.6	67623	669.01
DMU065	Northeast	2018	436136.45	59615.68	293474	3520.91	44528.48	44412.7	98713	1543.03
DMU066	Northeast	2018	8208.30	2334.78	20923	228.01	560.23	560.23	4136	25.57
DMU067	Northeast	2018	24108.83	4062.33	33424	315.7	1250.83	1250.83	12792	110.05
DMU068	Northeast	2018	123659.12	26759.17	149546	1616.41	11861.31	11861.31	58270	403.03
DMU069	Northeast	2018	258999.96	34315.14	199043	1570.13	19692.6	19692.6	100878	717.7
DMU070	Northeast	2018	32848.63	4715.84	41933	403.71	2150.9	2150.9	14961	193.09
DMU071	Northeast	2018	37080.94	6335.89	51184	665.89	4280.28	4280.28	36326	281.55
DMU072	Northeast	2018	5992.88	2233	18135	180	1428	1428	8842	177
DMU073	Northeast	2018	13155.72	2517.19	21219	466.08	168.27	168.27	1719	11.39
DMU074	Northeast	2018	69753.34	12973.75	79777	1132.55	4776.53	2922.13	30751	177.28
DMU075	Northeast	2018	28175.04	2679.44	25525	294.23	1333.45	1333.45	11938	176.47
DMU076	Northeast	2018	17288.70	1771.01	16393	218.28	1764.05	1764.05	10876	75.39
DMU077	Northeast	2018	13718.10	3794.94	33455	301.77	393.34	393.34	4288	23.73
DMU078	Northeast	2018	114626.47	19096.17	172474	2333.06	16889.83	16887.71	117348	653.97
DMU079	Northeast	2018	35312.90	5989.36	47747	596.56	4495.41	4495.41	31249	152.93
DMU080	Northeast	2018	7221.51	1454.05	15983	147.01	99.89	99.89	1104	10.46
DMU081	Northeast	2018	14602.54	2764.04	27554	408.4	390.11	379.6	4410	25.42
DMU082	Northeast	2018	10212.34	2179.86	22648	242.36	239.46	239.46	3005	17.3
DMU083	Northeast	2018	37437.05	14453	50686	439	13609.5	3604.5	43662	346
DMU084	Northeast	2018	5966.09	3238.5	23340.0	186.1	2074.9	506.7	22053.0	139.5

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU085	Northeast	2018	29563.50	5247.96	51947	495.52	5927.17	5927.17	47363	461.82
DMU086	Northeast	2018	18007.71	21133	63337	507	6351	5583	47736	241
DMU087	Northeast	2018	46261.27	10445.26	44516	410.16	4800.95	4747.72	20573	140.56
DMU088	Northeast	2018	16040.61	4659.8	33202	286.04	1585.03	1584.68	12115	147.85
DMU089	Northeast	2018	26875.09	3870.13	32400	358.87	5285.01	5285.01	30427	180
DMU090	Northeast	2018	788712.75	124294.58	494264	4829.87	144830.12	143251.39	526037	4063.57
DMU091	Northeast	2018	14349.24	2158.44	17192	121.89	913.18	913.18	8240	71.92
DMU092	Northeast	2018	15555.44	3676.61	35300	384.56	917.2	914.38	8384	44.89
DMU093	Northeast	2018	13126.28	5068.92	26523	288.89	316.7	316.7	3218	18.99
DMU094	Northeast	2018	26320.71	4958.48	27627	194.41	2762.3	2731.91	13762	76.82
DMU095	Northeast	2018	23439.05	4521.81	40079	439.89	2873.41	2873.41	22233	260.95
DMU096	Northeast	2018	63732.24	11404.06	96764	1231.92	10825.7	10825.7	84354	777.6
DMU097	Southeast	2018	17918.52	4034.17	31291	322.3	3138.65	3138.65	31084	314.87
DMU098	Southeast	2018	10173.90	16805.3	44960	501.33	13444.24	2302.13	43962	487.51
DMU099	Southeast	2018	23148.56	5464.69	40838	694.55	4250.08	4250.08	40557	542.07
DMU100	Southeast	2018	25968.46	6727.05	34113	294.98	3514.4	971.64	30155	262.79
DMU101	Southeast	2018	618619.40	136912.25	599387	6891.41	106602.58	106602.58	612732	4437.43
DMU102	Southeast	2018	88855.38	17036.95	125575	1516.18	11430.43	11430.43	107026	1050.67
DMU103	Southeast	2018	25252.67	5439.32	47365	446.15	3769.75	1881.74	42271	361.28
DMU104	Southeast	2018	139955.56	29031.3	184049	1978.88	21107.28	21107.28	173441	1246.33
DMU105	Southeast	2018	10915.58	2569.54	21966	195.28	2057.37	2057.37	22494	171.46
DMU106	Southeast	2018	46912.12	9827.06	70519	691.2	8403.99	8403.99	75098	558.92
DMU107	Southeast	2018	17291.07	6596.44	32486	388.95	5940.08	1896.92	30564	312.53
DMU108	Southeast	2018	19648.78	4896.47	32302	807.81	3608.63	3179.09	30841	339.31
DMU109	Southeast	2018	18193.57	6592.16	39541	562.98	6021.56	6021.56	39029	542.74
DMU110	Southeast	2018	10364.24	2817.08	24828	401.74	595.56	595.56	6812	101.87
DMU111	Southeast	2018	128600.53	30016.11	137854	1858.55	22384.91	1244.5	135511	1362.88
DMU112	Southeast	2018	15870.73	3848.23	24881	569.05	1562.35	1562.35	12480	208.89
DMU113	Southeast	2018	22433.82	4885.84	37923	482.23	3691.94	3691.94	36837	389.53
DMU114	Southeast	2018	7948.94	6090.32	20925	246	5486.32	6.2	15931	245
DMU115	Southeast	2018	83864.38	13168.11	133847	1800.04	10443.61	10443.61	135005	1276.16
DMU116	Southeast	2018	16848.34	5657.45	35137	472.81	4808.83	1595.7	35048	472.81
DMU117	Southeast	2018	20358.04	5780.47	29900	484.55	981.33	981.33	2957	62.69

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU118	Southeast	2018	15977.15	3248.6	28144	311.27	2314.73	2036.59	25963	266.89
DMU119	Southeast	2018	14799.40	7096.75	38784	534.95	5677.4	3305.45	38504	480.78
DMU120	Southeast	2018	12603.97	3747	28574	452	2998	2923	28216	401
DMU121	Southeast	2018	10045.82	3606.94	18432	289.37	1157	1157	7601	85.5
DMU122	Southeast	2018	33687.00	9905.04	55752	1084.68	8419.25	3987.25	55239	971.39
DMU123	Southeast	2018	31484.50	6809.8	50642	667.63	5302.45	5302.45	51205	542.6
DMU124	Southeast	2018	61476.55	12070.31	95043	1080.71	7797.49	3716.02	79910	818.67
DMU125	Southeast	2018	42149.99	7966.27	59041	776.81	5268.08	3717.21	50098	549.36
DMU126	Southeast	2018	6580.24	1403.56	12720	172.25	572.29	572.29	6503	92.46
DMU127	Southeast	2018	25136.49	12353.93	33614	420.46	12764.84	366.82	32098	320.16
DMU128	Southeast	2018	4804.88	2828.01	18717	255.05	3689.06	43.22	18646	222.46
DMU129	Southeast	2018	75068.04	24676.67	110284	1729.77	15936.53	12111.76	109635	1699.56
DMU130	Southeast	2018	115302.85	59252.36	191707	3377	49657.77	49657.77	189946	2770
DMU131	Southeast	2018	11761.46	4712.67	22885	327.79	3706.48	2788.39	20083	248.8
DMU132	Southeast	2018	30136.49	6560.73	49662	650.64	5101.29	5101.29	50164	544.63
DMU133	Southeast	2018	28852.15	4228.37	32204	497.26	2921.39	2921.39	28849	249.06
DMU134	Southeast	2018	7951.61	4212	20991	283	3368	33.68	19143	217
DMU135	Southeast	2018	19839.06	4347.39	30250	383.9	3461.11	1557.5	22918	247.5
DMU136	Southeast	2018	57998.68	9224.83	56068	645.06	7308	7173	51731	529.71
DMU137	Southeast	2018	56726.77	15987.96	85673	1283.81	5059.91	4267.24	31920	379.81
DMU138	Southeast	2018	16345.70	5967	27992	340	7207	380	24881	210
DMU139	Southeast	2018	27490.09	7270.14	30207	539.88	5374.63	5374.56	13795	229.05
DMU140	Southeast	2018	13711.11	7674.97	36090.00	460.20	8326.27	7077.33	25691.00	831.00
DMU141	Southeast	2018	8843.12	3826.87	28824	348.52	2997.98	209.86	18993	195.97
DMU142	Southeast	2018	116004.23	36743.14	105227	1827.27	13196.91	13196.91	75037	990.93
DMU143	Southeast	2018	10549.27	3195.91	14860	265.55	1074.37	901.25	7063	88.75
DMU144	Southeast	2018	94401.59	26950.37	93698	1364.29	15918.45	15913.59	32966	406.13
DMU145	Southeast	2018	83748.78	25295.47	56111	858.53	20871.43	20871.43	41292	480.4
DMU146	Southeast	2018	24140.04	16763.09	43025	488.17	6643.94	983.31	23069	239.37
DMU147	Southeast	2018	40105.27	7316.57	47224	2127.31	10529.24	300	39025	796
DMU148	Southeast	2018	45393.39	32095	83481	562.75	12210	1789	42367	418
DMU149	Southeast	2018	65510.65	9788	78417	1293	10291	10291	78417	38
DMU150	Southeast	2018	119847.24	17956.41	99645	1462.9	11899.34	11899.34	75197	884.7

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU151	Southeast	2018	94199.75	64242	153931	1311.17	25671	2443	76489	675
DMU152	Southeast	2018	7593.52	2842	23677	151	597	196	4780	23
DMU153	Southeast	2018	238458.23	36620.1	88546	1313.3	42609.1	42609.1	82364	773.9
DMU154	Southeast	2018	49589.91	8081.93	42413	726.01	7887.42	7277.79	39035	436.45
DMU155	Southeast	2018	67550.66	9951.2	59741	859	12705	10229	44361	285.6
DMU156	Southeast	2018	32529.69	7289.87	37056	503	7155.43	5143.97	35240	413
DMU157	Southeast	2018	45452.71	6151.4	35873	169.5	2617.93	2617.93	16757	223
DMU158	Southeast	2018	1271604.58	777585	1086868	10736.86	455922.73	333335.09	847533	6555.57
DMU159	Southeast	2018	198887.37	180349	178695	1687	44938	12512	73711	721
DMU160	Southeast	2018	27287.94	4384	39782	660	3489	3489	39782	56
DMU161	Southeast	2018	20461.79	11420	30152	496	11401	339.32	20446	465
DMU162	Southeast	2018	53939.31	17646.59	86438	1044.5	14117.27	4781.02	71543	904.37
DMU163	Southeast	2018	50381.83	14653.97	82131	1928.65	17436.16	9056.19	80793	2330.75
DMU164	Southeast	2018	13103.43	3574.99	24104	326.4	3112.38	1810.24	21520	228.96
DMU165	Southeast	2018	11375.58	3509	21636	262.24	3526.09	3509	23002	214.96
DMU166	Southeast	2018	54357.42	14371.67	75027	716.49	14687.43	14687.43	74171	677.47
DMU167	Southeast	2018	64629.28	16686.31	107295	1427.52	19919.91	19919.91	107683	1192.62
DMU168	Southeast	2018	25313.51	4713.61	27410	394.19	2327.53	2327.53	18287	198.45
DMU169	Southeast	2018	26261.16	6145.4	39339	484.47	6118.6	6118.6	39197	393.96
DMU170	Southeast	2018	41912.68	7137.66	42651	603.47	5133.35	4670.03	26702	260.23
DMU171	Southeast	2018	22631.48	4884.63	34487	380.92	4880.04	4880.04	33306	349.77
DMU172	Southeast	2018	34063.99	5795.68	49974	680	5766.85	5766.85	49974	620
DMU173	Southeast	2018	97692.74	18315.73	82411	732.18	11467.54	5715.36	63706	406.25
DMU174	Southeast	2018	13371.19	8625.2	30374.0	716.0	4608.0	2609.9	30350.0	716.0
DMU175	Southeast	2018	39250.00	4486.77	25659	356.57	2606.5	2606.5	12286	231.88
DMU176	Southeast	2018	15903.20	3082.78	19730	153.26	2276.3	2276.3	17107	69.58
DMU177	Southeast	2018	41817.07	8766.43	56171	655.9	8113.83	8113.83	53176	475.6
DMU178	South	2018	20867.02	4381.64	30748	484.59	1715.63	1715.63	13114	240.09
DMU179	South	2018	42639.67	6477.67	46017	617.59	5013.26	5013.26	35586	664.25
DMU180	South	2018	31589.92	5623.97	43133	626.52	3766.67	3766.67	27709	482.27
DMU181	South	2018	35606.21	6895.71	39477	671.07	3990.98	3990.98	28964	498.67
DMU182	South	2018	28329.71	5602.82	37248	377.52	4918.98	4918.98	33887	517.8
DMU183	South	2018	29225.23	5127.43	35769	664.81	3084.08	3084.08	23349	555.89

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU184	South	2018	25678.86	4997.49	35434	486.98	4360.09	4360.09	30251	532.51
DMU185	South	2018	79818.80	14913.21	98455	1415.38	15208.37	15208.37	89260	1408.41
DMU186	South	2018	12129.48	2436.35	19407	284.51	1931.89	1931.89	15219	246.29
DMU187	South	2018	29696.42	3958.1	25591	639.75	2662.35	2662.35	15425	253.94
DMU188	South	2018	48772.53	9974.42	66074	945.53	5835.53	5835.53	42229	593.27
DMU189	South	2018	542515.23	198084.4	487207	7383.19	102513.55	102513.55	449285	6274.53
DMU190	South	2018	24580.17	5012.4	44531	596.16	3315.91	3315.91	34753	521.1
DMU191	South	2018	72221.72	16711.3	87877	1502.6	13647.74	13647.74	65168	1184.88
DMU192	South	2018	23968.04	4214.55	25553	544.96	3344.69	3344.69	18436	388
DMU193	South	2018	42296.57	7847.93	52928	1039.37	6279.63	6279.63	41786	811.22
DMU194	South	2018	9030.42	3275.35	20566	369.06	2917.59	2917.58	18818	263.19
DMU195	South	2018	13025.15	2153.3	17492	391.59	1824.18	1824.18	15219	295.61
DMU196	South	2018	181328.37	41986.88	163231	1999.68	31696.63	31696.63	144846	1857.92
DMU197	South	2018	8586.86	3520.8	18018	594.54	598.26	598.26	4566	134.73
DMU198	South	2018	100328.19	22633.62	129310	1966.03	23142.02	23142.02	114888	1762.91
DMU199	South	2018	8010.74	1689.96	12796	231.04	1317.97	1317.97	9807	149.14
DMU200	South	2018	36775.57	5086.48	34881	647.08	4240.04	3257.09	23552	536.39
DMU201	South	2018	29655.72	4810.72	35271	747.59	4039.86	4039.86	28193	549.41
DMU202	South	2018	24251.62	4410.27	26998	631.87	3590.1	3590.1	20462	395.94
DMU203	South	2018	26395.66	77387.78	37707.00	615.19	5060.22	5060.22	30788.00	480.39
DMU204	South	2018	22282.56	4520.56	31410	529.94	3771.86	3771.86	26429	414.21
DMU205	South	2018	85818.26	16340.04	112933	1446.2	14357.07	14357.07	100485	1587.26
DMU206	South	2018	6510.57	1064.57	9603	174.84	824.96	824.96	7521	168.78
DMU207	South	2018	16066.11	3288.82	24099	350.74	1696.77	1696.77	11613	237.91
DMU208	South	2018	65275.23	26220.74	80785	1371.23	9891.08	9891.08	55273	850.39
DMU209	South	2018	20748.51	3494.87	24865	339.92	2791.07	2791.07	19626	254.12
DMU210	South	2018	35780.54	6788.15	43888	781.28	5333.03	5333.03	33329	703.17
DMU211	South	2018	30781.60	5978.22	41121	503.78	5497.1	5497.1	34584	561.02
DMU212	South	2018	15899.15	4467.09	17253	353.51	866.65	866.65	4585	89.31
DMU213	South	2018	33789.07	18811	28937	381	15169.12	15169.12	24593	300
DMU214	South	2018	81993.99	19469.29	90780	1583.01	6655	6312	26184	364
DMU215	South	2018	55514.15	8160.21	45795	685.41	4546.4	4546.4	12689	241.1
DMU216	South	2018	17936.63	2961.35	18890	297.57	45.99	45.99	1009	3.81

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU217	South	2018	254633.98	31339.33	107962	1425.11	15052.73	10806.31	42999	647.17
DMU218	South	2018	31178.99	4610.69	14684	284.45	2767.72	2767.72	4987	105.6
DMU219	South	2018	35287.90	8373.05	41177	879.1	5504.67	5504.67	31060	569.7
DMU220	South	2018	118848.10	34158	151543	2182	8424	8424	37927	553.34
DMU221	South	2018	41441.09	9706.99	49428	781.63	1941.39	1695.1	12582	155.41
DMU222	South	2018	18280.77	15960.02	48809	712	1014	1014	7686	85
DMU223	South	2018	14137.95	3871.64	26696	596	945.42	945.42	6332	149
DMU224	South	2018	72235.35	13699.46	51822	357.72	4473.08	4473.08	9987	97.95
DMU225	South	2018	18590.88	3057.3	22541	153.07	553.32	1171.5	3920	24.49
DMU226	South	2018	50489.63	25890.99	52194	599.95	1325.68	1116.72	13772	89.58
DMU227	South	2018	31183.83	7975.14	40429	476.52	3850.07	686.2	24954	305.68
DMU228	South	2018	19599.11	3560.6	26450	250.94	926.04	1141.49	7630	81.36
DMU229	South	2018	39008.05	16742.71	35979	329.54	2198.37	10815.34	21386	176.33
DMU230	South	2018	7578.74	817.61	7338	78.21	1540.44	100.37	10348	56
DMU231	South	2018	92695.26	17243.38	78862	844.88	3559.91	7254.07	16997	135.84
DMU232	South	2018	23258.88	5853.31	18539	360.67	1304.94	1298.1	3528	39.18
DMU233	South	2018	90566.89	26492.71	135217	2034	21194.17	10567.32	121364	1773.39
DMU234	South	2018	16382.19	2811.57	20377	224.31	400.41	388.48	2836	33
DMU235	South	2018	8978.89	2439.05	11921	162.98	44.24	19.33	417	7.2
DMU236	South	2018	22163.10	17514.81	20213	204.91	142.72	117.55	1013	3.28
DMU237	South	2018	90800.94	9540.56	61113	700.62	2257.6	1586.39	19959	240.34
DMU238	South	2018	37716.53	10932.9	52931	888.58	1388.44	1388.44	2705	52.15
DMU239	South	2018	49421.16	10269.21	54130	798.91	1742.26	3083.46	7305	33.61
DMU240	South	2018	75606.09	17568.12	88752	951.37	9308.6	3723.44	49157	419.9
DMU241	South	2018	300638.86	116467.25	300483	4155.81	72134.84	57075.67	246677	1991.92
DMU242	South	2018	64380.30	9964.53	58581	547.58	2173.14	3075.47	14615	183.94
DMU243	South	2018	33808.70	6027.48	36997	598.01	667.43	1095.89	4765	50.71
DMU244	South	2018	86774.85	12329.34	64619	740.58	4766.32	7371.27	28306	236.6
DMU245	South	2018	15786.82	3555.79	23780	282.35	985.46	315.64	9106	98.67
DMU246	South	2018	20378.49	3629.52	21038	253.31	787.18	422.91	4667	41.57
DMU247	South	2018	13550.08	2308.26	16326	155.91	327.62	683.11	2572	49.64
DMU248	South	2018	51158.82	11341.81	64043	768.18	3287.06	3287.06	6074	125.08
DMU249	South	2018	32974.94	6117.69	34580	346.3	242.37	228.82	244	1.97

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU250	South	2018	18852.69	2963.24	26723	396.94	539.87	1217.8	3319	46.87
DMU251	Center-West	2018	242704.07	51704.03	293536	3971.34	31920.18	31920.18	206663	2176.69
DMU252	Center-West	2018	61513.50	10547	71163	1333.85	6516.72	6516.72	45010	723.23
DMU253	Center-West	2018	10666.82	2621.8	18621	231.74	667.15	667.15	5636	96.18
DMU254	Center-West	2018	9791.67	2541.86	16432	331.28	292.78	292.78	2635	47.24
DMU255	Center-West	2018	16487.94	3418.39	24067	376.8	1549.18	1549.18	12479	214.8
DMU256	Center-West	2018	29602.96	6916.14	47181	741.4	3378.66	3378.66	28024	142.63
DMU257	Center-West	2018	7687.77	2249.36	14365	221.39	1175	1175	5109	117.51
DMU258	Center-West	2018	5200.69	4308.1	22457	435.37	1223.8	1223.8	6943	106.1
DMU259	Center-West	2018	11930.45	3246.02	19884	335.88	2527.58	2527.58	14626	311.64
DMU260	Center-West	2018	33776.66	10039.78	77133	1124.85	9584	9374	60071	609.78
DMU261	Center-West	2018	7196.51	4445	30354	355.15	1100	1100	6970	95.82
DMU262	Center-West	2018	25772.91	12914.85	72268	1201.24	6119	5413	21057	187.67
DMU263	Center-West	2018	86227.25	16053.93	135891	2040.3	10376.79	10376.79	78784	730.77
DMU264	Center-West	2018	84770.68	15399.42	129532	2986.61	7236.96	6732.55	58144	937.17
DMU265	Center-West	2018	11118.04	3866.68	41757	496.59	2281.01	2281.01	26617	349.2
DMU266	Center-West	2018	10469.99	2804.67	30751	294.74	1008.93	1008.93	10027	52.55
DMU267	Center-West	2018	5669.62	1612.97	12994	141.07	538.37	538.37	4897	80.45
DMU268	Center-West	2018	22342.91	4278.05	37574	365.9	3546.14	3546.14	32585	404.99
DMU269	Center-West	2018	12598.38	2420.24	20666	292.6	2420.23	2420.23	19370	161.17
DMU270	Center-West	2018	740184.27	93546.02	551704	7597.02	66508.97	57284.18	427738	4349.34
DMU271	Center-West	2018	10937.90	2232.9	19193	246.38	1745.78	1745.78	13882	99.98
DMU272	Center-West	2018	23168.98	5550.79	37811	594.37	5927.33	5530.2	38127	266.44
DMU273	Center-West	2018	7257.72	1835.78	15995	227.8	497.52	497.37	4345	62.32
DMU274	Center-West	2018	28900.73	4967.91	37040	557.71	4018	4018	27889	503.45
DMU275	Center-West	2018	25105.58	5558.24	52499	881.03	1553.75	1553.75	11243	100.81
DMU276	Center-West	2018	12892.27	3462.28	28942	310.45	1109.16	1109.16	9853	101.96
DMU277	Center-West	2018	15971.00	3591.11	36005	296.65	1595.55	1595.55	16170	233.93
DMU278	Center-West	2018	8125.99	2152.05	15817	204.6	2152.04	2152.04	16533	132.45
DMU279	Center-West	2018	44222.61	9304.19	67403	706.39	6080.08	6080.08	40010	458.42
DMU280	Center-West	2018	9701.22	2091.53	19385	203.26	1245.63	1245.63	11237	62.67
DMU281	Center-West	2018	25391.46	4977.03	46916	1331.3	2745.55	2745.55	24756	335.72
DMU282	Center-West	2018	21019.55	6297.32	61398	330.14	2527.21	2527.21	21242	108.51

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU283	Center-West	2018	1341391.01	147064	674317	9122	125201	125201	569117	6924
DMU001	North	2019	11485.22	4519.97	25078	439.35	1777.47	1777.47	17498	104
DMU002	North	2019	36068.80	13230.7	62898	1148.66	4472.62	4472.62	23075	548.34
DMU003	North	2019	317732.76	61492.28	443131	3865.45	19544.57	19544.57	64786	579.11
DMU004	North	2019	106572.31	17806.2	93821	1411.26	16025.58	16025.58	84662	970.68
DMU005	North	2019	243178.04	47503.6	221347	2127	14505.44	1337.72	40655	548.75
DMU006	Northeast	2019	14150.93	8783.53	42096	430.5	433	433	2214	59.05
DMU007	Northeast	2019	43235.17	12107.55	65453.00	595.33	4566.37	4566.37	21841.00	136.50
DMU008	Northeast	2019	233119.82	40849.05	191209	1980.48	32679.24	8090.04	90191	923.68
DMU009	Northeast	2019	190550.60	41712.28	311256	2897.49	10733.89	10733.89	61473	527
DMU010	Northeast	2019	3390.06	898.02	7445.00	102.81	103.16	103.16	1045.00	21.53
DMU011	Northeast	2019	4568.58	710.30	8464.00	54.40	124.57	124.57	1756.00	23.81
DMU012	Northeast	2019	5045.28	665.94	6558.00	147.09	319.20	319.20	3023.00	37.53
DMU013	Northeast	2019	12091.86	1766.45	15363.00	164.57	466.09	466.09	4485.00	52.54
DMU014	Northeast	2019	5380.79	1634.63	12944.00	98.55	182.54	182.54	1884.00	44.06
DMU015	Northeast	2019	2365.66	299.75	3369.00	58.45	107.71	107.71	1345.00	15.71
DMU016	Northeast	2019	2244.52	5550.0	18010.0	155.0	1845.0	1363.0	4982.0	87.0
DMU017	Northeast	2019	3027.66	1851.00	14665.00	109.30	404.00	404.00	3021.00	23.00
DMU018	Northeast	2019	5011.49	1049.78	12822.00	148.39	25.22	25.22	508.00	4.53
DMU019	Northeast	2019	40777.91	9339.07	89933.00	636.91	3719.76	3719.76	43407.00	280.19
DMU020	Northeast	2019	13308.16	1631.27	18650.00	204.23	655.52	655.52	10083.00	130.70
DMU021	Northeast	2019	8181.15	1996.86	16159.00	249.40	219.34	219.34	1865.00	25.43
DMU022	Northeast	2019	455629.22	101925.15	662869.00	4176.65	56427.95	56427.95	406645.00	2633.42
DMU023	Northeast	2019	8707.75	1490.31	18033.00	150.97	356.97	356.97	1750.00	12.73
DMU024	Northeast	2019	3109.47	3325.00	13661.00	140.00	1406.00	1338.00	4623.00	49.00
DMU025	Northeast	2019	11733.63	3487.34	31130.00	414.33	518.05	518.05	3969.00	31.00
DMU026	Northeast	2019	14116.56	2896.29	24423.00	313.16	1238.60	1238.60	11260.00	51.57
DMU027	Northeast	2019	43538.82	10501.73	87800.00	723.34	2384.93	2384.93	24545.00	170.42
DMU028	Northeast	2019	7592.10	6274.05	21310.00	201.39	1451.60	1451.60	5638.00	71.35
DMU029	Northeast	2019	44449.94	7981.82	74193.00	584.83	4981.98	4981.98	36560.00	227.28
DMU030	Northeast	2019	13188.31	2553.91	26831.00	275.71	312.69	312.69	4250.00	65.41
DMU031	Northeast	2019	5983.40	2546.00	18291.00	633.00	61.00	61.00	334.00	4.00
DMU032	Northeast	2019	5676.74	1242.06	14965.00	152.03	227.77	227.77	731.00	3.10

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU033	Northeast	2019	10875.84	2060.44	20401.00	170.49	943.56	943.56	12071.00	42.05
DMU034	Northeast	2019	13305.30	2053.95	19694	190.88	357.84	357.84	5179	83.56
DMU035	Northeast	2019	11271.82	1672.79	17248	163.6	462.98	462.98	5565	55.7
DMU036	Northeast	2019	28449.73	9130.74	63026	817.99	4484.21	4484.21	43540	540
DMU037	Northeast	2019	4760.92	1103.4	11398	103.87	106.09	106.09	1605	19.09
DMU038	Northeast	2019	12816.05	2052.33	21429	288.84	531.79	531.79	7399	68.93
DMU039	Northeast	2019	1779.24	305.29	3942	55.53	42.58	42.58	593	7
DMU040	Northeast	2019	10472.01	2364.37	20320	309.06	386.41	386.41	4079	59
DMU041	Northeast	2019	5203.62	3552.04	20758	204.5	382.3	382.3	4278	42.8
DMU042	Northeast	2019	8275.60	1546.6	14489	200.21	253.55	253.55	754	21.53
DMU043	Northeast	2019	58005.30	11177.95	74815	1200.62	6310.28	6310.28	37228	255
DMU044	Northeast	2019	174991.89	36795.85	212709	1674.7	20170.12	20170.12	84457	1056.04
DMU045	Northeast	2019	5840.27	3574.51	15598	78.98	879.65	879.65	1890	8.75
DMU046	Northeast	2019	12882.23	2251.45	20146	186.6	354.56	354.56	3136	23.92
DMU047	Northeast	2019	92638.28	17175.04	128255	763.74	12519.84	12519.84	106481	430.28
DMU048	Northeast	2019	18411.95	2239.47	18139	135.16	1234.37	1234.37	11137	57.04
DMU049	Northeast	2019	233976.59	42796.93	209441	1032.76	31025.97	31025.97	149174	654.28
DMU050	Northeast	2019	25848.30	4186.84	34220	217.4	533.98	533.98	4571	14.57
DMU051	Northeast	2019	4853.32	1062.94	10020	89.05	288.09	288.09	3525	18.39
DMU052	Northeast	2019	5538.50	2692.3	25180.0	225.1	936.6	936.6	6362.0	90.0
DMU053	Northeast	2019	12092.46	2384.03	22470	193.57	154.23	154.23	1110	13.06
DMU054	Northeast	2019	40654.28	22824.61	46998	578.1	888.04	888.04	5618	194.29
DMU055	Northeast	2019	7650.95	3806.46	30338	344.17	160.27	160.27	561	7.53
DMU056	Northeast	2019	38626.33	12194.98	109874	1070.4	5818.18	5818.18	50529	431.17
DMU057	Northeast	2019	19992.48	5200.17	45344	470.88	554.13	554.13	5153	129.72
DMU058	Northeast	2019	13309.38	4133.23	30305	348.12	83.09	83.09	340	6.52
DMU059	Northeast	2019	14982.89	2838.07	24843	317.37	193.34	193.34	999	18.93
DMU060	Northeast	2019	40823.23	22155.53	118891	1156.34	3391.44	3391.44	21775	360.45
DMU061	Northeast	2019	3641.38	1313.7	14815	141.29	442.51	442.51	5263	84.15
DMU062	Northeast	2019	42439.86	12217.17	93870	840.58	6437.59	6437.59	35776	470.64
DMU063	Northeast	2019	27938.80	9834.44	82307	1262.13	4490.16	4490.16	36671	623.44
DMU064	Northeast	2019	41211.40	13214.11	93571	970.74	9746.85	9746.85	69547	669.01
DMU065	Northeast	2019	461404.21	63462.11	297810	3578.36	47526.41	47402.84	99179	1742.51

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU066	Northeast	2019	7008.68	2539.33	21137	228.99	619.97	619.97	6793	70.13
DMU067	Northeast	2019	17102.61	4435	33653	319.91	1380.15	1380.15	12639	159.8
DMU068	Northeast	2019	282651.05	33351.2	155000	1616.41	13183	13183	59401	403.03
DMU069	Northeast	2019	254913.09	40496.27	218515	1785.93	21492.74	21492.74	115959	1070.06
DMU070	Northeast	2019	33636.18	8057.87	45267	412.84	2161.71	2161.71	15185	165.09
DMU071	Northeast	2019	36945.63	6564.4	52677	670.1	4528.46	4528.46	37460	298.93
DMU072	Northeast	2019	7910.63	2941	18639	222	1833.56	1493.24	9039	179
DMU073	Northeast	2019	10527.69	2548.44	21717	468.22	157.45	157.45	1743	11.39
DMU074	Northeast	2019	73405.86	13545.79	81491	1142.12	5049.11	3212.38	33978	181.93
DMU075	Northeast	2019	27868.23	2717.03	25826	299.96	1231.31	1219.37	12923	176.47
DMU076	Northeast	2019	17691.54	1771.42	16991	220	1388.78	1388.78	11060	93.48
DMU077	Northeast	2019	13929.90	3756.4	34078	301.77	376.65	376.65	4375	23.73
DMU078	Northeast	2019	118890.45	19787.22	174078	2357.88	14752.28	14752.28	117291	678.22
DMU079	Northeast	2019	35964.55	5977.27	48341	596.56	4064.51	4064.51	31630	152.92
DMU080	Northeast	2019	7356.76	1421.22	16306	154.37	83.88	83.88	1086	9.97
DMU081	Northeast	2019	16244.90	2746.15	28138	408.4	373.73	373.73	4394	25.42
DMU082	Northeast	2019	9929.24	2087.66	23251	243.08	277.83	277.83	4088	23.76
DMU083	Northeast	2019	39867.22	18457.29	50686	441	14396.69	4606.93	40114	353
DMU084	Northeast	2019	6173.25	3515.6	23501.0	189.9	2381.5	503.1	22160.0	140.1
DMU085	Northeast	2019	32020.92	5321.45	52517	496.65	4855.08	4855.08	47775	461.97
DMU086	Northeast	2019	22623.25	20653	66430	514	6460	5679	58180	444
DMU087	Northeast	2019	46083.88	10506.74	43732	575.99	4057.1	3974.46	20586	140.56
DMU088	Northeast	2019	17540.45	4619.38	33878	286.96	1520.88	1520.88	12834	148.16
DMU089	Northeast	2019	28619.73	4009.88	33551	368.46	4782.55	4782.55	30817	345.35
DMU090	Northeast	2019	802261.35	121417.93	489845	4580.11	128009.58	125423.29	526876	4088.85
DMU091	Northeast	2019	14240.36	2658.77	17241	122.89	804.38	804.38	8270	71.91
DMU092	Northeast	2019	16547.90	3675.08	35987	384.56	837.78	831.47	8728	49.41
DMU093	Northeast	2019	13300.25	5097.98	27388	303.45	269.64	269.64	3189	18.99
DMU094	Northeast	2019	28704.56	5084.61	25262	436.7	1792.07	1755.59	14112	76.82
DMU095	Northeast	2019	25845.21	4298.16	40364	442.95	2768.12	2768.12	24256	248.64
DMU096	Northeast	2019	68696.91	11895.89	99302	1252.33	10876.36	10876.36	88189	777.59
DMU097	Southeast	2019	21183.93	4144.98	31819	322.38	3221.44	3219.26	31605	314.87
DMU098	Southeast	2019	11508.25	16739.30	46165.00	505.00	13391.44	5801.33	45190.00	490.55

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU099	Southeast	2019	27536.31	5518.33	41389	694.55	4314.41	4314.41	41315	542.07
DMU100	Southeast	2019	26429.98	6968.71	34778	299.67	3707.04	815.93	28919	265.17
DMU101	Southeast	2019	717360.44	139031.11	602243	6935.52	108635.54	108635.54	614720	4464.32
DMU102	Southeast	2019	99684.84	17679.22	127157	1521.35	11861.23	11861.23	107478	1062.73
DMU103	Southeast	2019	30324.09	5605.1	48002	446.42	3902.07	3176.52	42983	362.32
DMU104	Southeast	2019	164122.65	29707.66	185179	1970.66	21840.4	21840.4	175948	1287.09
DMU105	Southeast	2019	13126.21	2671.47	22643	195.39	2138.84	2138.84	23079	171.54
DMU106	Southeast	2019	55578.93	10225.72	71692	691.21	8770.89	8770.89	76035	558.92
DMU107	Southeast	2019	15979.64	6725.16	32824	423.62	6523.41	2338.15	30644	323.03
DMU108	Southeast	2019	22925.84	4934.71	32530	814.24	3633.7	3294.46	30962	343.16
DMU109	Southeast	2019	19064.22	6949	40406	565.34	5941.85	5745.78	39912	543.47
DMU110	Southeast	2019	12087.11	2950.58	25503	406.32	630.4	630.4	7051	102.44
DMU111	Southeast	2019	129433.22	31157.93	140190	1865.82	23327.26	1487.67	137807	1365.7
DMU112	Southeast	2019	19436.74	4210.59	25555	586.22	1777.28	1777.28	13096	259.21
DMU113	Southeast	2019	26680.94	4930.08	38449	482.23	3729.94	3729.94	37568	389.53
DMU114	Southeast	2019	9507.29	4816.65	21320	260.4	4345.32	5.2	16244	173.2
DMU115	Southeast	2019	98267.58	14353.73	136665	1805.91	11482.64	11482.64	137767	1278.74
DMU116	Southeast	2019	18114.09	5832.77	35751	476.73	4957.85	1668.3	35660	477.65
DMU117	Southeast	2019	24234.80	6017.94	30628	504.26	1030.53	1030.53	3112	72.6
DMU118	Southeast	2019	19560.09	3339.1	28626	311.27	2380.75	2380.75	26423	266.89
DMU119	Southeast	2019	15018.87	7495.51	39378	535.92	5996.41	3036.12	39078	480.87
DMU120	Southeast	2019	15629.89	3938	29160	469	3150	3072	28634	410
DMU121	Southeast	2019	10080.99	3680.36	18476	289.37	1160.09	1160.09	7949	86.29
DMU122	Southeast	2019	33401.58	10107.54	56688	1087.65	8589.4	2576.82	56152	973.04
DMU123	Southeast	2019	37002.92	7016.43	51922	668.63	5485.37	5485.37	52568	545.11
DMU124	Southeast	2019	71109.81	12273.32	94332	1095.09	8074.55	6159.45	81448	817.18
DMU125	Southeast	2019	48097.17	8124.01	59176	785.54	5497.17	5497.17	51096	470.01
DMU126	Southeast	2019	7446.98	1459.86	12838	173.87	607.2	607.2	6706	92.93
DMU127	Southeast	2019	15090.55	12381.96	33841	420.46	12785.55	387.53	32312	320.16
DMU128	Southeast	2019	7539.58	3007.46	19138	255.13	2405.97	48.44	19067	222.64
DMU129	Southeast	2019	93621.08	26064.06	112913	1902.74	26064.06	25933.74	112268	1869.51
DMU130	Southeast	2019	122136.19	60043.19	194497	3438.6	50217.05	50217.05	192710	2808.9
DMU131	Southeast	2019	13583.75	5006.86	23462	339.79	3435.43	2828.95	20605	248.8

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU132	Southeast	2019	36465.34	6711.36	50268	664.43	5218.11	5218.11	50841	555.39
DMU133	Southeast	2019	31660.18	4375.83	31706	540.5	3085.83	3085.83	29459	316.94
DMU134	Southeast	2019	7608.35	4181	21183	285.6	3345	33.45	19287	219.4
DMU135	Southeast	2019	24778.33	5191.45	31355	390.88	3557.92	1601.06	23559	248.93
DMU136	Southeast	2019	57349.10	9637.2	61745	659.02	7226.49	7092.8	56995	544.92
DMU137	Southeast	2019	54447.71	16345.25	85616	1297.73	5307.98	4382.97	32321	391.76
DMU138	Southeast	2019	17242.63	6545	28330	340	8419	44	25287	210
DMU139	Southeast	2019	25348.76	7609.72	30682	539.88	5148.05	5148	14213	229.05
DMU140	Southeast	2019	13564.97	8124.4	36448	506.48	6455.87	5487.49	26762	294.16
DMU141	Southeast	2019	8399.12	4211.9	29553	480	3094.82	216.64	19641	138
DMU142	Southeast	2019	123869.43	37033.71	106079	1844.55	14675.96	14675.96	77277	1018.15
DMU143	Southeast	2019	10616.82	3187.18	14902	272.11	1126.27	885.66	7119	90.14
DMU144	Southeast	2019	96272.41	28901.06	94664	1369.92	15918.7	15915.55	33947	408.31
DMU145	Southeast	2019	89277.36	26801.14	56373	864.14	20007.03	20007.03	41909	481.08
DMU146	Southeast	2019	24607.75	14834.8	45598	391.4	6803.21	1006.9	23622	226.2
DMU147	Southeast	2019	43106.06	7677.2	47516	3129	10607.31	300	39418	1602
DMU148	Southeast	2019	46627.35	27782.52	77888	563.33	12673.53	1016	41800	418
DMU149	Southeast	2019	59284.90	9996	80913	1317	12024	12024	80913	39
DMU150	Southeast	2019	137216.12	19178.29	101900	1537	12745	12745	77046	1013
DMU151	Southeast	2019	64582.75	70908.29	137973	1311.43	28652.03	2397	67500	675
DMU152	Southeast	2019	7316.41	3270.64	23911	160	267.42	184	2300	23
DMU153	Southeast	2019	245555.41	36818.4	88704	1314.98	42824.06	42824.06	82494	785.83
DMU154	Southeast	2019	57733.07	8384.5	43583	741.3	7822.97	7723.11	39872	438.7
DMU155	Southeast	2019	68300.82	10175.98	60710	876.3	12882	10419	44511	288.5
DMU156	Southeast	2019	34006.36	7431.63	37618	507.47	7308.48	5254.43	37541	418.64
DMU157	Southeast	2019	48610.65	9115.12	29996	169.5	2872.7	2872.7	16884	226
DMU158	Southeast	2019	1284647.10	527345.13	1357211	10839.45	427367.57	346019.45	965444	6765.73
DMU159	Southeast	2019	182943.30	138997.51	135191	1692	35719.65	11550	72100	721
DMU160	Southeast	2019	24694.65	4609	40759	701	3340	3340	40759	56
DMU161	Southeast	2019	21480.28	8950	24536	550	11450	350	17597	500
DMU162	Southeast	2019	60009.75	17437.99	87612	1045.6	13950.39	4224.66	71726	904.57
DMU163	Southeast	2019	47836.34	15296.61	82979	2162.5	14321.63	7722.53	81662	2331.54
DMU164	Southeast	2019	14681.86	3790.29	24577	326.4	3032.23	1767.17	21987	228.96

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU165	Southeast	2019	12725.45	3642.23	22467	293.26	3537	3537	22750	322.46
DMU166	Southeast	2019	56004.15	14799.77	75497	745.33	15323.01	15323.01	74440	848.34
DMU167	Southeast	2019	69583.16	17716.29	99189	1440.71	18963.41	18963.41	99449	1202.06
DMU168	Southeast	2019	28820.92	4882.96	27919	401.24	2457.08	2457.08	18850	201.78
DMU169	Southeast	2019	26216.86	6367.79	39862	498.14	6320.21	6320.21	39738	402.98
DMU170	Southeast	2019	50328.23	7248.31	42770	604.74	9735.37	5657.04	26483	404.7
DMU171	Southeast	2019	21394.23	5109.56	34959	421.2	5049.85	5049.85	33785	343.31
DMU172	Southeast	2019	37489.56	7778.36	51174	700	6781.11	6781.11	50307	650
DMU173	Southeast	2019	97695.41	19163.92	82488	747.72	12168.16	6224.09	64333	428.62
DMU174	Southeast	2019	14303.95	7101.8	30694.0	731.0	4617.3	2615.2	30670.0	729.0
DMU175	Southeast	2019	42819.50	4571.76	25825	357.62	2762.79	2762.79	13208	244.95
DMU176	Southeast	2019	16665.83	3286.03	20538	153.28	2416.46	2416.46	17692	69.58
DMU177	Southeast	2019	42048.32	9145.55	57606	659.23	8426.19	8426.19	54716	477.63
DMU178	South	2019	22017.24	4467.49	30834	488.27	1892.12	1892.12	17237	242.59
DMU179	South	2019	42983.02	6713.5	47175	621.44	5278.18	5278.18	36300	667.8
DMU180	South	2019	33423.31	5793.07	44089	628.83	3916.66	3916.66	28302	486.35
DMU181	South	2019	36892.34	7051.41	40129	680.06	4486.81	4486.81	30845	519.54
DMU182	South	2019	32254.56	5872.22	37820	379.49	5268.79	5268.79	35483	520.52
DMU183	South	2019	32270.90	5405.58	36298	676.92	3509.32	3509.32	24658	566.69
DMU184	South	2019	27696.81	5267.97	36304	500.83	4617.44	4617.44	31187	537.2
DMU185	South	2019	85495.91	15452.06	100613	1468.06	16083.6	16083.6	92686	1458.46
DMU186	South	2019	13147.40	2498.54	19717	288.37	2005.94	2005.94	15848	246.76
DMU187	South	2019	25667.57	4190.43	26892	673.83	2792.37	2792.37	16011	253.94
DMU188	South	2019	45630.18	10274.28	66641	950.93	6267.3	6267.3	44239	596.61
DMU189	South	2019	587863.08	200555.45	491362	7418.84	104925.19	104925.19	456696	6331.21
DMU190	South	2019	26588.24	5316.76	47048	608.56	4293.84	4293.84	38350	528.92
DMU191	South	2019	82622.46	17575.18	90150	1535.89	14417.13	14417.13	67416	1232.98
DMU192	South	2019	24703.31	4324.16	26059	569.27	3489.2	3489.2	19063	409.15
DMU193	South	2019	44729.43	8149.95	54090	1063.81	6628.65	6628.65	44389	818.48
DMU194	South	2019	9498.62	3361.57	20975	459.78	2989.63	2989.63	19178	299.57
DMU195	South	2019	13727.23	2183.19	17728	398.31	1859.52	1859.52	15470	300.73
DMU196	South	2019	199181.70	45073.4	164582	2018.43	33184.45	33184.45	150930	1874.96
DMU197	South	2019	9340.76	3721.55	18552	600.23	694.46	694.46	5085	159.45

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DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU198	South	2019	135152.83	23496.12	131071	1967.58	24885.08	24885.08	119052	1773.54
DMU199	South	2019	8271.06	1705.09	13017	239.04	1338.05	1338.05	9890	151.75
DMU200	South	2019	61107.39	5335.28	35929	653.77	4416.5	4416.5	31325	579.55
DMU201	South	2019	31512.62	5009.3	35869	749.65	4207.96	4207.96	28718	552.43
DMU202	South	2019	27025.19	4623.03	27856	669.09	3755.16	3755.16	21058	409.12
DMU203	South	2019	29026.55	77158.44	38168	617.68	5216.54	5216.54	31289	482.54
DMU204	South	2019	31584.07	4625.91	32175	567.38	3981.22	3981.22	28931	441.93
DMU205	South	2019	92326.87	16857.28	116530	1465.4	14821.55	14821.55	104300	1604.09
DMU206	South	2019	6570.57	1087.2	9768	186.6	867.75	867.75	7978	177.2
DMU207	South	2019	16215.90	3414.91	24663	350.85	1735.58	1735.58	11839	239.64
DMU208	South	2019	70941.26	29495.85	82705	1414.2	10579.26	10579.26	56616	859.17
DMU209	South	2019	22274.11	3620.92	25554	341.86	2934.28	2934.28	20710	256.28
DMU210	South	2019	38024.17	7249.67	45132	810.83	5715.18	5715.18	34630	731.48
DMU211	South	2019	34634.06	6248.01	42292	503.78	5755.27	5755.27	35607	561.02
DMU212	South	2019	13888.64	4570.84	17375	353.92	905.73	905.73	4727	89.31
DMU213	South	2019	34103.90	21370.37	30318	381	17424.32	17404.92	28121	310
DMU214	South	2019	66812.75	19997.88	92113	1598.46	6976	6624	26788	364
DMU215	South	2019	46839.48	8443.29	46503	687.13	5021.47	5021.47	12798	242.21
DMU216	South	2019	17742.18	3044.48	19233	309.37	39.54	39.54	1012	3.81
DMU217	South	2019	207996.94	60396.81	108634	1485.27	14553.44	10390.32	43749	660.72
DMU218	South	2019	32754.59	5399	14911	291.17	3042.59	3042.59	6787	175.9
DMU219	South	2019	40124.42	8916.69	42158	892.6	6355.52	6355.52	32539	590.8
DMU220	South	2019	125881.25	35597	154098	2252.34	9072	9072	41510	553.57
DMU221	South	2019	34247.80	9876.99	50193	783.13	2043.01	1778.87	11812	156.25
DMU222	South	2019	18973.92	11495	50504	715	1324.03	1297.55	8737	85
DMU223	South	2019	15331.70	3983	27175	606	933.98	933.98	6579	155
DMU224	South	2019	57480.10	14227.24	52251	608.9	9134.09	9134.09	11469	98.73
DMU225	South	2019	20549.99	3031.77	22559	281.11	600.2	938.5	3976	70.82
DMU226	South	2019	52882.33	26385.01	52084	599.95	1467.06	1310.7	14881	250.2
DMU227	South	2019	32620.89	4776.2	40329	482	4040.89	1037.32	28019	319.92
DMU228	South	2019	22282.90	3615.11	26716	250.94	1058.97	1459.96	8243	168.02
DMU229	South	2019	44709.32	17020.67	37533	398.91	2627.49	7307.44	23034	368.74
DMU230	South	2019	6755.61	810.62	7439	78.21	1540.44	100.37	10348	56

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU231	South	2019	122234.25	17342.67	79269	844.88	4587.69	8827.08	20120	752.48
DMU232	South	2019	27230.93	6132.67	18926	360.6	1500.95	2494.91	3583	80.8
DMU233	South	2019	93612.62	21967.25	136179	2056.85	17573.8	10217.28	122322	1802.39
DMU234	South	2019	18088.11	2821.2	20386	224.31	440.78	428.47	2886	59.06
DMU235	South	2019	10263.05	2684.23	12131	162.98	48.14	26.04	418	7.2
DMU236	South	2019	27573.43	17323.53	20343	204.91	254.36	126.68	1327	4.1
DMU237	South	2019	87784.55	9697.95	63703	700.62	2716.5	1639.85	23507	614.58
DMU238	South	2019	48379.55	10508.74	52763	896.42	791.11	791.11	2892	73.07
DMU239	South	2019	58178.05	10588.28	54876	798.91	2237.89	2868.65	10021	317.22
DMU240	South	2019	84583.29	17689.22	92669	1060.96	9840	2950	49664	488.75
DMU241	South	2019	273651.06	117241.29	302579	4170.02	74788.3	60373.99	252412	2022.88
DMU242	South	2019	74604.80	9379.17	58889	547.58	2360.34	2622.08	15269	183.94
DMU243	South	2019	42433.36	6258.85	37457	598.01	829.93	446.9	5731	161.72
DMU244	South	2019	101605.94	12641.72	64813	740.58	5426.91	6447.67	29157	304.03
DMU245	South	2019	16596.51	3523.1	24178	282.35	1482.35	1107.13	9297	98.67
DMU246	South	2019	23004.22	3751.18	21470	253.31	949.46	442.12	5162	98.25
DMU247	South	2019	13275.39	2305.44	16474	197.93	357.36	958.41	2639	49.64
DMU248	South	2019	54316.50	10999.42	64741	773	1453.7	180.09	5086	131.5
DMU249	South	2019	35189.53	6041.72	34895	346.3	258.53	235.39	246	1.97
DMU250	South	2019	21156.77	2985.5	27060	398.83	586.25	676.06	3319	54.91
DMU251	Center-West	2019	258629.29	53406.47	315912	4005.74	32534.53	32534.53	215459	2245.8
DMU252	Center-West	2019	66463.64	11626.34	73409	1355.72	7081.53	7081.53	46233	723.41
DMU253	Center-West	2019	11151.44	2761.01	19076	234.62	764.26	764.26	6321	96.47
DMU254	Center-West	2019	10212.60	2660.96	16790	345.94	488.79	488.79	4389	47.24
DMU255	Center-West	2019	18488.06	3720.01	25707	382.7	1737.26	1737.26	14013	236.74
DMU256	Center-West	2019	32274.21	7074.46	48669	746.44	3916.7	3916.7	33854	486.74
DMU257	Center-West	2019	7859.76	2337	14916	221.48	915	915	6307	117.51
DMU258	Center-West	2019	5571.85	5039.21	23032	436.5	1346.2	1346.2	7063	108.5
DMU259	Center-West	2019	14937.61	3471.86	21529	348.21	2673.52	2673.52	15964	320.18
DMU260	Center-West	2019	37406.39	10860.13	78588	1136.07	9991	9781	69818	704.23
DMU261	Center-West	2019	7800.64	4696.6	30953	355.15	3974	3974	7248	138.34
DMU262	Center-West	2019	30759.87	15625.99	74169	1250.45	9460	6046.7	21471	187.67
DMU263	Center-West	2019	120098.53	16711.62	141863	2044.43	11123.2	11123.2	87866	730.77

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Table A.2 - Continuation

DMU	Region	Year	TOTEX	VWCons	NWConn	Wnet	VSCol	VSTreat	NSConn	SNet
DMU264	Center-West	2019	110398.18	16186.3	134878	2996.94	9149.64	8548.94	80160	937.17
DMU265	Center-West	2019	13705.79	4814.26	43100	502.32	3034.19	2414.86	27802	360.69
DMU266	Center-West	2019	16195.20	3003.06	32365	294.74	1039.09	1039.09	10280	52.55
DMU267	Center-West	2019	8919.47	1712.15	13396	143.63	755.84	755.84	5986	80.45
DMU268	Center-West	2019	30667.46	4444.16	38474	365.9	3836.93	3836.93	32717	404.99
DMU269	Center-West	2019	14552.05	2504.82	21228	303.98	2524.55	2524.55	19899	161.17
DMU270	Center-West	2019	459209.65	97544.88	565143	7650.59	68784.88	58857.85	437939	4376.88
DMU271	Center-West	2019	15401.55	2477.95	19715	256.84	1876.67	1876.67	14027	99.98
DMU272	Center-West	2019	30255.16	5639.41	39177	594.37	6146.74	5690.46	39494	266.44
DMU273	Center-West	2019	9382.20	1864.57	16197	227.79	505.73	505.66	4441	62.32
DMU274	Center-West	2019	36678.93	5302.62	38093	558.78	4295.27	4295.27	30521	503.8
DMU275	Center-West	2019	31302.92	5924.51	54623	881.03	1633.76	1633.76	12088	100.81
DMU276	Center-West	2019	18216.51	3589.65	29643	351.34	1245.04	1245.04	10273	101.96
DMU277	Center-West	2019	24517.58	3657.25	36777	236.65	1656.02	1656.02	17885	233.93
DMU278	Center-West	2019	14127.28	1915.77	16124	204.6	2245.62	2245.62	16763	132.45
DMU279	Center-West	2019	59370.61	9852.05	69442	728.5	6649.56	6649.56	45225	458.42
DMU280	Center-West	2019	12340.01	2222.1	19883	204.7	1296.48	1296.48	11505	62.8
DMU281	Center-West	2019	35777.16	5287.4	48773	1331.29	3003.5	3003.5	26215	335.72
DMU282	Center-West	2019	32082.28	6841.33	64081	345.31	2771.7	2771.7	21434	108.76
DMU283	Center-West	2019	1203872.02	158200	688562	9269	129923	129923	591150	7286

A.3 Information and indicators used in Chapter 7

Table A.3: Data used in Chapter 7

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Almirante Tamandaré	PR	South	24681.74511	30834	17237	4467.49	1892.12	1892.12	488.27	242.59
Apucarana	PR	South	41533.95432	47175	36300	6713.5	5278.18	5278.18	621.44	667.8
Arapongas	PR	South	34283.97053	44089	28302	5793.07	3916.66	3916.66	628.83	486.35
Araucária	PR	South	40336.71229	40129	30845	7051.41	4486.81	4486.81	680.06	519.54
Cambé	PR	South	27634.97962	37820	35483	5872.22	5268.79	5268.79	379.49	520.52
Campo Largo	PR	South	32768.19546	36298	24658	5405.58	3509.32	3509.32	676.92	566.69
Campo Mourão	PR	South	29149.31661	36304	31187	5267.97	4617.44	4617.44	500.83	537.2
Cascavel	PR	South	85713.86001	100613	92686	15452.06	16083.6	16083.6	1468.06	1458.46
Castro	PR	South	13491.87491	19717	15848	2498.54	2005.94	2005.94	288.37	246.76
Cianorte	PR	South	30420.67847	26892	16011	4190.43	2792.37	2792.37	673.83	253.94
Colombo	PR	South	43627.72037	66641	44239	10274.28	6267.3	6267.3	950.93	596.61
Curitiba	PR	South	624406.4842	491362	456696	200555.45	104925.19	104925.19	7418.84	6331.21
Fazenda Rio Grande	PR	South	24071.12147	47048	38350	5316.76	4293.84	4293.84	608.56	528.92
Foz do Iguaçu	PR	South	79962.35215	90150	67416	17575.18	14417.13	14417.13	1535.89	1232.98
Francisco Beltrão	PR	South	26415.88631	26059	19063	4324.16	3489.2	3489.2	569.27	409.15
Guarapuava	PR	South	41519.25718	54090	44389	8149.95	6628.65	6628.65	1063.81	818.48
Ibiporã	PR	South	13567.43294	20975	19178	3361.57	2989.63	2989.63	459.78	299.57
Irati	PR	South	15690.40112	17728	15470	2183.19	1859.52	1859.52	398.31	300.73
Londrina	PR	South	222094.4431	164582	150930	45073.4	33184.45	33184.45	2018.43	1874.96
Marechal Cândido Rondon	PR	South	13847.13223	18552	5085	3721.55	694.46	694.46	600.23	159.45
Maringá	PR	South	119957.1771	131071	119052	23496.12	24885.08	24885.08	1967.58	1773.54
Palmas	PR	South	8614.44327	13017	9890	1705.09	1338.05	1338.05	239.04	151.75
Paranaguá	PR	South	43579.98351	35929	31325	5335.28	4416.5	4416.5	653.77	579.55
Paranavaí	PR	South	32821.6195	35869	28718	5009.3	4207.96	4207.96	749.65	552.43
Pato Branco	PR	South	29235.01354	27856	21058	4623.03	3755.16	3755.16	669.09	409.12
Pinhais	PR	South	25659.81878	38168	31289	77158.44	5216.54	5216.54	617.68	482.54
Piraquara	PR	South	21431.32437	32175	28931	4625.91	3981.22	3981.22	567.38	441.93
Ponta Grossa	PR	South	94227.57192	116530	104300	16857.28	14821.55	14821.55	1465.4	1604.09
Prudentópolis	PR	South	7142.8193	9768	7978	1087.2	867.75	867.75	186.6	177.2
Rolândia	PR	South	16875.86823	24663	11839	3414.91	1735.58	1735.58	350.85	239.64
São José dos Pinhais	PR	South	69111.67683	82705	56616	29495.85	10579.26	10579.26	1414.2	859.17
Telêmaco Borba	PR	South	24513.51989	25554	20710	3620.92	2934.28	2934.28	341.86	256.28
Toledo	PR	South	38635.73621	45132	34630	7249.67	5715.18	5715.18	810.83	731.48

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Umuarama	PR	South	39207.29767	42292	35607	6248.01	5755.27	5755.27	503.78	561.02
União da Vitória	PR	South	16427.92216	17375	4727	4570.84	905.73	905.73	353.92	89.31
Araranguá	SC	South	6570.9551	16400	2160	3308.69	473.04	473.04	593.46	63.18
Balneário Camboriú	SC	South	48188.14681	30318	28121	21370.37	17424.32	17404.92	381	310
Canoinhas	SC	South	12317.24016	15227	2191	2721.82	259.75	259.75	377.93	51.17
Chapecó	SC	South	50469.89934	46503	12798	8443.29	5021.47	5021.47	687.13	242.21
Concórdia	SC	South	22136.93644	19233	1012	3044.48	39.54	39.54	309.37	3.81
Criciúma	SC	South	65547.69689	53448	7470	19826.33	2809.86	2809.86	1137.96	157.8
Florianópolis	SC	South	201794.914	108634	43749	60396.81	14553.44	10390.32	1485.27	660.72
Gaspar	SC	South	14081.18135	17760	240	3759.97	44.18	44.18	418.81	1.9
Içara	SC	South	14559.54826	15570	3257	2206.33	135.91	135.91	215.63	48.11
Indaial	SC	South	15924.5986	18260	2647	3180.49	455.67	455.67	388.02	20.04
Itajaí	SC	South	62357.10911	55387	6559	23510.05	3173.27	3173.27	709.81	163.26
Itapema	SC	South	25739.04113	14911	6787	5399	3042.59	3042.59	291.17	175.9
Jaraguá do Sul	SC	South	51442.19338	42158	32539	8916.69	6355.52	6355.52	892.6	590.8
Joinville	SC	South	146657.3372	154098	41510	35597	9072	9072	2252.34	553.57
Lages	SC	South	50978.2651	50193	11812	9876.99	2043.01	1778.87	783.13	156.25
Palhoça	SC	South	28242.91723	50504	8737	11495	1324.03	1297.55	715	85
São Bento do Sul	SC	South	17251.34612	27175	6579	3983	933.98	933.98	606	155
São José	SC	South	56683.94443	52251	11469	14227.24	9134.09	9134.09	608.9	98.73
Videira	SC	South	12748.32762	14696	78	2495.04	10.1	10.1	276.12	1.43
Alegrete	RS	South	24297.4343	22559	3976	3031.77	600.2	938.5	281.11	70.82
Alvorada	RS	South	61643.56014	52084	14881	26385.01	1467.06	1310.7	599.95	250.2
Bagé	RS	South	32027.7117	40329	28019	4776.2	4040.89	1037.32	482	319.92
Cachoeira do Sul	RS	South	26797.11256	26716	8243	3615.11	1058.97	1459.96	250.94	168.02
Cachoeirinha	RS	South	52529.10907	37533	23034	17020.67	2627.49	7307.44	398.91	368.74
Canoas	RS	South	145038.3981	79269	20120	17342.67	4587.69	8827.08	844.88	752.48
Capão da Canoa	RS	South	29497.24108	18926	3583	6132.67	1500.95	2494.91	360.6	80.8
Cruz Alta	RS	South	22036.3863	20386	2886	2821.2	440.78	428.47	224.31	59.06
Estância Velha	RS	South	11874.41249	12131	418	2684.23	48.14	26.04	162.98	7.2
Esteio	RS	South	32267.81133	20343	1327	17323.53	254.36	126.68	204.91	4.1
Gravataí	RS	South	106399.3366	63703	23507	9697.95	2716.5	1639.85	700.62	614.58
Guaíba	RS	South	26795.94628	28154	1806	6984.25	204.82	513.65	589.98	110.54

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Ijuí	RS	South	28287.1406	23921	1799	4350.8	398.65	353.4	299.42	44.64
Lajeado	RS	South	22457.77557	19476	238	4520.17	30.77	33	344.62	6.46
Novo Hamburgo	RS	South	53536.18972	52763	2892	10508.74	791.11	791.11	896.42	73.07
Passo Fundo	RS	South	66736.21332	54876	10021	10588.28	2237.89	2868.65	798.91	317.22
Porto Alegre	RS	South	398825.2361	302579	252412	117241.29	74788.3	60373.99	4170.02	2022.88
Santa Cruz do Sul	RS	South	50438.5736	37457	5731	6258.85	829.93	446.9	598.01	161.72
Santa Rosa	RS	South	27244.66341	21470	5162	3751.18	949.46	442.12	253.31	98.25
Santo Ângelo	RS	South	38830.883	23778	3762	3897.41	733.88	1593.1	435.17	68.34
São Borja	RS	South	16003.80309	16474	2639	2305.44	357.36	958.41	197.93	49.64
São Gabriel	RS	South	11803.71509	19361	2844	2672.21	507.94	507.94	209	27
São Leopoldo	RS	South	80389.93982	64741	5086	10999.42	1453.7	180.09	773	131.5
Sapucaia do Sul	RS	South	41850.64432	34895	246	6041.72	258.53	235.39	346.3	1.97
Tramandaí	RS	South	23091.83944	27060	3319	2985.5	586.25	676.06	398.83	54.91
Barreirinhas	MA	Northeast	4203.66163	4445	1196	728.81	619.49	619.49	46.4	22.75
Caxias	MA	Northeast	21063.82936	42096	2214	8783.53	433	433	430.5	59.05
Coroatá	MA	Northeast	8999.80069	13613	1000	2539.24	166.52	166.52	180.15	6
Imperatriz	MA	Northeast	41215.84395	65453	21841	12107.55	4566.37	4566.37	595.33	136.5
São José de Ribamar	MA	Northeast	21993.8403	59455	18956	8470	5845	5382	566	119
São Luís	MA	Northeast	260701.077	191209	90191	40849.05	32679.24	8090.04	1980.48	923.68
Floriano	PI	Northeast	18847.03901	20117	641	3073.81	80.79	80.79	225.4	6.86
Parnaíba	PI	Northeast	43288.77875	48593	17132	6331.86	1766.06	1766.06	623.51	171.32
Picos	PI	Northeast	20500.21496	23697	12042	3174.58	1196.19	1196.19	120	120.42
Acaraú	CE	Northeast	4056.469	7445	1045	898.02	103.16	103.16	102.81	21.53
Acopiara	CE	Northeast	6103.52062	8464	1756	710.3	124.57	124.57	54.4	23.81
Aquiraz	CE	Northeast	5218.07483	6558	3023	665.94	319.2	319.2	147.09	37.53
Aracati	CE	Northeast	12331.21428	15363	4485	1766.45	466.09	466.09	164.57	52.54
Barbalha	CE	Northeast	6753.56722	12944	1884	1634.63	182.54	182.54	98.55	44.06
Beberibe	CE	Northeast	2844.92416	3369	1345	299.75	107.71	107.71	58.45	15.71
Camocim	CE	Northeast	3284.71893	18010	4982	5550	1845	1363	155	87
Canindé	CE	Northeast	4506.71357	14665	3021	1851	404	404	109.3	23
Cascavel	CE	Northeast	6531.29171	12822	508	1049.78	25.22	25.22	148.39	4.53
Caucaia	CE	Northeast	47403.32736	89933	43407	9339.07	3719.76	3719.76	636.91	280.19
Crateús	CE	Northeast	16155.86318	18650	10083	1631.27	655.52	655.52	204.23	130.7

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Crato	CE	Northeast	12920.5264	36782	10641	10164.84	3058	107.28	320.63	106.28
Eusébio	CE	Northeast	8627.91771	16159	1865	1996.86	219.34	219.34	249.4	25.43
Fortaleza	CE	Northeast	507689.463	662869	406645	101925.15	56427.95	56427.95	4176.65	2633.42
Granja	CE	Northeast	2491.35554	5711	250	2505	36	36	52.3	1.86
Horizonte	CE	Northeast	9893.10316	18033	1750	1490.31	356.97	356.97	150.97	12.73
Icó	CE	Northeast	4628.482	13661	4623	3325	1406	1338	140	49
Iguatu	CE	Northeast	17465.65495	31130	3969	3487.34	518.05	518.05	414.33	31
Itapipoca	CE	Northeast	16907.49188	24423	11260	2896.29	1238.6	1238.6	313.16	51.57
Juazeiro do Norte	CE	Northeast	54168.90153	87800	24545	10501.73	2384.93	2384.93	723.34	170.42
Limoeiro do Norte	CE	Northeast	11300.93966	21310	5638	6274.05	1451.6	1451.6	201.39	71.35
Maracanaú	CE	Northeast	47762.36873	74193	36560	7981.82	4981.98	4981.98	584.83	227.28
Maranguape	CE	Northeast	14165.1178	26831	4250	2553.91	312.69	312.69	275.71	65.41
Morada Nova	CE	Northeast	6955.95126	18291	334	2546	61	61	633	4
Pacajus	CE	Northeast	6696.20036	14965	731	1242.06	227.77	227.77	152.03	3.1
Pacatuba	CE	Northeast	10604.77467	20401	12071	2060.44	943.56	943.56	170.49	42.05
Quixadá	CE	Northeast	16406.77678	19694	5179	2053.95	357.84	357.84	190.88	83.56
Russas	CE	Northeast	13402.06847	17248	5565	1672.79	462.98	462.98	163.6	55.7
Tauá	CE	Northeast	5632.3477	11398	1605	1103.4	106.09	106.09	103.87	19.09
Tianguá	CE	Northeast	14598.79882	21429	7399	2052.33	531.79	531.79	288.84	68.93
Trairi	CE	Northeast	2378.23457	3942	593	305.29	42.58	42.58	55.53	7
Caicó	RN	Northeast	12323.82698	20320	4079	2364.37	386.41	386.41	309.06	59
Parnamirim	RN	Northeast	47850.16724	67729	3452	10647.53	641.83	641.83	444.67	69
Macaíba	RN	Northeast	11775.43362	14489	754	1546.6	253.55	253.55	200.21	21.53
Mossoró	RN	Northeast	71821.29323	74815	37228	11177.95	6310.28	6310.28	1200.62	255
Natal	RN	Northeast	214565.4212	212709	84457	36795.85	20170.12	20170.12	1674.7	1056.04
São Gonçalo do Amarante	RN	Northeast	583.84434	4284	1722	545.66	419.87	419.87	380	48
Bayeux	PB	Northeast	5592.7825	20915	2697	2751.96	362.66	362.66	105.86	19.8
Cabedelo	PB	Northeast	6181.41831	15598	1890	3574.51	879.65	879.65	78.98	8.75
Cajazeiras	PB	Northeast	17440.13036	20146	3136	2251.45	354.56	354.56	186.6	23.92
Campina Grande	PB	Northeast	122144.4799	128255	106481	17175.04	12519.84	12519.84	763.74	430.28
Guarabira	PB	Northeast	25406.90085	18139	11137	2239.47	1234.37	1234.37	135.16	57.04
João Pessoa	PB	Northeast	316055.5304	209441	149174	42796.93	31025.97	31025.97	1032.76	654.28
Patos	PB	Northeast	35556.32041	34220	4571	4186.84	533.98	533.98	217.4	14.57

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Santa Rita	PB	Northeast	12263.34321	34006	1767	5406.41	240.94	240.94	131.04	21.83
Sapé	PB	Northeast	5552.19904	10020	3525	1062.94	288.09	288.09	89.05	18.39
Abreu e Lima	PE	Northeast	6828.79832	25180	6362	2692.33	936.55	936.55	225.07	90.03
Arcoverde	PE	Northeast	16402.56943	22470	1110	2384.03	154.23	154.23	193.57	13.06
Cabo de Santo Agostinho	PE	Northeast	45746.02495	46998	5618	22824.61	888.04	888.04	578.1	194.29
Camaragibe	PE	Northeast	9650.90329	30338	561	3806.46	160.27	160.27	344.17	7.53
Caruaru	PE	Northeast	47510.34096	109874	50529	12194.98	5818.18	5818.18	1070.4	431.17
Garanhuns	PE	Northeast	26784.32969	45344	5153	5200.17	554.13	554.13	470.88	129.72
Gravatá	PE	Northeast	17541.83746	30305	340	4133.23	83.09	83.09	348.12	6.52
Igarassu	PE	Northeast	21040.70145	24843	999	2838.07	193.34	193.34	317.37	18.93
Ipojuca	PE	Northeast	16675.38916	14327	3053	2016.82	408.88	408.88	215.38	117.65
Jaboatão dos Guararapes	PE	Northeast	52361.39132	118891	21775	22155.53	3391.44	3391.44	1156.34	360.45
Moreno	PE	Northeast	4603.38904	14815	5263	1313.7	442.51	442.51	141.29	84.15
Olinda	PE	Northeast	56567.50291	93870	35776	12217.17	6437.59	6437.59	840.58	470.64
Paulista	PE	Northeast	36967.12776	82307	36671	9834.44	4490.16	4490.16	1262.13	623.44
Petrolina	PE	Northeast	52566.08589	93571	69547	13214.11	9746.85	9746.85	970.74	669.01
Recife	PE	Northeast	650917.1822	297810	99179	63462.11	47526.41	47402.84	3578.36	1742.51
Salgueiro	PE	Northeast	15293.25586	20963	6855	2190.09	757.33	757.33	267.9	94.54
São Lourenço da Mata	PE	Northeast	8953.67151	21137	6793	2539.33	619.97	619.97	228.99	70.13
Surubim	PE	Northeast	6579.44377	19404	2380	1629.16	57.22	57.22	166.26	25.85
Vitória de Santo Antão	PE	Northeast	22641.00182	33653	12639	4435	1380.15	1380.15	319.91	159.8
Arapiraca	AL	Northeast	25572.36168	56801	1070	7378.2	109.49	109.49	640.78	36.64
Coruripe	AL	Northeast	5510.34713	15586	3333	7080.1	578.89	578.89	252	25.13
Maceió	AL	Northeast	276113.6274	155000	59401	33351.2	13183	13183	1616.41	403.03
Marechal Deodoro	AL	Northeast	13781.53712	21401	5967	4715.45	1430.89	1430.89	157.2	44.6
Palmeira dos Índios	AL	Northeast	11145.38333	18679	837	2181.43	88.34	88.34	313.16	4.91
Rio Largo	AL	Northeast	14051.34343	15901	6132	1607.93	585.96	585.96	193	25
São Miguel dos Campos	AL	Northeast	7424.5564	17600	9823	2089	1652.6	315.46	195	109.75
União dos Palmares	AL	Northeast	9740.88573	18310	15855	1967.98	806.2	672.1	136.3	70.34
Aracaju	SE	Northeast	296220.0194	218515	115959	40496.27	21492.74	21492.74	1785.93	1070.06
Estância	SE	Northeast	7981.39221	19365	1916	2598.1	89.3	89.3	168.18	10.38
Lagarto	SE	Northeast	23283.65406	27887	2123	3631.6	322.29	322.29	290.92	25.2
Nossa Senhora do Socorro	SE	Northeast	48633.84009	45267	15185	8057.87	2161.71	2161.71	412.84	165.09

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Alagoinhas	BA	Northeast	31248.819	51317	13111	5145	1738	1318	626.3	100.18
Barreiras	BA	Northeast	37321.30044	52677	37460	6564.4	4528.46	4528.46	670.1	298.93
Bom Jesus da Lapa	BA	Northeast	11775.068	18639	9039	2941	1833.56	1493.24	222	179
Brumado	BA	Northeast	12059.59697	21717	1743	2548.44	157.45	157.45	468.22	11.39
Camaçari	BA	Northeast	88658.17246	81491	33978	13545.79	5049.11	3212.38	1142.12	181.93
Campo Formoso	BA	Northeast	4999.48785	10370	858	885.03	56.48	56.48	51.25	2.69
Candeias	BA	Northeast	32390.23933	25826	12923	2717.03	1231.31	1219.37	299.96	176.47
Conceição do Coité	BA	Northeast	10058.13382	19094	1025	1944.15	67.59	67.59	240.9	6.72
Cruz das Almas	BA	Northeast	11067.36412	19171	8104	1879.3	785.45	785.45	383.12	152.4
Dias d Ávila	BA	Northeast	21984.37852	16991	11060	1771.42	1388.78	1388.78	220	93.48
Euclides da Cunha	BA	Northeast	7117.05176	15411	3656	1465.68	353.82	353.82	373.26	46.6
Eunápolis	BA	Northeast	16970.46121	34078	4375	3756.4	376.65	376.65	301.77	23.73
Feira de Santana	BA	Northeast	131955.3387	174078	117291	19787.22	14752.28	14752.28	2357.88	678.22
Guanambi	BA	Northeast	20213.20803	27090	16212	3366.06	2104.42	2104.42	674.58	238.73
Ilhéus	BA	Northeast	40848.76548	48341	31630	5977.27	4064.51	4064.51	596.56	152.92
Ipirá	BA	Northeast	9152.93799	16306	1086	1421.22	83.88	83.88	154.37	9.97
Irecê	BA	Northeast	19609.46673	28138	4394	2746.15	373.73	373.73	408.4	25.42
Itaberaba	BA	Northeast	12479.87313	23251	4088	2087.66	277.83	277.83	243.08	23.76
Itabuna	BA	Northeast	39737.28866	50686	40114	18457.29	14396.69	4606.93	441	353
Itamaraju	BA	Northeast	12041.31116	18737	14835	1827.38	1431.63	1431.63	174.48	29.67
Itapetinga	BA	Northeast	9188.9603	23501	22160	3515.61	2381.5	503.09	189.9	140.1
Jacobina	BA	Northeast	13905.82682	25673	1871	2436.34	155.29	155.29	375.16	3.3
Jaguaquara	BA	Northeast	8250.87445	14073	5533	1347.32	500.2	500.02	122.1	88.52
Jequié	BA	Northeast	35317.41229	52517	47775	5321.45	4855.08	4855.08	496.65	461.97
Juazeiro	BA	Northeast	33674.99055	66430	58180	20653	6460	5679	514	444
Lauro de Freitas	BA	Northeast	51214.26563	43732	20586	10506.74	4057.1	3974.46	575.99	140.56
Luís Eduardo Magalhães	BA	Northeast	15322.26324	29096	16056	3771.38	2004.1	2004.1	268.41	237.6
Paulo Afonso	BA	Northeast	20784.5887	33878	12834	4619.38	1520.88	1520.88	286.96	148.16
Porto Seguro	BA	Northeast	31199.39575	33551	30817	4009.88	4782.55	4782.55	368.46	345.35
Salvador	BA	Northeast	793821.7411	489845	526876	121417.93	128009.58	125423.29	4580.11	4088.85
Santo Amaro	BA	Northeast	14455.00557	17241	8270	2658.77	804.38	804.38	122.89	71.91
Santo Antônio de Jesus	BA	Northeast	20186.79553	35987	8728	3675.08	837.78	831.47	384.56	49.41
Santo Estêvão	BA	Northeast	8066.94253	14542	1804	1392.67	165.66	165.66	192.2	3.43

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Senhor do Bonfim	BA	Northeast	14876.74519	27493	2068	3628.06	142.71	142.71	216.45	13.56
Serrinha	BA	Northeast	14834.99591	27388	3189	5097.98	269.64	269.64	303.45	18.99
Simões Filho	BA	Northeast	27210.47436	25262	14112	5084.61	1792.07	1755.59	436.7	76.82
Teixeira de Freitas	BA	Northeast	24628.2768	40364	24256	4298.16	2768.12	2768.12	442.95	248.64
Tucano	BA	Northeast	4699.71978	9729	4457	906.39	428.36	428.36	83.72	28.66
Vitória da Conquista	BA	Northeast	80642.67669	99302	88189	11895.89	10876.36	10876.36	1252.33	777.59
Alfenas	MG	Southeast	21494.63311	31819	31605	4144.98	3221.44	3219.26	322.38	314.87
Araguari	MG	Southeast	16875.50033	46165	45190	16739.3	13391.44	5801.33	505	490.55
Araxá	MG	Southeast	26817.91964	41389	41315	5518.33	4314.41	4314.41	694.55	542.07
Belo Horizonte	MG	Southeast	721027.2874	602243	614720	139031.11	108635.54	108635.54	6935.52	4464.32
Betim	MG	Southeast	98435.34408	127157	107478	17679.22	11861.23	11861.23	1521.35	1062.73
Bom Despacho	MG	Southeast	16842.95948	20287	20027	2355.34	1762.07	1762.07	279.68	206.41
Caratinga	MG	Southeast	18869.05266	25702	21058	3302.01	2141.1	1236.88	206.85	116.72
Conselheiro Lafaiete	MG	Southeast	31631.7538	48002	42983	5605.1	3902.07	3176.52	446.42	362.32
Contagem	MG	Southeast	155888.7895	185179	175948	29707.66	21840.4	21840.4	1970.66	1287.09
Curvelo	MG	Southeast	24496.40833	30241	25628	3355.6	2250.5	2250.5	321.78	196.22
Divinópolis	MG	Southeast	57796.94074	78329	68072	12338.73	8568.76	287.43	1175.34	831.52
Esmeraldas	MG	Southeast	14161.90928	24183	5006	2449.32	382.35	382.35	427.47	39.12
Frutal	MG	Southeast	13772.75264	22643	23079	2671.47	2138.84	2138.84	195.39	171.54
Ibirité	MG	Southeast	36500.43919	51926	43868	6334.39	4170.99	2534.98	511.53	247.48
Ipatinga	MG	Southeast	58064.91302	71692	76035	10225.72	8770.89	8770.89	691.21	558.92
Itabira	MG	Southeast	23785.88541	32824	30644	6725.16	6523.41	2338.15	423.62	323.03
Itabirito	MG	Southeast	20138.06769	18233	15791	3781.85	2376.34	1998.44	440.84	219.08
Itajubá	MG	Southeast	22852.81623	32530	30962	4934.71	3633.7	3294.46	814.24	343.16
Ituiutaba	MG	Southeast	27964.19968	40406	39912	6949	5941.85	5745.78	565.34	543.47
Janaúba	MG	Southeast	12491.11083	25503	7051	2950.58	630.4	630.4	406.32	102.44
Januária	MG	Southeast	12361.49679	17704	4579	1988.08	371.36	371.36	237.09	67.29
Juiz de Fora	MG	Southeast	145784.1821	140190	137807	31157.93	23327.26	1487.67	1865.82	1365.7
Lagoa da Prata	MG	Southeast	12495.8408	18707	18525	3112.12	2649	2649	314.67	272.33
Lagoa Santa	MG	Southeast	19704.76073	25555	13096	4210.59	1777.28	1777.28	586.22	259.21
Lavras	MG	Southeast	28047.65473	38449	37568	4930.08	3729.94	3729.94	482.23	389.53
Manhuaçu	MG	Southeast	14151.71581	21320	16244	4816.65	4345.32	5.2	260.4	173.2
Montes Claros	MG	Southeast	99368.37132	136665	137767	14353.73	11482.64	11482.64	1805.91	1278.74

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Muriaé	MG	Southeast	26933.21131	35751	35660	5832.77	4957.85	1668.3	476.73	477.65
Nova Lima	MG	Southeast	25725.00575	30628	3112	6017.94	1030.53	1030.53	504.26	72.6
Paracatu	MG	Southeast	21951.14554	28626	26423	3339.1	2380.75	2380.75	311.27	266.89
Pará de Minas	MG	Southeast	32309.8011	36425	34572	4725.52	3919.46	3919.46	507.31	330.23
Passos	MG	Southeast	21230.84761	39378	39078	7495.51	5996.41	3036.12	535.92	480.87
Patos de Minas	MG	Southeast	35260.84421	59244	58222	8758.87	6837.18	4040.54	883.86	668.71
Patrocínio	MG	Southeast	16991.46036	29160	28634	3938	3150	3072	469	410
Pedro Leopoldo	MG	Southeast	17210.79779	22210	15391	2987.65	1628.14	1023.94	361.52	115.25
Pirapora	MG	Southeast	14685.57532	18476	7949	3680.36	1160.09	1160.09	289.37	86.29
Poços de Caldas	MG	Southeast	49718.65272	56688	56152	10107.54	8589.4	2576.82	1087.65	973.04
Pouso Alegre	MG	Southeast	36605.31517	51922	52568	7016.43	5485.37	5485.37	668.63	545.11
Ribeirão das Neves	MG	Southeast	62921.91692	94332	81448	12273.32	8074.55	6159.45	1095.09	817.18
Santa Luzia	MG	Southeast	48723.66525	59176	51096	8124.01	5497.17	5497.17	785.54	470.01
São Francisco	MG	Southeast	7793.00853	12838	6706	1459.86	607.2	607.2	173.87	92.93
São Sebastião do Paraíso	MG	Southeast	17432.52296	27226	26234	3494.41	2663.02	1967.59	308.09	247.49
Sete Lagoas	MG	Southeast	70676.86701	74371	70751	11562.94	9250.35	2775.1	1172.84	949.57
Timóteo	MG	Southeast	20994.85164	24604	24579	3544.09	2800.09	1372.52	275.06	196.28
Três Corações	MG	Southeast	16403.14427	26188	25809	3429.49	2597.86	664.41	360.34	292.64
Três Pontas	MG	Southeast	6732.34465	19138	19067	3007.46	2405.97	48.44	255.13	222.64
Uberaba	MG	Southeast	134337.1123	112913	112268	26064.06	26064.06	25933.74	1902.74	1869.51
Uberlândia	MG	Southeast	172750.3838	194497	192710	60043.19	50217.05	50217.05	3438.6	2808.9
Unaí	MG	Southeast	19508.74514	23462	20605	5006.86	3435.43	2828.95	339.79	248.8
Varginha	MG	Southeast	39967.43382	50268	50841	6711.36	5218.11	5218.11	664.43	555.39
Vespasiano	MG	Southeast	31736.65283	31706	29459	4375.83	3085.83	3085.83	540.5	316.94
Viçosa	MG	Southeast	11179.88238	21183	19287	4181	3345	33.45	285.6	219.4
Aracruz	ES	Southeast	22897.48746	31355	23559	5191.45	3557.92	1601.06	390.88	248.93
Cachoeiro de Itapemirim	ES	Southeast	56922.88009	61745	56995	9637.2	7226.49	7092.8	659.02	544.92
Cariacica	ES	Southeast	69535.72397	85616	32321	16345.25	5307.98	4382.97	1297.73	391.76
Colatina	ES	Southeast	25511.99122	28330	25287	6545	8419	44	340	210
Guarapari	ES	Southeast	32373.15975	30682	14213	7609.72	5148.05	5148	539.88	229.05
Linhares	ES	Southeast	20191.62926	36448	26762	8124.4	6455.87	5487.49	506.48	294.16
Nova Venécia	ES	Southeast	7806.64293	12107	1723	1835.05	172.52	172.52	196.77	72.44
São Mateus	ES	Southeast	11516.08806	29553	19641	4211.9	3094.82	216.64	480	138

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Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Serra	ES	Southeast	158194.9047	106079	77277	37033.71	14675.96	14675.96	1844.55	1018.15
Viana	ES	Southeast	13558.85464	14902	7119	3187.18	1126.27	885.66	272.11	90.14
Vila Velha	ES	Southeast	122950.4676	94664	33947	28901.06	15918.7	15915.55	1369.92	408.31
Vitória	ES	Southeast	114017.0186	56373	41909	26801.14	20007.03	20007.03	864.14	481.08
Belford Roxo	RJ	Southeast	49148.02367	77888	41800	27782.52	12673.53	1016	563.33	418
Cabo Frio	RJ	Southeast	51603.255	80913	80913	9996	12024	12024	1317	39
Duque de Caxias	RJ	Southeast	55560.72746	137973	67500	70908.29	28652.03	2397	1311.43	675
Maricá	RJ	Southeast	8962.34102	23911	2300	3270.64	267.42	184	160	23
Niterói	RJ	Southeast	278605.2589	88704	82494	36818.4	42824.06	42824.06	1314.98	785.83
São Gonçalo	RJ	Southeast	158557.1438	135191	72100	138997.51	35719.65	11550	1692	721
São Pedro da Aldeia	RJ	Southeast	21494.923	40759	40759	4609	3340	3340	701	56
Seropédica	RJ	Southeast	8336.28231	12801	5300	4533.29	1595.39	168	301.11	53
Americana	SP	Southeast	70848.97563	82979	81662	15296.61	14321.63	7722.53	2162.5	2331.54
Amparo	SP	Southeast	17398.6285	24577	21987	3790.29	3032.23	1767.17	326.4	228.96
Andradina	SP	Southeast	13758.72686	22467	22750	3642.23	3537	3537	293.26	322.46
Araçatuba	SP	Southeast	63466.17712	75497	74440	14799.77	15323.01	15323.01	745.33	848.34
Araraquara	SP	Southeast	96086.36317	99189	99449	17716.29	18963.41	18963.41	1440.71	1202.06
Artur Nogueira	SP	Southeast	14654.29886	16614	16176	2676.31	1803.92	595.29	175.66	167.47
Arujá	SP	Southeast	27957.73534	27919	18850	4882.96	2457.08	2457.08	401.24	201.78
Assis	SP	Southeast	27124.64059	39862	39738	6367.79	6320.21	6320.21	498.14	402.98
Atibaia	SP	Southeast	68111.29497	42770	26483	7248.31	9735.37	5657.04	604.74	404.7
Avaré	SP	Southeast	24436.46822	34959	33785	5109.56	5049.85	5049.85	421.2	343.31
Barretos	SP	Southeast	48349.12944	51174	50307	7778.36	6781.11	6781.11	700	650
Barueri	SP	Southeast	90311.33509	82488	64333	19163.92	12168.16	6224.09	747.72	428.62
Batatais	SP	Southeast	16046.63734	23796	23000	8300	6640	5046	300	280
Bebedouro	SP	Southeast	21291.59929	30694	30670	7101.75	4617.3	2615.17	731	729
Bertioga	SP	Southeast	51507.0386	25825	13208	4571.76	2762.79	2762.79	357.62	244.95
Birigui	SP	Southeast	19472.28823	48894	47529	11346.22	11200	11200	470.5	459.5
Boituva	SP	Southeast	18478.56772	20538	17692	3286.03	2416.46	2416.46	153.28	69.58
Botucatu	SP	Southeast	45780.41461	57606	54716	9145.55	8426.19	8426.19	659.23	477.63
Bragança Paulista	SP	Southeast	38013.0799	54803	48864	9239.94	6512.89	6512.89	859.42	529.69
Caçapava	SP	Southeast	32399.04799	35205	29824	5413.66	4528.85	4497.51	489.91	293.45
Campinas	SP	Southeast	708092.7954	356746	331899	80797.22	63678.82	56832.33	4730.69	4464.89

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Campo Limpo Paulista	SP	Southeast	15602.16224	23199	18595	3760.52	2935.99	2883.55	295.45	179.75
Campos do Jordão	SP	Southeast	25655.56149	16287	13985	3445.52	2690.34	2690.34	321.14	124.36
Capivari	SP	Southeast	17744.62299	18895	17867	3270.7	2833.14	1085.09	309.72	276
Caraguatatuba	SP	Southeast	54901.43394	57828	47975	8713.74	7453.41	7453.41	633.9	508.2
Carapicuíba	SP	Southeast	63800.51871	101763	72087	18545.88	10519.1	5423.95	647.9	434.83
Catanduva	SP	Southeast	38593.39074	51436	49333	10257.23	10053.42	8125.76	500	500
Cotia	SP	Southeast	69536.90251	71765	33220	13751.1	5183.02	2331.99	1158.18	391.6
Cruzeiro	SP	Southeast	12600.13583	27665	26440	4289.87	4286.4	3.1	315	295.8
Cubatão	SP	Southeast	37066.79368	29947	17067	7111.18	3619.13	3619.13	255.22	148.35
Diadema	SP	Southeast	87015.81791	112643	106053	20865.76	15805.45	8328.54	824.67	495.07
Embu das Artes	SP	Southeast	51205.29286	80225	52756	12060.8	6682.92	3675.61	641.57	313.29
Embu-Guaçu	SP	Southeast	16201.10547	17801	8273	2398.31	910.72	910.72	258.48	126.72
Fernandópolis	SP	Southeast	21170.60343	30777	30627	5048.94	4866.66	4866.66	335.38	283.52
Ferraz de Vasconcelos	SP	Southeast	31765.8693	47769	40533	7774.34	5300.77	2968.44	322.62	262.19
Franca	SP	Southeast	108034.6493	133372	131789	20549.69	20304.87	20304.87	1518.36	1253.35
Guaratinguetá	SP	Southeast	40508.59826	42966	39795	8216.34	6572.77	1617.93	630	338.81
Guarujá	SP	Southeast	154679.3105	68841	50759	18527.2	12807.42	12807.42	841.24	446.04
Hortolândia	SP	Southeast	43959.58852	72587	68886	12699.44	11374.1	11374.1	602.44	358.46
Ibiúna	SP	Southeast	13507.63502	14426	5827	2195.76	802.7	802.7	147.13	28.61
Indaiatuba	SP	Southeast	100654.1849	84602	83984	17226.95	14642.91	10069.2	1104.87	985.89
Itanhaém	SP	Southeast	50139.78938	72414	33469	7889.1	4317.58	4317.58	962.06	429.88
Itapecerica da Serra	SP	Southeast	22454.92967	48306	23410	6798.61	2532.25	2481.6	450.7	216.48
Itapetininga	SP	Southeast	40670.17743	54574	51149	7949.59	7287.53	7287.53	643.31	458.86
Itapeva	SP	Southeast	23596.0566	30394	26649	4170.36	3634.7	3547.05	395.7	250.27
Itapevi	SP	Southeast	32151.28373	60906	40321	9272.78	4855.79	2668.15	498.07	273.38
Itapira	SP	Southeast	22334.49068	27552	26516	4398.75	4398.75	4398.75	351.54	315.25
Itaquaquecetuba	SP	Southeast	56959.3211	97711	65552	15053.4	8047.96	1319.71	915.1	469.45
Itararé	SP	Southeast	12937.60419	16999	15516	2196.96	2013.83	2013.83	212.36	140.58
Itatiba	SP	Southeast	36356.6427	31424	29364	5902.7	5156.62	5156.62	235.51	159.07
Itu	SP	Southeast	52874.19581	55318	53081	9157.99	8453.71	8453.71	831.7	597.24
Itupeva	SP	Southeast	22475.40137	17344	15214	3265.64	2345.15	2345.15	87.54	36.43
Jaboticabal	SP	Southeast	19382.04241	29114	31098	5241.25	6739	5241.25	365.66	250.91
Jacareí	SP	Southeast	74838.00613	73918	73634	13389.01	10480.06	8189.75	801.06	620.16

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Jaguariúna	SP	Southeast	12942.86657	20146	18691	3744.79	3690.37	3101.98	212	207
Jandira	SP	Southeast	23227.12019	34896	25686	5571.82	3222.86	1468.92	249.07	157.87
Jaú	SP	Southeast	67830.916	53337	56420	9363.83	10125.2	433	897	736.7
Jundiaí	SP	Southeast	276320.3091	109452	105671	31216.37	36079.34	37156.75	1942.56	998.74
Leme	SP	Southeast	26912.13226	37434	37181	6074.78	5972.85	5972.85	460	440
Lençóis Paulista	SP	Southeast	20590.20885	24476	24081	7978.99	7200.01	7145.78	337.1	277.97
Limeira	SP	Southeast	114628.901	101730	100962	20655	16932	16932	1198.66	1048.88
Lins	SP	Southeast	24096.82248	31027	30817	5695.56	5173.17	5173.17	238.11	214.04
Lorena	SP	Southeast	25479.95009	31442	30984	4833.66	4479.42	4479.42	267.61	208.09
Mairiporã	SP	Southeast	22668.88167	18712	7182	2588.7	849.97	611.75	367.68	74.32
Mirassol	SP	Southeast	17622.608	23347	23943	3854	4000	3000	475	492
Mococa	SP	Southeast	21286.64985	25436	25104	3886.2	3593.46	3593.46	405.6	172.16
Mogi das Cruzes	SP	Southeast	154133.8606	134769	121033	24274.67	18733.64	5885.88	1151	829
Mogi Guaçu	SP	Southeast	44961.70891	58868	57766	9988.35	7743.65	5807.74	645.95	576.67
Mogi Mirim	SP	Southeast	43370.30009	34602	32636	5745.41	5221.07	4744.49	496	400
Mongaguá	SP	Southeast	31194.5523	39325	31672	4305.79	3767.18	3767.18	425.56	321.17
Monte Alto	SP	Southeast	17800.30982	19787	19631	3166.18	3166.18	3166.18	278.96	260.92
Monte Mor	SP	Southeast	23905.51821	23201	18896	3452.18	2507.31	2507.31	248.61	91.65
Nova Odessa	SP	Southeast	27363.13698	25263	24661	3764.88	3764.88	3764.88	282.76	273.59
Olímpia	SP	Southeast	15306.4999	23100	23094	4804.16	3531.51	1059.44	246.38	236.44
Osasco	SP	Southeast	135405.0035	189018	143652	40569.65	24537.78	13684.55	1281.87	823.17
Ourinhos	SP	Southeast	28019.24655	41468	41126	6572.21	5119.11	4312.85	643.7	525.75
Paulínia	SP	Southeast	35934.01397	36674	34646	7513.22	6113.79	6113.79	492.84	232.22
Peruíbe	SP	Southeast	36117.90647	44733	34725	5397.35	4842.84	4842.84	541.8	473.77
Piedade	SP	Southeast	10839.61159	11462	7165	1646.19	1029.41	1016.93	178.33	63.21
Pindamonhangaba	SP	Southeast	48371.92147	57396	55158	9078.22	8469.86	8469.86	608.17	446.89
Piracicaba	SP	Southeast	207959.6537	155758	150884	29364.47	29364.47	29364.47	1708.76	1441.49
Pirassununga	SP	Southeast	25820.773	31551	31530	5206.69	4295.35	4201.3	524	441
Poá	SP	Southeast	27061.31189	34158	32497	5417.45	4746.67	4090.5	302.54	253.72
Porto Feliz	SP	Southeast	15803.0517	16114	15871	2816.39	2814.21	2550.8	205.01	151.31
Porto Ferreira	SP	Southeast	18987.747	21632	21082	4195	2975	2443	338	313
Praia Grande	SP	Southeast	100739.0879	109892	65625	23245.95	16066.86	16066.86	1004.27	640.46
Presidente Prudente	SP	Southeast	79808.63288	87433	87097	15408.62	15408.62	15408.62	1117.9	951.83

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Table A.3 - Continuation

Municipality	State	Region	OPEX	NoWConn	NoSConn	VolWCons	VolSCol	VolSTreat	WNetL	SNetL
Registro	SP	Southeast	15918.1291	20526	18643	3029.43	2776.25	2776.25	225.18	219.32
Ribeirão Pires	SP	Southeast	28159.59854	31745	26059	5058.88	3312.15	2318.51	570.62	362.59
Ribeirão Preto	SP	Southeast	236476.6173	203466	202623	58536.74	58536.74	58536.74	2338.52	1990.07
Rio Claro	SP	Southeast	94289.57126	75004	73911	14753.27	17789	16366	925.57	738
Rio Grande da Serra	SP	Southeast	8883.33912	12538	7762	1725.25	963.87	819.29	168.37	85.12
Santa Bárbara D Oeste	SP	Southeast	68448.73195	67227	66621	11313	10102.88	7819.01	831.86	713.74
Santa Isabel	SP	Southeast	11689.88635	12103	8143	1994.6	1331.24	103.03	120.18	78.83
Santana de Parnaíba	SP	Southeast	39190.21725	41550	17305	8837.57	2964.52	772.47	707.36	311.9
Santo André	SP	Southeast	78233.8286	203247	199545	14004.29	11044.05	5080.26	39.95	68.51
Santos	SP	Southeast	129936.4168	68044	64473	37392.24	36505.49	36505.49	1404.05	549.99
São Bernardo do Campo	SP	Southeast	237277.0638	195456	172403	48370.47	35289.39	9760.01	2028.09	1288.1
São Carlos	SP	Southeast	103872.4659	109121	108303	20475.77	17600.63	16720.6	1056.13	989
São João da Boa Vista	SP	Southeast	27662.04747	37661	36843	6202.05	5914.76	5914.76	562.74	364.69
São José do Rio Pardo	SP	Southeast	11900.5	21036	20925	3900	3000	420	270	250
São José do Rio Preto	SP	Southeast	167251.4124	173862	173862	40062.92	37653.98	37653.98	2055	1987.4
São José dos Campos	SP	Southeast	190907.824	188077	177408	39970.83	37693.19	37693.19	1841.68	1260.56
Sertãozinho	SP	Southeast	40007.98663	46153	45791	11573.49	9258.79	9258.79	540	440
Sorocaba	SP	Southeast	170963.1423	231585	220705	45313	38407.29	37447.1	2094.64	1451.54
Sumaré	SP	Southeast	68018.376	89462	85068	15504	12103	3315	795	678
Taboão da Serra	SP	Southeast	43468.88734	76736	66385	14220.79	10001.1	5422.05	420.3	322.47
Taquaritinga	SP	Southeast	13710.93585	23905	23905	3548.74	2778.71	2778.71	276	274
Valinhos	SP	Southeast	40955.66735	38051	36272	7696.52	7104.35	7104.35	672.45	629.54
Vargem Grande Paulista	SP	Southeast	7405.83467	12625	4849	2119.92	559.93	178.98	326.26	78.17
Várzea Paulista	SP	Southeast	33359.01803	32740	31286	5283.72	5242.83	5242.83	300.6	222.59
Vinhedo	SP	Southeast	33096.03201	25525	21309	5292.17	4498.34	4498.34	562.9	352.26
Votorantim	SP	Southeast	35986.05405	35951	34959	7602.81	6054.07	5726.88	571.7	421.26
Votuporanga	SP	Southeast	21786.97216	40449	40040	6634.79	5305.97	5305.97	522.11	502.68

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