Bridging Sanitation Infrastructure Gaps: An Input–Output Analysis of Investments in Southern Brazil

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Resumo

Este trabalho avalia os impactos macroeconômicas do Novo Marco Legal do Saneamento no Rio Grande do Sul por meio da aplicação de um modelo insumo–produto à matriz estadual de 2019, desagregada para isolar as atividades de água e esgoto. Os fluxos de investimento projetados e realizados para o período de 2020–2033 foram inseridos no modelo como choques de demanda final. Entre 2020 e 2023, os desembolsos efetivos de US$ 0.61 bilhão geraram um adicional de US$ 0.87 bilhão em valor bruto da produção, US$ 0.42 bilhão em PIB e 17,881 empregos formais, com multiplicadores constantes de 1.41 para valor bruto da produção, 0.69 para PIB e cinco postos de trabalho a cada US$ 0.17 milhão investido. Caso o programa previsto tivesse sido integralmente executado, os ganhos em produto e emprego teriam sido cerca de 15% superiores até 2023. A extensão do fluxo contratual de US$ 0.26 bilhão por ano até 2033 elevaria os investimentos acumulados para US$ 2.55 bilhões, ocasionando US$ 3.6 bilhões em valor bruto da produção, US$ 1.74 bilhão em PIB e aproximadamente 74,400 empregos formais. Embora 71% do estímulo permaneça concentrado no setor de água e esgoto, efeitos indiretos relevantes atingem os setores de construção, utilidades, comércio e manufatura básica.

Palavras-chave: Saneamento; Insumo–Produto; Novo Marco Legal do Saneamento; Água e Esgoto.
Área temática: Planejamento regional e políticas públicas.

Abstract

This paper assesses the macro-economic repercussions of Brazil's New Sanitation Legal Framework in Rio Grande do Sul by applying a static input–output model to the State's 2019 table, disaggregated to isolate water-and-sewage activities. Projected and realised investment flows for 2020-33 are injected as exogenous final-demand shocks. Between 2020 and 2023 effective outlays of US$ 0.61 billion generated US$ 0.87 billion in additional gross output, US$ 0.42 billion in GDP and 17,881 formal jobs, with constant multipliers of 1.41 for output, 0.69 for GDP and five posts per US$ 0.17 million invested. Had the scheduled programme been fully executed, output and employment gains would have been about 15% higher by 2023. Extending the contracted flow of US$ 0.26 billion per annum through 2033 would raise cumulative investments to US$ 2.55 billion, supporting US$ 3.6 billion in output, US$ 1.74 billion in GDP and roughly 74,400 jobs. Although 71% of the stimulus remains within the water-and-sewage sector, meaningful spill-overs accrue to construction, utilities, trade and basic manufacturing.

Keywords: Sanitation; Input–Output; New Sanitation Legal Framework; Water and Sewage.
Category: Regional planning and public policies.

JEL Codes: R15; R11; H54.

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1. Introduction

In Brazil, Law No. 11,445/2007 — subsequently amended by Law No. 14,026/2020 — defines sanitation as the integrated set of: (i) potable-water supply; (ii) sewage collection and treatment; (iii) street cleaning and solid-waste management; and (iv) urban storm-water drainage and management (Brazil, 2007, 2020). At the global level, access to improved water and sanitation rose between 2000 and 2020, benefiting an additional 870 million people with safe drinking water and 2 billion people with sanitation services (Ando et al., 2025).

The link between basic sanitation and health, education and quality of life is now almost axiomatic, rendering the sector a reliable indicator of human development. Empirical studies demonstrate that the absence of adequate sanitation depresses educational outcomes and curtails individuals' future earnings. In Brazil, for instance, young people without sanitation access earn, on average, 33.4% less than their peers with access to it. The underlying mechanisms include recurrent morbidity and shorter schooling — 1.8 years less on average nationwide and identically so in Rio Grande do Sul — which weaken labour-market opportunities. Thus, the resulting lifetime income differential averages 12.7%. In educational terms, final-year secondary-school pupils (about 17 years old) who lack an in-home bathroom face difficulties interpreting irony and solving trivial arithmetic progressions (Freitas and Magnabosco, 2024).

Poor sanitation's after-effect also burdens public health, aggravating the incidence of water-borne diseases — such as diarrhoea — along with respiratory infections — such as pneumonia — and oral conditions — such as gingivitis. These ailments disproportionately affect residents of Brazil's North, where coverage of basic sanitation's services is lowest, thereby worsening regional inequality. It is worth noting that, between 2008 and 2024, Rio Grande do Sul registered both the sharpest growth and the highest absolute incidence of water-related illnesses among Brazilian states (Freitas and Magnabosco, 2024).

The New Sanitation Legal Framework, established by Law No. 14,026/2020, addresses these structural flaws through reforms aimed at universal service delivery, economic-financial sustainability and greater private-sector participation. It seeks to rectify historically low coverage in peripheral and rural areas and to integrate sanitation with wider programmes in urban development and water-resources management (Leite et al., 2022).

Salient features include: (a) obligatory, time-bound contracts with explicit expansion targets; (b) mandatory competitive tendering for new concessions, replacing the former model of direct contracting through cooperation agreements; (c) a strengthened regulatory architecture, whereby the National Water and Basic Sanitation Agency (ANA) issues reference norms, reducing the fragmentation and legal uncertainty that plagued the previous system; and (d) a clear legal basis for regionalised provision, enabling smaller municipalities — often lacking the financial and technical wherewithal — to achieve economies of scale (Leite et al., 2022). Nonetheless, as Leite et al. (2022) caution, while wider private involvement may offer benefits, it demands meticulous regulation to prevent potential pitfalls, such as tariff hikes and service deterioration, as evidenced in some international privatisations.

The central target is that, by 2033, 99% of Brazilians will have access to potable water and 90% to sewage collection, in line with Sustainable Development Goal 6, clean water and sanitation (Leite et al., 2022).

Recent data indicate that implementing universal coverage would require annual investments of US$ 39.84 per inhabitant, according to the National Plan for Basic Sanitation (PLANSAB). Yet the current mean for Brazil's 100 largest cities is a mere US$ 23.91, leaving a gap of US$ 15.93 (Oliveira et al., 2024a). In Rio Grande do Sul, although 87.7% of the population enjoys potable water, only 35.8% benefits from sewage collection (Freitas and Magnabosco, 2024), and just 26.6% of effluent is treated. This results in a daily dump equivalent to 448 Olympic size swimming pools of untreated sewage into the environment. Moreover, water-loss rates reach 39.5%, signalling major inefficiencies in the distribution system (Instituto Trata Brasil, 2024).

Pescke et al. (2022) emphasise the precarious state of sanitation in Rio Grande do Sul and beyond. Whilst the South-East leads Brazil in sewage treatment, large portions of the North and North-East still contend with open sewers. Nationally, about 37% of the population lacks sewage treatment — either services are absent or effluent, though collected, is discharged untreated. Within Rio Grande do Sul, only 26% of sewage is collected and treated, while 24% is managed through individual on-site solutions. This leaves more than half of the state's wastewater being discharged untreated into watercourses. The outcome is that the Porto Alegre Metropolitan Region contains three of Brazil's ten most polluted rivers — the Sinos, Gravataí and Caí — all of which empty into Lake Guaíba, the capital's main water source.

In 2023, a consortium led by Aegea Saneamento purchased the state-owned Rio Grande do Sul Sanitation Company (Corsan), pledging to treble annual investment from US$ 68.97–86.20 million to nearly US$ 0.26 billion through 2033 (Nuñez, 2023). Before the auction, Corsan was a mixed-capital company in which the State of Rio Grande do Sul held 99.99% of ordinary shares (Corsan, 2019).

Because sanitation debates in Brazil often prioritise health-related outcomes — their most pressing dimension — macroeconomic spill-overs receive scant attention. Even when the monetary aspects are considered, it is often eclipsed by the predominance of qualitative or econometric modelling, focusing on sanitation and health. Accordingly, this paper evaluates, from a macroeconomic perspective, the implementation of the New Sanitation Framework in Rio Grande do Sul, using an input–output (I–O) model. The method reveals how demand for sanitation, driven by universalisation targets, propagates through the state's productive structure. By applying static shocks equal to projected and actual investment flows, it quantifies impacts on output (GO), gross value added (GVA), final output (GDP) and formal employment, capturing both direct and indirect inter-industry linkages.

2. Empirical Framework

In order to frame the discussion on sanitation, an overview of studies at three levels — international, national, and regional — is presented below.

2.1. International Evidence

Merid et al. (2023) analyse data from 27 low- and middle-income countries to investigate how improved water and sanitation affect diarrhoea incidence amongst rural children under five. Employing propensity-score matching to control for confounders — household wealth and hand-washing habits — they find a 24.5% reduction in diarrhoea where both water and sanitation infrastructure are present. The authors conclude that fulfilling Sustainable Development Goal 6 could markedly lower morbidity from water-borne diseases.

Luby et al. (2018) conduct a Cluster Randomised Controlled Trial (cluster RCT) in rural Bangladesh, comparing interventions in water, sanitation, hand-washing and nutrition. Sanitation and hygiene measures significantly cut diarrhoea prevalence, but water treatment alone does not. Nutrition supplements modestly improve linear growth, yet combining all interventions yields no additional benefit over individual measures.

González (2011) devises a methodology to gauge the macro-economic impact of constraints on water supply by first estimating sector-level aggregate production functions that incorporate water consumption as a factor of production and then simulating the effects within Catalonia's 2005 input–output table. Two situations are analysed: "exceptionality" (moderate restrictions) and "emergency" (severe restrictions), based on sector-specific supply-guarantee percentages defined by the Catalan Water Agency. The econometric estimation adopts a Cobb–Douglas specification with capital, labour and water consumption as independent variables, the parameters being obtained via the Seemingly Unrelated Regressions (SUR) method. Employing the Leontief supply model, i.e. the Ghosh model, the estimated GDP loss for Catalonia in 2005 would amount to 0.34% under the exceptionality scenario and 2.8% under the emergency scenario. At the sectoral level, the most affected branches in terms of value added and output would be agriculture, other social activities and manufacturing industries. Regarding employment, the heaviest losses would fall upon the sectors of other social activities, retail business and manufacturing industries.

2.2. National Analyses (Brazil)

Silva et al. (2024) employed a Brazil's 2015 national input–output table to simulate the socio-economic repercussions of nation-wide sanitation universalisation. Their model projects a cumulative US$ 0.24 trillion expansion in gross output and the creation of 14 million jobs between 2019 and 2033, with the construction sector emerging as the most stimulated branch of activity. Disaggregating the origin of the impacts, the authors find that the expansion of new distribution and collection networks accounts for 63.7% of the total effect, while the rehabilitation of existing infrastructure contributes a further 32.6%. The study also indicates that every US$ 0.17 billion invested in the sector could generate US$ 0.31 billion in gross output and create more than 18,000 direct and indirect jobs.

Oliveira et al. (2024b) also relied on the 2015 table but impose a recurring annual shock of US$ 7.98 billion, calibrated as the shortfall between the US$ 95 billion identified in PLANSAB and the investments already recorded in 2021–2022, net of a 12% import share. Allocating the domestic vector according to the sector's cost structure, the authors solve the Leontief system and obtain, for each yearly round, an increase of US$ 25.88 billion in production, US$ 10.02 billion in GDP, 1.09 million formal jobs and US$ 0.64 billion in tax revenue. Only 2% of the impulse remains in the primary sector, whereas 41% is absorbed by industry and 57% by services.

2.3. Regional Studies (Rio Grande do Sul)

Macedo and Sampaio (2021) evaluated the technical efficiency of 18 Brazilian state-owned sanitation companies in 2015 using Data Envelopment Analysis (DEA). The average efficiency score was 88%, indicating that, on average, companies could increase their output by 12% without changing their input levels. Among the top-performing benchmarks were Sabesp (São Paulo), Copasa (Minas Gerais), and Sanepar (Paraná), which stood out for their operational performance and more efficient resource use, whereas Corsan recorded the lowest score, at just 54%, underscoring its operational and managerial deficiencies.

3. Method

The analysis follows the classical input–output approach pioneered by Leontief (1936) and detailed in Miller and Blair (2009), seeking to measure the effects of a final-demand shock in the water and sewage sector on the economy of Rio Grande do Sul.

For clarity of interpretation, all monetary and real-economy indicators reported in the subsequent results accord with the System of National Accounts. Gross Output (GO) denotes the total market value of all goods and services produced by a given sector, inclusive of intermediate consumption. Gross Value Added (GVA) equals GO less the cost of intermediate inputs and therefore represents the new value generated by the production process. Gross Domestic Product (GDP) is computed as the sum of GVA across all sectors plus net taxes on products — that is, indirect taxes minus product-specific subsidies — thereby furnishing the economy-wide measure of final output at market prices. Employment, finally, captures the total number of formal jobs directly associated with the production activities embodied in GO. These definitions are applied consistently in the analysis that follows.

3.1. Data

The simulations employ the 2019 State input–output table for Rio Grande do Sul, originally comprising 52 sectors and developed jointly by the State Finance Department, the Inter-American Development Bank and the Federal University of Rio de Janeiro (UFRJ), with support from the State Department of Economics and Statistics and the Federal Revenue Service (UFRJ, 2024). In order to capture exclusively the impact of water and sewage, as intended by the new legal framework, the sanitation sector was disaggregated into two segments: one consisting solely of water supply and sewage collection/treatment, and another encompassing other sanitation activities.

Projected investment requirements (2020-33) are drawn from Corsan and Aegea disclosures (Corsan, 2022; Aegea Saneamento, 2023). Realised investments derive from the National Sanitation Information System (SNIS, 2024) and the National Information System on Basic Sanitation (SINISA, 2025). For 2020-22, the required investment series reflects Corsan's pre-privatisation estimates; post-privatisation, starting from 2023, Aegea announced US$ 2.59 billion, or US$ 0.26 billion per annum. These flows underpin the shocks applied to the I–O model (Table 1).

3.2. The State of Rio Grande do Sul

One of the State's most recent events with far-reaching consequences for sanitation — stemming both from potable-water shortages and failures in urban storm-water drainage — was the flooding that struck Rio Grande do Sul in April and May 2024. Classified as one of the country's worst climate-related disasters, the floods affected 418 of the State's 497 municipalities and caused 173 confirmed deaths by May 2024 (Schabbach et al., 2024). State-government data show that, by 14 June, the death toll had risen to 176 and more than 422,000 people had been displaced (Machado, 2024). The latest figures record 184 deaths, 25 missing persons, 806 injured, 478 municipalities impacted and 2,398,255 residents affected (Correio do Povo, 2025). The economic fallout was equally severe, the regions hit — responsible for 53.3% of State GDP — suffered industrial sales declines of up to 29.8% during the first fortnight of May. In retail, the share of firms registering payments via Pix or debit fell by 8.6% in the first week after the rains began, with only partial recovery in June (Banco Central do Brasil, 2024). Infrastructure was also heavily damaged, around one million people lost access to safe drinking-water, and several hospitals had to evacuate critical patients owing to structural failures (Machado, 2024). The institutional response laid bare shortcomings in risk and disaster management, merely 23% of small municipalities exposed to flooding possessed a Master Plan that addressed flood prevention and only 6.8% had specific plans for risk-reduction works (Schabbach et al., 2024). Social vulnerability was also evident, as many evacuees were housed near areas still inundated, a circumstance that favoured the spread of water-borne diseases — such as dengue and leptospirosis — during the ensuing sanitation crisis (Machado, 2024).

3.3. Model Specification

In the model, the inter-industry flow matrix $\mathbf{X}$ (dimension $n \times n$) contains elements x_{ij} that indicate the monetary value of the goods/services supplied by sector i to sector j. Let x_j be the total value of output of sector j, each element of the direct technical-coefficient matrix $\mathbf{A}$ is defined as:

$$a_{ij} = \frac{x_{ij}}{x_j}, \tag{1}$$

where a_{ij} represents the share of sector j's output that derives from the input supplied by i. This relation summarises how much sector j, in proportional terms, depends on inputs from i to produce one unit of its product.

The fundamental Leontief identity states that the total-output vector, $\mathbf{x}$, can be decomposed between intermediate use and final demand, $\mathbf{f}$, as follows:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f}. \tag{2}$$

Rearranging yields:

$$(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{f} \;\; \Rightarrow \;\; \mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}. \tag{3}$$

The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse, here denoted $\mathbf{L}$. Each element l_{ij} of $\mathbf{L}$ measures the total (direct + indirect) impact on the output of sector i, arising from a unit increase in the final demand of sector j. However, this does not include the induced ones.

To isolate the effect of water and sewage, sectoral disaggregation was performed so as to adjust and, consequently, , creating a category entitled “Water and Sewage”. Using employment data from the Annual Report of Social Information (Ministério do Trabalho, 2019) and its distribution across sanitation services in 2019, the inter-industry transactions of the former sanitation sector were split between the new “Water Supply and Sewage” category and the sub-heading “Other Sanitation Services”. This procedure ensures that, when additional demand is injected into the new sector, the model does not assign undue effects to activities unrelated to water and sewage services.

Once the new matrix $\mathbf{A}$ is defined and the Leontief inverse, $\mathbf{L}$, recalculated, an exogenous final-demand shock, $\Delta\mathbf{f}$, is simulated, focused solely on the component corresponding to the “Water and Sewage” sector. If that sector's position in the final-demand vector is k, an increment $\Delta\mathbf{f}_k$ is placed in that single entry, with all others remaining unchanged. The resulting change in output, $\Delta\mathbf{x}$, satisfies:

$$\Delta\mathbf{x} = \mathbf{L}\Delta\mathbf{f}. \tag{4}$$

Each component Δx_i indicates how much the output of sector i responds to the exogenous increase directed at sector k. The value of $\Delta\mathbf{f}_k$ could, for example, be “US$ 0.17 billion” or “the amount still required to achieve universalisation targets by 2033”.

For gross value added (GVA) analysis, consider a vector of value-added coefficients $\mathbf{v}$ (dimension $1 \times n$), in which each v_i is the ratio of GVA to the output value of sector i. The total change in value added resulting from the shock is estimated as:

$$\Delta \text{VA} = \mathbf{v}\Delta\mathbf{x}. \tag{5}$$

Similarly, the employment impact can be gauged by a vector $\mathbf{v}$ (also $1 \times n$), whose elements e_i indicate the number of jobs required per unit of output in sector i. The total change in employment corresponding to the shock, ΔEmp, is obtained via:

$$\Delta \text{Emp} = \mathbf{e}\Delta\mathbf{x}. \tag{6}$$

Analogous expressions apply to GDP and taxes. These metrics allow a joint assessment of gains, or losses, in output, value added and employment, taking into account not only direct effects on the stimulated sector but also indirect linkages arising from its input purchases.

As a complement, backward and forward linkage indices are calculated in line with Rasmussen (1957) and Hirschman (1958). For each sector j, the backward linkage (BL) equals the sum of column j of $\mathbf{L}$ and is normalised against the mean of $\mathbf{L}$'s elements:

$$\text{B}L_J = \frac{\sum_{i=1}^{n} l_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} l_{ij}}. \tag{7}$$

Conversely, the forward linkage (FL) of sector i corresponds to the sum of row i of $\mathbf{L}$ and is expressed as:

$$\text{F}L_i = \frac{\sum_{j=1}^{n} l_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} l_{ij}}. \tag{8}$$

These indices classify the importance of each sector as a demander (backward linkage) and as a supplier (forward linkage) within the productive structure, indicating whether its participation in production chains is above or below the economy-wide average. Values above 1 denote linkages stronger than the average; sectors for which both indices exceed 1 are classified as key sectors.

Finally, for the multipliers, the output multiplier for sector k is given by the sum of all elements in column k of the matrix $\mathbf{L}$, that is:

$$m_k^x = \sum_{i=1}^{n} l_{ik}. \tag{9}$$

In terms of value added, it is defined as:

$$m_k^{\text{VA}} = \mathbf{v}\mathbf{L}_{\cdot k}. \tag{10}$$

Meanwhile, for employment, the multiplier is given by:

$$m_k^{\text{E}mp} = \mathbf{e}\mathbf{L}_{\cdot k}. \tag{11}$$

The same principle applies to other indicators. These expressions allow for quantifying how the economy, on average, responds to a unit increase in final demand in a given sector — for instance, expressing how much additional output is generated when resources are injected into a particular sector.

In summary, the methodological strategy consists of: (i) disaggregating the sanitation sector to isolate water-and-sewage activities; (ii) computing the technical-coefficient matrix and the Leontief inverse; (iii) introducing exogenous final-demand shocks into the disaggregated sector; and (iv) estimating, via equations (4-6), the effects on output, value added and employment, while also assessing the sector's structural relevance through linkage indices and multipliers. Database constraints prevented closure of the model for household consumption, and insufficient data precluded dynamic modelling. This approach therefore analyses the macro-economic role of investment in water and sewage in Rio Grande do Sul, moving beyond the statistical perspective that typically views sanitation solely through its disease outcomes.

4. Results

Figure 1 juxtaposes the effective investment series with the projected trajectory required to meet the universal-coverage targets of Law No. 14,026/2020. The solid line depicts the amounts actually disbursed each year (current prices), while the dashed line represents the schedule announced first by Corsan and, in 2023, by Aegea. Two vertical dotted markers identify the most salient institutional milestones: promulgation of the New Sanitation Legal Framework (July 2020) and Corsan's privatisation (July 2023). The shaded area delimits the cumulative investment gap — the shortfall between projected and realised outlays.

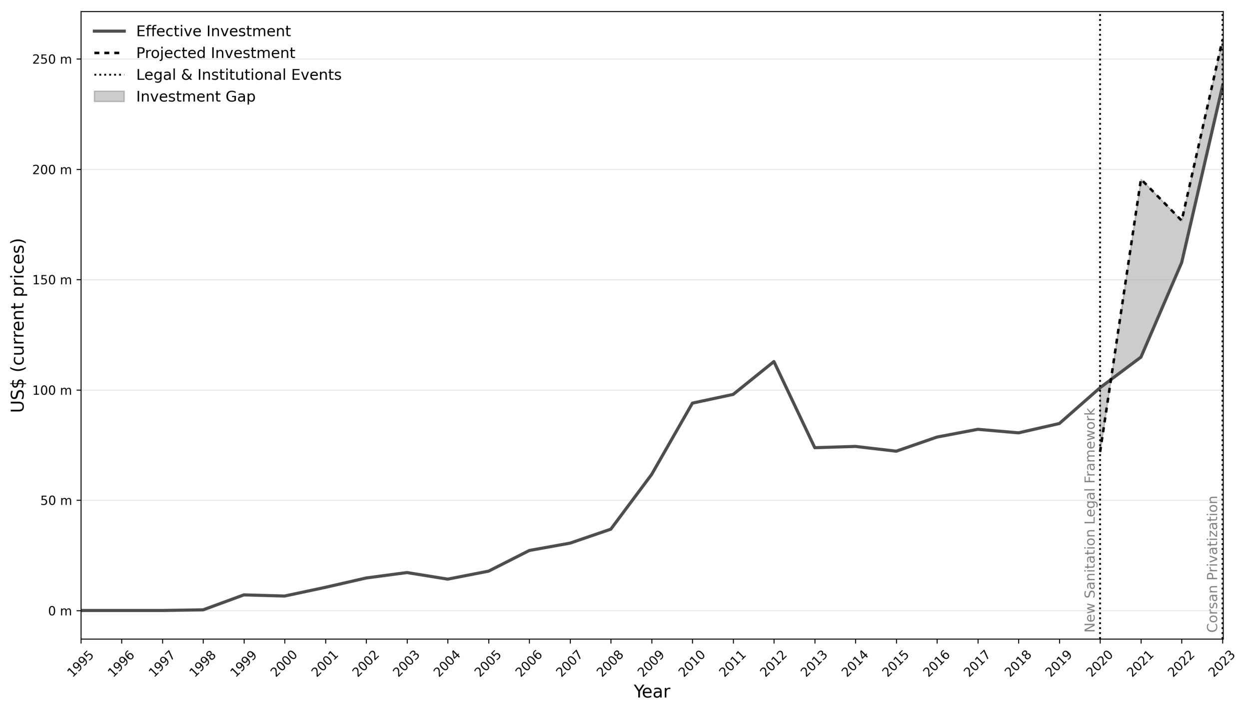

Figure 1. Historical evolution of sanitation investments in Rio Grande do Sul
Note. Values converted at an exchange rate of US$ 1.00 = R$ 5.80.
Source: Authors' elaboration based on SNIS (2024), SINISA (2025), Corsan (2022) and Aegea Saneamento (2023).

Between 1995 and 2006, annual disbursements on water-and-sewage infrastructure seldom exceeded US$ 20 million. Spending accelerated sharply during the 2007–2011 cycle, coinciding with the launch of the first Growth Acceleration Programme (PAC-1). The total disbursements under

PAC projects reached US$ 18 million over that period, of which approximately US$ 2 million — 8.2% — were directed to the South region — encompassing Rio Grande do Sul. From 2008 to 2011 alone, national financing for water and sewage projects rose from US$ 138 million to US$ 259 million, totalling US$ 1 billion over the four-year span (Banco Nacional de Desenvolvimento Econômico e Social, 2012). Disbursements fell back after 2012, such that a modest recovering began only in 2019. Effective spending overtook the regulatory trajectory in 2020, yet the gap widened rapidly thereafter, topping US$ 80 million in 2021. Thus, although the New Sanitation Legal Framework has galvanised renewed capital flows, execution has persistently lagged behind the regulatory timetable established for 2033.

Spatial disparities in service provision are shown in Figure 2, which maps household access to sanitation (water and sewage) by municipality. Of the State's 497 municipalities, 41 record coverage within 0–10% and a further 149 lie in the 10–30% band. The modal bracket is 30–50% (183 municipalities), while only 22 municipalities — less than 5% of the total — exceed 70% coverage, with a mere five surpassing 90%. High-coverage municipalities are strongly clustered (i) in the Porto Alegre metropolitan conurbation (Porto Alegre 96%, Canoas 80%, São Leopoldo 88%), and (ii) in the Serra Gaúcha agro-industrial belt centred on Caxias do Sul (96%) and Garibaldi (89%). Isolated regional hubs such as Pelotas (89%) and Santa Maria (80%) also attain relatively high figures. By contrast, extensive pockets of under-provision persist across the northern uplands (Nonoai 38%, Sananduva 35%) and the south-eastern coastal plain (Mostardas 7%, Tavares 8%), as well as in numerous small rural municipalities scattered through the interior.

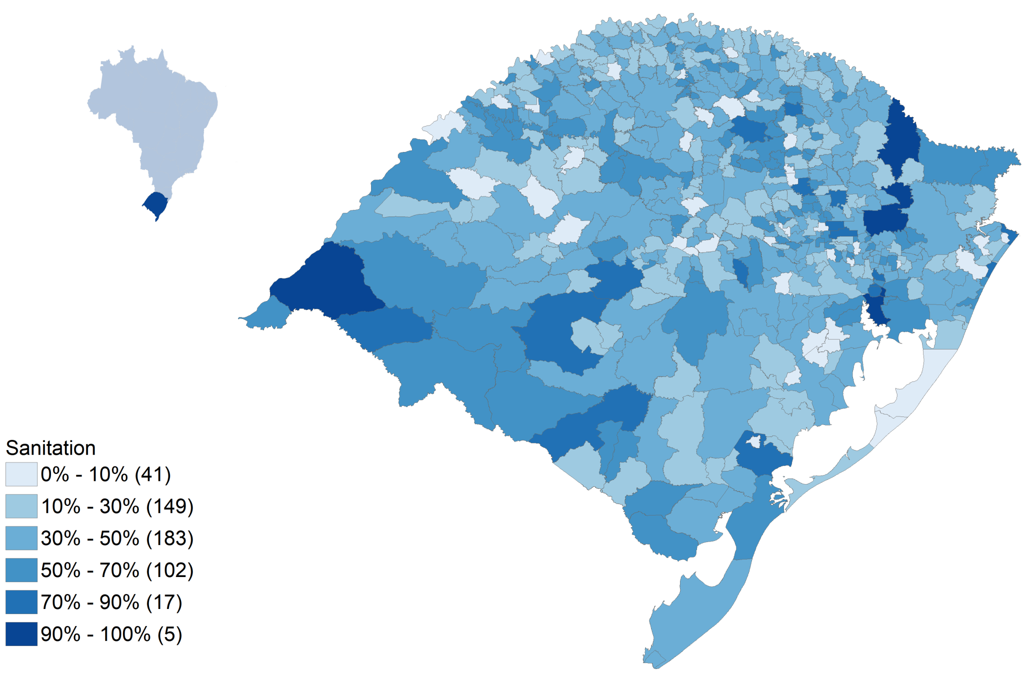

Figure 2. Basic sanitation coverage in the municipalities of Rio Grande do Sul (2023)
Note. The upper-left inset shows the State's location within Brazil.
Source: Authors' elaboration based on SINISA (2025).

Because the administrative datasets are available only up to 2023, the quantitative assessment is confined to that horizon. Table 1 summarises the cumulative macro-economic effects — estimated with the static input–output model — under two scenarios: the effective trajectory and the projected counter-factual schedule. The figures represent stock impacts. For example, the 2022 line aggregates the repercussions of all investments executed, or earmarked, from 2020 through 2022. Induced household consumption and dynamic feedbacks are deliberately excluded, so the multipliers derived in Appendix C remain constant over time.

Table 1. Cumulative economic effects of investment flows (public/private), by scenario

Year	Investment (US$)	GO (US$)	GVA (US$)	GDP (US$)	Employment
	Benchmarking				
2019	-	146,647,429	72,439,328	83,183,479	2,893,188
	Effective				
Year	*Investment (US$)*	*GO (US$)*	*GVA (US$)*	*GDP (US$)*	*Employment*
2020	100,993,580	142,865,081	63,314,808	69,288,957	2,955
2021	114,857,188	305,341,561	135,320,978	148,089,361	6,315
2022	157,753,571	528,499,081	234,219,711	256,319,811	10,93
2023	237,619,601	864,634,740	383,187,987	419,344,178	17,881
	Projected				
Year	*Investment (US$)*	*GO (US$)*	*GVA (US$)*	*GDP (US$)*	*Employment*
2020	71,896,552	101,704,551	45,073,324	49,326,276	2,103
2021	195,517,241	378,282,395	167,646,826	183,465,355	7,823
2022	176,724,137	628,275,596	278,438,571	304,710,997	12,993
2023	258,620,690	994,119,305	440,572,832	482,143,642	20,559
...	...	...	...	...	...
2033	258,620,690	4,286,712,686	1,899,781,179	2,079,037,454	88,651

Note. The benchmarking refers to the values of the indicators of the table, in order to compare to the values generated by the shocks. Also, consider US$ 1.00 = R$ 5.80. The projected scenario simulates the economic effects of anticipated investments aligned with sectoral targets and regulatory frameworks under the new legal milestone.
Source: Authors' elaboration based on research.

Between 2020 and 2023, Corsan/Aegea carried out US$ 0.61 billion in effective investments in water and sanitation, 13% below the US$ 0.7 billion scheduled, yet sufficient to produce measurable macroeconomic effects. In this model, each new investment is added to the cumulative expenditure stock and multiplied by the Leontief inverse, which explains why the multipliers remain constant over time: in all years analysed, each US$ 0.17 invested generated approximately US$ 0.24 in gross output (GO), US$ 0.12 in gross domestic product (GDP), and five formal jobs per US$ 0.17 million invested. Accordingly, the cumulative US$ 0.61 billion invested sustained, by 2023, US$ 0.87 billion in additional production, US$ 0.38 billion in GVA, US$ 0.42 billion in GDP, and 17,881 new formal jobs — figures below the national benchmarks estimated in studies such as Silva et al.

(2024) and Oliveira et al. (2024b).

When comparing the actual scenario to the projected one, the execution gap is that: had the original schedule been fulfilled, the investment stock would have reached US$ 0.7 billion by 2023, resulting in US$ 0.99 billion in gross output, US$ 0.48 billion in GDP, and 20,559 formal jobs. The shortfall in implementation thus cost the state, in 2023 alone, approximately US$ 129.48 million in output, US$ 62.76 million in GDP, and 2,678 formal jobs.

The contracted investment flow of US$ 0.26 billion per year from 2024 to 2033 would raise cumulative investments to around US$ 2.55 billion. By the same multipliers, this would result in US$ 3.6 billion in additional production, US$ 1.6 billion in GVA, US$ 1.74 billion in GDP, US$ 150.52 million in net taxes, and 74,407 formal jobs by the end of the period. Had the projected investments been fully executed since 2020, the total value generated over the 2020–2033 period would be approximately 119.14% the sum of the actual value generated between 2020 and 2023 and the expected value from 2024 to 2033 based on the projected investment path.

Although the new "Water and Sanitation" sector presents relatively modest direct linkages with the rest of the input–output table and largely absorbs the benefits of investment internally, any demand shock reveals non-negligible spillovers to other sectors: 71.1% of the production increase remains within the sector itself, but the remaining 28.9% spreads mainly across construction (5.7%), energy and other utilities (3.4%), wholesale and retail trade (1.5%), and a group of basic industrial activities — metallurgy (0.2%), non-metallic mineral products (1.6%) and metal products (1.2%) — which together account for another 3% of the total impact. This dispersion suggests that accelerating sanitation investments not only supports the universalization targets set by Law No. 14,026/2020, with multiplier effects reinforcing the initial outlays, but also activates capital and labor intensive value chains, expanding GVA, GDP, and employment across several sectors of the Rio Grande do Sul economy (Appendix D).

5. Final Remarks

The evidence confirms that accelerating sanitation investment in Rio Grande do Sul delivers measurable macro-economic dividends beyond the sector itself. Each US$ 0.17 invested between 2020 and 2023 yielded US$ 0.24 in gross output and US$ 0.12 in GDP, while creating five formal jobs per US$ 0.17 million. Failure to meet the original schedule curtailed those gains by roughly US$ 0.13 billion in output and 2,700 jobs in 2023 alone.

Looking forward, maintaining the contracted flow of US$ 0.26 billion annually would sustain output and employment across construction, energy, trade and selected industrial branches, reinforcing value chains that are both capital- and labour-intensive. Conversely, any further slippage jeopardises not only universal-coverage targets under Law No. 14,026/2020 but also wider regional-development objectives.

From a policy standpoint, three priorities emerge. First, regulatory authorities should monitor concessionaires' delivery schedules and, where necessary, enforce contractual penalties to deter under-investment. Secondly, complementary measures to reduce network water losses — currently near 40% — could enhance the return on each US$ 0.17 invested. Thirdly, closer co-ordination with housing and urban-development programmes would magnify the social pay-off of infrastructure spending.

Methodologically, the static input–output framework employed in this study provides transparent multipliers, though it does not incorporate induced consumption effects or dynamic supply-side responses. Future research could address these aspects by integrating a Social Accounting Matrix or Computable General Equilibrium (CGE) models, and by extending the database beyond 2023 to capture post-privatisation dynamics. Despite these limitations, the present findings reinforce the argument for viewing sanitation not merely as a public health imperative, but as a strategic lever for regional economic growth.

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Appendix

Appendix A. Sector code reference table

Code	*Sector Description*
AT 01	Agriculture, including support and post-harvest activities
AT 02	Livestock, including support activities
AT 03	Forestry, fishing and aquaculture
AT 04	Oil and gas extraction, including support activities
AT 05	Extraction of other mineral products
AT 06	Slaughter and meat products, including dairy and fish products
AT 07	Manufacture and refining of sugar and other food products
AT 08	Manufacture of beverages
AT 09	Manufacture of tobacco products
AT 10	Manufacture of textiles
AT 11	Manufacture of apparel and accessories
AT 12	Manufacture of footwear and leather goods
AT 13	Manufacture of wood products
AT 14	Manufacture of pulp, paper and paper products
AT 15	Printing and reproduction of recordings
AT 16	Petroleum refining and coking
AT 17	Biofuel manufacturing
AT 18	Manufacture of organic and inorganic chemicals, resins and elastomers
AT 19	Manufacture of other chemical products
AT 20	Manufacture of pharmaceutical and pharmochemical products
AT 21	Manufacture of rubber and plastic products
AT 22	Manufacture of non-metallic mineral products
AT 23	Metallurgy
AT 24	Manufacture of fabricated metal products, except machinery and equipment
AT 25	Manufacture of computer, electronic and optical products
AT 26	Manufacture of electrical machinery and equipment
AT 27	Manufacture of mechanical machinery and equipment
AT 28	Manufacture of automobiles, trucks and buses, except parts
AT 29	Manufacture of parts and accessories for motor vehicles
AT 30	Manufacture of other transportation equipment, except motor vehicles
AT 31	Manufacture of furniture and miscellaneous products
AT 32	Maintenance, repair and installation of machinery and equipment
AT 33	Electricity, natural gas and other utilities
AT 34a	Water supply and sewage
AT 34b	Other sanitation services
AT 35	Construction
AT 36	Wholesale and retail trade
AT 37	Land transport

Table continues on next page

Appendix A (continued)

Code	*Sector Description*
AT 38	Water transport
AT 39	Air transport
AT 40	Storage, auxiliary transport activities and postal services
AT 41	Accommodation
AT 42	Food services
AT 43	Telecommunications services
AT 44	Other information services
AT 45	Financial intermediation, insurance and supplementary pension
AT 46	Real estate activities
AT 47	Professional, scientific and technical activities
AT 48	Administrative activities and support services
AT 49	Public administration, education, health, R&D, defence, social security
AT 50	Private education and healthcare
AT 51	Arts, culture, sports and recreation, and other service activities
AT 52	Domestic services

Source: Authors' elaboration based on research.

Appendix B. Sectors ranked by the total linkage index $U_i + U_j$

Sector	*(Rank)*	U_i	U_j	*Linkage Classification*
AT 36	(1)	2.52	0.92	FL
AT 37	(2)	2.23	1.12	Key Sector
AT 47	(3)	2.39	0.87	FL
AT 16	(4)	2.23	0.89	FL
AT 18	(5)	1.76	1.09	Key Sector
AT 45	(6)	1.80	0.90	FL
AT 07	(7)	1.29	1.32	Key Sector
AT 33	(8)	1.55	1.01	Key Sector
AT 01	(9)	1.50	0.89	FL
AT 48	(10)	1.44	0.83	FL
AT 17	(11)	0.64	1.60	BL
AT 06	(12)	0.82	1.41	BL
AT 21	(13)	1.05	1.11	Key Sector
AT 24	(14)	1.15	0.96	FL
AT 40	(15)	1.14	0.95	FL
AT 23	(16)	0.95	1.09	BL
AT 02	(17)	0.96	1.03	BL
AT 44	(18)	1.12	0.86	FL
AT 35	(19)	0.96	1.01	BL

Table continues on next page

Appendix B (continued)

Sector	$^{(Rank)}$	U_i	U_j	*Linkage Classification*
AT 32	(20)	1.02	0.91	FL
AT 08	(21)	0.71	1.21	BL
AT 43	(22)	0.90	1.02	BL
AT 19	(23)	0.82	1.08	BL
AT 29	(24)	0.85	1.03	BL
AT 22	(25)	0.84	1.03	BL
AT 13	(26)	0.76	1.10	BL
AT 27	(27)	0.80	1.04	BL
AT 38	(28)	0.69	1.15	BL
AT 10	(29)	0.83	1.00	-
AT 09	(30)	0.68	1.15	BL
AT 12	(31)	0.73	1.09	BL
AT 14	(32)	0.83	0.97	-
AT 42	(33)	0.74	1.05	BL
AT 39	(34)	0.67	1.10	BL
AT 25	(35)	0.78	0.99	-
AT 28	(36)	0.65	1.11	BL
AT 26	(37)	0.74	1.00	-
AT 05	(38)	0.76	0.96	-
AT 46	(39)	1.01	0.69	FL
AT 51	(40)	0.74	0.95	-
AT 31	(41)	0.69	0.99	-
AT 50	(42)	0.79	0.88	-
AT 20	(43)	0.64	1.02	BL
AT 03	(44)	0.81	0.83	-
AT 30	(45)	0.66	0.97	-
AT 15	(46)	0.69	0.92	-
AT 34a	(47)	0.71	0.89	-
AT 41	(48)	0.67	0.93	-
AT 34b	(49)	0.68	0.90	-
AT 11	(50)	0.65	0.87	-
AT 49	(51)	0.69	0.82	-
AT 04	(52)	0.63	0.86	-
AT 52	(53)	0.63	0.63	-

Note. Sector codes (AT 01 – AT 52) refer to Appendix A. FL: Foward Linkage – sector is an important supplier to others ($U_i > 1$). BL: Backward Linkage – sector is a significant consumer of inputs ($U_j > 1$). Key Sector: sectors with both $U_i > 1$ and $U_j > 1$.
Source: Authors' elaboration based on research.

Appendix C. Sectors ranked by total multiplier effects

Code	*GO*	*GVA*	*Employment*	*GDP*	*Net Taxes*
AT 48	1.31	0.83	13.16	0.88	0.05
AT 41	1.48	0.74	11.95	0.82	0.08
AT 12	1.73	0.50	9.72	0.78	0.28
AT 04	1.36	0.52	1.90	4.28	3.75
AT 15	1.46	0.42	9.08	0.56	0.15
AT 50	1.39	0.86	7.90	0.90	0.04
AT 36	1.46	0.83	7.84	0.87	0.04
AT 51	1.50	0.78	7.77	0.83	0.05
AT 17	2.53	0.81	3.98	2.16	1.35
AT 20	1.61	0.50	5.24	1.91	1.40
AT 13	1.74	0.52	7.52	0.69	0.17
AT 30	1.54	0.46	7.44	0.74	0.28
AT 42	1.66	0.77	6.72	0.88	0.11
AT 11	1.38	0.38	7.00	0.85	0.47
AT 49	1.30	0.91	6.87	0.92	0.02
AT 29	1.64	0.46	6.48	0.61	0.15
AT 06	2.23	0.77	5.19	0.92	0.15
AT 40	1.50	0.64	6.03	0.70	0.06
AT 25	1.57	0.46	5.37	0.96	0.51
AT 26	1.58	0.46	5.43	0.89	0.43
AT 05	1.52	0.59	5.82	0.71	0.12
AT 31	1.57	0.45	5.72	0.70	0.26
AT 21	1.76	0.50	5.50	0.71	0.21
AT 22	1.63	0.48	5.60	0.69	0.21
AT 10	1.58	0.46	5.38	0.77	0.31
AT 37	1.76	0.65	5.15	0.76	0.11
AT 08	1.91	0.59	4.43	0.90	0.31
AT 24	1.52	0.42	5.29	0.58	0.16
AT 34b	1.42	0.63	5.04	0.69	0.06
AT 34a	1.41	0.63	5.04	0.69	0.06
AT 07	2.10	0.70	3.97	0.86	0.15
AT 44	1.37	0.78	4.75	0.83	0.04
AT 35	1.60	0.66	4.60	0.74	0.08
AT 27	1.64	0.47	4.39	0.61	0.15
AT 23	1.72	0.53	4.00	0.68	0.15
AT 03	1.31	0.70	3.17	0.80	0.10
AT 38	1.82	0.74	3.93	0.81	0.07
AT 39	1.73	0.74	3.55	0.82	0.08
AT 19	1.70	0.48	3.75	0.99	0.50
AT 09	1.82	0.63	2.19	1.10	0.47

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Appendix C (continued)

Code	*GO*	*GVA*	*Employment*	*GDP*	*Net Taxes*
AT 45	1.42	0.91	2.91	1.00	0.10
AT 43	1.61	0.93	3.29	1.13	0.20
AT 14	1.54	0.45	3.09	0.59	0.14
AT 28	1.76	0.51	3.09	0.77	0.25
AT 46	1.09	0.97	0.54	0.98	0.01
AT 01	1.41	0.71	1.78	0.75	0.05
AT 18	1.73	0.49	1.84	0.61	0.12
AT 33	1.59	0.71	1.43	0.96	0.25
AT 02	1.63	0.81	2.84	0.88	0.07
AT 47	1.38	0.88	3.33	0.93	0.05
AT 16	1.40	0.34	0.37	0.54	0.20
AT 32	1.44	0.41	4.81	0.48	0.07
AT 52	1.00	1.00	0.02	1.00	0.00

Note. Sector codes (AT 01 – AT 52) refer to Appendix A. For definitions of GO, GVA, and others, see Table 1. Each multiplier represents the amount by which the total effect of the indicators increases in response to an exogenous shock in the respective sector.
Source: Authors' elaboration based on research.

Appendix D. Sector's absorption of shocks from water and sewage

Code	*GO*	*GVA*	*Employment*	*GDP*	*Net Taxes*
AT 01	0.07%	0.09%	0.02%	0.08%	0.02%
AT 02	0.04%	0.05%	0.02%	0.05%	0.02%
AT 03	0.03%	0.04%	0.02%	0.04%	0.05%
AT 04	0.00%	0.00%	0.00%	0.01%	0.08%
AT 05	0.27%	0.23%	0.34%	0.25%	0.42%
AT 06	0.01%	0.01%	0.01%	0.01%	0.03%
AT 07	0.03%	0.01%	0.01%	0.02%	0.06%
AT 08	0.00%	0.00%	0.00%	0.00%	0.01%
AT 09	0.00%	0.00%	0.00%	0.00%	0.01%
AT 10	0.02%	0.01%	0.02%	0.02%	0.10%
AT 11	0.05%	0.03%	0.08%	0.07%	0.53%
AT 12	0.00%	0.00%	0.00%	0.00%	0.01%
AT 13	0.07%	0.03%	0.10%	0.05%	0.17%
AT 14	0.08%	0.04%	0.04%	0.06%	0.20%
AT 15	0.04%	0.02%	0.08%	0.03%	0.09%
AT 16	1.85%	0.93%	0.02%	1.40%	6.41%
AT 17	0.01%	0.01%	0.00%	0.03%	0.32%
AT 18	0.45%	0.23%	0.03%	0.27%	0.76%
AT 19	0.29%	0.15%	0.16%	0.40%	3.11%

Table continues on next page

Appendix D (continued)

Code	*GO*	*GVA*	*Employment*	*GDP*	*Net Taxes*
AT 20	0.00%	0.00%	0.00%	0.00%	0.00%
AT 21	0.43%	0.22%	0.44%	0.33%	1.54%
AT 22	1.57%	0.79%	1.58%	1.24%	6.00%
AT 23	0.23%	0.11%	0.10%	0.15%	0.53%
AT 24	1.20%	0.60%	1.22%	0.84%	3.41%
AT 25	0.02%	0.01%	0.02%	0.03%	0.22%
AT 26	0.18%	0.09%	0.18%	0.22%	1.63%
AT 27	0.10%	0.05%	0.06%	0.06%	0.22%
AT 28	0.00%	0.00%	0.00%	0.00%	0.01%
AT 29	0.03%	0.02%	0.04%	0.02%	0.08%
AT 30	0.00%	0.00%	0.00%	0.00%	0.01%
AT 31	0.03%	0.01%	0.03%	0.02%	0.13%
AT 32	0.35%	0.18%	0.31%	0.18%	0.24%
AT 33	3.36%	3.30%	0.54%	4.18%	13.49%
AT 34a	71.06%	69.82%	75.16%	67.64%	44.55%
AT 34b	0.35%	0.34%	0.36%	0.33%	0.22%
AT 35	5.73%	5.49%	4.24%	5.36%	3.90%
AT 36	1.53%	2.03%	2.77%	1.90%	0.54%
AT 37	0.76%	0.65%	0.75%	0.65%	0.58%
AT 38	0.03%	0.03%	0.01%	0.02%	0.02%
AT 39	0.03%	0.03%	0.01%	0.03%	0.02%
AT 40	0.15%	0.13%	0.18%	0.13%	0.12%
AT 41	0.02%	0.02%	0.06%	0.02%	0.02%
AT 42	0.03%	0.03%	0.04%	0.03%	0.05%
AT 43	0.34%	0.43%	0.11%	0.51%	1.31%
AT 44	0.80%	1.03%	0.78%	0.99%	0.51%
AT 45	2.63%	3.86%	1.11%	3.93%	4.62%
AT 46	0.52%	1.08%	0.04%	0.99%	0.01%
AT 47	2.85%	4.25%	1.64%	4.07%	2.12%
AT 48	2.01%	3.00%	6.72%	2.86%	1.44%
AT 49	0.22%	0.36%	0.34%	0.33%	0.01%
AT 50	0.08%	0.12%	0.14%	0.11%	0.03%
AT 51	0.05%	0.06%	0.08%	0.05%	0.02%
AT 52	0.00%	0.00%	0.00%	0.00%	0.00%
Total	100.00%	100.00%	100.00%	100.00%	100.00%

Note. Sector codes (AT 01 – AT 52) refer to Appendix A. The concept adopted for absorption refers to the percentage of the total effect that floats to each sector.
Source: Authors' elaboration based on research.