Innovation and efficiency in local tax administration: evidence from Brazil

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Abstract

This article examines how Brazilian municipalities enhance their fiscal capacity through administrative and technological innovations, utilising three local taxes: property, service, and property transfer taxes. Using a mixed-method design that integrates three-stage Data Envelopment Analysis and the Malmquist Productivity Index with Qualitative

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Comparative Analysis, we examine both efficiency levels and the configurations of practices that produce high performance. The results indicate that there is no single dominant model for tax collection success, and different combinations of administrative, technological, and regulatory instruments can support efficiency gains, depending on the institutional context and the trajectory of each municipality. The findings advance theory on fiscal capacity and dynamic capabilities by showing that efficiency stems from complementary or substitutive practices, demonstrating methodologically the value of combining symmetric and asymmetric approaches to capture causal complexity, and highlighting the policy relevance of strengthening data infrastructures before deploying context-sensitive instruments to enhance revenue mobilisation and fiscal autonomy.

Keywords: municipal tax administration, tax collection, innovation, fiscal capacity, dynamic capabilities.

Inovação e eficiência na administração tributária local: evidências do Brasil

Resumo

Este artigo analisa como municípios brasileiros fortalecem sua capacidade fiscal por meio de inovações administrativas e tecnológicas nos impostos IPTU, ISS e ITBI. A pesquisa adota uma estratégia metodológica mista, combinando Análise Envoltória de Dados (DEA) em três estágios, Índice de Produtividade de Malmquist e Análise Comparativa Qualitativa (fsQCA) para avaliar níveis de eficiência e identificar configurações de práticas associadas a alto desempenho. Os resultados mostram que não há um modelo único para o sucesso na arrecadação: diferentes combinações de instrumentos administrativos, tecnológicos e regulatórios podem gerar eficiência, conforme o contexto e a trajetória municipal. As evidências avançam a teoria sobre capacidade fiscal e capacidades dinâmicas ao demonstrar que a eficiência emerge de práticas complementares ou substitutivas, ao mesmo tempo em que evidenciam o valor de integrar métodos simétricos e assimétricos para captar complexidade causal. Politicamente, destacam a importância de fortalecer infraestruturas de dados antes de adotar instrumentos sensíveis ao contexto para ampliar receitas e autonomia fiscal.

Palavras-chave: administração tributária municipal, arrecadação de impostos, inovação, capacidade fiscal, capacidades dinâmicas.

Innovación y eficiencia en la administración tributaria local: el caso de Brasil

Resumen

Este artículo analiza cómo los municipios brasileños fortalecen su capacidad fiscal mediante innovaciones administrativas y tecnológicas en los impuestos predial, de servicios y de transferencia de propiedad. El estudio emplea un diseño mixto que combina el Análisis Envolvente de Datos (DEA) en tres etapas, el Índice de Productividad de Malmquist y el Análisis Comparativo Cualitativo (fsQCA) para evaluar la eficiencia y las configuraciones de prácticas asociadas a un desempeño elevado. Los resultados muestran que no existe un único modelo dominante de éxito tributario: diversas combinaciones de instrumentos administrativos, tecnológicos y regulatorios pueden generar eficiencia según el contexto institucional y la trayectoria municipal. Los hallazgos avanzan la teoría sobre capacidad fiscal y capacidades dinámicas al demostrar que la eficiencia surge de prácticas complementarias o sustitutivas, al tiempo que evidencian el valor de integrar métodos simétricos y asimétricos para capturar la complejidad causal. Asimismo, destacan la importancia de fortalecer las infraestructuras de datos antes de adoptar instrumentos sensibles al contexto para mejorar la movilización de ingresos y la autonomía fiscal.

Palabras-clave: administración tributaria municipal, recaudación tributaria, innovación, capacidad fiscal, capacidades dinámicas.

1. INTRODUCTION

Efficient tax collection is generally regarded as a cornerstone of fiscal capacity and service delivery in both developed and developing economies. Seminal contributions emphasise that fiscal systems are not only technical devices for raising revenue but also institutions that support state-building and legitimacy (Bird & Jantscher, 1992; R. Musgrave & P. Musgrave, 1980). The quality of tax administration, in this sense, is as relevant as the quantity of resources mobilised, shaping governments' ability to respond to citizens' demands and sustain long-term development (Alm & Duncan, 2014).

In emerging economies, structural inequalities and institutional fragmentation pose a challenge to building local fiscal capacity. Local governments frequently depend on intergovernmental transfers, and their fiscal autonomy is often constrained by political, economic, and legal arrangements (Smoke, 2014). In the Brazilian case, a typical example

of decentralised federalism, municipalities enjoy constitutional autonomy but face disparities in their capacity to raise their own revenues (Abrucio, 2022).

Building on this institutional background, the present study draws on the Dynamic Capabilities Theory (Teece et al., 1997) combined with the literature on Public Sector Innovation (Organisation for Economic Co-operation and Development [OECD], 2018; Osborne & Brown, 2013). These perspectives view innovation as an adaptive capability that enables organisations, including local governments, to sense opportunities, reconfigure processes, and mobilise resources to improve performance. In the municipal tax context, tax administration initiatives such as adopting geoprocessing technologies, implementing electronic invoicing programmes, and digitalization can be understood as manifestations of these dynamic capabilities. Rather than radically transforming the tax system, these incremental innovations enhance calculation, monitoring, and enforcement mechanisms, thereby broadening the tax base, reducing losses, and strengthening fiscal autonomy.

Scholars increasingly highlight the role of administrative and technological innovations in strengthening tax governance. In Nigeria, electronic systems improved collection procedures but faced taxpayer resistance and limited staff skills (Adeyeye, 2019). In Brazil, monitoring tools and information systems enhanced efficiency and compliance, though their impact depends on enforcement capacity and bureaucratic quality (Cabello et al., 2019). Evidence from Taiwan shows that efficiency in local tax offices relies not only on resources but also on managerial practices and institutional design (Huang et al., 2017). Additional studies emphasise tools such as electronic service invoicing (Couto & Jorge, 2022), cadastral modernisation (Eguino et al., 2020), drones for monitoring and expanding property taxation (Marhani & Murwendah, 2018), and artificial intelligence for detecting evasion (Xavier et al., 2022). Collectively, these findings reinforce that technological and organisational innovations matter, but their effectiveness is mediated by institutional capabilities and socio-political context.

Despite these advances, the literature remains fragmented. Most empirical studies examine isolated taxes, such as property taxation (Anjos & Pinheiro, 2024) or service taxation regimes (Ozaki & Biderman, 2004), or focus on specific municipal practices (Goes & Pinto, 2016; Lucena et al., 2022; Roza, 2012). Although useful, these works do not show how multiple practices interact to shape efficiency, nor how innovations across cadastres, electronic invoicing, geospatial technologies, and fiscal intelligence may

combine to improve performance. Even in Brazil, where property and service taxes are central to municipal budgets, comparative studies that systematically assess the determinants of efficiency across multiple local governments remain scarce (Vieira et al., 2021).

Methodologically, most studies rely on either regression techniques or isolated efficiency tools. Data Envelopment Analysis (DEA) and the Malmquist index are widely used to assess productivity and efficiency in public finance (Adam et al., 2011; Fried et al., 2002) but typically assume linearity and symmetric effects. In contrast, configurational methods-such as fuzzy-set Qualitative Comparative Analysis (fsQCA), are rarely applied in public administration, despite their ability to capture causal complexity, conjunctural causation, and equifinality (Fiss, 2011; Ragin, 2008; Schneider & Wagemann, 2012). Recent studies combining DEA and fsQCA in fields such as healthcare, innovation, and environmental management (Lei & Wei, 2023; Li et al., 2023; Wang & Chen, 2024; Xie & Hu, 2024) demonstrate the value of integrating symmetric and asymmetric approaches, a strategy still largely unexplored in public finance and tax administration.

This article addresses these gaps by examining how innovative practices in tax administration collectively impact the efficiency of municipal revenue collection. We analyse three core local taxes: property tax (PT), service tax (ST), and property transfer tax (PTT). By integrating DEA and the Malmquist index to measure efficiency and productivity over time, and using fsQCA to identify multiple causal pathways, the study uncovers how different configurations of innovations contribute to efficient outcomes.

The justification for this study rests on three dimensions. From a practical and policy perspective, understanding which bundles of innovations matter most can inform municipal reforms, guiding investments in electronic invoicing, cadastral modernisation, geospatial analytics, and fiscal intelligence systems. From a social perspective, improving local revenue collection has direct consequences for financing essential public services, such as education, health, and infrastructure, thus enhancing citizens' well-being and strengthening democratic accountability. From a methodological perspective, the integration of DEA/Malmquist with fsQCA provides an original analytical design for public administration research, allowing for the simultaneous evaluation of efficiency levels and the identification of equifinal causal configurations.

2. THEORETICAL PERSPECTIVES ON TAX ADMINISTRATION INNOVATION

The conceptual foundation of this study draws on two complementary strands of theory: Dynamic Capabilities Theory (Teece et al., 1997) and the literature on Public Sector Innovation (OECD, 2018; Osborne & Brown, 2013). Together, these perspectives help explain why innovation in tax administration is not merely a technical reform, but rather an adaptive process of capability-building within local governments.

Dynamic Capabilities Theory (Teece et al., 1997) emphasizes how organizations sense opportunities and threats, seize them through reconfiguring processes, and transform resources and routines to sustain performance. Applied to municipal taxation, cadastral modernization, electronic invoicing, and digital enforcement tools are not isolated initiatives but manifestations of these capabilities. For instance, drone-assisted geoprocessing allows municipalities to sense previously unreported properties; the implementation of electronic invoicing systems reflects the capacity to seize opportunities to expand compliance; and the creation of updated valuation rolls demonstrates the ability to transform administrative routines into more transparent and sustainable practices.

In this study, tax administration innovations are analytically interpreted through the lens of these three dynamic capability dimensions. Initiatives related to the identification of fiscal opportunities and information gaps (e.g., geospatial mapping and data integration) are associated with sensing capabilities; the implementation of managerial or technological solutions to expand compliance (e.g., electronic invoicing or digital billing systems) reflects seizing capabilities; and the institutionalization of new administrative routines, such as updated valuation rolls or integrated fiscal management systems, represents transforming capabilities. This conceptual mapping helps situate tax administration innovation as a process of adaptive capability-building within municipal governments.

The public sector innovation literature (OECD, 2018; Osborne & Brown, 2013) complements this view by highlighting that innovation in government is often incremental and adaptive, rather than disruptive. Such innovations typically involve reconfiguring existing processes, leveraging available technologies, and engaging citizens and stakeholders in ways that improve efficiency, equity, and accountability (OECD, 2018). In this sense, the adoption of digital PT billing, the creation of ST

incentive programs, or the use of AI in services tax (ST) exemplify innovations that enhance fiscal performance without altering the constitutional or legal foundations of municipal taxation.

Positioning municipal tax practices within these frameworks contributes to the broader literature on fiscal capacity and governance in emerging economies. Local governments often operate under conditions of resource scarcity, fragmented authority, and political constraints (Abrucio, 2022). In such settings, dynamic capabilities and incremental innovations provide pathways for municipalities to build resilience, mobilize own-source revenues, and strengthen fiscal autonomy.

By integrating these theoretical perspectives into the analysis of tax administration innovations, this study advances the view that fiscal efficiency emerges from processes of adaptive capability-building.

Fiscal capacity is a multidimensional concept encompassing political authority, institutional legitimacy, and the administrative capability to mobilize public revenues. This study focuses on one operational dimension of fiscal capacity: the efficiency with which municipal tax administrations convert their available tax bases into actual revenue. While this perspective does not capture the broader structural dimensions of state-building, it provides empirical evidence on how administrative innovation and organizational capabilities may influence the operational performance of local tax systems.

2.1 Cadastral and valuation innovations in Property Tax (PT)

Evidence shows that cadastral modernization, such as integrating drone imagery with GIS (Geographic Information System), significantly improves municipal property tax performance (Farahane et al., 2024; Marhani & Murwendah, 2018; Oliveira et al., 2021).

Valuation practices also matter, as heterogeneous assessment systems produce divergent revenue outcomes (Perez, 2020). In Brazil, periodic, legally grounded updates of the Official Property Valuation Roll (OPVR), supported by geospatial data, help correct outdated values and reduce inequities (Tolentino et al., 2025).

Digitalization reduces transaction costs, improves transparency, and supports compliance through electronic billing and integrated cadastral systems (Eguino et al., 2020; Lucena et al., 2022).

Drones provide cost-effective cadastral updates, improving land-use accuracy, accelerating revenue growth, and reducing field risks in both Brazil and Indonesia. (Marhani & Murwendah, 2018; Oliveira et al., 2021). Yet their adoption depends on legal and institutional conditions, including enforcement capacity, skilled personnel (Li & Kim, 2022), and compliance with privacy and airspace regulations (Brobst, 2020; Skorup, 2020).

Targeted IPTU programs also contribute to municipal tax performance by simplifying access to billing, enabling electronic payments, and automating notifications, which reduces compliance costs and delinquency while enhancing transparency and predictability (Eguino et al., 2020). When combined with cadastral and valuation systems, these programs help translate digital capacities into effective revenue outcomes, especially in contexts of limited institutional capacity.

Overall, a coherent capability bundle emerges: geospatial data acquisition, data integration, regular valuation routines, and digital service delivery. When these capabilities are aligned and routinised, municipalities achieve broader tax bases, fewer errors, greater transparency, and higher yields, consistent with innovation as an incremental, efficiency-oriented dynamic capability in local tax administration.

2.2 Digital invoicing and fiscal intelligence in Service Tax (ST)

Studies on electronic invoicing for services (NFS-e) show mixed results. Angeli and Martinez (2016) found that, although the system reduced transaction costs for taxpayers, it did not significantly raise revenues. The main benefit was administrative efficiency rather than fiscal gains.

Other analyses, however, report positive impacts. Couto and Jorge (2022) observed that NFS-e adoption correlated with higher per capita revenues, especially where incomes were growing, while Lucena et al. (2022) found increases of up to 46% in adopting municipalities. These studies suggest that technology's effect depends on broader economic and demographic conditions.

Municipalities have also experimented with estimation regimes, where tax liabilities are predetermined by activity type or turnover. Ozaki and Biderman (2004) found that these regimes improved revenue in some contexts but not others, underscoring the need for context-sensitive application.

Complementary initiatives include incentive programs that reward taxpayers for issuing invoices, often through property tax credits or cash equivalents. Iensen and Kulitch (2023) found that, although only a small share of municipalities adopted such schemes, participating ones achieved measurable increases in invoice issuance and revenue.

Another mechanism is service tax withholding, which shifts collection responsibility to the contracting party. This approach reduces evasion by concentrating compliance among large, easily monitored taxpayers (Kleven et al., 2009). Brazilian municipalities use it in contracts with major firms and public entities to stabilize revenues and mitigate fraud risks.

More recent evidence emphasizes the role of analytical capabilities. By integrating open data and artificial intelligence, municipalities can improve enforcement targeting and detect tax evasion more effectively, reinforcing the gains from digital and regulatory innovations (Xavier et al., 2022). Overall, these instruments operate as complementary components of local tax administration: digitalization lowers costs and expands information, regulatory design shapes incentives, and analytical capacity determines whether innovation translates into sustained revenue performance.

2.3 Transaction monitoring and enforcement in Property Transfer Tax (PTT)

The property transfer tax faces challenges distinct from the PT. While PT relies on the Official Property Valuation Roll (OPVR), PTT is based on declared transaction values, creating room for undervaluation and revenue loss (Oliveira, 2022). Strategic underreporting and valuation distortions can generate both fiscal losses and legal disputes.

Technological innovations help address these issues. Georeferencing and aerial imagery enhance valuation accuracy by linking assessments to observable property and urban characteristics (Oliveira et al., 2021). Integration between municipal databases and notarial registries via APIs can further reduce information asymmetries and enable automatic value verification (Oliveira, 2022).

Artificial intelligence (AI) and machine learning applications show promise for valuation and fraud detection. Studies using neural networks (Codes, 2018) and blockchain-based AI systems (Kim & Huh, 2020) demonstrate improved accuracy and legal certainty in PTT assessments. Early Brazilian research (Gonzáles, 2002) already

highlighted the role of algorithmic quality in preventing errors and inefficiency, while recent work confirms that AI tools used in PT administration can be adapted to PTT (Anjos & Pinheiro, 2024).

International experiences reinforce these trends. In Seoul, deep learning models applied to real estate tax data improved fraud detection (Lee, 2022), and in Indonesia, drone-assisted cadastral audits reduced mismatches between declared and actual land use (Marhani & Murwendah, 2018). These cases show that combining imaging and data processing technologies can reduce evasion and monitoring costs.

Overall, PTT efficiency depends on valuation design and technological adoption. While geospatial integration and AI enhance accuracy and compliance, their impact ultimately hinges on institutional incentives, regulatory quality, and the broader political economy of municipal finance.

Table 1 summarises the main innovative practices grouped into the operational dimensions identified above.

Table 1

Dimensions of innovation in municipal tax administration

Tax	Dimension	Examples of Practices	References
Property Tax	Geoprocessing	GIS, drones, remote sensing	Farahane et al. (2024); Marhani & Murwendah (2018); Oliveira et al. (2021)
	Property Valuation Roll	Periodic updates; legal reforms	Tolentino et. al. (2025)
	Cadastre Management	Agreements with notaries, real estate agencies	Chuerubim (2015)
	Programmes	Digitalization; Discounts; tax credits.	Eguino et al. (2020)
Service Tax	Cadastre Integration	Data sharing with tax authorities, digital platforms	Lucena et al. (2022)
	Withholding	Resident and non-resident service providers	Kleven et al. (2009)
	Fiscal Intelligence Units	Artificial Intelligence, predictive analytics	Xavier et al. (2022)
	Estimation Regimes	Applied to specific activities	Ozaki & Biderman (2004)

	Incentive Programmes	Tax credit for electronic invoice	Iensen & Kulitch (2023)
Property transfer tax	Cadastre Integration	Agreements with notaries, real estate agencies	Oliveira (2022)
	Basis of Assessment	Transaction value; reference value; PT value	Oliveira (2022)
	Specific Valuation Roll	Updates every 5–10 years	Oliveira (2022)
	Digital Tools	Apps, portals for simulation/payment	Eguino et al. (2020)

Source: Elaborated by the authors.

It is also important to recognize that municipal tax administration reforms are not purely technical processes but may involve significant political constraints. Due to the proximity between local governments and taxpayers, initiatives such as property tax cadastre updates, valuation revisions, or intensified enforcement may generate electoral costs for local authorities (Slack & Bird, 2014). Consequently, political considerations may delay or limit the implementation of administrative innovations, even when such measures could improve fiscal performance. While this political dimension is widely recognized in the political economy of taxation, the empirical strategy adopted in this study focuses on administrative and organizational factors affecting tax collection efficiency and does not directly model political incentives.

3. METHOD

3.1 Research design

This study employs a comparative mixed-methods design to analyse how innovation practices in municipal tax administration impact the efficiency of revenue collection. The research combines a quantitative assessment of efficiency through Data Envelopment Analysis (DEA) and the Malmquist Productivity Index with fsQCA. This approach allows us to capture both levels of efficiency and the multiple causal pathways through which municipalities achieve efficient outcomes, addressing recent calls in public administration research for pluralistic methodological strategies (Pappas & Woodside, 2021; Rasoolimanesh et al., 2021).

The empirical analysis covers the period 2013-2022, using multiple data sources:

- SICONFI (Brazilian National Treasury's Accounting and Fiscal Information System) provided data on municipal revenues, outstanding tax receivables, and administrative expenditures.
- Freedom of Information (LAI) requests supplied information on property registrations, service companies' registrations, and real estate transactions.
- Instituto Brasileiro de Geografia e Estatística (IBGE, 2023) contributed municipal GDP data and population, used as control variables.

Table 2 summarises the variables employed in the analysis, grouped as inputs, outputs, and environmental controls.

Table 2

Variables used in the DEA analysis

Category	Variable	Source	Purpose
Inputs	Personnel expenditures; Outstanding tax receivables (short-term and long-term)	SICONFI	Resources used in tax administration
Outputs	PT revenue; ST revenue; PTT revenue	SICONFI	Dependent variable: efficiency of tax collection
Environmental controls	Number of property registrations; Number of service companies; Number of real estate transactions; Municipal population; Municipal GDP	LAI / SICONFI / IBGE	Contextual factors affecting efficiency

Source: Elaborated by the authors.

The analysis focuses on municipalities in São Paulo State with populations above 100,000 in 2022, corresponding to 81 municipalities (12.6% of the total). This group accounts for 76% of the state's population and current revenues, making it an appropriate sample for studying fiscal capacity under decentralised federalism.

Due to incomplete responses to LAI requests, the final sample comprised 19 municipalities for property tax and service tax and 18 municipalities for property transfer tax, including São Paulo, Campinas, Santos, and other large urban centres. This selection strategy balances representativeness with data availability, consistent previous research that employs purposive and judgmental sampling for in-depth comparative analysis (Seawright & Gerring, 2008).

3.2 Efficiency analysis: DEA/SFA and Malmquist (Stage 1)

Relative efficiency was evaluated using DEA under the BCC model (Banker, Charnes, and Cooper), input-oriented and assuming variable returns to scale. Inputs included personnel expenditures and outstanding tax receivables, while outputs were revenues from PT, ST, and PTT.

To account for contextual variation, we applied the three-stage DEA/SFA approach (Fried et al., 2002), following Alm and Duncan (2014) steps: (i) Initial DEA efficiency scores were estimated for each tax; (ii) Scores were regressed on environmental controls (e.g., Number of property registrations, Number of service companies; Number of real estate transactions, population, GDP), and (iii) Inputs were adjusted based on residuals, and efficiency was recalculated, controlling for external factors.

Dynamic efficiency was assessed using the Malmquist Productivity Index, enabling biennial comparisons of efficiency changes between 2013 and 2022. This enabled us to observe not only which municipalities were efficient at a given point, but also their ability to sustain or improve performance over time.

3.3 Configurational analysis: fsQCA (Stage 2)

To explore the relationship between innovation practices and efficiency, we employed fuzzy-set fsQCA. This method enables the identification of equifinal causal configurations, consistent with the theoretical premise that municipalities may follow multiple pathways to achieving efficiency.

Questionnaires were administered online in April 2025 to finance secretaries and senior tax officials in the sampled municipalities. The instruments were developed based on prior literature (Table 1) and refined through expert consultation.

To operationalize the dimensions of tax innovation across the three municipal taxes (PT, ST, and PTT), we developed a structured questionnaire that allowed us to assign standardized scores ("ratings") to each reported practice. These scores reflected the frequency, technological sophistication, and institutionalization of each practice, ensuring comparability across municipalities while preserving qualitative differences in the degree of modernization.

For PT, geoprocessing could score up to seven points, combining both periodicity (less than five years = 3; 5–10 years = 2; more than ten years = 1), technological level (manual mapping = 1; GIS = 2; drones and automated valuation = 3), and field verification in case of doubt (0–1). The property valuation roll (OPVR) could reach up to five points, depending on periodicity and whether reforms were introduced by law (2) or simple updates were performed (1). Cadastre management accounted for up to four points, considering the existence of structured processes, obligations from real estate registries (CNJ), integration with notary offices, or other quality-enhancing practices. Specific PT programmes were scored binarily (0 or 1).

For ST, cadastre integration with other agencies and withholding regimes was evaluated using binary or additive logic. The estimation regime ranged from 1 to 3 points depending on the number of activities covered (up to more than ten). Incentive programmes for NFS-e issuance contributed up to two points, depending on existence and continuity. Additionally, the presence of a fiscal intelligence unit based on NFS-e data was scored up to three points, covering the use of machine learning/deep learning, predictive analytics for audit targeting, and broader artificial intelligence applications.

For PTT, cadastre integration accounted for up to three points, while the basis of assessment varied from three points (transaction value) to two points (reference value) or one point (property tax value). A specific valuation roll for PTT could reach seven points, depending on its existence and periodicity (annual = 4; up to 5 years = 3; 5-10 years = 2; more than 10 years = 1), with additional points for legal reforms (2) or updates (1). The adoption of digital tools, such as simulation and payment portals, was also considered, ranging from one point (simulation only) to three points (both simulation and payment).

Indicators derived from these scoring rules were calibrated into fuzzy sets (0-1) using percentile anchors: 0.80 (full membership, 80th percentile), 0.50 (crossover, 50th percentile), and 0.20 (full non-membership, 20th percentile), consistent with best practices (Pappas & Woodside, 2021; Ragin, 2008). Tests of necessary conditions were

conducted (consistency ≥ 0.90), followed by the construction of truth tables with thresholds of 0.75 consistency and frequency ≥ 1 (Rihoux & Ragin, 2008). Solutions were derived by distinguishing core from contributing conditions, based on their presence across parsimonious and intermediate solutions. All analyses were performed using fsQCA 3.1 software.

4. RESULTS

4.1 Stage 1: static and dynamic efficiency patterns

The results indicate a heterogeneous distribution of efficiency across municipalities. For PT and PTT, a considerable proportion of cities presented positive Malmquist indices (≥1), suggesting productivity gains over time. In contrast, ST displayed greater dispersion: while several municipalities improved their performance, others remained stagnant. Rather than revealing a single dominant trajectory, the findings point to the emergence of clusters of municipalities in the top quartile, which combine relatively high static efficiency with sustained or improving productivity. These patterns provide the rationale for Stage 2 of the analysis: if multiple cities can improve simultaneously without the predominance of a unique model, then equifinal administrative configurations are likely to operate.

When examined individually, each tax exhibits distinct dynamics. In the case of PT, a sizeable share of municipalities recorded productivity gains, with a subset maintaining consistently high adjusted DEA scores. For ST, the higher dispersion indicates multiple trajectories: some municipalities appear to benefit from digital compliance tools, whereas others face persistent organizational frictions. PTT, in turn, reveals a smaller group of municipalities that combine strong static efficiency with marked productivity growth, suggesting that targeted process and data innovations have been particularly influential in this domain.

4.2 Stage 2: configurational pathways (fsQCA)

We examined how innovation practices combine to yield high performance, using the adjusted DEA scores and Malmquist indices as outcome measures. The conditions were

derived from the municipal questionnaires and organized by tax domain. For the property tax (PT), the practices considered included geoprocessing (GEO), valuation roll updates (OPVR), cadastre quality (CADASTRE), and the implementation of targeted programmes (PROG). In the case of service tax (ST), the relevant practices included cadastre integration (CADASTRE), withholding (WITHHOLDING), the establishment of fiscal intelligence units (FIU), the use of estimation regimes (ESTIMATION), and incentive programs to encourage e-invoicing (ProgST). For the real estate transfer tax (PTT), the analysis focused on trigger identification and cadastre integration (CADASTRE), the basis of assessment (BC), the development of PTT-specific valuation rolls (OPVR-PTT), and the introduction of digital portals or applications (SITE).

Calibration followed fuzzy-set methodological standards, with empirical anchors guiding the construction of sets. Tests of necessity revealed that no single condition reached the conventional threshold of 0.90 across any of the taxes, indicating that high performance is not dependent on the presence of one isolated practice. The subsequent derivation of intermediate solutions allowed for the distinction between core and contributing conditions, shedding light on how different configurations of practices can generate equivalent outcomes in terms of tax efficiency and productivity.

4.2.1 Property tax

The fsQCA results identified three sufficient pathways to high adjusted DEA scores (static efficiency), with solution consistency of approximately 0.81 and solution coverage of 0.64, values close to those reported in recent DEA and fsQCA applications. In all three configurations (Table 3), geoprocessing (GEO) consistently appeared as the only core condition. In Path 1, GEO was combined with cadaster quality (CADASTRE). In Path 2, GEO was reinforced by valuation roll updates (OPVR) and CADASTRE. In Path 3, GEO was complemented by targeted programs (PROGPT), compensating for the absence of stronger cadastral or valuation structures. These findings emphasize the centrality of geoprocessing as the recurrent driver of static efficiency, while other practices play supporting or compensatory roles.

Table 3

Causal pathways to efficiency in property tax (PT) collection

Condition	Path 1	Path 2	Path 3
GEO	●	●	●
OPVR		●	○
CADASTRE	●	●	○
PROGPT	○		●
Cities	Araçatuba and Osasco	São Paulo, Araçatuba, Bauru, Americana, Campinas and Jacarei	São Bernardo do Campo and Jundiaí
Raw coverage	0.189	0.388	0.280
Unique coverage	0.062	0.224	0.188
Consistency	0.893	0.786	0.892
Solution coverage	0.637		
Solution consistency	0.810		

Note: ● = core causal condition (present); ◯ = core causal condition (absent); = ● contributing causal condition (present); ○ = contributing causal condition (absent).

Source: Elaborated by the authors.

When examining productivity gains through the Malmquist index, the most consistent pathways involved a re-weighting of these components (Table 4). In some contexts, the combination of GEO, OPVR, and CADASTRE proved sufficient without the presence of targeted programs. In others, CADASTRE alone appeared as a core driver, while in yet other cases targeted programs played a compensatory role. Overall, property tax performance can be achieved either by establishing a strong data backbone, anchored in geoprocessing, cadastral quality, and valuation roll updates, or by designing effective programs that offset structural constraints. This pattern illustrates a case of equifinality, where distinct configurations of practices converge toward similar outcomes in terms of efficiency and productivity.

Table 4

Causal pathways for the evolution of efficiency in property tax (PT) collection

Condition	Path 1	Path 2	Path 3
GEO	●	◯	◯
OPVR	●	○	◯
CADASTRE	●	●	◯
PROGPT		◯	●

Cities	São Paulo, Araçatuba, Bauru and Americana	São José do Rio Preto	Diadema
Raw coverage	0.425	0.118	0.271
Unique coverage	0.337	0.061	0.180
Consistency	0.893	0.822	0.799
Solution coverage	0.669		
Solution consistency	0.841		

Note: ● = core causal condition (present); ◯ = core causal condition (absent); = ● contributing causal condition (present); ○ = contributing causal condition (absent).

Source: Elaborated by the authors.

Taken together, these results indicate that efficient PT collection can be achieved through alternative governance logics. In the static dimension, geoprocessing (GEO) consistently emerges as the only recurrent core element, complemented by cadastral quality, valuation updates, or targeted programs in contributing roles. In the dynamic dimension, however, other practices become central: valuation roll updates (OPVR), cadaster quality (CADASTRE), or targeted programs (PROGPT) appear as core conditions depending on the configuration, while GEO no longer plays a decisive role. This shift underscores that municipalities may sustain efficiency either by strengthening a robust data backbone or by adopting targeted reforms and programs that compensate for structural weaknesses. The results illustrate the principle of equifinality, whereby distinct combinations of practices converge toward similar outcomes in terms of efficiency and productivity.

4.2.2 Service tax

For static efficiency, the analysis identified two principal pathways (Table 5). In the first, cadaster integration (CADASTRE) was the core condition, supported by fiscal intelligence units (FIU), estimation regimes (ESTIMATION), and incentive programs for e-invoicing (PROGST) as contributing conditions. In the second pathway, withholding at source (WITHHOLDING) and ESTIMATION were core, with FIU as a contributing condition, and CADASTRE was absent as a contributing condition.

Table 5

Causal pathways to efficiency in service tax (ST) collection

Condition	Path 1	Path 2
CADASTRE	●	○
WITHHOLDING		●
FIU	●	●
ESTIMATION	●	●
PROGST	●	
Cities	São Bernardo do Campo and São Paulo	Santos
Raw coverage	0.405	0.415
Unique coverage	0.213	0.224
Consistency	0.701	0.662
Solution coverage	0.629	
Solution consistency	0.700	

Note: ● = core causal condition (present); ◯ = core causal condition (absent); = ● contributing causal condition (present); ○ = contributing causal condition (absent).

Source: Elaborated by the authors.

When productivity gains were considered, two distinct pathways emerged (Table 6). The first combined withholding (WITHHOLDING) and incentive programs for e-invoicing (PROGST) as core conditions, with fiscal intelligence units (FIU) and estimation regimes (ESTIMATION) as contributing conditions, a configuration observed in Americana and São Bernardo do Campo. The second pathway, identified in Araçatuba, relied solely on FIU as a contributing condition, suggesting that even without a core element, analytical capacity can still provide incremental productivity improvements.

Table 6

Causal pathways for the evolution of efficiency in service tax (ST) collection

Condition	Path 1	Path 2
CADASTRE		
WITHHOLDING	●	
FIU	●	●
ESTIMATION	●	
PROGST	●	
Cities	Americana and São Bernardo do Campo	Araçatuba

Raw coverage	0.451	0.140
Unique coverage	0.374	0.063
Consistency	0.738	0.707
Solution coverage	0.514	
Solution consistency	0.710	

Note: ● = core causal condition (present); ◯ = core causal condition (absent); = ● contributing causal condition (present); ○ = contributing causal condition (absent).

Source: Elaborated by the authors.

Taken together, these results indicate two distinct governance logics for efficient ST collection. One is a data-driven model, in which cadaster integration (CADASTRE) can anchor static efficiency, complemented by fiscal intelligence units (FIU), estimation regimes (ESTIMATION), and incentive programs. The other is a rules-driven model, where withholding (WITHHOLDING) and estimation regimes (ESTIMATION), and in dynamic terms, incentive programs for e-invoicing (PROGST), form the backbone of efficiency. Across both logics, FIU consistently emerges as an important supporting element, underscoring the role of analytical capacities in sustaining and enhancing municipal tax performance.

4.2.3 Property transfer tax

In the case of the real estate transfer tax (PTT), both static efficiency and productivity growth were consistently explained by a single robust configuration (Tables 7 and 8). The basis of assessment (BC) emerged as the core condition, reflecting the importance of adopting credible valuation standards (e.g., transaction or reference values) for ensuring fiscal performance. This was complemented by cadaster integration (CADASTRE), the development of PTT-specific valuation rolls (OPVR), and the introduction of digital portals (SITE), which acted as contributing conditions.

Table 7

Causal pathways to efficiency in property transfer tax (PTT) collection

Condition	Path 1
CADASTRE	●
BC	●
OPVR	●
SITE	●

Cities	São Paulo and Bauru
Raw coverage	0.534
Unique coverage	0.534
Consistency	0.646
Solution coverage	0.534
Solution consistency	0.646

Note: ● = core causal condition (present); ◯ = core causal condition (absent); = ● contributing causal condition (present); ○ = contributing causal condition (absent)

Source: Elaborated by the authors.

Table 8

Causal pathways for the evolution of efficiency in property transfer tax (PTT) collection

Condition	**Path 1**
CADASTRE	●
BC	●
OPVR	●
SITE	●
Cities	São Paulo
Raw coverage	0.358
Unique coverage	0.358
Consistency	0.842
Solution coverage	0.358
Solution consistency	0.842

Note: ● = core causal condition (present); ◯ = core causal condition (absent); = ● contributing causal condition (present); ○ = contributing causal condition (absent)

Source: Elaborated by the authors.

Taken together, these results highlight the centrality of a credible basis of assessment (BC) as the foundation of efficient PTT collection. However, efficiency and productivity gains are only fully realized when this core element is complemented by cadastral integration, domain-specific valuation rolls, and digital tools that streamline taxpayer interaction. Importantly, the evidence reinforces the value of maintaining valuation rolls tailored to property transfer operations, rather than relying solely on those developed for recurrent property taxation.

The analysis across the three municipal taxes reveals three overarching insights. First, a reliable data backbone is essential: cadaster integration and geoprocessing in the case of property tax, emerges repeatedly as a core or quasi-core condition, without which other instruments underperform. Second, policy instruments can act as complements or substitutes. Targeted programs (PROGST), withholding (WITHHOLDING), and estimation regimes (ESTIMATION) may reinforce robust data infrastructures or compensate, at least partially, when such infrastructures are weaker, thereby generating alternative high-performance pathways. Third, task-specific design matters. The PTT demonstrates gains when supported by valuation rolls designed specifically for property transfers and by credible bases of assessment, while the service tax responds more

strongly to withholding, estimation, and fiscal intelligence measures, particularly when these are well routinised.

5. DISCUSSION

The results highlight three overarching insights into the dynamics of local tax administration in a decentralized federation.

First, efficiency is a multidimensional and context-dependent concept. The DEA and Malmquist analyses showed that static efficiency is concentrated in a relatively small subset of municipalities, but dynamic improvements are more widespread. This aligns with the argument that fiscal capacity is not a fixed attribute of local governments but a capability that can evolve (Bird & Jantscher, 1992; R. Musgrave & P. Musgrave, 1980). The pattern suggests that even municipalities with initial administrative weaknesses may achieve performance gains when adopting incremental innovations, supporting the view of taxation as both a technical and institutional process (Alm & Duncan, 2014).

Second, the configurational findings confirm the principle of equifinality. Different combinations of practices, such as geoprocessing with updated cadastral rolls, or incentive programmes compensating for structural gaps, proved sufficient to generate efficiency. This resonates with fsQCA applications in public administration, which stress conjunctural causation and multiple pathways to outcomes (Fiss, 2011; Ragin, 2008). For the property tax: cadastral management and geospatial technologies consistently emerged as central drivers, while for the Service Tax, fiscal intelligence and withholding mechanisms played a stronger role. In the Property Transfer Tax, efficiency was associated with integrated digital infrastructures, including specific valuation rolls and online payment platforms. The diversity of pathways illustrates that institutional capacity in tax governance cannot be reduced to single reforms but rather depends on tailored combinations of practices adapted to local conditions.

Third, the results underscore the role of dynamic capabilities in municipal tax governance. Theoretical perspectives on dynamic capabilities emphasise organisations' ability to sense opportunities, seize them through reconfiguration of processes, and transform resources to sustain performance (Teece et al., 1997). In line with this framework, the evidence shows that local governments improved efficiency not only by adopting new technologies but by embedding them into broader administrative routines.

Practices such as geoprocessing, electronic invoicing, and fiscal intelligence represent incremental innovations that extend municipalities' ability to mobilise revenues, consistent with the literature on public sector innovation (OECD, 2018; Osborne & Brown, 2013).

Taken together, these findings contribute to three academic debates. First, they advance research on fiscal capacity in emerging economies by demonstrating how local governments achieve efficiency through distinct, context-dependent pathways (Abrucio, 2022). Second, they demonstrate the value of methodological pluralism by integrating symmetric and asymmetric techniques to capture both levels of efficiency and causal configurations (Pappas & Woodside, 2021; Rasoolimanesh et al., 2021). Third, they provide empirical evidence of how incremental innovation and capability-building shape tax governance, reinforcing the importance of organisational and institutional factors beyond purely economic determinants (Adam et al., 2011; Huang et al., 2017).

From a policy perspective, the results imply that there is no universal recipe for efficiency. Municipalities can compensate for structural limitations by mobilising different bundles of practices, whether investing in cadastral modernisation, leveraging digital technologies, or creating incentive schemes. These results highlight the need for reform strategies that are tailored to local trajectories and capacities, rather than relying on one-size-fits-all prescriptions.

6. CONCLUSION

This article examined how bundles of administrative and technological innovations combine to shape the efficiency of municipal tax collection under conditions typical of decentralised federations in the Global South. Using a mixed-method design that integrates three-stage DEA/SFA and the Malmquist index with fuzzy-set QCA, we showed that (i) static efficiency and dynamic productivity are uneven across municipalities and tax bases; (ii) multiple, context-dependent configurations can deliver high performance (equifinality); and (iii) data infrastructures, especially cadastral quality and geospatial capabilities, form the backbone upon which complementary instruments (e.g., electronic invoicing incentives, withholding, estimation regimes, Property Transfer Tax-specific valuation rolls, and digital portals) generate returns.

Theoretically, the findings advance debates on fiscal capacity and local governance by demonstrating that innovation in tax administration operates as a dynamic capability: municipalities that sense opportunities, reconfigure processes, and routinise digital tools are better able to mobilise own-source revenues. Rather than singular "silver bullets", efficiency emerges from capability bundles aligned to problem structure, cadastral/geoprocessing and valuation routines for property taxation (PT, PPT), and rules-cum-analytics (withholding, estimation, fiscal intelligence) for service taxation (ST). In doing so, the study extends the application of Dynamic Capabilities Theory to municipal public finance and connects the public sector innovation literature to concrete mechanisms of revenue mobilisation.

Policywise, the analysis cautions against one-size-fits-all reform packages. Three principles travel across contexts: (1) data backbone first, investment in cadastral governance and, for property taxes, geoprocessing and valuation routines; (2) complements or substitutes second, use incentive programmes, withholding, and estimation regimes to reinforce or temporarily offset structural gaps; and (3) task-specific design, tailor instruments to the informational risks of each tax (e.g., PPT-specific valuation rolls and transaction-value controls; analytics applied to NFS-e for ST). Prioritising these steps can strengthen local fiscal autonomy, improve compliance, and, ultimately, expand the resource base for essential services.

The study faces limitations that invite future research. The final sample was constrained by information availability from freedom-of-information requests, which may attenuate external validity. One limitation of DEA models is their sensitivity to sample size. In relatively small samples, it is possible to observe a larger number of units classified as efficient, which may inflate efficiency scores and reduce discriminatory power. Although the three-stage DEA approach helps mitigate environmental effects, the results should still be interpreted with caution. Our innovation indicators capture the presence and breadth of practices rather than their implementation quality or enforcement intensity. Moreover, while the design identifies sufficient pathways, causal process tracing would help specify how reforms become routinised within municipal bureaucracies. Future work could (a) extend the panel and geographic scope, (b) incorporate micro-level compliance and enforcement data, (c) evaluate distributional and equity effects of administrative innovations, (d) apply longitudinal configurational techniques to track capability maturation, (e) explore the interaction between political

constraints and administrative innovation in local tax systems, and (f) assess the robustness of configurational findings through alternative calibration anchors in fsQCA analyses.

Overall, the evidence supports a pragmatic message for scholars and practitioners: building municipal fiscal capacity is a pathway problem. Cities can reach efficient outcomes through different, feasible combinations of cadastral, digital, and regulatory instruments, provided these are embedded as enduring organisational capabilities rather than isolated technological fixes.

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Ricardo Rocha de Azevedo: Formal analysis (Supporting); Methodology (Supporting); Validation (Supporting); Writing – review & editing (Supporting).

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare. The above-mentioned institution does not have any responsibility for data collection and estimation. The views expressed in this article represent the authors' point of view, and not from any institution.

RESEARCH DATA AVAILABILITY STATEMENT

The entire dataset supporting the results of this study is available upon request to the corresponding author – Otávio Gomes Cabello. The dataset is not publicly available due to confidentiality agreements and the presence of identifiable or sensitive information related to participating municipalities and public officials, which could compromise anonymity.

AI USAGE STATEMENT

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