Today's Bonus, Tomorrow's Budget: Equity-Efficiency Tradeoff in Performance-Based Transfers*

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Abstract

To improve service delivery, central governments often tie intergovernmental transfers to local policy performance. While such performance-based transfers can raise efficiency by incentivizing municipalities, they may also create equity losses by disproportionately rewarding high-capacity governments with larger transfers. We study this equity-efficiency trade-off using transfers to Brazilian municipalities. When two states tied transfers to relative educational performance, student test scores rose substantially: moving from the 25th to the 75th percentile of per capita conditional transfers increased scores by 0.13 standard deviations. However, the reform also widened funding disparities, as municipalities with higher pre-existing capacity received larger transfers. In contrast, contemporaneous reforms to unconditional transfers had negligible effects on student outcomes. A simple model of optimal transfers interprets these findings, suggesting that performance-based transfers deliver large efficiency gains, limited equity costs, and should constitute a sizable share of the optimal transfer mix. We find minimal evidence of multitasking distortions or score manipulation. Instead, we document increased education-related inputs and suggestive evidence of reduced corruption.

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1 Introduction

Recent decades have witnessed significant decentralization in the provision of public goods (Gadenne and Singhal [2014]), motivated by the recognition that local governments possess superior information regarding citizens' preferences and cost structures (Oates [1972]). Despite this decentralization, local governments rely heavily on intergovernmental transfers, as only 38% of subnational revenues are raised locally (Gadenne and Singhal [2014]). These transfers are often justified on redistributive grounds, aiming to ensure equitable resource allocation across jurisdictions (Musgrave [1959]). Yet, reliance on external funds can exacerbate political agency problems, and potentially foster inefficiencies (Brollo et al. [2013], Gadenne [2017], and Martínez [2023]). This has led contributors from several literatures to question the role of unconditional transfers.[1] A growing alternative is performance-based transfers (Olken et al. [2014]), which condition funding on measurable outcomes, aiming to mitigate negative incentive effects. Despite promising results on efficiency, the literature has not yet documented potential equity losses from them.

In this paper, we analyze the equity-efficiency trade-off of performance-based transfers, and investigate the optimal allocation between them and unconditional funding. Performance-based transfers can enhance efficiency by incentivizing local governments to reduce political rents. However, they also produce equity losses because pay-for-performance rewards municipalities with high state capacity to produce the public good.[2] The equity concerns are aggravated in a dynamic setting: lower initial performance leads to reduced funding, constraining subsequent performance. In extreme cases, performance-based funding could lead to poverty traps of low performance and low transfers. Given this trade-off, how should governments split intergovernmental transfers between unconditional and performance-based funding?

We study this question in the context of state-to-muncipalities transfers in Brazil. Starting in 2007, the states of Ceará and Pernambuco introduced a performance-based transfer rule to the main state transfer, the ICMS. Each state splits a total amount–henceforth called bonus pool–to municipalities based on their relative performances on an education quality index. We find that the conditional transfer had a large overall effect on the performance of municipalities: going from the 25th to the 75th percentile of the distribution of the bonus pool per capita increased the test scores of students by 0.13 standard deviations. However, we also find that it increased the disparity of transfers: going from the 25th to the 75th percentile of the distribution of our measure of municipal state capacity in education production implied an ICMS transfer 8.3% larger. To understand how detrimental these equity losses are, we investigate how an extra dollar in governments' budgets translate into performance. We leverage simultaneous shifts to the three main transfers to

[1] See, for instance, in the foreign aid literature Easterly [2006] and Deaton [2013], and state capacity literature Besley and Persson [2013].

[2] Transfers generally aim to target recipients based on a measure of deservingness—income transfers might aim at workers with low skills, while intergovernmental transfers aim at subgovernments with lower state capacity. However, conditional on political rents levels, municipalities with lower capacity perform worse and receive smaller conditional transfers, despite being more deserving. When comparing to an individual income transfer, conditioning on performance is akin to a regressive transfer that rewards higher earnings.

municipalities, which overall acount for 65% of municipalities' revenues. Our results imply that the increase in disparity of transfers led to muted losses: the 8.3% increase in transfers imply only a 0.000007 standard deviations increase in test scores.

To interpret the welfare implications of our empirical findings, we extend a simple model of optimal transfers that emphasizes the equity-efficiency tradeoff faced by central governments. In this framework, the government allocates a fixed total budget between two types of transfers: an unconditional (uniform) transfer and a bonus pool that gets split based on municipalities' relative performances. The model provides sufficient statistics to characterize the optimal allocation between these two instruments, highlighting the importance of differentiating between two empirical effects of performance-based transfers on education performance: (i) the effect of relaxing municipal governments' budget constraints (income effects), and (ii) the effect of incentivizing them to invest in public goods (substitution effects). Larger substitution effects leads to a larger optimal bonus pool, while larger income effects support larger unconditional transfers.

In the model, municipalities choose between immediately consuming privately the transfers or investing in public goods to secure higher future transfers. As is standard in optimal transfer models, municipalities differ in their capacity for producing public goods (types), though the central government cannot directly differentiate transfers by municipal type. The model elucidates the standard equity-efficiency trade-off of conditioning transfers on performance. Increasing the bonus pool generates efficiency gains by increasing the marginal return of investment, thereby incentivizing all municipalities to invest more in public goods. However, it simultaneously produces equity losses by disproportionately rewarding high types with larger transfers.

The key extension of the model is to analyze a two-period production setting where today's transfers form tomorrow's budget constraint. In the dynamic setting, the unequal transfers also constrain low types' production in the future. Thus, the equity losses are aggravated and have a direct effect on production.[3]

The model directly links the optimal transfer allocation to empirically estimable elasticities of municipalities' investment in public goods, and the distribution of municipalities' capacity types. It also provides a clear economic interpretation of the efficiency gains and equity losses associated with the bonus pool. First, larger substitution effects of the bonus pool—a measure of efficiency gains—increase its optimal size. Second the welfare value of a dollar transferred to a municipality depends on its welfare weight and the income effect on the municipality. This is because larger transfers relaxes the constraint of municipalities and translate into larger productions, which the planner values. Third, a more negative covariance between the social marginal valuation of transfers and the type of municipalities–a measure of equity losses–the smaller is the optimal bonus pool. This is because the bonus rewards high types with larger investment-independent transfers. The less valuable the planner finds transfers to high types (negative covariances), the smaller the optimal bonus pool.

[3]In static models, the unequal transfers only have equity losses because the consumption of low types may have a larger social value.

Empirically, we begin by documenting the overall effects of performance-based transfers on municipalities' educational outcomes. Our identification strategy exploits the uniform total size of the bonus pool available to municipalities, irrespective of their population size. Consistent with our conceptual framework—which assumes municipalities care about per capita transfers—this uniform structure implies that less populous municipalities faced larger incentives compared to more populous ones. To capture this variation, we estimate an event-study model comparing educational outcomes between municipalities with relatively larger and smaller per capita bonus pools.

We find substantial overall effects of the policy. Specifically, a one-dollar increase in the bonus pool per capita leads to a 0.002 standard deviation improvement in student test scores. Using the observed distribution of the bonus pool per capita, we estimate that moving from the 25th to the 75th percentile increases test scores by approximately 0.13 standard deviations. However, these improvements reflect both income and substitution effects, as each dollar increase in the bonus pool per capita directly translates into a dollar increase in total transfers received by municipalities.

Moreover, the positive overall effects could mask significant equity losses. To explore this concern, we estimate municipalities' types based on their performance on the education quality index prior to the reform. Our analysis of the distribution of municipal types indicates potentially large equity implications: moving from the 25th to the 75th percentile of the distribution of municipal state capacity implies an 8.3% increase in ICMS transfers. To fully understand how detrimental these equity losses might be, we further examine how additional financial resources translate into performance improvements.

To disentangle the effects of performance-based transfers and transfers that are independent of education improvements,[4] we estimate an extended event-study model. For the former, we use the same variation in the bonus pool per capita from the first analysis. For the latter, we use variation from three concurrent reforms to the three main transfers that municipalities receive.

The first source of variation in the transfers that are independent of education improvements arise from the reform to the ICMS transfer implemented in 2007. Before the reform, ICMS transfers depended on municipalities' demographic characteristics and corresponding policy weights. For example, 5% of the transfer in Ceará was based on population size. The reform adjusted these demographic weights, and introduced a new component based on educational performance. Thus, the amount transfered to municipalities changed after the reform for three reasons. First, policy weight adjustments to demographic characteristics. Second, the introduction of policy weights to educational performance. This implies that even if municipalities remain with the same pre-reform education performance, some municipalities will receive larger transfers than others. Third, municipalities could alter their characteristics and educational performance post-reform.

While the first two sources of variation can arguably provide quasi-experimental variation in transfers, the third source is endogenous. To address this endogeneity, we simulate the changes in ICMS transfers by applying post-reform weights to pre-reform municipal characteristics. Conceptu-

[4]In the paper, we will interchangebly call the "transfers independent of education improvements" as "transfer independent of investments." The latter nomenclature highlights that in our conceptual framework improvements to education come via larger investments.

ally, these predicted changes in transfers correspond to shifts to municipalities' budget constraints–i.e., shifts in transfers unrelated to education improvements.

The second source of variation in transfers independent of education improvements stems from a federal reform to Brazil's main education fund, the FUNDEB. The FUNDEB pools a share of governments' budgets and then provides equal per-student transfers. Students have differing weights assigned based on their categories, such as high school students in urban areas. In December of 2006, a reform adjusted the contribution of governments and the weights of students, resulting in differential transfer changes for municipalities depending on their budget and student composition. For instance, municipalities with higher proportions of high school students experienced larger transfer increases. As before, we simulate the change in the net of FUNDEB contributions and transfers while holding municipal characteristics constant to pre-reform levels. This provides us with another source of quasi-experimental variation to transfers unrelated to education improvements.

The third shift to municipalities' budget arises from Brazil's primary municipal transfer, the Fundo de Participação dos Municípios (FPM). This transfer constitutes the main source of revenue for Brazilian municipalities and depends on income per capita and population thresholds. A new population count conducted in 2007 led to shifts in transfer amounts across municipalities. Following Ferraz et al. [2025], we simulate changes in FPM transfers attributable solely to the updated population count.

We incorporate the bonus pool per capita and the three budget shifters per capita into an extended event-study framework. Results from this analysis suggest that increasing the bonus pool is substantially more effective at improving test scores than increasing transfers independent of education performance. Specifically, a one-dollar increase in the bonus pool per capita raises test scores by 0.0017 standard deviations, holding fixed other transfers. In contrast, even the upper bound of the 95% confidence interval implies that an equivalent increase in transfers independent of performance improvements produces an effect fourteen times smaller. Interpreted through the model, these estimates indicate strong substitution effects and comparatively modest income effects associated with performance-based transfers.

Next, we analyze mayors' responses to the performance-based transfers. The analysis has two main goals. First, we provide evidence on the perceived "hidden actions" of mayors. I.e., how education production can be improved from their perspective. Second, one of the strongest assumptions of our conceptual framework is that the improvements in education outcomes do not come at the expense of other valuable public goods. This assumption could fail if municipalities divert effort away from non-incentivized outcomes due to multitasking problems (Holmström and Milgrom [1991]) or if they manipulate the performance measures. We directly test for these two potential concerns.

We begin by examining input decisions within the education system, which was directly incentivized and for which we have detailed input data. Specifically, we utilize systematically measured responses from the school census and from teacher and principal surveys conducted through Prova Brasil.

Our results reveal three main patterns. First, following the introduction of performance-based transfers, the quality of education inputs improved, driven by enhancements in principal and teacher quality indexes. Second, the total number of schools decreased. Consolidating students into higher-performing schools was a policy initially implemented by Ceará's governor during his tenure as the mayor of Sobral, subsequently recommended as a best practice for other municipalities. Qualitative evidence suggests that these school closures were politically sensitive decisions frequently debated in local media. Third, complaints from teachers and principals about insufficient funds, staffing shortages, and missing educational materials declined.

We then turn to analyzing mayors' corruption responses. Data on corruption audits are available from a federal anti-corruption program initiated in 2003, auditing federal transfers dating back to 1996. Annually, the federal government conducted between one and three randomized audits, targeting around 60 municipalities each time. Starting in 2006, each inspection's findings were systematically recorded, detailing identified irregularities, their severity, and the specific sections of the expenditures inspected.

Our results indicate that municipalities reduced corrupt activities specifically in the education sector, while corruption in other sectors remained unaffected. Given the relatively small sample size available for corruption data, our analysis is limited, and these findings should be viewed as suggestive. For example, most municipalities are not observed in corruption audits both before and after the reform, limiting our ability to control flexibly for municipality-specific time-invariant heterogeneity.

We supplement our analysis of input choices with an examination of the effects on non-incentivized outcomes. We begin by examining non-incentivized outputs within the education system and subsequently assess impacts on non-incentivized sectors. We analyze performance in the only non-incentivized subject with available data both before (1999) and after (2019) the introduction of the performance-based transfer: natural sciences. Strikingly, our difference-in-differences estimates for natural sciences are positive and statistically indistinguishable from those for math and Portuguese. These results collectively suggest that the performance-based transfers did not lead to a reallocation of resources away from other valuable public goods.

Finally, we address three primary concerns related to the potential manipulation of performance measures. First, we examine whether mayors might push lower-performing students out of the education system to artificially inflate performance indicators. The decentralized educational environment in Ceará and Pernambuco largely mitigates such concerns, as primary education provision responsibilities had already shifted to municipalities. Additionally, constitutional mandates guarantee universal access to education. Furthermore, the incentive structure explicitly discouraged such manipulation by incorporating student completion rates in municipal primary schools into the transfer formulas. Empirically, we find that the share of elementary-age population enrolled in municipal schools increased slightly following the reform, which is contrary to the concern.

Second, we assess whether municipalities select students that take exams to inflate performance indicators. It is worth noting that the test scores we use (Prova Brasil) are not utilized in Ceará's performance measure, and that we find similar results in both states. Moreover, the incentive structure in Ceará explicitly avoided this manipulation by averaging test scores of all enrolled students, making student absences detrimental to performance metrics. To empirically test this concern, we trained a simple Lasso model on pre-reform test scores and students' observable characteristics. Post-reform, predicted test scores of students taking the exams rose slightly, but this effect is minimal when compared to the overall policy impact, indicating limited selection of students.

Third, municipalities could falsify exam results. To prevent this, exams were administered by external institutions. Moreover, the tests we analyze (Prova Brasil) differ are not used in Ceará's performance measure, and we find similar policy impacts in both states. Nonetheless, we cannot directly test for falsifications.

Our findings demonstrate that increasing the performance-based transfer leads to substantial improvements in education outcomes, while increasing transfers independent of educational improvements yields insignificant effects. This highlights the substantial role of substitution effects from performance-based transfers in driving overall impacts. When interpreted through the lens of our model, the results suggest that performance-based transfers yield significant efficiency gains with minimal equity losses, implying they should represent a substantial share of the optimal transfer mix. Additionally, we find no evidence that these education improvements detract from other public goods; instead, we observe suggestive evidence indicating a reduction in overall rents.

2 Context and Data

2.1 Fiscal Decentralization in Brazil

Brazil's municipal government structure comprises over five thousand municipalities distributed across 26 states. Each municipality is governed by an elected mayor and a city council. Local governments in Brazil bear significant responsibilities for providing essential public goods and services, including education, healthcare, infrastructure, and local transportation.

The Brazilian Constitution assigns shared responsibility for primary and secondary education to state and municipal governments. In practice, however, states predominantly manage secondary education, while municipalities typically oversee primary education. Regarding healthcare, the Law 8080/1990 specifies municipalities as the main providers of public health services. In practice, municipalities operate and manage most health establishments across the country.

Municipal governments face specific budgetary allocations mandated by law. They must allocate at least 15% of their budget to health services. For education, municipalities are required to spend at least 25% of their total budgets plus the net amount they contribute to or receive from FUNDEB, a pooled education fund shared among federal, state, and municipal governments. Municipalities must report their education expenditures to the federal government to demonstrate compliance with these minimum expenditure mandates (see Appendix figure A.1 for an example).

As shown in Appendix figure A.2, these minimum spending requirements on education were largely binding for municipalities in Ceará and Pernambuco as of 2006. Consequently, our primary analysis treats municipalities' sectoral expenditures as fixed. Nonetheless, we empirically test this assumption in section 6.

Intergovernmental transfers from state and federal governments constitute the primary source of funding for municipal services, accounting on average for 83.4% of municipalities' revenues in 2006. These transfers are supplemented by local tax revenues.

2.2 Introduction of Performance-Based Transfers

The Imposto sobre Circulação de Mercadorias e Serviços (ICMS) is a state-level value-added tax levied on the circulation of goods and services. A portion of the ICMS revenue is transferred to municipalities, representing the principal source of state-to-municipality funding. By the constitution, 75% percent of the ICMS transfer is allocated proportionally to each municipality's contribution to total state ICMS revenues. States have discretion over allocating the remaining 25 percent based on criteria they individually establish.

Before the reform analyzed in this paper, states determined the allocation of this remaining 25% based on criteria unrelated to educational quality. For example, in Ceará, 5% of the transfer depended on municipal population size. Nonetheless, two conditions were related to the education system. Specifically, the state of Ceará allocated 12.5% of the transfer based on the ratio of education expenditures to municipal revenues two years prior; however, since the minimum required spending for education was mostly binding, this criterion likely did not incentivize increased educational expenditures. In Pernambuco, 2% of the allocation depended on student enrollment in municipal schools. However, given that by 2007 97,6% of kids aged 7-14 were enrolled in school, this criteria was also unlikely to have a bite. Appendix B details the conditions pre- and post-reform for both states. All other state and federal transfers to municipalities were also unrelated to educational performance.

In 2007, the states of Ceará and Pernambuco reformed their ICMS transfer allocation rules to municipalities. The reforms introduced two main changes: (i) conditioning part of the transfer on educational performance and (ii) adjusting the weights of components unrelated to educational performance. Here, we detail the first change, but the changes to the components unrelated to educational performance are also detailed in Appendix B.

For the performance-based component, each state defined a bonus pool to be allocated according to the relative performance of municipalities in an education quality index. In the state of Ceará, the bonus pool was set as 18% of the total ICMS transfer to municipalities. In the state of Pernambuco, the bonus pool was set at 3%.[5] Our identification strategy leverages the uniformity of the bonus pool bonus across municipalities within each state. We assume that municipalities care about transfers per capita, which implies that less populous municipalities faced greater incentives from the reform.

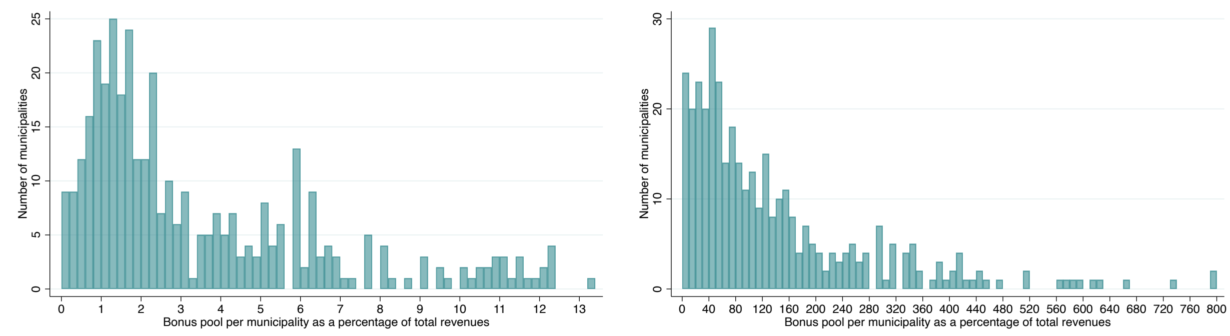
Municipal performance is defined based on math and Portuguese test scores for the 5th and 2nd grades, test participation rates, and primary education completion rates (grades 1–5). In Ceará, performance is assessed using both changes in and levels of average test scores, while in Pernambuco,

[5] In 2019, Pernambuco increased this allocation to 10%, but this change falls outside our data sample.

it relies solely on the levels. Detailed formulas for each state's performance metric are provided in Appendix B.

The bonus pool, β, represents a significant financial incentive for municipalities. Panel (a) of Figure 1 illustrates the magnitude of this incentive by plotting the bonus pool amount per municipality as a share of each municipality's total revenue. Panel (b) the bonus pool amount per municipality as a share of each municipality's total local taxes. On average, the bonus pool was equivalent to 3.5% of total revenues and 141% of all own tax revenues in 2007. To ensure mayors fully appreciate the impact of performance-based transfers, state officials in Ceará annually meet with mayors to demonstrate potential revenue changes under various performance scenarios.

Figure 1



(a) Share of total revenues

(b) Share of total local taxes

Notes: This figure illustrates the fiscal relevance of the performance-based transfer for municipalities. Panel (a) plots the bonus pool amount per municipality as a share of total municipal revenue; Panel (b) plots it as a share of total local tax revenue. The sample includes municipalities in Ceará and Pernambuco—the two states that adopted performance-based transfers—in the last pre-reform year.

The reform in Ceará was initiated by Cid Gomes, former mayor of Sobral, who previously implemented several reforms *"politically unattractive but educationally effective."*[6] These included merit-based personnel rehiring, performance-linked pay for teachers and principals, and consolidating students into higher-performing schools. Sobral's education policies resulted in significant improvements and have been widely recognized as a "miracle" in educational outcomes.[7] In their annual meetings, state officials in Ceará also recommend education improvement policies modeled after Sobral's successful reforms.

[6] This quote comes from a conversation with a former senior official in Cid Gomes' administration.

[7] In 2003, Sobral was ranked in the 26^{th} perentile of the math test scores distribution. By 2007, it was in the 65^{th}. By 2015, it was ranked as the best municipality in all of Brazil. Mentions in the media include several newspapers articles: 1, 2, 3, and policy reports, accessed 2025-05-08

2.3 Reforms to Unconditional Transfers

Our empirical analysis also exploits variations in two other significant transfers that are not directly linked to education performance: the Fundo de Participação dos Municípios (FPM), the primary federal transfer to municipalities, and the main education fund, FUNDEB.

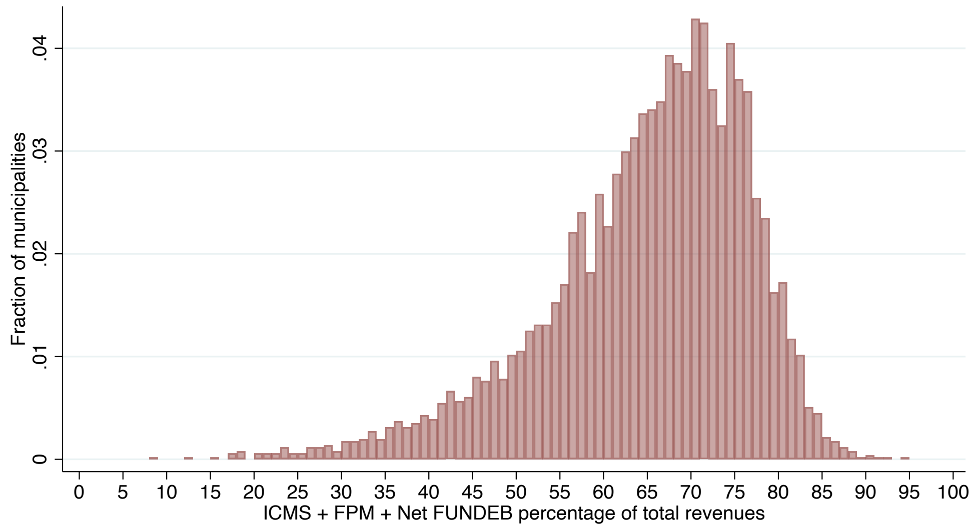
FPM: The FPM, financed by federal income and industrialized product taxes, represents the main revenue source for Brazilian municipalities. On average, it represented 35% of total revenues in 2007. Its allocation involves two stages: first, a fixed share is distributed to each state; second, municipalities within each state are grouped into 18 population brackets, each associated with a coefficient determining the transfer amount. These population coefficients are periodically updated by Brazil's Statistical Office (IBGE) using population counts approximately every five years. In 2007, IBGE conducted a comprehensive population count of 97% of the municipalities. The updated counts resulted in 443 municipalities moving to lower population brackets and 403 moving to higher brackets, thus shifting their FPM transfers.

FUNDEB: Brazil's largest national education fund, FUNDEF, was created in 1996 to ensure minimum per-student spending in primary education. Initially, FUNDEF pooled 15% of selected tax revenues from state and municipal governments. The federal government topped up funds in states not meeting a minimum per-student threshold. Redistribution to municipalities within states occurred equally per student, where students were weighted according to their category (e.g., students in the first to fourth grades). Thus, two municipalities within the same state and with identical student composition were transferred the same amount.

FUNDEF was reformed and renamed FUNDEB in December 2006. The reform increased municipal and state contributions to 20% and federal contributions from R$1.6 billion to R$5 billion. FUNDEB also expanded student categories, including pre-school and high school students, and adjusted category weights. Thus, municipalities with a larger share of certain student categories, such as high school students, experienced an increase in the net transfers received. FUNDEB implementation was phased in from 2007-2009.

The three transfers analyzed in this paper–ICMS, FPM, and FUNDEB–form a significant portion of municipalities' revenues. Figure 2 illustrates the percentage of the sum of ICMS, FPM, and net FUNDEB in municipalities' total revenues in 2007. On average, the sum of these three transfers accounted for 65% of municipalities total revenues.

Figure 2: Relevance of transfers studied to municipalities' total revenues



Notes: This figure illustrates the fiscal importance of the transfers studied in this paper. It plots the percentage of total municipal revenue accounted for by the sum of ICMS, FPM, and net FUNDEB in 2007. The sample includes all Brazilian municipalities. On average, these three transfers comprised 65% of total municipal revenue.

2.4 Data

We combine data from multiple sources for our empirical analysis. Detailed municipal public finance data, including revenues and expenditures, are drawn from the Sistema de Informações Contábeis e Fiscais do Setor Público Brasileiro (SICONFI) provided by the National Treasury. Population data, critical for calculating per capita transfers, come from the Brazilian Institute of Geography and Statistics (IBGE). Data regarding the number of students in each category used for FUNDEB's redistribution are sourced from official government publications issued by the Ministry of Education.

Our main outcome of interest is standardized test scores. These scores are derived from Prova Brasil, a standardized exam administered biennially by the federal government to fifth and ninth graders. Initially conducted with random samples from 1995 to 2005, Prova Brasil has included all public schools with at least 20 students since 2007.[8] We standardize test scores by grade using means and standard deviations from the 2007 assessments. The exam covers mathematics and Portuguese every year, with additional testing in natural sciences conducted once pre-reform (1999) and once post-reform (2019). Other subjects were not tested both pre- and post-reform. It is important to note that the test is not used in the performance evaluation of municipalities in Ceará, but it is used in Pernambuco.[9] It is also not used in any other transfer allocation or incentive scheme.

[8]In 2007, it also restricted the sample to "urban schools" only. To make the analysis comparable over time, we restrict the sample to "urban schools" in other years too.

[9]We discuss concerns of manipulation in section 6.3 and conduct our main analysis separably for each state in Appendix A.

To analyze mayoral responses to incentives and educational input decisions, we utilize school-level data from the annual school census (Censo Escolar), conducted by the Ministry of Education, which covers all public and private schools in Brazil. We supplement these data with survey responses from teachers and principals gathered through Prova Brasil, capturing their characteristics and perceptions. Additionally, we incorporate corruption audit data from the Office of the Comptroller General (Controladoria Geral da União – CGU). Initiated in 2003, the CGU's program audits the use of earmarked federal transfers by municipalities, conducting between one and three randomized audits annually through 2019. Starting in 2006, the CGU systematically recorded detailed findings for each inspection, including identified irregularities, their severity classifications, and the specific sectors of expenditures audited. The audits cover transfers dating back to 1996. Corruption cases are widespread–Ferraz and Finan [2011] estimate that 8 percent of the transfers were diverted from 2001-2003–and are relevant for the performance of municipalities–Ferraz et al. [2012] show that both school inputs and test scores are lower in municipalities where corruption in education was detected.

3 Conceptual framework

In this section, we develop a simple optimal transfer model, where municipalities can either privately consume the transfers or invest them in the public good (education). Inspired by the Brazilian intergovernmental transfer system, the state government has two policy instruments: a performance-based transfer and an unconditional transfer. The model highlights the traditional equity-efficiency trade-off of conditioning transfers. Increasing the performance-based transfer incentivizes all municipalities to invest more in the public good (efficiency gains). However, it also rewards municipalities with high state capacity to produce the public good with larger transfers (equity loss).

Relative to a standard transfer model, we make two key modifications. First, we analyze a two-period production setting where today's transfers form tomorrow's budget constraint. In the dynamic setting, the unequal transfers also constrain low capacity municipalities' production in the future. Thus, the equity losses are aggravated and have a direct effect on production. Second, we assume the objective of the central government is to maximize the production of the public good.[10] This is a strong assumption for two reasons. First, the assumption could fail if municipalities divert effort away from non-incentivized outcomes due to multitasking problems (Holmström and Milgrom [1991]). Second, mayors could manipulate the performance measures. We directly test for these two potential concerns in section 6.

We begin by analyzing a regime in which transfers to municipalities are restricted to a uniform unconditional transfer and a performance-based transfer. Under this regime, the central government

[10]In welfarist transfer models, the planner maximizes a social welfare function that is defined over individual utilities. Using a welfarist model, Saez [2002] finds that the planner would only want to incentivize performance when the extensive margin response of the agent is large enough. Other non-welfarist models (Besley and Coate [1992], Besley and Coate [1995]) have also found conditions in which the planner wants to incentivize performance even in the absence of extensive margin responses.

faces a clear trade-off between equity losses and efficiency gains from conditioning transfers on performance. We then analyze a benchmark scenario, in which the central government can differentiate municipalities through lump-sum unconditional transfers. This benchmark allows the government to alleviate the equity losses inherent in the performance-based transfer. The only remaining inefficiencies in this scenario stem from informational asymmetries—specifically, the government's inability to directly observe municipalities' investment and consumption choices, and the lack of perfect monitoring. The model yields sufficient statistics for characterizing the optimal transfer policy and provides guidance for our empirical exercises in Section 5.

3.1 Uniform transfers and bonus pool

There is a mass one of municipalities (agents) m. They receive transfers T_t^m in each period t and choose whether to privately consume them or invest to produce the public good. The municipalities are heterogeneous in their capacity (type) to produce the public good, A^m, which is normalized such that $\int_m A^m dm = 1$. Their production is simplified to be separable and linear in the type of municipality and the amount of the transfers invested in the public good: $f_t^m = \pi I_t^m + A^m$, where π is the marginal productivity of investment.

The state government is restricted to allocate a fixed budget B to two policy instruments: a bonus pool, β, or an uniform unconditional transfer, α_t. Inspired by the Brazilian intergovernmental transfer system, the transfer that municipalities receive is given by $T_t^m = \alpha_t + \beta \tilde{f}_t^m$, where $\tilde{f}_t^m = \frac{f_t^m}{\int_{m'} f_t^{m'} dm'}$ are relative productions of municipalities. In contrast to other performance-pay contracts, it is worth clarifying that the bonus pool, β, is a fixed dollar amount that will be distributed among municipalities according to their relative performance.

The timing of the model is as follows:

0. (a) Types, A^m, are drawn and productions, $f_0^m = \tilde{f}_0^m = A^m$, are realized.[11]

   (b) State pick municipalities' unconditional transfers α_1 and the bonus β such that $2\beta + \int_m (\alpha_1)\, dm = B$, where B is the total budget available for transfers.

1. (a) Initial transfers, $T_1^m = \alpha_1 + \beta A^m$, are received.

   (b) Mayors decide how much to invest $I^m \in [0, T_1^m]$ and consume: $C_1^m = T_1^m - I^m$ privately.[12]

2. Production $f_2^m = I^m + A^m$ is realized and municipalities consume $C_2^m = T_2^m = \beta \tilde{f}_2^m$.[13]

[11] Note that we assume that municipalities do not invest in the public good before the performance-based transfers are announced. This guides our empirical estimates of the types in section 4.

[12] As is common in the delegated resource management literature, one can interpret the investment choice as an effort pick. The unique conceptual point is that the action set is limited by the transfer received.

[13] We already assume that the state government sets $\alpha_2 = 0$ because all transfers get consumed away in the second period.

The municipality has utility $u(C_1, C_2)$, which is continuous, strictly increasing, and concave on consumption in each period. This setup allows us to translate the problem faced by the municipality as a standard consumption problem with two goods:

$$\max_{C_1, C_2} u(C_1, C_2)$$
$$\text{s.t. } C_1 + pC_2 = y^m$$

where the relative price of consuming tomorrow is given by the inverse of the marginal return of investment to the municipality, $p = \frac{\bar{f}_2}{\beta\pi}$. Moreover, the present-value investment-independent transfers, y^m, is given by $y^m = \alpha_1 + \left(\frac{1}{\pi} + \beta\right) A^m$. It reflects how much a municipality can consume in the first period if it does not invest in the public good at all. To see this, note that in the first period the municipality receives the unconditional transfer, α_1, and a bonus payment, βA^m, which didn't depend on investment. In the second period, even if the municipality does not invest at all, it still produces A^m units of the public good and gets paid $\frac{\beta A^m}{\bar{f}_2}$. In period one's dollars this is $\frac{1}{\pi} A^m$.

The municipality's problem defines Marshallian functions and Slutsky equations. E.g., the Marshallian demand for consumption in the first period is given by: $C_1(p, y^m)$ and the Slutsky equation with respect to the bonus pool β is given by:

$$\frac{dC_1}{d\beta} = \underbrace{\frac{\partial C_1^h}{\partial \beta}}_{\text{substitution effect}} + \underbrace{\left(\frac{\bar{f}_2}{\pi\beta^2} C_2 + A^m\right) \frac{\partial C_1}{\partial y^m}}_{\text{income effect}} \tag{1}$$

which is the standard Slutsky equation, except that it also scales the income effect by the type A^m. This comes from the fact that as the principal increases the bonus pool it automatically rewards the investment-independent transfer of the municipality by its type. As we will illustrate shortly, this is a key point to the equity loss in the model.

The state's problem is to choose α and β to maximize the social welfare function

$$\max_{\beta, \alpha} W = \int_m \gamma^m f_2^m dm$$
$$\text{s.t. } 2\beta + \int_m \alpha dm = B$$

where γ^m is the social welfare weight of municipality m and f_2^m is the production of the public good for municipality m in period 2. Note that we are making one key assumption: the state only cares about the production of the municipalities and not about the consumption. Crucially, this depends on what we think "private consumption" is reflecting. If it is corruption, we find it reasonable to assume that the state does not value it. If it is rewards which are being diverted from other sectors such as health, then the state may want to give it a positive value. Multitasking concerns are investigated in section 6.

Before we proceed with the solution of the model, it will be useful to illustrate the problem faced by the state with a simple example. Consider a case in which there are only two municipalities, one with high type and one with low. Panel (a) of Figure 3 illustrates the budget constraints of the two municipalities, where the high type is shifted upward because–for every investment level–it produces more and therefore can consume more. Now imagine a state that is considering a marginal increase in the bonus pool and a marginal decrease in the unconditional transfer to close the budget constraint. Panel (b) of Figure 3 illustrates that the marginal increase in the bonus pool will shift the budget constraint of both municipalities, but differentially by type because it rewards the high type with larger investment-independent tranfers. Moreover, panel (c) of Figure 3 shows that the marginal increase in the bonus pool also changes the relative price of consuming tomorrow because it increases the marginal return of investment to both municipalities. Panel (d) of Figure 3 shows the final budget constraints after the marginal decrease in the unconditional transfer. It illustrates the key equity-efficiency tradeoff faced by the state government: the increase in the bonus pool incentivizes both municipalities (slope change), but it rewards the high type with larger investment-independent transfers (shift upward) and punishes the low type with a smaller investment-independent transfers (shift downward).

The next proposition characterizes the interior solution of the optimal transfer schedule:

Proposition 1 (Intergovernamental transfers with uniform transfers)**.** *With uniform transfers, α, the optimal transfer satisfies*

$$\beta = \frac{\int_m (\lambda^m \epsilon_s I)\, dm + \frac{1}{\pi} Cov(w^m, f^m) - \frac{1}{\pi} Cov(\lambda^m, f^m) + \frac{1}{\pi}\left(1 - \frac{\pi}{\kappa}\right) E[f^m]}{1 - Cov(w^m, A^m)} \tag{2}$$

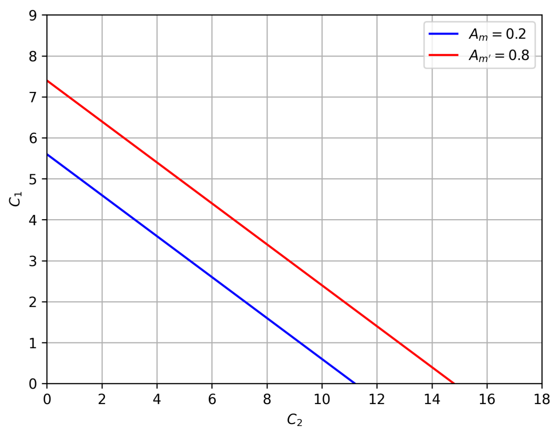
where $\epsilon_s = \frac{\partial I^h}{\partial \beta}\frac{\beta}{I}$ is the elasticity of the substitution effect, η is the marginal value of public funds, $w^m = \frac{\gamma^m}{\eta}\frac{\partial I}{\partial y^m}$ is the social marginal valuation of income, and $\lambda^m = \frac{\gamma^m}{\eta}$ are normalized welfare weights.

Proof. See appendix C for the proof □

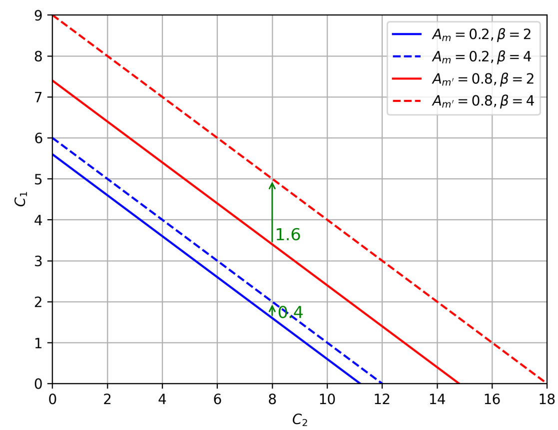
The connection of this relatively simple solution of optimal transfers to moments of parameters of the model helps understand the tradeoffs of the model. The intuitions provided are the same as the our two-agent example. First, the larger is the substitution effect, the more the performance-transfer incentivizes municipalities to invest in the public good. Thus, the larger is the optimal bonus pool. Second, the social marginal valuation of income depends on the income effect of the municipalities and their welfare weights. This is because larger transfers relaxes the constraint of municipalities and translate into larger productions. Third, the more negative is the covariance between the social marginal valuation of income and the type of municipality, the smaller is the optimal bonus pool. This is because the bonus rewards high types with larger investment-independent transfers. The less valuable the transfer is to the high type, the smaller the optimal bonus pool.

The solution depends on estimable elasticities and the distribution of types. In section 4, we turn to the data to estimate the overall change in the investment of the municipalites to changes in their bonus pool per capita they face. This should be interpreted as the Marshallian partial with respect to the bonus pool, and it reflects both substitution and income effects. In section 5, we will

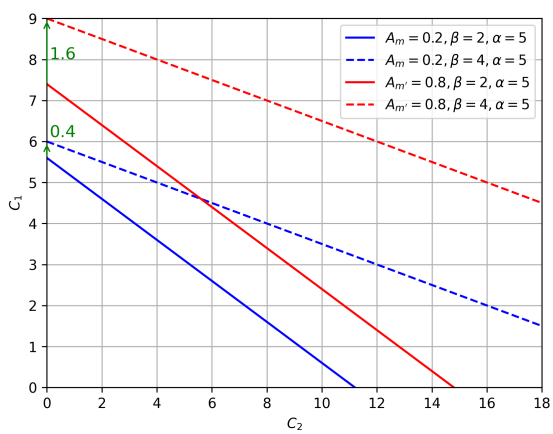
Figure 3: Budget constraints of two municipalities



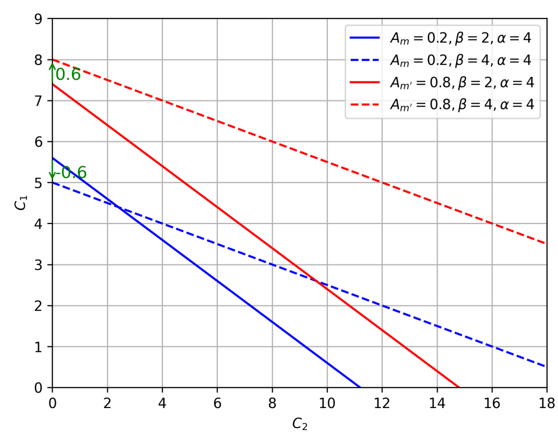
(a) Baseline budget constraints



(b) Intercept change from β



(c) Slope change from β



(d) Decrease in α to close the budget

Notes: The figure illustrates how the municipal budget constraint changes when the central government increases the bonus pool and reduces unconditional transfers to balance the budget, as described in Section 3.1. In this example, we consider two municipalities with state capacity (types) $A^m = 0.2$ and $A^{m'} = 0.8$. The bonus pool increases from $\beta = 2$ to $\beta = 4$, while unconditional transfers fall from $\alpha = 5$ to $\alpha = 4$. Panel (a) shows the initial budget constraints; Panel (b) isolates the intercept shift associated with the increase in β; Panel (c) adds the change in slope; and Panel (d) displays the final budget constraints after both changes and the reduction in α. The figure highlights the equity-efficiency tradeoff: raising the bonus pool strengthens incentives (via a steeper slope) but also shifts investment-independent transfers upward for high-capacity municipalities (via a larger intercept) and downward for low-capacity ones.

leverage variation in municipalities' investment-independent transfers to estimate the substitution and income effects.

3.2 Benchmark: lump-sum transfers and bonus pool

As a benchmark, consider the case in which the state can give lump-sum transfers to each municipality, α^m, and a bonus pool, β. In this case, the state can choose the unconditional transfers to balance the equity loss of the performance-based transfer.

The optimal transfer will equalize the social marginal value of transfering a dollar to each municipality, and it will tradeoff giving a guaranteed transfer to a performance-based one.

Proposition 2 (Intergovernamental transfers with lump-sum transfers)**.** *With lump-sum transfers, α^m, the optimal unconditional transfer satisfies*

$$\gamma^m \frac{\partial I}{\partial \alpha_m} = \eta \tag{3}$$

where η is the marginal value of public funds. The optimal bonus is:

$$\beta = \frac{\bar{f}_2(\eta - 1) - \text{Cov}\left(\gamma^m, f_2^m\right)}{\text{Cov}\left(\gamma^m, A^m\right) + 1 + \eta - \bar{S}} \tag{4}$$

where $\bar{S}$ is the average social marginal value of public funds. The optimal unconditional transfer is the weighted average substitution effect: $\int_{m' \in M} \left(\gamma_{m'} \frac{\partial I^h}{\partial \beta}\right) dm = \bar{S}$.

Proof. See appendix C for the proof □

In the case of Utilitarian welfare weights the optimal unconditional transfers provide an intuitive corollary:

Corollary 3. *Utilitarian preferences plus diminishing return to transfers α^m implies egalitarianism. Specifically, the optimal lump-sum transfers are given by:*

$$\alpha^m = B - 2\beta + (1 + \beta)\left(\bar{A} - A^m\right) \tag{5}$$

and each municipality has the same investment-independent transfer, $y = B - 2\beta + (1 + \beta)\bar{A}$.

In other words, if given the possibility of lump-sum transfers, the state government would use it to remove any inequity caused by the performance-based transfer and types.

4 Overall effects of performance-based transfers

We begin our empirical analysis by showing the overall effects of a dollar increase in the bonus pool on students' test scores. To do this, we leverage the introduction of the performance-based transfer to estimate an event-study design.

The identification strategy exploits the fact that the bonus pool, as described in Section 2, is the same for all municipalities in the same state. E.g., municipalities in Ceará competed for 379.2 million reais, and each municipality received a share of the bonus pool based on their relative performance. In section 3, we make a key assumption that municipalities care about per capita consumption and education depends on per capita investment. This implies that the relevant bonus pool for municipalities decisions is the per capita bonus pool. Thus, municipalities with smaller populations effectively received a larger treatment intensity from the policy change.

We exploit this quasi-experimental variation in a flexible event-study design as follows:

$$f_{imt} = \nu_m + \nu_{st} + \sum_{y \neq 2007} \gamma_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{imt} \tag{6}$$

where f_{imt} is the standardized test score of student i in municipality m in year t. In specifications on the municipality level, such as the ones using revenues or expenditures, the outcome variable is Y_{mt} for municipality m in year t. The terms ν_m are municipality fixed effects, which captures any time-invariant differences among municipalities, such as their state capacity to produce education. The term ν_{st} are state-year fixed effects, which capture any time-varying shocks that are common to all municipalities in the same state, such as other common policies described in section 2. The term $\Delta\beta^m$ is the change in per capita bonus pool in municipality m in year t, which was zero pre-reform. Since the bonus pool is the same for all municipalities in the same state, our variation in $\Delta\beta^m$ comes entirely from differential population sizes in the last pre-reform year, 2007. The term $\mathbf{1}[t = y]$ is an indicator function that takes the value of one if year t is equal to year y. Thus, the coefficient γ_y captures the overall changes in the outcome variable for municipalities with a dollar increase in the bonus pool per capita. We cluster standard errors at the municipality level.

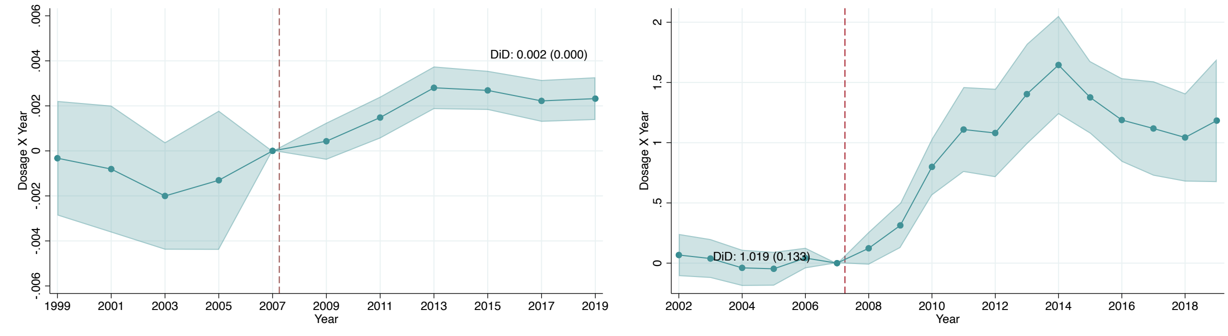
The average effect of the bonus pool per capita across all post-implementation periods can be estimated with a standard DD specification:

$$f_{imt} = \nu_m + \nu_{st} + \gamma\Delta\beta^m \times Post_t + \epsilon_{imt} \tag{7}$$

where $Post_t$ is an indicator function that takes the value of one if $t > 2007$. I.e., after the introduction of the performance-based transfer.

Panel A of figure 4 plots the γ_y coefficients and the 95 percent confidence intervals from estimating equation 6. Consistent with our assumption of parallel trends, we find no signficant changes in test scores prior to the introduction of the performance-based transfer. However, it is worth noting that the standard errors were larger in the pre-reform period because the data consisted of repeated cross-sectional random samples. The first year with data for all schools with at least 20 students was 2007, the last pre-reform year. Post-reform, we find a significant increase in the test scores of students in municipalities with a larger per capita bonus pool. A 1 dollar increase in the per capita bonus pool led to a 0.002 standard deviation increase in test scores. This is a large effect: when we scale by the distribution of the bonus pool, going from the 25th to the 75th percentile of the distribution implies 0.13 standard deviation increase in test scores.

Figure 4: Overall effects of performance-based transfers



(a) Portuguese standardized test scores

(b) ICMS transfers received

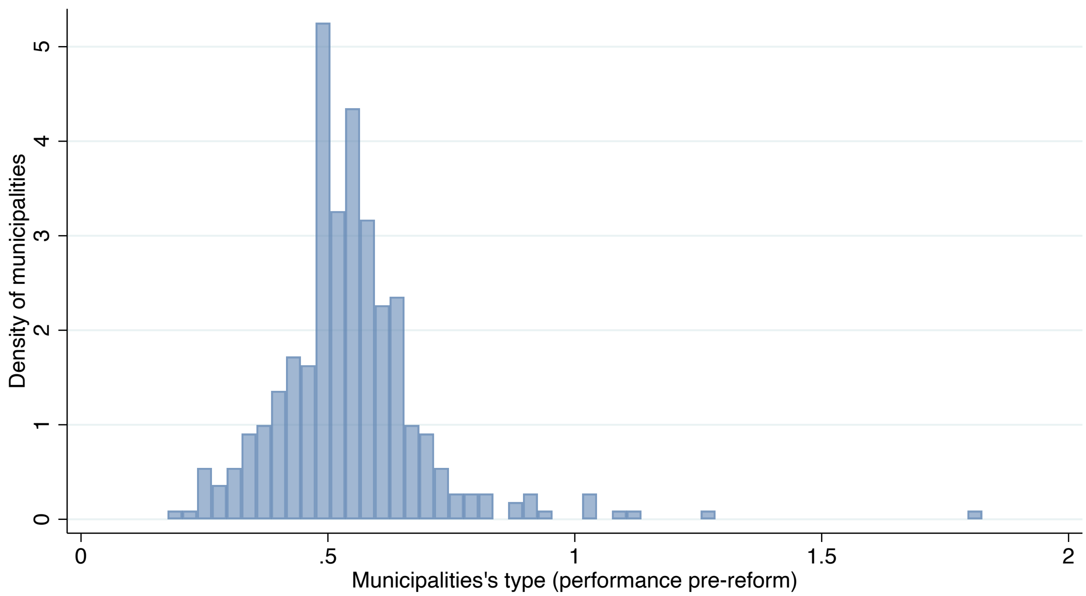
This figure shows the overall effects of performance-based transfers on student test scores and ICMS transfers received by municipalities. Panel (a) plots the γ_y coefficients from estimating equation 7: $f_{imt} = \nu_m + \nu_{st} + \sum_{y \neq 2007} \gamma_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, $\mathbf{1}[t = y]$ is a year indicator, and ϵ_{imt} is the residual. The outcome is the standardized test score of student i in municipality m in year t. Standard errors are clustered at the municipality level, and shaded areas denote 95 percent confidence intervals. From 2007 onward, the sample includes all students in municipal schools with at least 20 test-takers; prior to 2005, the sample comprises random student samples from municipal schools. Panel (b) estimates the same equation with ICMS transfers received by the municipality as the outcome. The residual is defined at the municipality-year level (ϵ_{mt}).

Panel B of figure 4 shows the result of estimating equation 6 with the outcome variable being the ICMS transfers received by the municipality. The results show that a 1 dollar increase in the per capita bonus pool led to a 1.02 dollar increase in the ICMS transfers received by the municipality. This result reminds us that the overall effect of the performance-based transfer is a combination of income and substitution effects.

However, as highlighted in section 3, the overall effect of the performance-based transfer could mask significant equity losses. Specifically, the performance-based transfer rewards municipalities with higher state capacity to produce education.

Based on our conceptual framework, we begin estimating municipalities' types (A^m) using their performance on the education quality index prior to the reform. Figure 5 shows that there is a wide distribution of types across municipalities. To interpret the magnitude of the distribution, note that absent any improvements in education municipalities would be transferred $\frac{A^m}{\sum_{m'} A^{m'}} \times \beta^m$ for their performances payments, where β^m is the per capita bonus pool. Using the average β^m, we estimate that going from the 25$^{\text{th}}$ percentile of A^m to the 75$^{\text{th}}$ percentile would lead to overall ICMS transfers 8.3% larger.

Figure 5: Distribution of municipalities' types



This figure shows the distribution of municipal types A^m, which capture state capacity to produce education. Types are proxied by municipalities' pre-reform performance on the education quality index. A wider distribution of A^m implies greater potential for inequities in transfer allocations under performance-based schemes.

As highlighted in section 3 the extent of these equity losses depends on how the inequity in transfers translates into inequity in performance of education. In the next section, we will estimate an extended event-study design to separate the income and substitution effects of the performance-based transfer. This will allow us to gauge the equity losses and connect the data to optimal transfers.

5 Income and substitution effects

As discussed in section 4, the overall effect of the performance-based bonus pool reflects both income and substitution effects. Separating these two effects is crucial to understanding the optimal design of performance-based transfers, as highlighted in section 3.

In this section, we estimate the impacts of both the bonus pool, β, and investment-independent revenues, y, using an extended event-study approach. Appendix D details how estimates from this analysis can be directly mapped to our conceptual framework, enabling us to disentangle income and substitution effects. Intuitively, the effect of investment-independent revenues captures the magnitude of income effects, while the difference between the effects of the bonus pool and investment-independent revenues reflects the magnitude of substitution effects.

In section 2, we outlined three reforms passed in 2007, which altered the three primary intergovernmental transfers received by Brazilian municipalities from state and federal governments. Here, we detail how these reforms provide quasi-experimental variation in both the bonus pool and the investment-independent revenues faced by municipalities.

The reform of the ICMS, the primary state transfer, generates quasi-experimental variation in both the bonus pool and investment-independent revenues. The variation in the bonus pool municipalities face was discussed in section 4. Specifically, while the bonus pool is uniform across municipalities within the same state, we assume municipalities respond to the per capita bonus pool. Therefore, our main source of variation comes from differences in pre-reform population sizes combined with the timing of the performance-based transfer introduction.

Next, we detail how the three reforms generate quasi-experimental variation in investment-independent transfers.

ICMS transfers to municipalities changed after the reform for three reasons. First, the reform updated weights on municipal characteristics unrelated to education. For example, in Ceará, the weight on population size decreased from 5% to 0%. Second, the reform introduced a performance-based criteria, allocating 3% of transfers in Pernambuco and 18% in Ceará based on education outcomes. Thus, even if municipalities did not alter educational investments, those with higher pre-existing education production technologies would receive larger transfers post-reform. Third, the reform could incentivize municipalities to change behaviors, altering their characteristics and educational performance post-reform.

The first two sources of variation are plausibly exogenous, potentially satisfying parallel trends assumptions. However, the third–municipal behavioral responses post-reform–is endogenous and likely violates parallel trends. To address this endogeneity, we simulate counterfactual ICMS transfers using post-reform policy weights applied to pre-reform municipal characteristics and educational performance. We label these simulated predicted changes in ICMS transfers as $\hat{\Delta} y_{ICMS}$.

This simulation exercise relies on accurately observing municipalities' pre-reform characteristics and correctly interpreting the changes in reform weights. Panel (a) of Appendix Figure A.3 demonstrates that our predicted ICMS, based on pre-reform characteristics and weights, closely matches actual ICMS transfers before the reform, exhibiting a correlation of 0.999. Panel (b) further confirms that our predicted ICMS using post-reform characteristics and weights similarly predicts actual post-reform transfers effectively.

The second reform generating quasi-experimental variation in investment-independent revenues involves the primary federal transfer, the FPM. As detailed in section 2, FPM allocations depend on 18 population brackets, with municipalities in the same state and bracket receiving identical transfer amounts. We leverage the 2007 population recount to identify municipalities that shifted brackets and simulate how their FPM transfers should have changed accordingly. We denote these simulated predicted changes in FPM transfers as $\hat{\Delta} y_{FPM}$.

The third reform generating quasi-experimental variation in investment-independent revenues involves Brazil's primary education fund, the FUNDEB. As outlined in section 2, FUNDEB pools municipal contributions and redistributes them based on student enrollment across various educational categories (e.g., pre-school). Similar to previous transfers, we simulate how contributions and transfers would change if municipal characteristics—such as local taxes and student numbers—remained constant. This approach isolates variation in net FUNDEB transfers arising solely from policy parameter changes. We denote these simulated predicted changes as $\hat{\Delta} y_{FUNDEB}$.

As detailed in Appendix D, these predicted changes conceptually correspond to shifts in municipalities' investment-independent revenues. We combine these simulated changes to construct a comprehensive measure of the predicted change in investment-independent revenues:

$$\hat{\Delta} y^m = \hat{\Delta} y^m_{ICMS} + \hat{\Delta} y^m_{FPM} + \hat{\Delta} y^m_{FUNDEB} \tag{8}$$

Using these quasi-experimental variations, we separately estimate the income and substitution effects through the following extended event-study design:

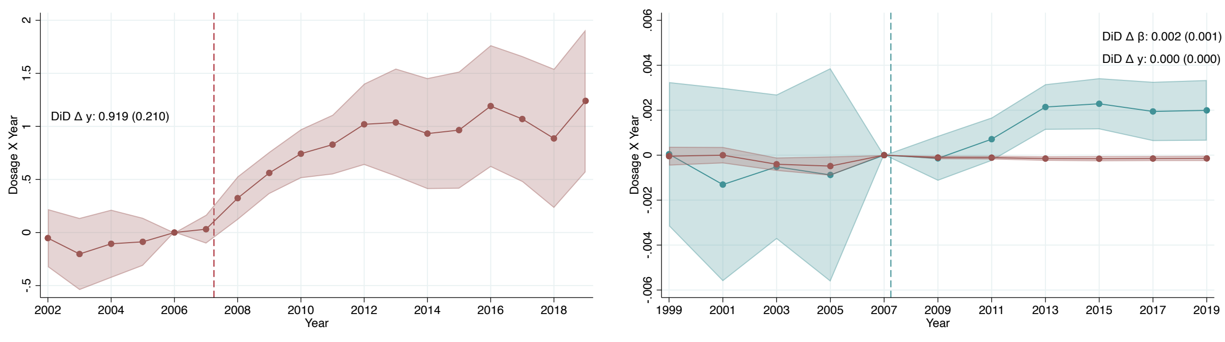
$$f_{imt} = \nu_m + \nu_{tS} + \sum_{s \neq 2007} (\gamma_s \Delta\beta^m + \eta_s \Delta\hat{y}^m) \times \mathbf{1}[t = s] + \epsilon_{imt} \tag{9}$$

where f_{imt} is the standardized test score of student i in municipality m at time t for the reduced form. The first stage of has municipal revenues, y^m, on the left-hand side. ν_m are municipality fixed effects, controlling for any time-invariant heterogeneity across municipalities. ν_{tS} are state-year fixed effects, controlling for any common shocks within states. $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, and Δy^m is the change in investment-independent revenues for municipality m. The coefficients γ_s and η_s estimate the effects of the bonus pool and the investment-independent revenues separately and over time.

Panel (a) of Figure 6 presents the first-stage estimates of η_s. Municipalities with larger predicted changes in investment-independent revenues exhibit similar pre-reform revenue trends. After the reform, each additional dollar in predicted revenue changes results in a corresponding dollar increase in actual revenues. This alignment confirms our simulation accurately predicts realized revenue changes. Appendix Figure A.6 shows first-stage estimates of γ_s. The results are very noisy, but indicate that after controlling for predicted investment-independent revenues, municipalities with larger bonus pools experience no significant revenue changes.

Panel (b) of Figure 6 reports reduced-form estimates of η_s and γ_s. Supporting the parallel trends assumption, pre-reform standardized test scores are similar across municipalities with differing predicted revenue changes and bonus pools. Post-reform, a one-dollar increase in investment-independent revenues yields an effect close to zero and precisely estimated (the 95% confidence interval is [-0.00014, 0.00012]). Conversely, a one-dollar increase in the bonus pool significantly improves test scores by 0.0017111 standard deviations. As shown formally in Appendix D, these results indicate a substantial substitution effect and minimal income effect from performance-based transfers. This highlights the relative importance of incentives over revenue increases in producing educational outcomes, a crucial insight for designing optimal transfers simulated in section 7.

Figure 6: Effects of the bonus pool and investment-independent transfers



(a) First stage: predicted change in virtual budget

(b) Reduced form

This figure shows the effects of both the bonus pool (β) and investment-independent revenues (y), estimated using the extended event-study specification from equation 9: $f_{imt} = \nu_m + \nu_{tS} + \sum_{s\neq 2007} (\gamma_s \Delta\beta^m + \eta_s \Delta\hat{y}^m) \times \mathbf{1}[t = s] + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{tS} are state-year fixed effects, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, $\Delta\hat{y}^m$ is the change in investment-independent revenues, $\mathbf{1}[t = s]$ is a year indicator, and ϵ_{imt} is the residual. The coefficients γ_s and η_s capture the dynamic effects of the bonus pool and investment-independent revenues, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. Panel (a) plots η_s using total municipal revenue as the outcome. Appendix Figure A.6 shows γ_s estimates using the same outcome. In Panel (b), both η_s and γ_s are estimated using standardized Portuguese test scores. From 2007 onward, the sample includes all students in municipal schools with at least 20 test-takers; prior to 2005, the sample comprises random samples of municipal school students.

6 Mayors' responses

This section presents the results of our analysis of mayors' responses to the introduction of performance-based transfers. We first examine mayors' choice of inputs, providing evidence on their perceived "hidden actions." Subsequently, we address concerns regarding potential manipulation and multi-tasking induced by performance incentives.

6.1 Input choices

In this section, we analyze mayors' choices of inputs. We begin by examining input decisions within the education system, which was directly incentivized and for which we have detailed input data. We then explore corruption across sectors. These analyses serve two important purposes. First, they shed light on mayors' perceived "hidden actions" and reveal their beliefs about effective strategies for educational improvement. Second, our findings suggest that mayors increased inputs that are arguably associated with improvements in test scores, without clear detriments to other inputs. Additionally, qualitative evidence indicates that these input decisions were politically challenging. Section 6.2 explicitly tests whether performance-based transfers affected non-incentivized outputs.

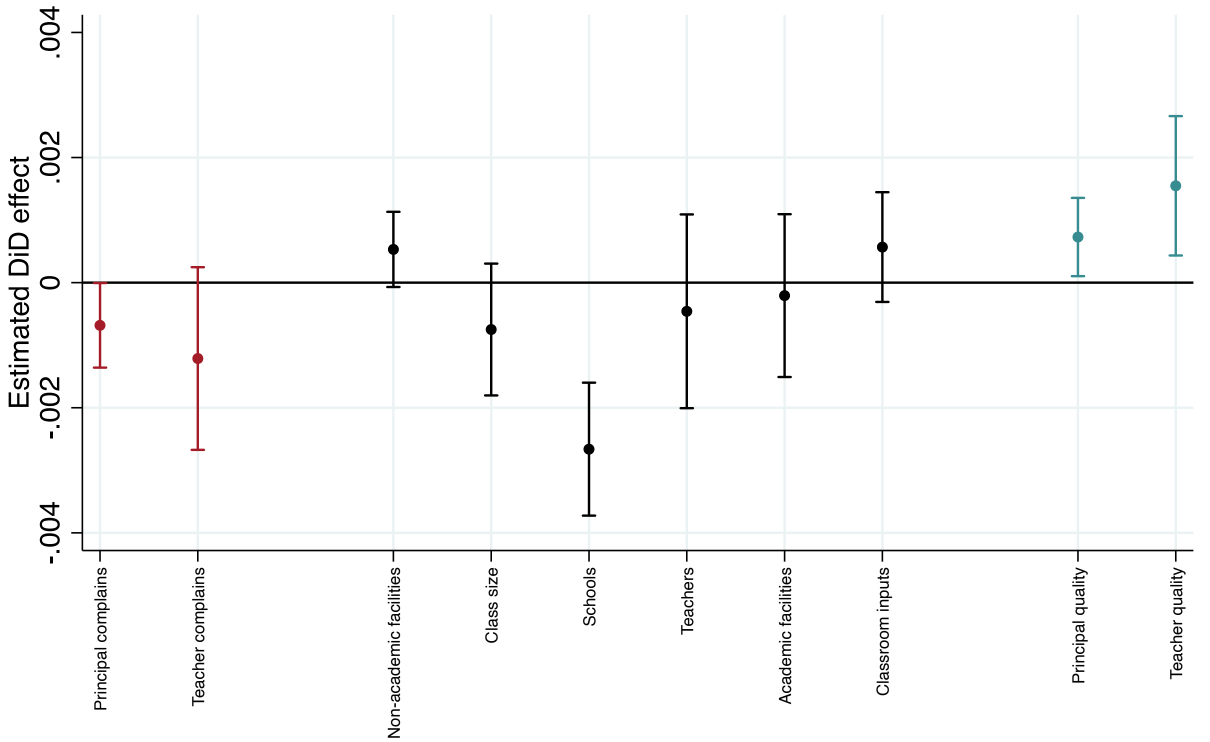
We begin our analysis using systematically measured responses derived from the school census, and teacher and principal surveys from Prova Brasil. All variables are standardized, and we exclude binary inputs that were extensively adopted (above 95%) prior to the reform, resulting in a final set of 35 input variables. To facilitate interpretation, we categorize inputs into three groups: (i) complaints from personnel, (ii) quantity-related educational inputs, and (iii) quality-related educational inputs.

Given the extensive number of inputs, we further consolidate them into 10 more interpretable indexes, each constructed as an average of the standardized variables within the respective category. Appendix F provides detailed descriptions of the index constructions and results for individual inputs. We then estimate the same difference-in-differences specification as in equation 7 from section 4, using these indexes as dependent variables.

The estimated overall effects of the bonus pool on mayors' education input choices are illustrated in Figure 7. While the results are somewhat noisy, certain patterns emerge. First, inputs related to the quality of education improve, driven particularly by improvements in principal and teacher quality indexes. Second, the number of schools decreases. As discussed in section 2, consolidating students into higher-performing schools was a policy initially implemented by Ceará's governor when he served as the mayor of Sobral. This approach was later recommended as a best practice to other municipalities. Appendix Figure F.1 shows that school closures are politically challenging decisions frequently debated in the media. Third, complaints from teachers and principals regarding insufficient funds, staffing, and missing books decrease.

These results should not be interpreted as direct mechanisms of the overall effect, as mayors might be responding through other unmeasured channels. Nonetheless, these findings offer valuable insights into the nature of mayors' responses to performance-based incentives.

Figure 7: Mayors' responses to performance-based transfers: input choices



This figure shows estimates from the difference-in-differences specification in equation 7, $h_{jmt} = \nu_m + \nu_{st} + \gamma\Delta\beta^m \times Post_t + \epsilon_{imt}$ for various education input measures. Here, ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $\Delta\beta^m$ is the change in the per capita bonus pool for municipality m, and $Post_t$ is an indicator equal to one for years after 2007. To facilitate comparison across measures, all education input variables are standardized to have unit standard deviation. Each outcome h_{jmt} is an education input index constructed as the average of standardized input variables at the school j, municipality m, and year t levels. Teacher complaints and teacher quality indexes are measured at the teacher level, while the number of schools index is aggregated at the municipality level. Appendix F provides detailed descriptions of index construction and presents estimates for individual inputs. Colors indicate three categories of indexes: (i) personnel complaints (red), (ii) quantity-related education inputs (black), and (iii) quality-related education inputs (green). The sample includes all municipalities in the treated states. Standard errors are clustered at the municipality level; capped spikes denote 95 percent confidence intervals.

Next, we analyze mayors' corruption responses. Given that corruption audits only selected approximately 60 municipalities per round, Appendix Figure A.7 illustrates our limited observations per year of transfer. Consequently, many municipalities lack corruption measurements both pre- and post-introduction of performance-based transfers. Therefore, we employ a modified difference-in-differences specification:

$$\text{Corruption}_{m,t} = \nu_s + \nu_{r,t} + f(n)_{m,t} + \gamma_1 \cdot \beta^m + \gamma_2 \cdot \beta^m \cdot \mathbf{1}[t > 2007] + \varepsilon_{m,t} \tag{10}$$

where ν_s denotes state fixed effects, β^m is the bonus pool per capita for municipality m, and $\mathbf{1}[t > 2007]$ is an indicator variable for post-2007 observations. Region-by-year fixed effects are captured by $\nu_{r,t}$, where we vary the definition of "region" to include individual states, treated-control regions, or five broader geographic regions within Brazil. The variable $n_{m,t}$ captures the number of inspection orders issued to municipality m in year t. We flexibly control for its influence using dummy variables corresponding to the count of inspection orders received, recognizing that higher numbers typically lead to larger findings of corruption.

The results are presented in Table 1. Column (1) shows results controlling for broader region-by-year fixed effects, with the number of corruption findings in education as the dependent variable. Column (2) repeats the analysis for corruption findings in other sectors. The findings suggest that introducing the bonus pool reduced corruption within the education sector but not in other sectors. Columns (3) and (4) replicate these analyses with treated-control region-by-year fixed effects, yielding similar results. However, when including state-by-year fixed effects in columns (5) and (6), the results become insignificant. The point estimates are smaller but still meaningful–going from the 25th to the 75th percentile of the per capita bonus pool distribution would imply a reduction of 0.228 corruption cases (27% of the mean). This could indicate either that previous findings were driven by state-level trends or insufficient observations within treated states.

We advise interpreting these findings cautiously for two reasons. First, the limited sample size from corruption audits prevents us from formally testing parallel trends. Second, the robustness of our results is sensitive to the inclusion of state-by-year fixed effects.

Table 1: Mayors' responses to performance-based transfers: corruption

	(1) Education	(2) Not Education	(3) Education	(4) Not Education	(5) Education	(6) Not Education
β^m	0.004	-0.003	0.005	-0.006	-0.001	-0.010
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
$1(t > 2007) \times \beta^m$	-0.010***	-0.003	-0.013**	0.001	-0.003	0.008
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.390	0.377	0.378	0.121	0.472	0.190
# Order service FEs	✓	✓	✓	✓	✓	✓
Transfer year FEs	✓	✓	✓	✓	✓	✓
UF FEs	✓	✓	✓	✓	✓	✓
Region-year FEs	✓	✓	✓	✓	✓	✓
Treated-year FEs	✗	✗	✓	✓	✓	✓
State-year FEs	✗	✗	✗	✗	✓	✓
Mean corruption	0.84	1.84	0.84	1.84	0.84	1.84
N	4271	4270	4276	4276	4215	4215

This table presents estimates from the difference-in-differences specification in equation 10: $\text{Corruption}_{m,t} = \nu_s + \nu_{r,t} + f(n)_{m,t} + \gamma_1 \cdot \beta^m + \gamma_2 \cdot \beta^m \cdot \mathbf{1}[t > 2007] + \varepsilon_{m,t}$ where ν_s are state fixed effects, $\nu_{r,t}$ are region-by-year fixed effects (with the definition of "region" varying across columns), and β^m is the per capita bonus pool for municipality m. The indicator $\mathbf{1}[t > 2007]$ equals one for post-2007 years. The variable $n_{m,t}$ measures the number of inspection orders issued to municipality m in year t, whose effect is flexibly captured by dummy variables for each count of inspections. Columns (1) and (2) use five broad regions-by-year fixed effects, examining corruption findings in education and other sectors, respectively. Columns (3) and (4) repeat these analyses with treated-by-year fixed effects, while columns (5) and (6) use state-by-year fixed effects. Standard errors, clustered at the municipality level, are in parentheses.

6.2 Multitasking concerns

In this section, we test for concerns related to multitasking problems (Holmström and Milgrom [1991]), where municipalities could improve incentivized performance measures at the expense of non-incentivized outputs. We first examine the effects on non-incentivized outputs within the education system and subsequently assess impacts on non-incentivized sectors.

The impact on non-incentivized educational outputs depends on the nature of the production function. For example, if one teacher instructs both an incentivized subject (e.g., math) and a non-incentivized subject (e.g., natural sciences) within fixed teaching hours, improvements in teacher quality could potentially enhance performance in both subjects. Conversely, if municipalities allocate their best resources exclusively to incentivized subjects, performance in non-incentivized subjects might deteriorate.

We analyze the performance in the only non-incentivized subject with available data before (1999) and after (2019) the introduction of the performance-based transfer: natural sciences. Since the 1999 test was administered to a random sample and the 2019 test included all schools with at least 20 students, we restrict the analysis to municipalities tested in both years. We then estimate a difference-in-differences specification analogous to the one in section 4, including math, language, and natural sciences as dependent variables. The specification is as follows:

$$f_{imt} = \nu_m + \nu_t + \gamma_1 \mathbf{1}(\text{ post }_t) \times \mathbf{1}(T_s) + \gamma_2 \mathbf{1}(\text{ post }_t) \times \mathbf{1}(T_s) \times \beta^m + \epsilon_{imt} \tag{11}$$

where f_{imt} are the test scores of student i in municipality m in year t, ν_m are municipality fixed effects, ν_t are year fixed effects, T_s is a dummy variable that takes the value of 1 if the municipality is in the treated states, and β_m is the bonus pool per capita of municipality m.

The results are shown in table 2. The estimates for the overall effect of the performance-based transfer, γ_2, are shown in the third row. Column (1) shows the results for natural sciences, column (2) shows the results for math, and column (3) shows the results for portuguese. The estimates for natural sciences are of similar magnitude, and statistically indistinguishable from the other two effects. This suggests that the performance-transfer did not have detrimental effects on the performance of the unincentivized natural sciences.

Table 2: Overall effect of performance-transfers on incentivized and non-incentivized subjects

	(1) Natural Science	(2) Math	(3) Portuguese
1(t = 2019)	0.193***	0.313***	0.249***
	(0.071)	(0.047)	(0.071)
1(t = 2019) × 1[treated]	0.075	0.173**	0.316***
	(0.100)	(0.069)	(0.080)
1(t = 2019) × 1[treated] ×β^m	0.004***	0.005**	0.003
	(0.001)	(0.002)	(0.003)
R^2	0.106	0.105	0.092
Municipal FEs	✓	✓	✓
Municipal schools	✓	✓	✓
Other schools	✗	✗	✗
N	10511	196212	196277

his table shows the effects of performance-based transfers on test scores in incentivized subjects (mathematics and Portuguese) and non-incentivized subjects (natural sciences). Estimates come from the following difference-in-differences specification (11): $f_{imt} = \nu_m + \nu_t + \gamma_1 \mathbf{1}(\text{ post }_t) \times \mathbf{1}(T_s) + \gamma_2 \mathbf{1}(\text{ post }_t) \times \mathbf{1}(T_s) \times \beta^m + \epsilon_{imt}$ where f_{imt} is the test score of student i in municipality m in year t, ν_m are municipality fixed effects, and ν_t are year fixed effects. $\mathbf{1}[T_s]$ equals one if municipality m is located in a treated state, $\mathbf{1}[\text{Post}_t]$ indicates years after the reform, and β^m is the per capita bonus pool for municipality m. The sample includes all municipalities with available test data in both periods. Standard errors, clustered at the municipality level, are reported in parentheses.

6.3 Manipulation concerns

In this section, we address concerns regarding manipulation of performance measures, which could lead to detrimental welfare effects. For example, if mayors push lower-performing students out of the education system to artificially inflate performance indicators, this could severely impact the welfare of these students.

The decentralized education environment in Ceará and Pernambuco mitigated such concerns. By 2007, responsibilities to provide primary education had largely shifted to municipalities, and constitutional mandates ensured universal access to education for all children. Additionally, the incentive structure of performance-based transfers explicitly accounted for student completion rates in municipal primary schools, penalizing any strategies to exclude students to enhance performance metrics.

Nonetheless, we empirically examine whether municipalities engaged in student exclusion. Utilizing Census data, we estimate the effect of the bonus pool on the share of the elementary education-age population (ages 5-14) enrolled in municipal schools. Figure 8 displays the results from the event-study analysis specified in equation 6. The findings indicate that there were likely pretrends. However, if anything, municipal schools continued on a trend of attracting more students following the introduction of the performance-based transfers, alleviating concerns about exclusionary manipulation.

The second manipulation concern is that municipalities might select which students take exams used in performance measures. To prevent this, the education quality index in Ceará is calculated as the average test scores of all students enrolled in the municipality; thus, any absence counts as zero, harming the municipality's overall score. Moreover, it is worth emphasizing that the test scores from Prova Brasil are not used in the performance measure of the state of Ceará.[14]

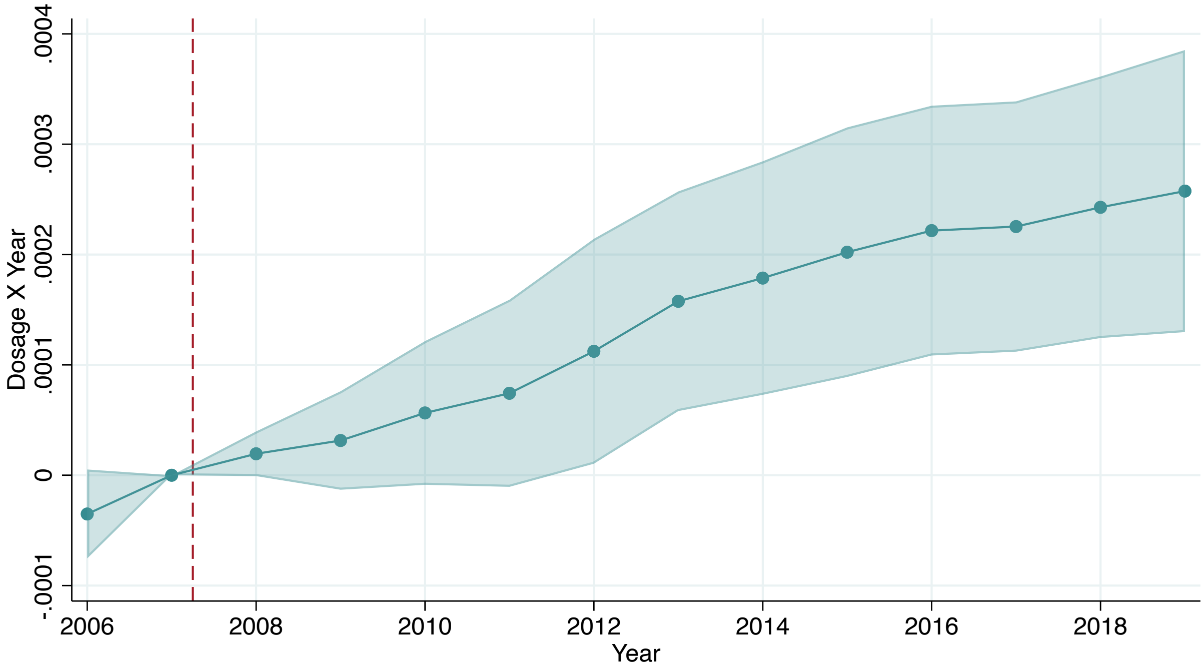
To empirically test for this manipulation, we analyze changes in the composition of students taking the exams following the introduction of performance-based transfers. Specifically, we examine if the students who took exams became predictably better performers. First, we regress test scores from the last pre-reform year on municipality fixed effects. Using the residuals, we perform a Lasso regression on various student covariates, including parental education and household assets (e.g., number of TVs, cars, computers). The estimated Lasso coefficients are then used to predict test scores for students in all periods. Finally, we apply the event-study design from equation 6 on these predicted test scores.

The results are presented in Figure 9. They indicate a small, gradual increase in the predicted test scores of students taking exams after the introduction of the performance-based transfers. However, this effect is minimal when compared to the overall effect documented in Figure 4, Section 4, suggesting that any potential manipulation did not significantly drive the observed improvements in performance measures.

The third manipulation concern is that mayors could falsify exam results. To prevent this, the exams were administered by external institutions. Additionally, it is worth emphasizing again that Prova Brasil scores are not utilized in Ceará's performance measure. Appendix A separately estimates the overall effects of the bonus pool for each state, demonstrating similar results.

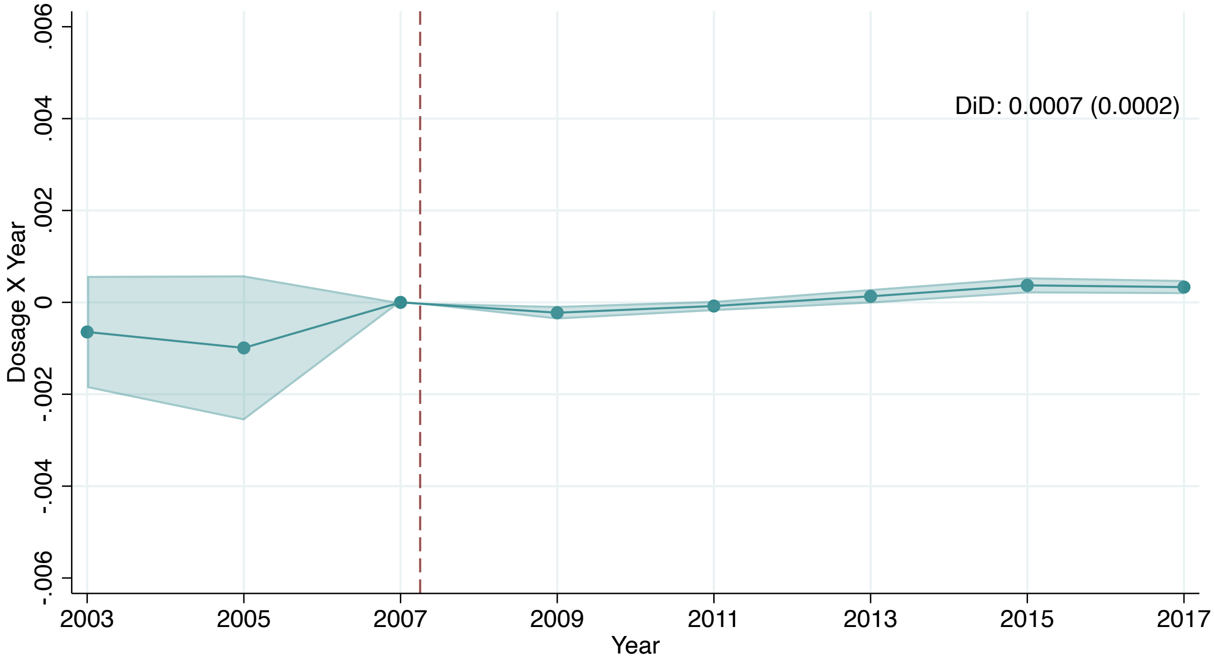
[14] The state of Pernambuco did not adopt such measures. Appendix A shows the overall effects of the bonus pool are similar in both states.

Figure 8: Effect of performance-based transfers on the share of elementary education age population in municipal schools



This figure shows the overall effects of performance-based transfers on the share of elementary education age population in municipal schools. It plots the γ_y coefficients from estimating equation 7: $f_{mt} = \nu_m + \nu_{st} + \sum_{y \neq 2007} \gamma_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{mt}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, $\mathbf{1}[t = y]$ is a year indicator, and ϵ_{mt} is the residual. The outcome is the share of the elementary education age population in municipal schools. Standard errors are clustered at the municipality level, and shaded areas denote 95 percent confidence intervals. The residual is defined at the municipality-year level (ϵ_{mt}).

Figure 9: Increase in predicted math test scores is relatively small



This figure shows the overall effects of performance-based transfers on predicted test scores. It plots the γ_y coefficients from estimating equation 7: $\hat{f}_{imt} = \nu_m + \nu_{st} + \sum_{y \neq 2007} \gamma_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{mt} is the residual. The outcome variable, $\hat{f}_{imt}$, is the predicted test score of student i in municipality m in year t. The prediction is based on a Lasso regression of the test scores from the last pre-reform year on municipality fixed effects and various student covariates, including parental education and household assets (e.g., number of TVs, cars, computers). The estimated Lasso coefficients are then used to predict test scores for students in all periods. Standard errors are clustered at the municipality level, and shaded areas denote 95 percent confidence intervals. The scale of the plot is set to match the scale of the overall effects of performance-based transfers on test scores in figure 4 (panel a).

7 Optimal transfers

8 Conclusion

This paper investigates the equity-efficiency trade-off associated with performance-based intergovernmental transfers, a crucial policy issue in light of the widespread decentralization of public good provision financed primarily through intergovernmental transfers. Central governments often rely on these transfers to achieve redistributive goals and ensure equitable resource allocation across municipalities. However, unconditional transfers, while promoting equity, may reduce efficiency by exacerbating political agency problems. Performance-based transfers have emerged as an alternative mechanism, designed to mitigate these incentive issues by linking funding to measurable outcomes.

Using the introduction of performance-based transfers in Brazilian municipalities as a case study, we document significant overall gains: moving from the 25th to the 75th percentile of per-capita bonus pool increases student test scores by 0.13 standard deviations. Yet, these transfers also widen funding disparities, disproportionately benefiting municipalities with higher initial state capacity with larger transfers.

To disentangle income and substitution effects of performance-based transfers, we exploit concurrent reforms to major transfers independent of performance improvements. Empirically, we find that increasing the performance-based bonus pool substantially improves educational outcomes, whereas comparable increases in unconditional transfers have negligible effects. These findings suggest that the substitution effects—municipalities' incentives to invest in public goods—dominate the income effects.

We integrate these empirical insights into a simple theoretical framework of optimal transfer allocation, highlighting the fundamental trade-off faced by policymakers between equity and efficiency. The model derives sufficient statistics for policy design: larger substitution effects justify greater reliance on performance-based funding, whereas significant income effects suggest a larger role for unconditional transfers. Our empirical estimates imply that optimal policy should allocate a substantial fraction of total intergovernmental transfers to performance-based mechanisms, as the efficiency gains significantly outweigh modest equity losses.

Importantly, we find no evidence of common concerns associated with performance-based incentives—such as multitasking distortions, student selection, or manipulation of test scores. Instead, municipalities respond by improving the quality of education inputs. We also document suggestive evidence of reduced corruption within the education sector.

Overall, our analysis indicates that performance-based transfers can effectively enhance public service delivery without undermining equity or other valuable public goods. By carefully balancing performance incentives with unconditional funding, central governments can improve local governance and service outcomes, suggesting a powerful and practical policy tool for addressing agency problems inherent in decentralization.

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Appendices

A Additional tables and figures

Figure A.1: Example of the calculation for the consitutional requirement for expenses

RECEITAS	PREVISÃO INICIAL	PREVISÃO ATUALIZADA (a)	RECEITAS REALIZADAS		
				No Ano (b)	% (b/a)
1 - RECEITAS DE IMPOSTOS		433.991.053,60		433.991.053,60	100,00
2 - RECEITAS DE TRANSFERÊNCIAS CONSTITUCIONAIS E LEGAIS		853.074.181,50		853.074.181,50	100,00
2.1 - Cota-Parte FPM		423.056.210,88		423.056.210,88	100,00
2.2 - Cota-Parte ICMS		356.151.538,00		356.151.538,00	100,00
2.3 - ICMS-Desoneração - L.C. nº 87/1996		3.264.897,61		3.264.897,61	100,00
2.4 - Cota-Parte IPI-Exportação		3.116.086,57		3.116.086,57	100,00
2.5 - Cota-Parte ITR		6.033,79		6.033,79	100,00
2.6 - Cota-Parte IPVA		67.479.414,65		67.479.414,65	100,00
2.7 - Cota-Parte IOF-Ouro		0,00		0,00	0,00
3 - TOTAL DA RECEITA BRUTA DE IMPOSTOS (1+2)		1.287.065.235,10		1.287.065.235,10	100,00
DESPESAS COM AÇÕES TÍPICAS DE MANUTENÇÃO E DESENVOLVIMENTO DO ENSINO	DOTAÇÃO INICIAL	DOTAÇÃO ATUALIZADA (d)	DESPESAS EMPENHADAS		
				No Ano (e)	% (f)=(e/d)x100
17 - EDUCAÇÃO INFANTIL		43.923.010,36		40.369.896,04	91,91
18 - ENSINO FUNDAMENTAL		403.835.978,64		380.469.829,41	94,21
29 - RECEITA DE APLICAÇÃO FINANCEIRA DOS RECURSOS DO FUNDEB ATÉ O BIMESTRE = (41)					1.007.908,64
30 - TOTAL DAS DEDUÇÕES / ADIÇÕES CONSIDERADAS PARA FINS DE LIMITE CONSTITUCIONAL (24+25+26+27+28+29)					67.904.461,55
31 - MÍNIMO DE 25% DAS RECEITAS RESULTANTES DE IMPOSTOS NA MANUTENÇÃO E DESENVOLVIMENTO DO ENSINO[3] [(17+18) - (30) / (3)] X 100%					27,42

Figure A.2: Distribution of the percentage of transfers and taxes spent on education

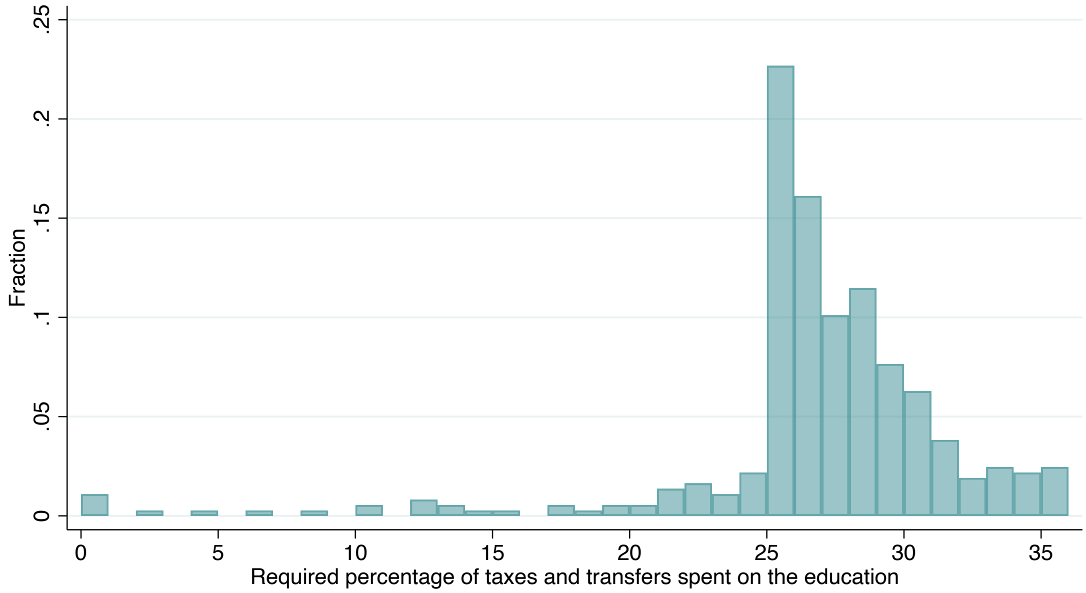
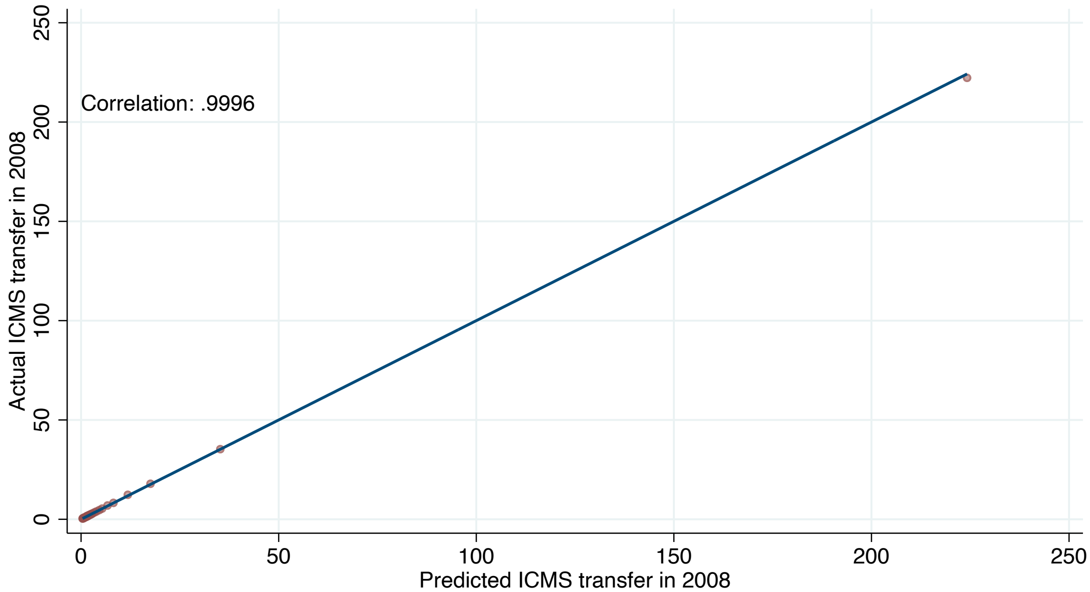
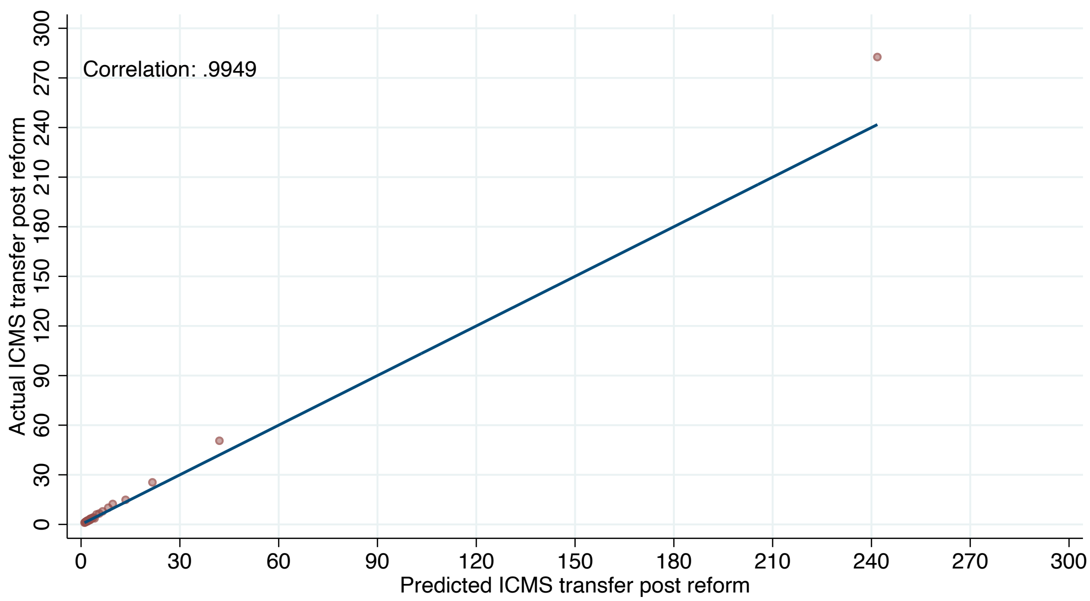


Figure A.3: Predicted vs reported ICMS transfer

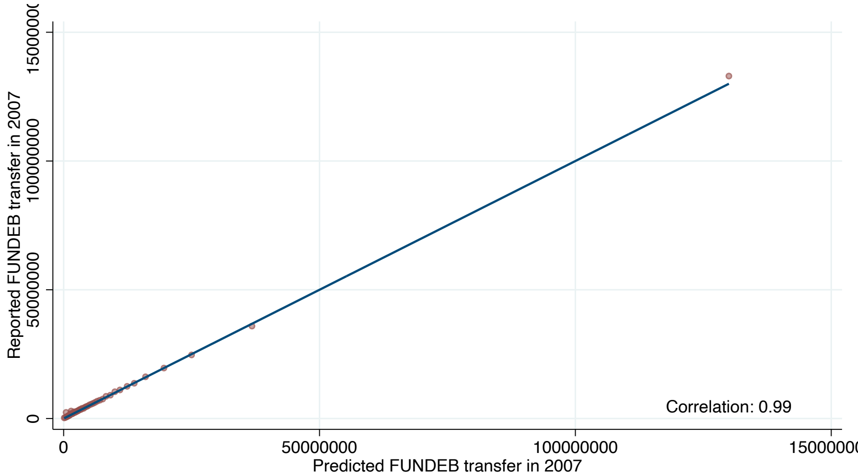


(a) Pre-reform

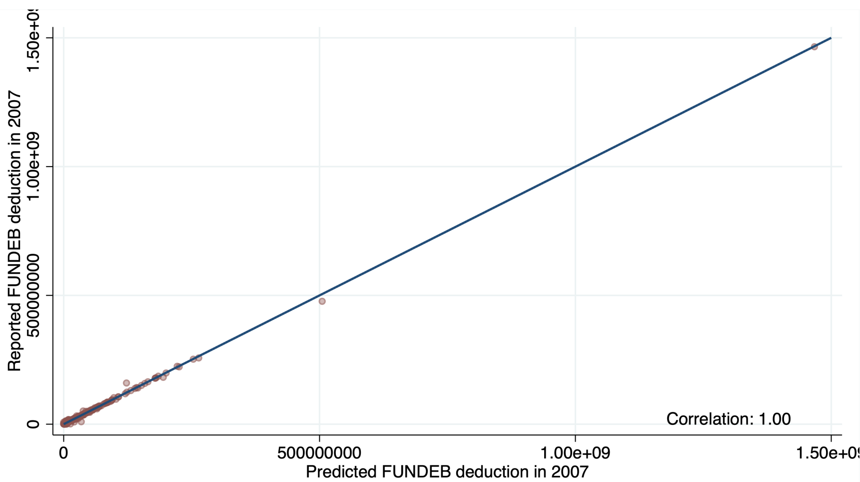


(b) Post-reform

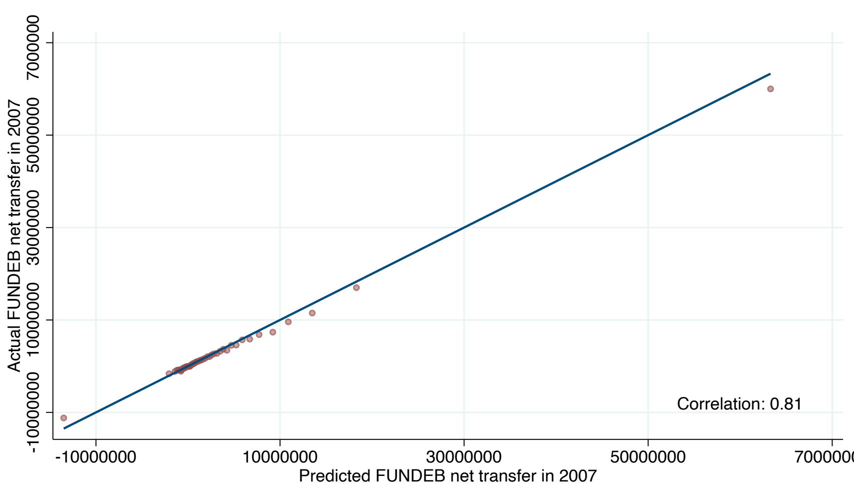
Figure A.4: Predicted vs reported FUNDEB transfer, post-reform



(a) Transfers received

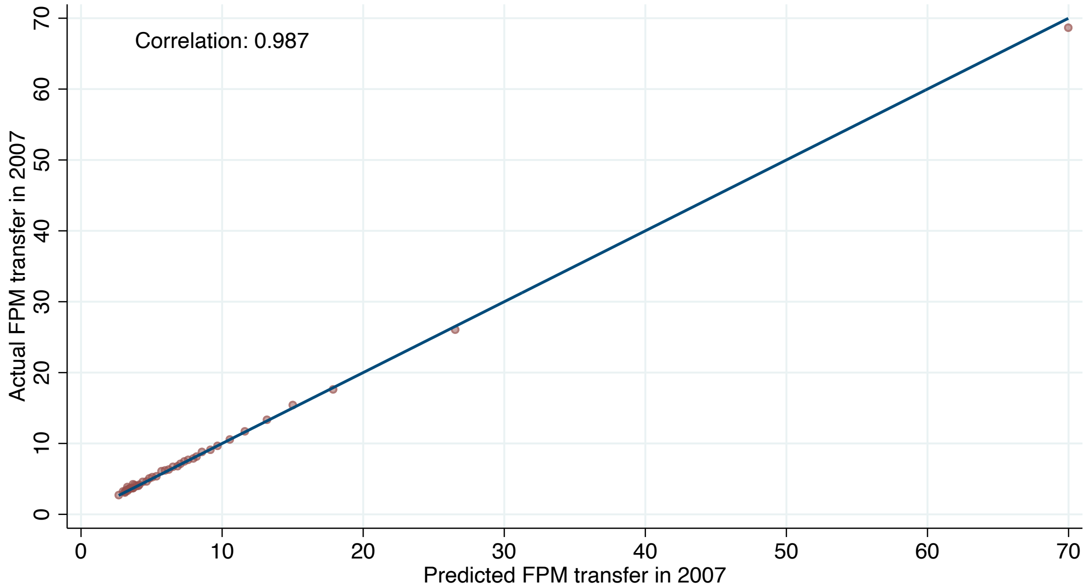


(b) Contributions

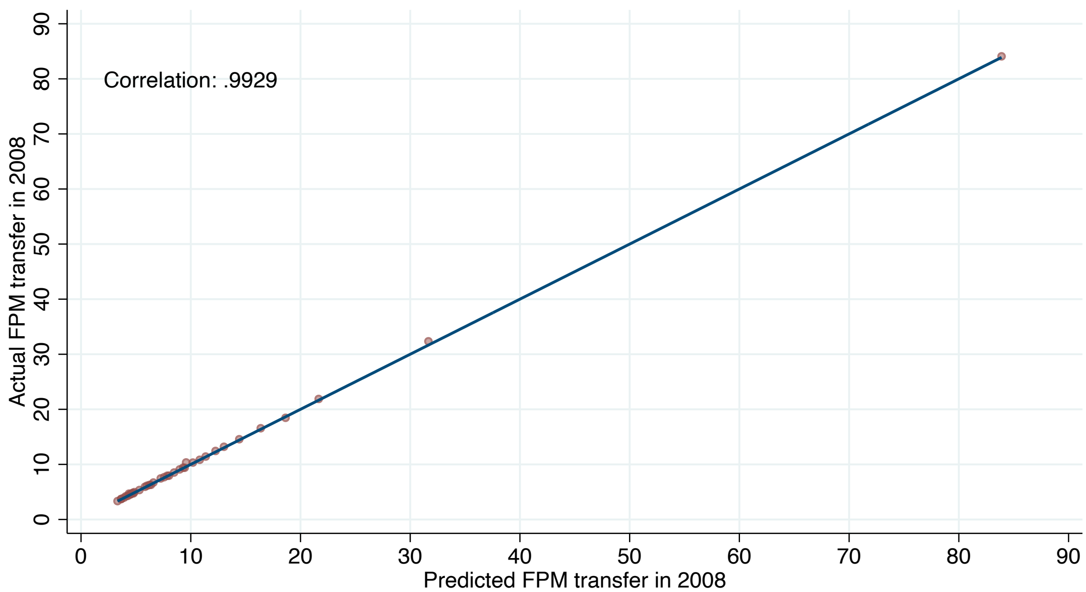


(c) Net FUNDEB transfer

Figure A.5: Predicted vs reported FPM transfer



(a) Pre-population count



(b) Post-population count

Figure A.6: Augmented event-study first stage: estimates of the bonus pool effect

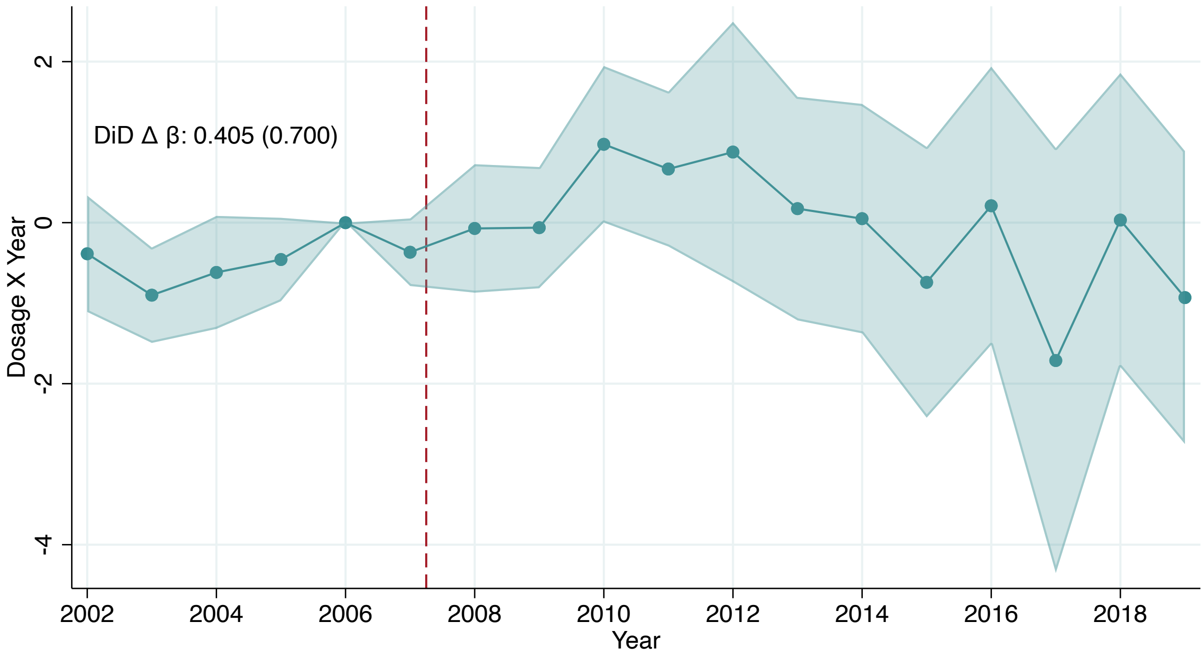
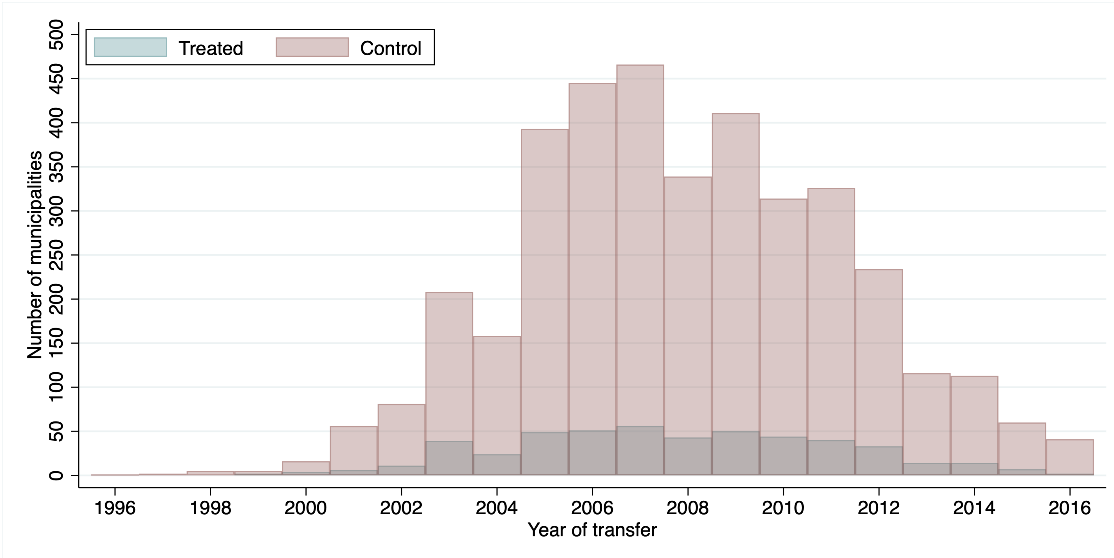


Figure A.7: Number of municipalities with audited transfers by year



B Additional details on the performance-based transfers

The Imposto sobre Circulação de Mercadorias e Serviços (ICMS) is a state-level value-added tax levied on the circulation of goods and services across municipalities or states. 25% of the ICMS total revenue is transferred to municipalities. From the total distributed to municipalities, article 158 from the consitution requires that 75% must be in proportion to the amount collected in the municipalities.[15] The remaining 25% can be determined by the states. Up until 2007, none of the states conditioned their transfers on education quality. In 2007, the states of Ceará and Pernambuco reformed their ICMS transfer allocation rules to municipalities. Below, table B.1 summarizes the conditions applied by the state of Pernambuco pre- and post-reform, and table B.2 summarizes the conditions applied by the state of Ceará pre- and post-reform.

In 2007, both states started conditioning a percentage of the ICMS transfers to municipalities on different education quality indeces, which measure relative performances of municipalities. The index in Ceará is two thirds based on an index measured for fifth graders and one third based on an index measured for second graders:

$$E^m_{CE} = 0.4 \cdot E^m_{CE,5^{\text{th}}} + 0.6 \cdot E^m_{CE,2^{\text{nd}}}$$

where E^m_{CE} is the education quality index for municipality m in Ceará, $E^m_{CE,5^{\text{th}}}$ is the education quality index for fifth graders, and $E^m_{CE,2^{\text{nd}}}$ is the education quality index for second graders. We include a tilde in the name to remind the reader that the index measures relative performances. Each grade's index is calculated as follows:

$$E^m_{CE,5^{\text{th}}} = 0.2 \times \tilde{c}^m + 0.32 \times \tilde{g}(f^m) + 0.48 \times \tilde{\Delta} g(f^m)$$

where the tilde each subcomponent denotes relative performances. I.e., $\tilde{x}^m = \frac{x^m}{\sum_{m'} x^{m'}}$. c^m is the average completion rate in grades 1-5 in municipality m, and $g(f^m)$ is a function of test scores (f^m) in the fifth grade. Specifically, $g(f^m)$ is defined as follows:

$$g(f^m) = \left(\frac{h(f^m) - \min_m h(f^m)}{\max_m h(f^m) - \min_m h(f^m)} \right)$$

where the function $h(f^m)$ is defined as:

$$\frac{f^m}{0.5\sigma^m}$$

where σ^m is the standard deviation of the test scores in municipality m and f^m is the average test score in municipality m. Importantly, the average score is calculated using all students enrolled in the fifth grade in a municipality, not just those who took the exam. Thus, any student absence counts as zero for the performance index, which prevents municipalities from selecting students to take the exam. $\Delta g(f^m)$ is the change in the function $g(f^m)$ between the current and previous three

[15] There was a federal reform to the ICMS transfer conditions in 2020, but our data sample period ends in 2019.

previous years:

$$\Delta g(f_t^m) = g\left(f_t^m\right) - \frac{1}{3}\left[g\left(f_{t-1}^m\right) + g\left(f_{t-2}^m\right) + g\left(f_{t-3}^m\right)\right]$$

where t is the year. The index for second graders is calculated in a very similar way, but using the test scores for second graders. Specifically, the index is defined as:

$$E_{CE,2^{\text{nd}}}^m = 0.5 \times \tilde{g}(f_{2^{\text{nd}}}^m) + 0.48 \times \Delta\tilde{g}(f_{2^{\text{nd}}}^m)$$

where the function $g(\cdot)$ is defined just as before and $f_{2^{\text{nd}}}^m$ are literacy test scores for second graders.

It is worth remining that the test scores used in the calculation of the index are not the same as the test scores used in the analysis. Specifically, we use the test scores from the national standardized exam Prova Brasil. Ceará uses their own test scores conducted by the state government.

The education quality index in Pernambuco is set to equal the relative performance of the municipality in the national index "Índice de Desenvolvimento da Educação Básica" (IDEB). This index is calculated as follows:

$$E_{PE}^m = \frac{IDEB^m}{\sum_{m'} IDEB^{m'}}$$

where

$$IDEB^m = c^m \times \left(\frac{g(f_{\text{port}}^m) + 10 \times g(f_{\text{math}}^m)}{2}\right)$$

where c^m is the average completion rate in grades 1-5 in municipality m, f_{port}^m is the average test score in Portuguese, and f_{math}^m is the average test score in math. The function $g(f^m)$ is defined in the same way as in the case of Ceará, but they use the min and max of the test scores in 1997. Any score above the max or below the min is set to the max or min, respectively.

Table B.1: ICMS Distribution Rules in Pernambuco by Reform Period

Pct.	Condition	Details
		Pre-Reform
75	Collection rate	Proportional to the amount collected in the municipality.
17	Smooth change	Proportional to the difference between the municipality's share of distribution in year $t-1$ and the share in all calculated using all other facthers in year t. Zero if the difference is negative.
1	Environmental index	Distributed among municipalities with "conservation units," based on a conservation index.
2	Waste management	Distributed among municipalities with an approved license of a waste management system. Proportional to the population size times an index of the implementation of the system.
2	Health index	Proportional to the inverse of child mortality.
2	School enrollment	Proportional to the number of students enrolled in basic education.
1	Local taxes	Proportional to the amount of local taxes raised per capita.
		Post-Reform
75	Collection rate	Proportional to the amount collected in the municipality
5	Smooth change	Proportional to the difference between the municipality's share of distribution in year $t-1$ and the share in all calculated using all other facthers in year t. Zero if the difference is negative.
1	Environmental index	Distributed among municipalities with "conservation units," based on a conservation index.
2	Waste management	Distributed among municipalities with an approved license of a waste management system. Proportional to an index of the implementation of the system.
3	Health index	Two-thirds proportional to the inverse of child mortality, and one-third proportional to the number of teams per capita in the health program "Programa Saúde na Família."
3	Education quality	Proportional to an education quality index detailed below.
1	Local taxes	Proportional to the amount of local taxes raised per capita.
3	GDP per capita	Proportional to inverse of the GDP per capita.
3	Safety index	Two-thirds proportional to the inverse of the number of homicides per 100,000 inhabitants, and one-third to municipalities with prisons with a capacity greater than 300 inmates.
4	Population size	Proportional to the population size.

Notes: This table shows the distribution rules of the ICMS tax in the state of Pernambuco by reform period. The first column shows the percentage of the portion to municipalities that is distributed according to the condition in the second column. The third column describes the condition in more detail. The pre-reform period is until 2007, and the post-reform period is after 2007.

Table B.2: ICMS Distribution Rules in Ceará by Reform Period

Pct.	Condition	Details
		Pre-Reform
75	Collection rate	Proportional to the amount collected in the municipality.
7.5	Equally	Distributed equally to all.
5	Population size	Proportional to population size.
12.5	Education expenditures	Proportional to the ratio of education expenditures to revenues two years before.
		Post-Reform
75	Collection rate	Proportional to the amount collected in the municipality.
18	Education quality	Proportional to an education quality index detailed below.
5	Health index	Half is proportional to the level of child mortality and half proportional to the change.
2	Waste management	Split equally to municipalities with an approved waste management system.

Notes: This table shows the distribution rules of the ICMS tax in the state of Ceará by reform period. The first column shows the percentage of the portion to municipalities that is distributed according to the condition in the second column. The third column describes the condition in more detail. The pre-reform period is until 2007, and the post-reform period is after 2007.

C Model proofs

C.1 Proof of proposition 1

We begin using the problem of the municipality to define the investment Marshallian supply function and Slutsky equation, which will allow us to link changes in the bonus pool (β^m) and the investment-independent transfers (y^m) to the investment decision of municipalities. Then, we consider marginal changes to each policy instrument and use the Slutsky equation to derive the optimal transfers.

In our conceptual framework in section 3, recall that the amount invested is defined as $I^m = T_1^t - C_t^m$ where $T_m^1 = \alpha_1 + \beta A^m$ is the total amount transferred to the municipality in period 1 and C_1^m is the amount consumed privately. Also recall that the problem defines a Marshallian demand function $C_1^m(p, y^m)$ where $p = \frac{\bar{f}_2}{\beta\pi}$ is the relative price of consuming tomorrow and $y^m = \alpha_1 + \left(\frac{1}{\pi} + \beta\right) A^m$ are all transfers independent of investments in education. Thus, the problem naturally defines a Marshallian investment supply function derived from the consumption function:

$$I^m\left(p, y^m, A^m\right) = y^m - \frac{1}{\pi}A^m - C_1^m(p, y^m) \tag{C.1}$$

To obtain the Slutsky equation, we leverage the mechanical relationship between the investment function and the consumption function, and the consumption Slutsky equation. Taking the total derivative of the investment function, we have:

$$\frac{dI}{d\beta} = \underbrace{A^m}_{\text{direct change in initial resources}} - \underbrace{\frac{dC_1}{d\beta}}_{\text{change in consumption}}.$$

Using the consumption's Slutsky equation, we can rewrite the above as

$$\frac{dI}{d\beta} = A^m - \frac{\partial C_1^h}{\partial \beta} - \left(\frac{\bar{f}_2}{\pi\beta^2}C_2 + A^m\right)\frac{\partial C_1}{\partial y^m}$$

Using $C_2 = \beta\frac{\pi I + A^m}{\bar{f}_2}$, the above can be simplified to:

$$\frac{dI}{d\beta} = -\frac{\partial C_1^h}{\partial \beta} + A^m\left(1 - \frac{\partial C_1}{\partial y^m}\right) - \left(\frac{\pi I + A^m}{\pi\beta}\right)\frac{\partial C_1}{\partial y^m}$$

To rewrite the investment slutsky equation in terms of investment changes, we note that $\frac{\partial I}{\partial y^m} = 1 - \frac{\partial C_1}{\partial y_m}$ and we define $\frac{\partial I^h}{\partial \beta} = -\frac{\partial C_1^h}{\partial \beta}$. Thus, we can rewrite the investment Slutsky equation in its final form as:

$$\frac{dI}{d\beta} = \underbrace{\frac{\partial I^h}{\partial \beta}}_{\text{subs effect}} + \underbrace{A^m\frac{\partial I}{\partial y^m}}_{\text{inc effect from shift}} - \underbrace{\left(\frac{\pi I + A^m}{\pi\beta}\right)\left(1 - \frac{\partial I}{\partial y^m}\right)}_{\text{cons inc effect from min exp}} \tag{C.2}$$

The intuitive interpretation is as follows: as we increase β^m, the substitution effect implies it's more attractive to invest in education to consume tomorrow. Moreover, an increase in β^m shifts the budget constraint by A^m, which leads to an income effect. Finally, the change in β^m also impacts the minimum expenditure of consumption. This leads to the classic income effect that is consumed away.

With this at hand, we can now solve the central government's problem. Recall that the central government maximizes:

$$\max_{\beta,\alpha} W = \int_m \gamma_m \left(\pi I^m + A^m\right) dm$$

$$\text{s.t. } 2\beta + \int_m \alpha dm = B$$

We form the Lagrangian:

$$L = \int_m \left[\gamma_m \left(\pi I^m + A_m\right) + \kappa \left(B - \alpha - 2\beta\right) dm\right]$$

The first order conditions with respect to β and α are as follows:

$$\int_m \left[\gamma^m \pi \frac{\partial I}{\partial \alpha}\right] dm = \kappa$$

and

$$\int_m \left[\gamma^m \pi \frac{\partial I}{\partial \beta}\right] dm = 2\kappa$$

Define the social marginal valuation of investment $\lambda^m = \frac{\gamma^m}{\kappa}\pi$ and the social marginal valuation of income as $w^m = \frac{\gamma^m}{\kappa}\pi\frac{\partial I}{\partial \alpha}$. The interpretation of these terms is the following: when a municipality increases investment by 1, production increases by π. The planner values that increase in production by weighting by the social weight γ^m. Dividing by κ normalizes the increase in welfare of having m invest one dollar to the increasing the total budget by 1 dollar. To understand the social marginal valuation of income, not that as we transfer one dolar to m, it increases the investment by $\frac{\partial I}{\partial \alpha}$. The value of that investment is then given by the social marginal valuation of investment already discussed.

This allows us to rewrite the first FOC as

$$\int_m w^m dm = 1.$$

The first FOC has a simple interpretation: the lump-sum transfer should be adjusted such that the average social marginal valuation of the transfer of \$1 should be equal to the cost (\$1).

Using the Slutsky equation and second FOC, one can obtain that:

$$\beta = \frac{\int_m \left[\lambda^m \left(\epsilon_s I\right)^m + w^m \left(\frac{f^m}{\pi}\right) - \lambda^m \left(\frac{f^m}{\pi}\right)\right] dm}{\left[2 - \int_m w^m A^m dm\right]}$$

where $\epsilon_s = \frac{\partial I^h}{\partial \beta}\frac{\beta}{I}$ is the elasticity of the substitution effect. Using $\int_m x^m y^m dm = Cov(x^m, y^m) + E[x^m]E[y^m]$, we can arrive at the final expression for the optimal transfer:

$$\beta = \frac{\int_m \left(\lambda^m \epsilon_s I\right) dm + \frac{1}{\pi} Cov(w^m, f^m) - \frac{1}{\pi} Cov(\lambda^m, f^m) + \frac{1}{\pi}\left(1 - \frac{\pi}{\kappa}\right) E[f^m]}{1 - Cov(w^m, A^m)} \tag{C.3}$$

D Connecting the model to the data estimates

In this Appendix, we detail the assumptions and steps that allows us to map the empirical findings from our extended event-study in section 5 to measures of income and substitution effects. As shown in our conceptual framework in section 3, these measures are crucial to estimate the optimal transfer policy.

We begin defining an empirical version of our test score production function:

$$f_t^m = \pi I_t^m + A^m + \varepsilon_t^m,$$

where I_t^m is the amount invested in education by municipality m at time t, π is the marginal productivity of investment, A^m is the state capacity of municipality m, and ε_t^m is an error term.

Then, we leverage that the municipality's problem defines a Marshallian investment supply function, as derived in Appendix C:

$$I^m\left(p, y^m, A^m\right) = y^m - \frac{1}{\pi}A^m - C_1^m(p, y^m) \tag{D.1}$$

This allows us to rewrite the production function as a function of Marshallian investment supply function:

$$f_t^m = \pi I_t^m\left(p, y^m, A^m\right) + A^m + \varepsilon_t^m,$$

Since we estimate our extended event-study using z-scores, let's rewrite the empirical production function accordingly. Let μ and σ be the mean and standard deviation of the test scores pre-reform in the control group, respectively. Then, we can write the standardized production function as:

$$f_t^{m,z} = \frac{\pi I_t^m\left(p, y^m, A^m\right) + A^m + \varepsilon_{mt} - \mu}{\sigma}$$

If we take differences over time, we obtain:

$$\Delta f_t^{m,z} = \frac{\pi \Delta I_t^m\left(p, y^m, A^m\right) + \Delta\varepsilon_{mt}}{\sigma}$$

Using a first-order approximation, we get:

$$\Delta f_t^{m,z} \approx \pi\frac{1}{\sigma}\frac{\partial I}{\partial y}\Delta y_t^m + \pi\frac{1}{\sigma}\frac{\partial I}{\partial \beta}\Delta\beta_t^m + \frac{1}{\sigma}\Delta\varepsilon_{mt}$$

In our extended event-study, we assume we have constant $\pi\frac{1}{\sigma}\frac{\partial I}{\partial \beta} = \eta$ and $\pi\frac{1}{\sigma}\frac{\partial I}{\partial y} = \gamma$ and estimate η and γ.

Next, we use the investment Slutsky equation, which we derived in Appendix C:

$$\frac{dI}{d\beta} = \underbrace{\frac{\partial I^h}{\partial \beta}}_{\text{subs effect}} + \underbrace{A^m\frac{\partial I}{\partial y^m}}_{\text{inc effect from shift}} - \underbrace{\left(\frac{\pi I + A^m}{\pi\beta}\right)\left(1 - \frac{\partial I}{\partial y^m}\right)}_{\text{cons inc effect from min exp}} \tag{D.2}$$

to further investigate what we estimate in our extended event-study:

$$\Delta f_t^{m,z} \approx \pi \frac{1}{\sigma} \frac{\partial I}{\partial y^m} \left(\Delta y_t^m + A^m \Delta \beta_t^m \right) + \pi \frac{1}{\sigma} \left[\frac{\partial I^h}{\partial \beta} - \left(\frac{\pi I + A^m}{\pi \beta} \right) \left(1 - \frac{\partial I}{\partial y^m} \right) \right] \Delta \beta_t^m + \Delta \varepsilon_{mt}$$

Recall that in our empirical analysis we already incorporate the shift in the budget constraint coming from the performance-based transfer, $\Delta \beta_t^m A^m$, in our simulated instrument of Δy^m. Thus, we are estimating

$$\Delta f_t^{m,z} \approx \underbrace{\pi \frac{1}{\sigma} \frac{\partial I}{\partial y}}_{\eta} \Delta y_t^m + \underbrace{\pi \frac{1}{\sigma} \left[\frac{\partial I^h}{\partial \beta} - \left(\frac{\pi I + A^m}{\pi \beta} \right) \left(1 - \frac{\partial I}{\partial y} \right) \right]}_{\gamma} \Delta \beta_t^m + \Delta \varepsilon_{mt}$$

where we assume that η and γ are constants.

E Other policies

F Details of the inputs indeces

In section 6.1, we analyze how mayors' choices of inputs change after the introduction of the performance-based transfers. The analysis was presented with ten indexes of inputs to the education. In this appendix, we provide aditionnal details on how we constructed these indexes and present results for each input separately.

Our first step was to select the inputs to be included in the analysis. We begin with all data on questions that are asked systematically in the teacher and principal surveys from Prova Brasil, and in the school census. We exclude binary inputs that were extensively adopted (above 95%) prior to the reform, which results in a list of 35 inputs.

To ease interpretation, we standardize all inputs and we group some of them into indexes. The indexes are constructed as the average of the standardized inputs. To guide the reader, we also categorize the indexes into three subjective groups, which only serve as guide: (i) complaints from personnel, (ii) quantity-related educational inputs, and (iii) quality-related educational inputs.

Table F.1 below details the indexes we constructed, the inputs included in each index, the source of the data, and the subjective groups we assigned to each index.

Table F.1: Indexes constructed for education inputs

Index	**Inputs**	**Sources**
	Complaints from personnel group	
Principal complains index	• Insufficient funds • Insufficient teachers • Insufficient administrative staff • Insufficient pedagogic support • Missing books	Prova Brasil
Teacher complains index	• Missing books • Books arrived late • Insufficient administrative staff	Prova Brasil
	Quality-related education inputs group	

Table F.1: Indexes constructed for education inputs

Index	**Inputs**	**Sources**
Non-academic facilities index	• School offices • Director Office • Secretariat • Teachers Room • Kitchen • Dining Hall • Playground • Sports Court	Census
Academic facilities index	• Library • Computer lab • Science lab • Reading room	Census
Classroom inputs index	• Internet connection • Television • Overhead projector • Printer • DVD player	Census
Class size	Class size	Census
Number of schools	Number of schools	Census
Number of teachers	Number of teachers	Census

Table F.1: Indexes constructed for education inputs

Index	**Inputs**	**Sources**
Quantity-related education inputs group		
Principal quality index	• Postgraduate degree • Postgrad in management • Years as principal • Years in school	Prova Brasil
Teacher quality index	• Undergraduate degree • Post graduate degree • Years as teacher • Years as teacher in school	Prova Brasil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10 de agosto de 2018

Figure F.1: School closures in the media