Bonus or Budget? Equity-Efficiency Tradeoff in Performance-Based Transfers*

Luigi Caloi Andrea Ciccarone

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Abstract

To improve service delivery, central governments can tie intergovernmental transfers to local policy performance. While performance-based transfers incentivizes local governments and generate efficiency gains, they also shift transfers from low-capacity to high-capacity governments which leads to equity losses. We study this equity-efficiency trade-off using a bundle of transfer reforms 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 0.16 standard deviations. However, the reform also widened funding disparities, which translated to disparities in expenditures across sectors. In contrast, contemporaneous reforms to unconditional transfers had negligible effects on student outcomes. We use a simple model of optimal transfers to interpret these findings. Our results suggest that the introduction of performance-based transfers delivered large efficiency gains, limited equity costs, and was welfare enhancing. 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

Decentralization is a defining feature of modern public policy. Subnational governments are responsible for 42 percent of total public expenditures in federal countries (OECD [2022]), making them central actors in the delivery of public services.[1] Local spending is largely financed through intergovernmental transfers, which comprise 45 percent of subnational revenues (OECD [2022]). The design of these transfers is therefore a key policy instrument for improving service provision.[2]

A key design question is whether transfers should be allocated unconditionally or conditionally. Unconditional transfers are based on measures beyond local control, such as population size, while conditional transfers are tied to outcomes that local governments can influence, such as the quality of public services.[3] Performance-based transfers raise efficiency because they reward improvements in outcomes deemed valuable.[4] However, they also reward inframarginal performance that reflect preexisting capacity rather than new effort. This shifts transfers from low- to high-capacity municipalities and generates equity losses.[5]

This paper studies this equity-efficiency trade-off using a bundle of transfer reforms to Brazilian municipalities. We begin by analyzing a performance-based reform introduced in two states, which tied a share of the main state transfer to each municipality's relative performance on an education quality index. We then compare this policy to two concurrent reforms affecting the largest federal and education-specific unconditional transfers. To interpret the empirical findings, we use a simple model of optimal transfers that maps the reduced-form estimates into sufficient statistics of the welfare optimal transfer mix. To fully assess welfare impacts, we also investigate empirically concerns of multitasking with non-incentivized outcomes and the potential manipulation of performance metrics. Finally, to understand mayors' behavioral responses, we analyze their input allocations and corruption responses to both transfer instruments.

The reform we exploit to analyze the effects of performance-based transfers was introduced by the states of Ceará and Pernambuco in Brazil. The reform modified the allocation of revenues

[1] Including unitary countries, subnational governments represent 21.5 percent of total public spending—equivalent to 8.3 percent of GDP—and rely on transfers for 52 percent of their revenues.

[2] The decentralization and fiscal federalism literature distinguishes between the expenditure problem—which level of government should provide a public good—and the fiscal problem—which level should finance it. See Gadenne and Singhal [2014], Bardhan [2002], and Oates [2005] for recent reviews. This paper takes the scale of transfers as given and focuses on their optimal design.

[3] Appendix Table A.1 lists examples and shows that performance-based transfers are adopted across countries. Many governments also condition transfers on input choices, which raise similar conceptual trade-offs. For instance, the U.S. federal government provides matching grants for state Medicaid expenditures. Figure 7 in Dougherty et al. [2024] documents the distribution of conditional and unconditional transfers across OECD countries, where most allocate a significant share conditionally. Fewer countries adopt transfers based on performance changes. We discuss their tradeoffs in section 5.2.

[4] Scholars across several literatures question the role of unconditional transfers due to their lack of incentives provision. See, for instance, the foreign aid literature (Easterly [2006], Deaton [2013]) and the state capacity literature (Besley and Persson [2013]).

[5] Transfers typically target recipients based on a measure of deservingness: income transfers might prioritize low-skilled workers, while intergovernmental transfers often favor jurisdictions with lower capacity to provide public services. Rewards on inframarginal performance reverses this logic, as low capacity governments receive smaller transfers despite greater need. Conceptually, conditioning on performance is akin to a regressive income transfer that rewards higher earnings.

from the state value-added tax (VAT) to municipalities. After 2007, each state earmarked a fixed share of the total VAT revenues to be distributed across municipalities according to their relative performance on an education quality index. We refer to this earmarked share—the portion of the VAT revenues tied to performance—as the bonus pool. The bonus pool represented a meaningful fiscal incentive: if distributed uniformly to municipalities, they would represent 141 percent of municipal own-tax revenues prior to the reform on average.

To identify the overall effect of the performance-based transfer, we estimate an event-study design comparing municipalities with different exposure to the reform. Within each state, the total size of the bonus pool is fixed at the state level and identical across municipalities. Therefore, smaller municipalities faced larger per-capita bonus pools and thus stronger incentives to improve performance.

The resulting exposure measure–bonus pool per capita–depends on the state's total VAT revenues, the share tied to education performance, and each municipality's population size. One potential concern is that municipalities with different per capita VAT revenues may have differential outcome trends. To address this, we use municipalities in states without performance-based transfers as a pure control group. These control municipalities allow us to flexibly account for any relationship between per-capita VAT revenues and outcome trends. Our identifying assumption is that, conditional on these controls, differences in exposure in the treated states are unrelated to trends in education quality and other outcomes.

We estimate substantial overall effects of performance-based transfers. A R$ 1 increase in the bonus pool per capita raises student test scores by 0.003 standard deviations. To interpret the magnitude of this effect, we note that this result implies that moving from the 25th to the 75th percentile of the observed bonus pool distribution corresponds to a gain of 0.16 standard deviations. This result is comparable to successful educational interventions documented in the past, such as Krueger [1999] and Muralidharan and Sundararaman [2011].

The magnitude of the overall effect does not, by itself, imply that the introduction of performance-transfers was desirable because it may mask significant equity losses. To see this, consider that municipalities differ in their capacity to provide education. When a performance-based system is introduced, high-performing municipalities receive larger transfers, even absent any behavioral responses. We call these *passive transfers*: transfers independent of performance improvements. They combine unconditional transfers and those due to inframarginal performance. When compared to an equal-sized unconditional transfer, these disparities represent a reallocation of funds from low- to high-capacity municipalities governments that are in lesser need.

Empirically, we document substantial potential equity losses of the performance-based transfers. We begin by estimating municipalities' inframarginal performance using their education quality index prior to the reform. Using these baseline scores, we simulate how much each municipality would have received in VAT transfers if the allocation rule were based on baseline performance or distributed uniformly. This exercise isolates the mechanical disparities that arise from rewarding existing differences in capacity. Our exercise shows that the rewards on baseline performances leads to relevant increases in disparity–under the performance-based rule, "losers" have on average 6.2 % smaller VAT transfers, and "winners" 6.5% larger. Consistent with our simulation, event-study estimates confirm that after the reform, municipalities with higher baseline performance experienced larger increases in transfers.

Next, we quantify how the increase in transfer disparity translates to equity losses. Intuitively, this depends on how additional resources translate into better policy outcomes. To measure this, we decompose the overall effects of the bonus pool into two components: an *incentive effect* and a *passive transfer effect*. The incentive effect is akin to a price effect: bonus pools increase the returns to performance improvements, inducing municipalities to improve outcomes. The passive transfer effect is akin to an income effect: bonus pools reward municipalities' inframarginal actions with larger transfers and relaxe their budget constraints. Because high-capacity municipalities earn disproportionately larger transfers, they achieve disproportionately larger improvements. The incentive effect maps to efficiency gains and are unambiguously desirable from the central government's perspective. The passive transfer effect links disparity in transfers to disparity in outcomes, allowing us to assess the magnitude of equity losses.

We measure variation in passive transfers using quasi-experimental shifts from concurrent reforms to major transfer programs. Specifically, we exploit reforms to two main unconditional transfers, along with variation from the VAT-transfer reform itself. We combine this passive transfer variation with variation in return to improvements from the bonus pool to separately estimate the passive transfer and incentive effects.

The first source of variation in passive transfers arises from the 2007 reform to the state VAT transfer. Prior to the reform, VAT transfers depended on municipalities' demographic characteristics and associated policy weights. For instance, in Ceará, five percent of transfers were based on population size. The reform revised these demographic weights and introduced a new component linked to educational performance. As a result, transfers to municipalities changed for three reasons: (i) adjustments in policy weights for demographic characteristics, (ii) the introduction of weights tied to education, which redistributed funds even with municipalities' performance fixed to pre-reform levels, and (iii) changes in municipalities' characteristics and performance after the reform.

The first two sources of variation are unrelated to municipalities' behavioral responses and therefore provide quasi-experimental variation in passive transfers. In contrast, the third source depends on municipalities' endogenous responses to the reform. To isolate the first two, we simulate the change in ICMS transfers by applying post-reform weights to pre-reform municipal characteristics and performance. Conceptually, these predicted changes in transfers are unrelated to municipalities' performance improvements and correspond to changes in passive transfers.

The second source of variation in passive transfers stems from a federal reform to Brazil's main education fund, the FUNDEB. The education fund 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 a second source of quasi-experimental variation to passive transfer changes.

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

We incorporate the changes in rewards for improvement and passive transfers into an extended event-study framework. Passive transfers vary along two dimensions: changes in unconditional transfers and changes in rewards on inframarginal performance. The former are plausibly more exogenous, as they depend on demographic characteristics such as population size. Accordingly, in our preferred specification we instrument changes in passive transfers using the exogenous variation in unconditional transfers, though the OLS estimates yield similar results.

The estimates indicate that incentive effects from the bonus pool account for virtually all of the policy's overall impact. A one-dollar increase in the bonus pool per capita raises test scores by 0.0027 standard deviations, holding passive transfers constant. By contrast, even the upper bound of the 95 percent confidence interval suggests that an equivalent increase in passive transfers produces an effect roughly fourteen times smaller.

To interpret our findings, we use a simple model of optimal linear transfers in which a central government maximizes aggregate education production and municipalities' utilities with distributional concerns.[6] The model highlights the different implications of the incentive and passive transfer effects to the optimal transfer allocation. Larger incentive effects favor a greater share on conditional transfers, while larger passive transfer effects justify more unconditional ones. Moreover, the model directly maps our empirical estimates to sufficient statistics of the welfare optimal split. The model also highlights a missing piece for welfare analysis–the distributional impact of passive transfers on non-incentivized sectors and outcomes–which we then investigate empirically.[7]

To fully assess the welfare implications of each transfer instrument, we examine their effects beyond the incentivized outcomes. The disparity in transfers could spill over to non-incentivized outcomes through passive transfer effects. Morevover, incentive effects may come at the expense

[6]Since the central government puts more weight on education productio, it is not purely welfarist. Misalignment between central and local governments can stem from multiple sources—for example, interjurisdictional externalities (Oates [1972]), limited voter awareness (Bardhan and Mookherjee [2000]), or interest-group influence (Bardhan and Mookherjee [2006]).

[7]The envelope theorem states that the transfer instruments only impact municipalities' utilities through their budget constraints–any behavioral responses of municipalities should not have first-order impacts to their utilities. However, this may not hold for large policy changes or if the incentivized outcomes are multidimensional, such as in Holmström and Milgrom [1991]. Thus, we also investigate incentives effects on non-incentivized outcomes.

of other valuable outputs, creating multitasking distortions (Holmström and Milgrom [1991]). Observed improvements in incentivized outcomes could also reflect selection of test-takers or manipulation of performance measures rather than genuine learning gains. We investigate each of these potential concerns in turn.

We begin examining effects on municipalities' official expenditures across sectors. We find no evidence of multitasking: incentive effects do not induce reallocation away from non-incentivized areas toward education. However, we find that the disparity in passive transfers leads to disparities in expenditures across sectors, especially in education, health, and adminstrative costs.

Next, we examine non-incentivized outcomes within the education system. Specifically, we analyze performance in the only subject with comparable data before (1999) and after (2019) the introduction of the performance-based transfer: natural sciences. The estimated incentive effects for natural sciences are positive and statistically significant, with a magnitude that lies between the effects observed for the two incentivized subjects, suggesting no evidence of multitasking distortions within education. By contrast, the passive transfer effects are indistinguishable from zero, indicating that the increase in funding disparities did not translate into disparities in non-incentivized educational outcomes.

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 and 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 incentives effect did not impact the share of elementary-age population enrolled in municipal schools, which assuages the concern. The passive transfer effects was also null, indicating no equity concerns in terms of enrollment.

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. The difference-in-difference estimate for the incentive effect on the predicted test scores is statistically indistinguishable from zero, indicating that mayors did not exclude predictably lower-performing students following the introduction of performance-based transfers. As expected, there are no passive transfer effects with respect to the type of student taking the exam. This supports our assumption that changes in passive transfers were exogenous to trends in student composition.

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.

Taken together, our results also indicate that the incentives improvements in test scores were not driven by an increase in educational expenditures, reallocating efforts to incentivized subjects, or the selection of students. This raises the question of what "hidden actions" by mayors led to these improvements. We shed light on this by examining their behavioral responses to the reforms. We begin with input decisions within the education system, which was directly incentivized and for which we have detailed data. Specifically, we draw on systematically collected information from the school census and from teacher and principal surveys conducted through Prova Brasil.

Our results reveal that mayors react significantly different when incentivized and when they receive extra funds. The incentive effect leads mayors to reduce the number of schools and teachers. Consolidating students into well-equiped 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 and widely debated in local media, and consistent with mayors making difficult decisions aimed at improving student performance. In contrast, the passive transfer effect leads mayors to expand staffing, hiring more teachers.

We next examine mayors' responses in terms of corruption. Our data come from a federal anti-corruption program launched in 2003, which audited the use of federal transfers dating back to 1996. Each year, the federal government conducted one to three randomized audits, covering roughly sixty municipalities per round. Beginning in 2006, audit reports were systematically standardized, documenting the identified irregularities, their severity, and the specific expenditure categories inspected.

Our results suggest that municipalities reduced corrupt activities specifically within the education sector, while corruption in other sectors remained unchanged. Because the corruption audit data cover a relatively small number of municipalities, these findings should be viewed as suggestive. Most municipalities were not audited both before and after the reform, limiting our ability to flexibly control for municipality-specific heterogeneity. We estimate multiple specifications to assess robustness. In our favorite specification, which includes state-by-year fixed effects, the incentive effect loses statistical significance but remains economically meaningful.

Overall, our evidence suggests that municipalities improved education outcomes through better management rather than by reallocating resources from other sectors or manipulating performance metrics. At the same time, passive transfers widened disparities in municipal spending, with higher-capacity municipalities increasing expenditures across sectors. We use our model to interpret the welfare implications of our results in two ways. First, we evaluate the desirability of the current reform. Passive transfer disparities have two welfare effects: they change the direct utility that municipalities derive from spending, and the social value from changes in education outcomes. As long as the central government does not value the direct utility from an additional dollar of municipal spending more than eighteen times the social value from education improvements, the reform was welfare enhancing. Second, under stronger assumptions of out sample behavioral responses, the model also allows us simulate the globally optimal mix of conditional and unconditional transfers. Under different assumptions of distributional concerns and valuation of non-incentivized sectors, the results indicate that performance-based transfers should constitute a sizable share of the optimal transfer mix.

Our paper contributes to three strands of literature. First, we contribute to the literature on fiscal federalism. A large body of work studies how intergovernmental transfers shape local public policy, examining both unconditional transfers (Litschig and Morrison [2013], Brollo et al. [2013], Caselli and Michaels [2013], Borge et al. [2015], Loayza and Rigolini [2016], Maldonado and Ardanaz [2021], Aragón and Winkler [2023]) and education-specific transfers (Card and Payne [2002], Hoxby [2001], Jackson et al. [2016], Hyman [2017], Lafortune et al. [2018], Biasi [2021], Jackson and Mackevicius [2021], Jackson and Mackevicius [2024], Otero et al. [2025]) on local public policy outcomes, finding mixed results.[8] Relative to these papers, we compare the relative merits of unconditional and conditional on performance transfers. The closest paper to ours is Olken et al. [2014], who randomized village block grants in Indonesia to either a performance-based or an unconditional design. We extend their analysis in two ways. First, we document that performance-based transfers amplify fiscal disparities across municipalities, translating into unequal spending across sectors. Second, we map our reduced-form estimates into sufficient statistics for the optimal transfer mix, quantifying the efficiency–equity trade-off inherent to transfer design.

Second, we contribute to the literature comparing conditional and unconditional cash transfer programs. Several papers study the impacts of unconditional transfers (e.g., Haushofer and Shapiro [2016], Barr et al. [2022], Egger et al. [2022], Banerjee et al. [2023]), conditional transfers (e.g., Angelucci and Giorgi [2009], Barrera-Osorio et al. [2011], Glewwe and Kassouf [2012], Chioda et al. [2016], Gérard et al. [2024]), or directly compare the two (e.g., Baird et al. [2011]). A central insight from this literature is that conditional transfers can more effectively improve targeted outcomes but may exclude noncompliers who are often the most in need–analogous to low-capacity municipalities in our setting. We extend this literature along three dimensions. First, we study intergovernmental rather than individual transfers. Second, we quantify the equity losses associated with performance-based transfers. Third, we connect our empirical estimates to a model of optimal transfer design to assess the welfare-maximizing mix of conditional and unconditional instruments.

Third, we contribute to the literature on incentives versus resources in education. Several paper study performance pay or increases in wages for teachers (e.g., Brown and Andrabi [2025], Andrabi and Brown [2025], Biasi [2021], de Ree et al. [2018], Fryer [2013], Goodman and Turner [2013], Leaver et al. [2021], Muralidharan and Sundararaman [2011], Rothstein [2015]), others have analyzed incentives and increased resources to schools (e.g., Mbiti et al. [2019], Loyalka et al. [2019], Reback et al. [2014], Kane and Staiger [2002], Nguyen and Redding [2025], Kraft et al. [2020]), and some have analyzed increased transfers to local governments as cited above. Relatively

[8] The evidence on unconditional transfers, especially in Brazil, find disappointing results. An important exception is Litschig and Morrison [2013]. The evidence on education-specific transfers, mostly from the U.S., is generally positive.

few papers investigated performance-based transfers to local governments for education, with the notable exception of Olken et al. [2014] and others that analyzed the policies in Ceará (Lautharte et al. [2020], Evans et al. [2020]). Relative to this literature, we disentangle the incentive and resource effects of performance-based transfers at the local government level, and analyze the optimal mix of transfer instruments.

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.

As shown in Appendix figure A.1, these minimum spending requirements on education were largely binding for municipalities in Ceará and Pernambuco as of 2006. Consequently, we consider municipalities' share of expenditures across sectors as fixed. Nonetheless, we empirically test this assumption in section 7.

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 (VAT) levied on the circulation of goods and services. A portion of the VAT revenue is transferred to municipalities, representing the principal source of state-to-municipality funding. By the constitution, 75% percent of the VAT transfer is allocated proportionally to each municipality's contribution to total state VAT 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 VAT 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 linked a share (τ) of the state VAT revenues (T_{VAT}) to municipalities' relative performances in education. In the state of Ceará, the share τ was set as 18% of the total VAT revenues. In the state of Pernambuco, it was set to 3%.[9]

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

The reform in Ceará was initiated by the former mayor of Sobral, who previously implemented several reforms *"politically unattractive but educationally effective."*[10] These included merit-based personnel rehiring, performance-linked pay for teachers and principals, and consolidating students into well-equiped schools. Sobral's education policies resulted in significant improvements and have been widely recognized as a case of success in educational policies.[11] In their annual meetings, state officials in Ceará also recommend education improvement policies modeled after Sobral's successful reforms.

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

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

[10] This quote comes from a conversation with a former senior official in Ceará's administration.

[11] In 2003, Sobral was ranked in the 26$^{\text{th}}$ perentile of the math test scores distribution. By 2007, it was in the 65$^{\text{th}}$. 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

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–VAT, FPM, and FUNDEB–form a significant portion of municipalities' revenues. Appendix figure A.3 illustrates the percentage of the sum of VAT, 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.

2.4 Measuring Changes to the Bonus Pool and Passive Transfers

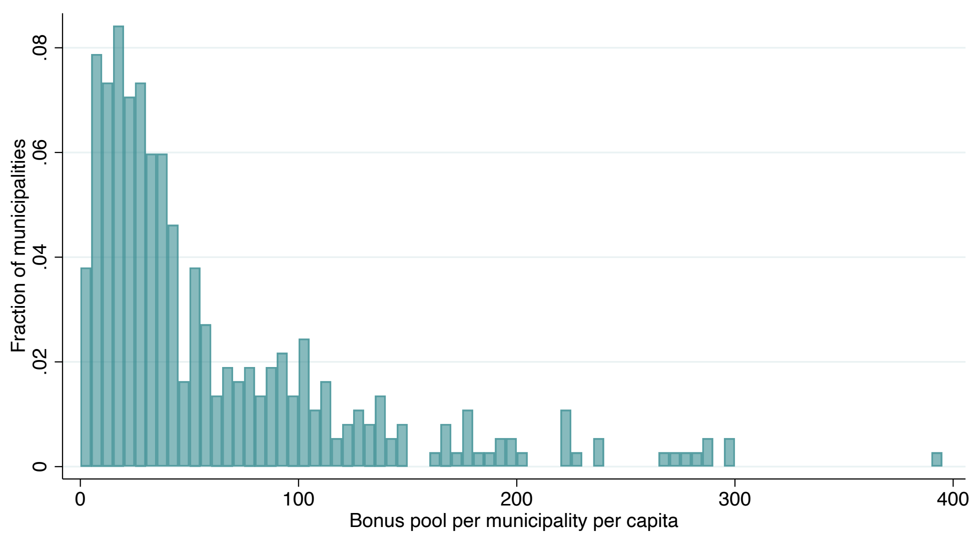
Measuring changes to the bonus pool: Note that the resulting state-level bonus pool, $T_{\text{VAT}} \cdot \tau$, is identical across municipalities, regardless of population size. Our identification strategy assumes that municipalities care about transfers per capita, which implies that less populous municipalities faced greater incentives from the reform. Thus, our measure exposure to the performance-based transfer is defined as the bonus pool per capita:

$$\Delta\beta^m = \frac{T_{\text{VAT}} \cdot \tau}{N^m} \tag{1}$$

where N^m is each municipality's population size pre-reform, T_{VAT} are the state VAT revenues and τ is the share conditional on performance.

The per capita bonus pool, β^m, represents a significant financial incentive for municipalities. Figure 1 shows the distribution of the per capita bonus pool for the treated municipalities. To gauge the their fiscal relevance for municipalities, Panel (a) of Appendix figure A.2 shows the distribution of the per capita bonus pool as a share of each municipality's total revenue. Panel (b) shows the per capita bonus pool 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: Distribution of the bonus pool per capita



Notes: This figure shows the distribution of the per capita bonus pool for the treated municipalities. To gauge the their fiscal relevance for municipalities, Panel (a) of Appendix figure A.2 shows the distribution of the per capita bonus pool as a share of each municipality's total revenue. Panel (b) shows the per capita bonus pool 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, the last pre-reform year.

Measuring changes in passive transfers: We define passive transfers as all transfers that are independent of improvements in educational performance. Passive transfers combine both unconditional transfers and transfers that depend on baseline performance. Thus, changes in passive transfes are measured as:

$$\Delta y^m = \Delta\alpha^m + \Delta\beta^m \cdot f_{\tilde{A^m}} \tag{2}$$

where $\Delta\alpha^m$ represents changes in per capita unconditional transfers, $\Delta\beta^m$ captures changes in the per capita bonus pool, and $f_{\tilde{A^m}} = \frac{A^m}{\int_{m'} A^{m'} dm'}$ denotes each municipality's relative pre-reform performance level. Equation 2 makes clear that municipalities with larger baseline performances are rewarded with larger passive transfers.

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

The VAT transfers received by municipalities changed after the reform for three reasons. First, the reform updated weights on municipal demographic characteristics unrelated to education. Second, the introduction of a performance-based component rewarded municipalities' with larger baseline performances. Third, municipalities could alter their characteristics and educational performance post-reform.

The first two sources of variation from VAT transfers are plausibly exogenous and correspond to changes in passive transfers. The first variation corresponds to changes in the unconditional component of VAT transfers, and we denote it $\Delta\alpha^m_{\text{VAT}}$. The second correspond to the component conditional on baseline performance, and we denote it as $\Delta\beta^m \cdot A^m$. To exclude the variation in transfers coming from municipalities' behavioral change, we simulate counterfactual VAT transfers using post-reform policy weights applied to pre-reform municipal characteristics and educational performance.

The two unconditional transfers analyzed–FPM and FUNDEB–also generated variation to the unconditional component of passive transfers. As described in section 2.3, 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 $\Delta\alpha^m_{\text{FPM}}$.

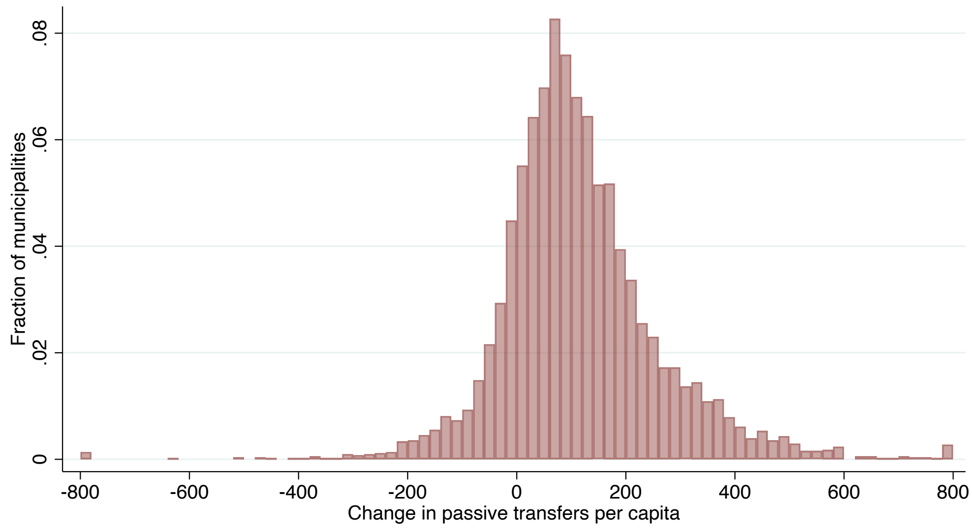
As described in section 2.3, FUNDEB pools municipal contributions and redistributes them based on student enrollment across various educational categories (e.g., high school). Similar to previous transfers, we simulate how contributions and transfers would change if municipal characteristics–such as local taxes and student numbers–remained constant and denote it as $\Delta\alpha^m_{\text{FUNDEB}}$.

We combine these simulated changes to construct a comprehensive measure of the change in passive transfers:

$$\Delta y^m = \Delta\alpha^m_{\text{FPM}} + \Delta\alpha^m_{\text{FUNDEB}} + \Delta\alpha^m_{\text{VAT}} + \Delta\beta^m \cdot \tilde{f_{A^m}} \tag{3}$$

Figure 2 plots the distribution of the change in passive transfers per capita across municipalities, showing that the changes were substantial and relevant for municipalities service provision.

Figure 2: Change in passive transfers per capita



Notes: This figure shows the changes in passive transfers per capita for municipalities. Passive transfers combine unconditional transfers and transfers that depend on inframarginal performance. Variation comes from concurrent reforms to three municipal transfers that on average correspond to 65% of municipalities' total revenues. Our measure of changes in passive transfers is constructed simulating how the reforms change transfers if municipal characteristics and educational performance remained constant.

These simulation exercises require accurate measurement of municipalities' pre-reform characteristics and correct interpretation of the formula weights. Appendix C details the construction of simulated passive transfers and validates our procedure. Appendix Figure C.1 shows that our predicted transfers based on pre-reform characteristics and weights correlate at 0.999 with actual pre-reform VAT transfers. Predictions using post-reform parameters perform similarly well. Appendix figures C.2 and C.3 demonstrate comparable accuracy for FUNDEB and FPM transfers, respectively.

2.5 Data and Sample Selection

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.[12] 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.[13] It is also not used in any other transfer allocation or incentive scheme.

Given that the reform was inspired by the municipality of Sobral's education policies and that other municipalities were encouraged to adopt similar strategies, one could argue that the municipality of Sobral should be removed from the analysis. In Appendix F.2, we replicate the main results excluding Sobral and show that the results are robust to its exclusion.

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 Overall effects of performance-based transfers

3.1 Overall Effects on Incentivized Outcomes

We begin our empirical analysis by estimating the overall effect of performance-based transfers on student achievement. Specifically, we examine how a one-dollar increase in the per capita bonus pool affects test scores, leveraging the introduction of the reform in an event-study design. This total effect reflects two underlying forces: an incentive effect, as larger bonus pools raise the returns to performance improvements, and a passive transfer effect, as they also relax municipal budget constraints. In Section 4, we disentangle these two channels empirically.

[12]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.

[13]We discuss concerns of manipulation in section 6.2 and conduct our main analysis separately for each state in Appendix A.

As described in Section 2, the identification strategy exploits the fact that the bonus pool is the same for all municipalities in the same state. E.g., municipalities in Ceará competed for 379.2 million reais in 2008, and each municipality received a share of the bonus pool based on their relative performance. We assume that municipalities care about per capita transfers, which 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:

$$f_{it}^{m} = \nu^{m} + \nu_{st} + g_t\left(T^{m}\right) + \sum_{y \neq 2007} \theta_y \Delta\beta^{m} \times \mathbf{1}[t = y] + \epsilon_{imt} \tag{4}$$

where f_{it}^{m} denotes the standardized test of student i in municipality m in year t. In specifications with municipality-level outcomes, such as revenues or expenditures, the outcome variable is Y_t^m for municipality m in year t. The municipality fixed effects (ν^m) absorb all time-invariant differences among municipalities, such as differences in production capacity. The state-year fixed effects (ν_{st}) capture any time-varying shocks that are common to all municipalities in the same state.

The variable of interest, $\Delta\beta^m$, represents the change in per-capita bonus pool for municipality m. As shown in equation 1, this change depends on per-capita VAT revenues, $T^m = \frac{T_{\text{VAT}}}{N^m}$, and the share tied to education performance, τ. One potential concern is that municipalities with different per-capita VAT revenues may exhibit different trends in outcomes. To address this, we use the pure control group–states that never introduced performance-based transfers–to flexibly account for heterogeneous trends. Specifically, we include decile-by-year fixed effects based on per-capita VAT revenues, $g_t\left(T^m\right)$. Treatment effects are thus identified from leftover variation in bonus pool exposure within treated states, exploiting the fact that share τ of VAT revenues was tied to education performance. Standard errors are clustered 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:

$$f_{it}^{m} = \nu^{m} + \nu_{st} + g_t\left(T^{m}\right) + \theta\Delta\beta^{m} \cdot Post_t + \epsilon_{it}^{m} \tag{5}$$

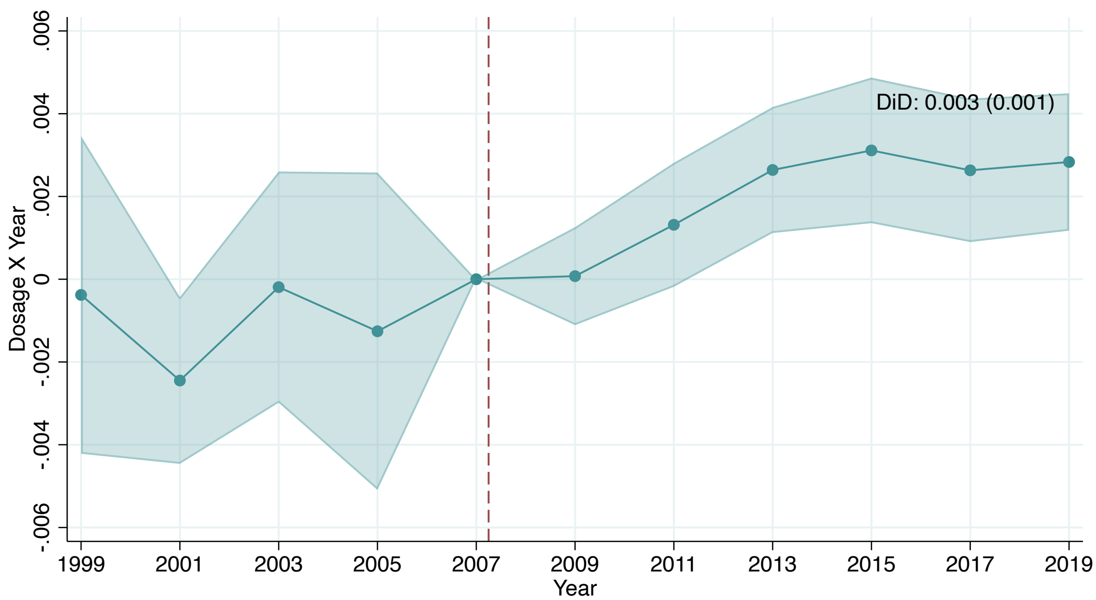
where $Post_t$ is an indicator function that takes the value of one if $t > 2007$. I.e., after the introduction of the performance-based transfer.

Our empirical strategy is akin to a triple-difference design. The first difference compares municipalities with varying per-capita VAT revenues (T^m) within control states. Because the state VAT revenues is common within a state, this comparison effectively traces how municipal population size correlates with trends in student outcomes absent the reform. Appendix figure D.1 presents the corresponding event-study and shows no evidence of differential pre-trends.

The second difference compares municipalities with different per-capita bonus pools within treated states. Appendix Figure D.2 reports the event-study estimates: test scores rise post-reform in municipalities with larger per-capita bonus pools, with no significant pre-trends.

Our main specification in Equation 4 nets out both differences. Figure 3 plots the estimated coefficients ρ_y and their 95 percent confidence intervals. Consistent with the parallel pre-trends assumption, test scores show no significant changes prior to the introduction of performance-based transfers. It is worth noting, however, that pre-reform standard errors are larger because the data for early years consist of repeated cross-sectional samples rather than a full census of schools. The first year with data covering all schools with at least 20 students is 2007, the last pre-reform observation. Following the reform, we find sizable and statistically significant improvements in student performance among municipalities with larger per-capita bonus pools. A R$ 1 increase in the per-capita bonus pool raises test scores by 0.002 standard deviations. Scaling by the observed distribution of the bonus pool, moving from the 25th to the 75th percentile implies an improvement of 0.13 standard deviations. This is a substantial effect, comparable to the impact of successful major education interventions documented in the literature such as Krueger (1999) and Muralidharan and Sundararaman (2011).

Figure 3: Overall effects of performance-based transfers



This figure shows the overall effects of performance-based transfers on student test scores. It plots the θ_y coefficients from estimating equation 5: $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{it}^m$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{it}^m 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 students; prior to 2005, the sample comprises random student samples from municipal schools.

The overall effects of the performance-based transfer do not, by themselves, reveal whether improvements in student performance were driven by stronger incentives or by larger passive transfers.

To illustrate this point, Appendix Figure A.4 panels (a)-(c) plot the effect of the bonus pool on per-capita VAT transfers, total municipal revenues, and education expenditures. The estimates show that municipalities exposed to larger bonus pools received higher transfers and, correspondingly, increased their revenues and education spending. In section 4, we decompose the overall effects into incentive and passive transfer effects.

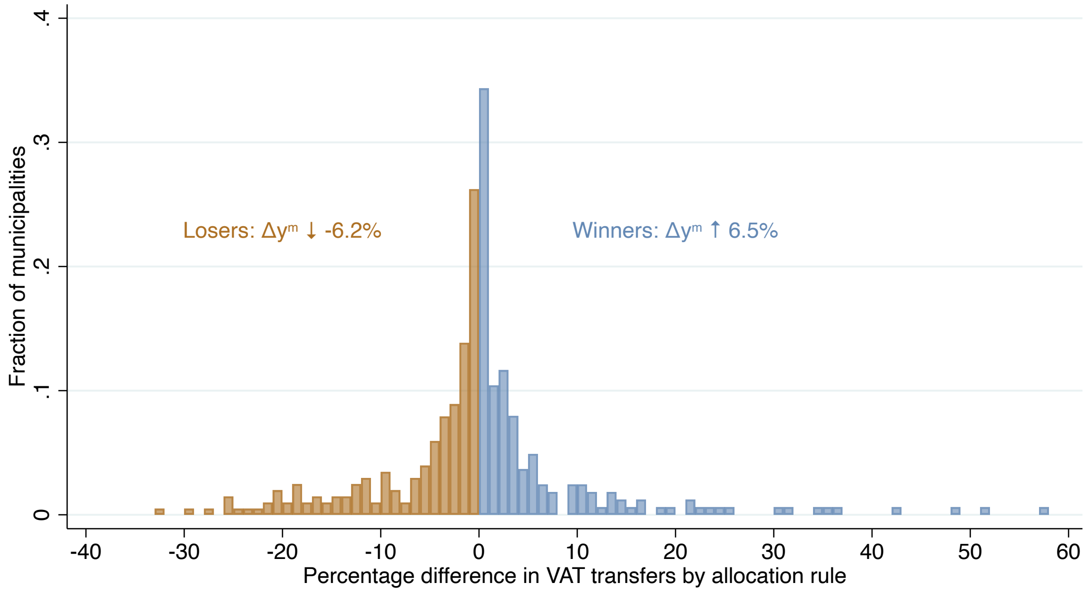
Appendix F reports robustness checks for our main results. While our primary analysis examines standardized math scores, figure F.1 presents analogous estimates using Portuguese test scores as the outcome. Both subjects were incentivized under the reform. Figure F.4 excludes the municipality of Sobral, whose earlier reforms inspired the statewide policy. The results remain qualitatively similar across both specifications. We address concerns about multitasking distortions and strategic manipulation in section 6.

3.2 Potential Equity Losses from Performance-Based Transfers

Despite substantial magnitudes of the overall effects on test scores, we cannot yet conclude if the introduction of performance transfers was desirable because it could mask significant equity losses. The performance-based allocation rule rewards municipalities with higher baseline performance, generating disparities in transfers across municipalities. Compared to an equal-sized unconditional transfer, this represents a reallocation of funds from low- to high-capacity municipal governments.

To quantify the potential equity losses created by performance-based transfers, we simulate how the reform reallocates resources across municipalities. We first estimate each municipality's baseline performance using its pre-reform education quality index. We then compute the VAT transfers each municipality would have received if the bonus pool were distributed according to baseline performance versus uniformly across municipalities. Figure 4 plots the distribution of percentage differences between the two allocations. The results reveal substantial potential equity losses: "losers"—municipalities with below-average baseline performance—receive on average 6.2 percent less, while "winners" with above-average performance gain 6.5 percent.

Figure 4: Increase in disparity of passive transfers



This figure shows the distribution of percentage differences in VAT transfers received by municipalities if the bonus pool were distributed according to baseline performance versus uniformly across municipalities. The x-axis represents the percentage difference in transfers, while the y-axis indicates the fraction of municipalities. The results reveal substantial increase in the disparity of passive transfers and potential equity losses.

To probe the simulation results, we estimate how transfers changed across municipalities with different baseline performance levels using an event-study framework. The results, shown in appendix figure A.5, confirm that municipalities with higher pre-reform performance experienced disproportionately larger transfer increases, consistent with the simulated disparities.

Whether these disparities translate into equity losses depends on how additional passive transfers affect policy outcomes. The next section decomposes the overall effects of the bonus pool into incentive and passive transfer effects. As detailed in Section 5, our conceptual framework maps these two empirical effects into measures of efficiency gains and equity losses from performance-based transfers.

4 Incentives and passive transfer effects

As discussed in Section 3, the overall impact of the bonus pool combines two distinct components: an incentive and a passive-transfer effect. The incentive effect arises because a larger bonus pool increases the return to performance improvements. The passive-transfer effect arises because a larger pool also relaxes municipal budget constraints. Disentangling these two components empirically is crucial for assessing how much the resulting disparities in transfers translate into equity losses. As shown in Section 5, the two effects are also part of the sufficient statistics for the optimal allocation of transfers.

To formalize the discussion and link the data to the two mechanisms, we define the empirical production function for standardized test scores as

$$f_{i,t}^{m} = zI(r_t^m, y_t^m) + f_{\tilde{A^m}} + \varepsilon_{it}^{m} \tag{6}$$

where $I(r_t^m, y_t^m)$ denotes the Marshallian investment demand function,[14] which depends on the return to performance improvements r_t^m and on passive transfers y_t^m, and z is the marginal productivity of investments. The term A^m captures inframarginal productivity differences across municipalities. We assume that $f_{\tilde{A^m}}$ is time invariant and that investment decisions do not depend on it, though we relax the latter assumption in heterogeneity analyses in Appendix E. Finally, ε_{it}^{m}represents idiosyncratic shocks to student i outcomes.

Using a first-order approximation of the investment function, we show in Appendix H.1 that the effect of the reforms on student outcomes can be decomposed as

$$\Delta f_t^{m,z} \approx \underbrace{z\left(\frac{\partial I_t^m}{\partial r}\frac{\partial r}{\partial \beta}\right)}_{\rho}\Delta\beta^m + \underbrace{\pi\left(\frac{\partial I_t^m}{\partial y^m}\right)}_{\gamma}\Delta y^m + \Delta\varepsilon_t^m \tag{7}$$

where $\Delta\beta^m$ denotes the change in the per-capita bonus pool, while $\Delta y^m = \Delta\alpha^m + f_{\tilde{A^m}}\Delta\beta^m$ represents the change in passive transfers, combining both the shift in unconditional transfers ($\Delta\alpha^m$) and the increase due to bonuses rewarding higher inframarginal performance ($f_{\tilde{A^m}}\Delta\beta^m$). The parameter ρ captures the incentive effect: how higher returns to performance improvements translate into gains in educational outcomes. By contrast, γ captures the passive transfer effect, reflecting how additional resources affect outcomes. In section 5, we will show how both ρ and γ are key sufficient statistics for the optimal allocation of transfers.

In Section 2, we described how three concurrent transfer reforms generate quasi-experimental variation in both the bonus pool and passive transfers. We now use the estimated changes in $\Delta\beta^m$ and Δy^m to separately identify the two effects through the following extended event-study design:

$$f_{it}^{m} = \nu^m + \nu_{st} + g_t\left(T^m\right) + \sum_{y \neq 2007}\left(\rho_s\Delta\beta^m + \gamma_s\Delta y^m\right) \times 1[t = y] + \epsilon_{imt}. \tag{8}$$

The coefficients ρ and γ estimate the incentive and passive-transfer effects, respectively. The specification includes the same controls as equation 4. Municipality fixed effects (ν^m) absorb time-invariant differences such as production capacity, while state-year fixed effects (ν_{st}) account for time-varying shocks common within states, including contemporaneous policies.

The change in the bonus pool, $\Delta\beta^m$, is defined in equation 1 and depends on per-capita VAT revenues $T^m = T_{\text{VAT}}/N^m$ and the share tied to educational performance τ. A potential concern is that municipalities with different per-capita VAT revenues may follow distinct underlying trends. To

[14] The Marshallian investment demand function will be defined formally in section 5, but for the empirical exercise it suffices to interpret the investment decision as depending on these two parameters which we measure in the data.

address this, we use the control states—those that never introduced performance-based transfers—to flexibly account for heterogeneous trends across municipalities with different per-capita VAT levels. Specifically, we include decile-by-year fixed effects in per-capita VAT revenues, $g_t(T^m)$.

The average effect of the incentive and passive transfer effects across all post-implementation periods can be estimated with a standard DD specification:

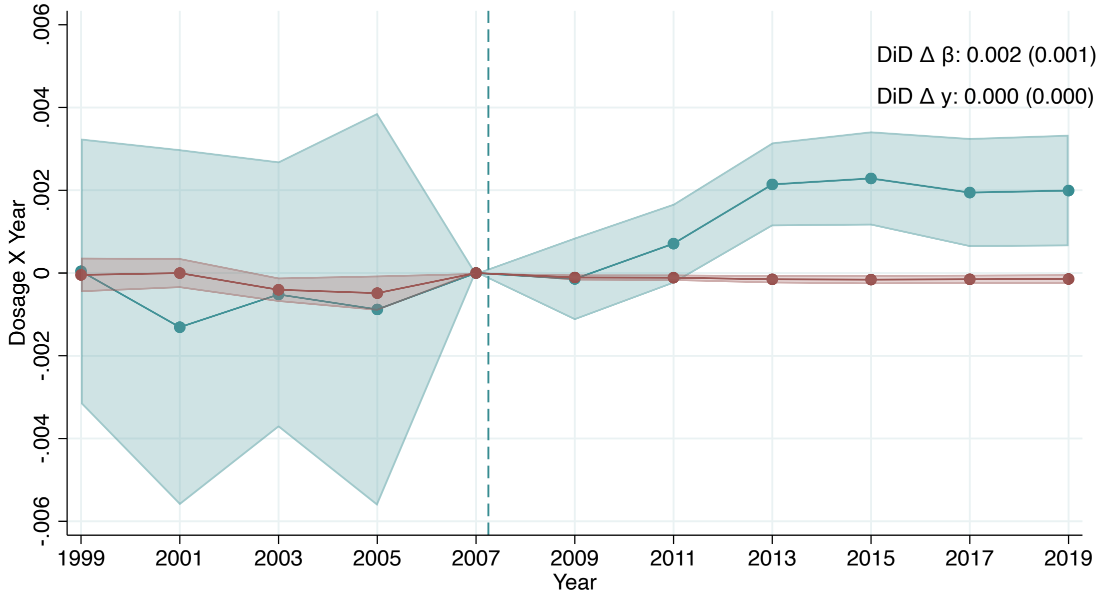
$$f_{it}^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \rho\left(\Delta\beta^m \cdot Post_t\right) + \gamma_s\left(\Delta y^m \cdot Post_t\right) + \epsilon_{it}^m \tag{9}$$

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.

Figure 5 reports estimates of ρ_s and γ_s.[15] 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 passive transfers 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 0.0017 standard deviations.

[15] Figure A.6 presents the estimates of γ_s using total revenues as the outcome. After the reform, each additional dollar in predicted passive transfers results in a corresponding dollar increase in actual revenues. Appendix Figure A.7 shows the corresponding estimates of ρ_s. The results are noisy, but indicate that after controlling for predicted passive transfers, municipalities with larger bonus pools experience no significant revenue changes.

Figure 5: Incentive effects and passive transfers



This figure shows the incentive and passive transfer effects, estimated using the extended event-study specification from equation 8: $f_{it}^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \sum_{y \neq 2007}\left(\rho_s \Delta\beta^m + \gamma_s \Delta y^m\right) \times 1[t = y] + \epsilon_{it}^m$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t\left(T^m\right)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_{it}^m is the residual. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 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 samples of municipal school students. Appendix Figure A.7 shows ρ_s estimates using the using total municipal revenue as the outcome, and Appendix figure A.6 shows the γ_s estimates. They confirm that the bonus pool does not impact revenues when conditioned on passive transfers, while changes in passive transfers increase revenues.

The identification of the null effects of passive transfers may be challenged on two main grounds. First, recall that passive transfers are defined as the sum of unconditional transfers ($\Delta\alpha^m$) and transfers conditional on relative baseline performance, $\Delta\beta \tilde{f_{A^m}}$. Our simulation of changes in unconditional transfers relies on pre-reform municipal characteristics and policy-weight adjustments—a plausibly exogenous and widely used approach in the literature. However, the simulated changes in transfers conditional on relative baseline performance, $\Delta\beta \tilde{f_{A^m}}$, may be subject to mean reversion bias.[16] To address this concern, Appendix Figure F.6 reports estimates of equation 8 using only variation in unconditional transfers within the control group—states that never adopted performance-based transfers. The estimated coefficients remain close to zero and precisely estimated, supporting

[16]To see this, suppose that the distribution of test scores follows a random walk. Municipalities experiencing a positive shock before the reform would appear to have high relative performance ($\tilde{f_{A^m}}$) and thus a large simulated increase in passive transfers. Because the positive pre-reform shock was random, these municipalities would exhibit lower subsequent test scores, biasing the estimated passive transfer effect downward.

the validity of our identification strategy. This contrasts to their positive effects on revenues and expenditures in education shown in figure F.7, which validates our simulation of the the unconditional transfers.

Second, our baseline specification assumes that both components of passive transfers have identical effects on student outcomes. This assumption may not hold in practice. For example, $\Delta\beta f_{\tilde{A^m}}$ could partly capture heterogeneity in the incentive effect with respect to baseline performance. To explore this possibility, Appendix E conducts a series of heterogeneity exercises. Appendix Figure E.1 first estimates equation 8 including each component of passive transfers separately. The resulting estimates are noisy and do not provide clear evidence of differential effects. In a complementary analysis, we divide municipalities into deciles of baseline performance $f_{\tilde{A^m}}$ and estimate, for each subsample, a difference-in-differences specification analogous to equation 9. The results from figure E.2 show that the effects of the bonus pool, $\Delta\beta^m$, are positive only among municipalities with high baseline performance. This pattern admits two possible interpretations: (i) incentive effects may be stronger for high-capacity municipalities, or (ii) passive transfer effects may differ between transfers tied to inframarginal performance and unconditional transfers. Under either interpretation, these findings suggest that equity losses may be even larger once the heterogeneity of effects is taken into account.

The overall null effects of passive transfers on education outcomes may appear surprising, given the positive impacts of additional funding documented in the literature. We see two main reasons for this difference. First, studies in the Brazilian context have typically found discouraging effects of increases in unconditional transfers on policy outcomes. Second, most education finance reforms examined in prior work reallocated resources from low- to high-need areas, while none of the reforms we study were designed with such redistributive goals. As discussed in Section 2, the reform to the main education fund (FUNDEB) modified the weights assigned to student categories—for example, municipalities with relatively more high-school students benefited disproportionately. Variation in FPM transfers arose from updates in population counts. The VAT-transfer reform, if anything, favored higher-capacity municipalities with stronger baseline performance. Appendix Figure E.3 reinforces this interpretation: when restricting the sample to the control group, we find that the effects of unconditional transfers are positive only among low-performance municipalities—consistent with the literature showing positive returns to resources in high-need settings.

Section 3 documented large overall effects of the bonus pool but suggested that these could mask substantial equity losses. In this section, we decomposed the overall effect into two components and found muted passive transfer effects, with the incentive effect accounting for nearly all observed improvements. The next section formalizes this equity-efficiency trade-off through a simple conceptual framework that derives sufficient statistics for the optimal transfer mix. It also highlights additional empirical implications for evaluating the desirability of performance-based transfers, which we test in Section 6.2.

5 Conceptual framework

In this section, we develop a simple optimal transfer model, where municipalities can either invest their transfers in the public good (education) or consume them elsewhere. Inspired by the Brazilian intergovernmental transfer system, the central government has two policy instruments: a performance-based transfer and an unconditional transfer.[17] The model highlights the equity-efficiency trade-off of conditioning transfers. Increasing the performance-based transfer incentivizes all municipalities to invest more in the public good, which leads to efficiency gains. However, it also rewards municipalities with high state capacity to produce the public good with larger transfers, which leads to equity losses.

Relative to a standard linear income transfer model,[18] we make two simple modifications. The first difference is in the misalignment of agents and the planner. In the standard linear income transfer model, misalignment arises because of the fiscal externality: labor decisions affect the public budget but are not internalized by the individual. In our model, misalignment arises because of differences in preferences: the central government values municipalities' utilities but places additional weight on education production.[19] The second difference is in the production function. We explicitly model an inframarginal component of production depedent on municipalities' capacity. This implies that larger bonuses reward high capacity municipalities with larger transfers for every investment choice.

The model yields sufficient statistics for characterizing the optimal transfer policy and in appendix H we show how to map the reduced form estimates from Section 4 to formula.

5.1 Uniform Unconditional Transfers and Bonus Pool

There is one central government and a unit mass of municipalities m. They receive transfers T^m and choose whether to invest them to produce the public good, I^m, or consume it elsewhere, C^m. The utility $u\left(I^m, C^m\right)$ is continuous, strictly increasing, and concave on investments in education and consumption elsewhere. Municipalities may enjoy allocating resources to either education and to other sectors because they represent valuable public goods for citizens. Alternatively, consumption elsewhere could also be interpreted as pure private consumption (corruption) from mayors.

The municipalities are heterogeneous in their capacity (type) to produce the public good, A^m. Their production is simplified to be separable and linear in the type of municipality and the amount

[17] A less common transfer instrument is a conditional transfer based on changes in performance metrics. We discuss their tradeoffs in section 5.2

[18] The standard linear income tax model is reviewed in Atkinson and Stiglitz (2015) chapter 13 and in Piketty and Saez (2013).

[19] In this sense, our model deviates from a pure welfarist planner. 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. Misalignment between central and local governments can stem from multiple sources—for example, interjurisdictional externalities (Oates [1972]), limited voter awareness (Bardhan and Mookherjee [2000]), or interest-group influence (Bardhan and Mookherjee [2006]).

of the transfers invested in the public good: $f^m = zI^m + f(A^m)$, where z is the marginal productivity of investment.[20] Call $f_I^m = zI^m$ the investment dependent production, $f_{A^m} = f(A^m)$ the inframarginal production, and $F = \int_m f^m dm$ the aggregate production.

The central government is restricted to allocate a fixed budget B to two policy instruments: a share τ is allocated to the bonus pool, β, and the remaining $1-\alpha$ is distributed via an uniform unconditional transfer, α. Inspired by the Brazilian intergovernmental transfer system, the transfer that municipalities receive is given by $T_t^m = \underbrace{\tau B}_{\beta} \tilde{f}^m + \underbrace{(1-\tau)B}_{\alpha}$, where $\tilde{f}_t^m = \frac{f_t^m}{F}$ are relative productions of municipalities.

Using the transfer allocation rule, we can rewrite the municipality's problem as a simple two-goods consumption problem:

$$\max_{C,I} u(C,I) \tag{10}$$
$$\text{s.t. } C^m + (1-r)I^m = y^m$$

where the relative price of investing in education is given by one minus the marginal return of investment to the municipality: $(1-r) = 1 - \frac{\tau B z}{F}$. The passive transfers–that is, transfers received without any investment–are denoted by y^m and equal to

$$y^m = \underbrace{(1-\tau)B}_{\text{Unconditional transfers } =\alpha} + \underbrace{\tau B \tilde{f_{A^m}}}_{\text{Conditional on inframarginal production}}$$

where $\tilde{f_{Am}} = \frac{f_{Am}}{F}$ is the relative inframarginal production. The first term represents the unconditional transfer, α, which is $(1-\tau)$ share of the budget B. The second term represents the performance-based transfer that municipalities receive based on their inframarginal production, f_{A^m}. This component of the transfer rewards high-capacity municipalities with larger transfers, leading to potential equity losses.

There are two results of the municipality's problem which are worth highlighting. First, the municipality's problem defines Marshallian functions and Slutsky equations.[21] E.g., the Marshallian demand for investments in education is given by $I((1-r), y^m)$ and the Slutsky equation with respect to the share allocated τ to the bonus pool is given by:

$$\frac{dI^m(1-r, y^m)}{d\tau} = \underbrace{\frac{\partial I^{m,h}}{\partial \tau}}_{\text{substitution effect}} + \underbrace{\frac{\partial I^m}{\partial y^m} B \left[\tilde{f_{I^m}}\right]}_{\text{usual income effect}} + \underbrace{\frac{\partial I^m}{\partial y^m} B \left(\tilde{f_{A^m}} - 1\right)}_{\text{inframarginal rewards}} \tag{11}$$

where $\frac{\partial I^{m,h}}{\partial \tau}$ is the Hicksian (compensated) substitution effect of investment, $\frac{\partial I^m}{\partial y^m}$ is the income partial of investment, $\tilde{f_{I^m}} = \frac{f_{I^m}}{F}$ is the relative investment production, and $\tilde{f_{A^m}} = \frac{f_{A^m}}{F}$ is the relative inframarginal production.

[20] In appendix E we allow empirically for the production on investment to be heterogeneous by type: $f^m = g(I^m, A^m) + f(A^m)$.

[21] The full derivation of the Slutsky equation is in appendix G.

The first term, the substitution effect, has the same meaning and interpretation as usual. It is positive and shifts transfers to more investments as the share τ increases. The second component, the income effect, also has the usual interpretation: it captures how investment changes due to the change in real passive transfers caused by a change in the return to investment. As always, it needs to scale the income partial, $\frac{\partial I^m}{\partial y^m}$, by the negative of the amount that the expenditure function changes as we change τ.

The third component reflects the key distributional tradeoff of the two transfer instruments. A decrease in unconditional transfers reduce the passive transfer of all municipalities by $1 \cdot B$. The increase in the bonus pool increases municipalities passive transfers by $\tilde{f_{A^m}} \cdot B$. Municipalities with inframarginal production above average production $f_{A^m} > F$ get rewarded with larger passive transfers $B\left(\tilde{f_{A^m}} - 1\right) > 0$, and municipalities with inframarginal production below average production get punished with lower passive transfers, $B\left(\tilde{f_{A^m}} - 1\right) < 0$.

The second result of the municipality's problem comes from the envelope theorem. Define the indirect utility of municipalities as $v(r, y^m(r))$. The envelope theorem states that their utility changes with the transfer instruments only via direct effects on their budget constraint:

$$\frac{\partial v(r, y^m(r))}{\partial \tau} = \lambda \left[B\left(\tilde{f_{A^m}} - 1\right) + B f_{I^m}\right]$$

where $\lambda = \frac{\partial u}{\partial C^m}$ is the lagrange multiplier of the municipality's problem–the private marginal utility of passive transfers. This result implies that any behavioral change (e.g., distortions to municipalities' consumption elsewhere) does not have first order impacts on municipalities' utilities. Nonetheless, we investigate multitasking concerns in section 6.

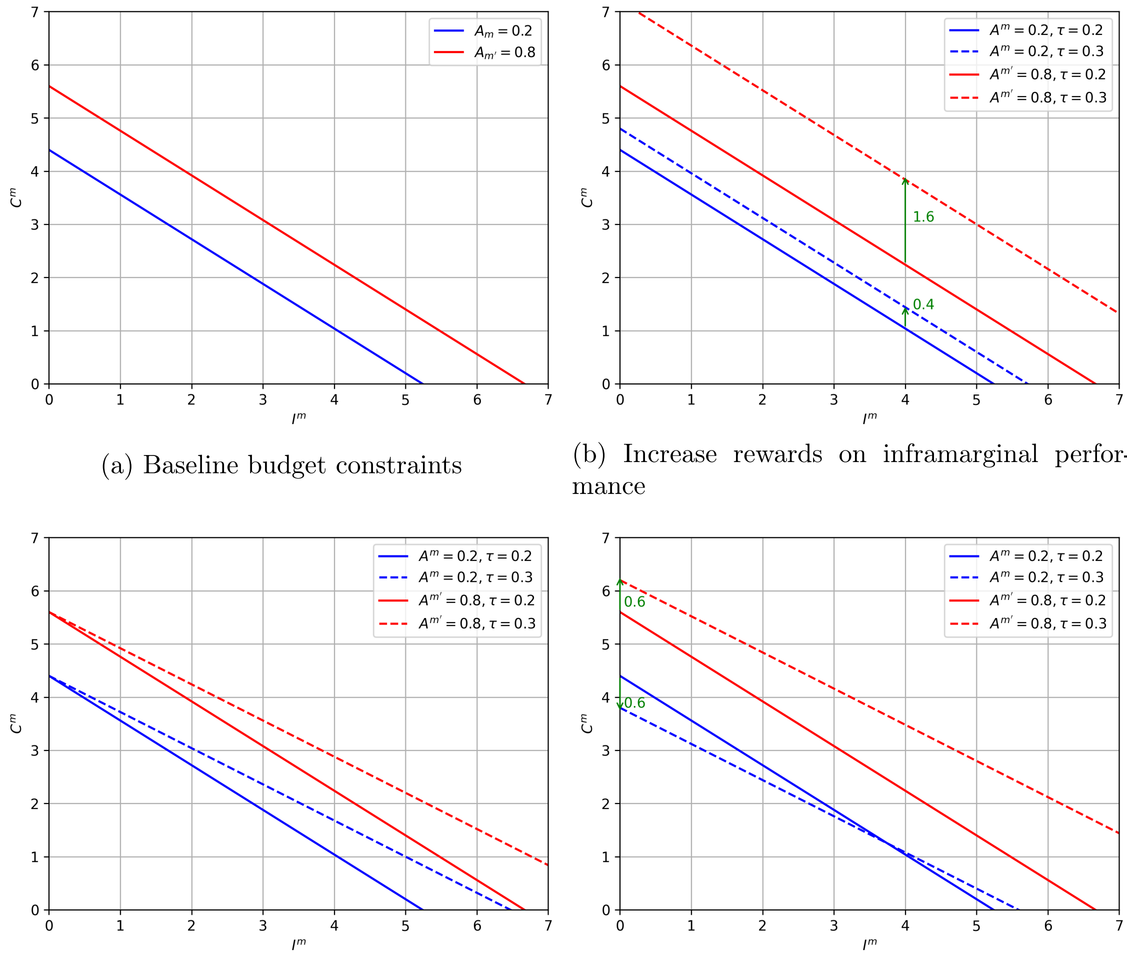
The state's problem is to choose the share τ of the budget B allocated to the bonus pool to maximize the social welfare function:

$$\max_{\tau} \int_m \psi^m \left(\kappa v\left(r, y^m\right) + f^m\left(r, y^m\right)\right) dm \tag{12}$$

where ψ^m are Pareto weights that sum to one. Note that the central government is welfarist–it values municipalities' utilities–but it also places additional weight on education production. Smaller values of κ indicate a stronger misalignment between the preferences of central government and municipalities.

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 6 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 an increase in the share τ allocated to the bonus pool. Panel (b) of Figure 6 illustrates that the increase in τ will shift the intercept of the budget constraint of both municipalities because it increases the rewards on inframarginal performance. However, the rewards are differential by type because high capacity municipalities have larger inframarginal performances. Panel (c) of Figure 6 shows that the marginal increase in τ also changes the relative price of investment because it increases the marginal return of investment to both municipalities. Panel (d) of Figure 6 shows the final budget constraints after the marginal decrease in the unconditional transfer to close the budget. The figure 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 passive transfers (shift upward) and punishes the low type with a smaller passive transfers (shift downward).

Figure 6: Budget constraints of two municipalities



(a) Baseline budget constraints

(b) Increase rewards on inframarginal performance

(c) Slope change from τ

(d) Decrease in α to close the budget

Notes: The figure illustrates how municipalities' budget constraint changes when the central government increases the share τ allocated to the bonus pool, as described in Section 5.1. In this example, we consider two municipalities with state capacity (types) $A^m = 0.2$ and $A^{m'} = 0.8$ and a total budget of $B = 10$. The share of to the bonus pool increases from $\tau = 0.2$ to $\tau = 0.4$, which implies total unconditional transfers fall from $\alpha = 8$ to $\alpha = 6$. Panel (a) shows the initial budget constraints; Panel (b) isolates the intercept shift associated with the increase in the rewards to inframarginal performance; 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 share to the bonus pool strengthens incentives (via a steeper slope) but also shifts passive transfers upward for high-capacity municipalities (via a larger intercept) and downward for low-capacity ones (smaller intercept).

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

Proposition 1 (Intergovernamental transfers with uniform transfers)**.** *With uniform transfers, the* *welfare-optimal share allocated to the bonus pool (τ) satisfies*

$$\underbrace{\int_m \iota^m \frac{\partial I^{m,h}}{\partial \tau} dm}_{\text{marginal social benefit: substitution}} + \underbrace{\int_m B \tilde{f_{I^m}} \omega^m dm}_{\text{marginal social benefit: income effect}} = \underbrace{-\int_m B \left(\tilde{f_{A^m}} - 1 \right) \omega^m dm}_{\text{marginal social cost: passive transfers}} \tag{13}$$

where $\frac{\partial I^{m,h}}{\partial \tau}$ *is the substitution effect of investment,* $\iota^m = \psi^m z$ *is the social marginal valuation of investment,* B *is the overall budget of the central government,* $\tilde{f_{I^m}}$ *is the relative investment production,* $\omega^m = \psi^m z \frac{\partial I^m}{\partial y^m} + \psi^m \kappa \lambda^m$ *is the social marginal valuation of income, and* $\tilde{f_{A^m}}$ *is the relative inframarginal production.*

Alternatively, we can write the optimality condition as:

$$\underbrace{\int_m \iota^m \frac{\partial I^{m,h}}{\partial \tau} dm}_{\text{marginal social benefit: substitution}} + \underbrace{\int_m B \tilde{f_{I^m}} \omega_f^m \left(1 + \omega_r^m\right) dm}_{\text{marginal social benefit: income effect}} = \underbrace{-\int_m B \left(\tilde{f_{A^m}} - 1 \right) \omega_f^m \left(1 + \omega_r^m\right) dm}_{\text{marginal social cost: passive transfers}} \tag{14}$$

where $\omega^m = \omega_f^m \left(1 + \omega_r^m\right)$ *where* $\omega_f^m = \psi^m z \frac{\partial I^m}{\partial y^m}$ *is the social marginal valuation of income in production and* $\omega_r^m = \frac{\kappa \lambda^m}{z \frac{\partial I^m}{\partial y^m}}$ *is the relative social value of private utility vs. performance gains*

Proof. See appendix G 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 the substitution effect of τ for the investment in education, the larger are the welfare gains. As τ increases, the municipality shifts resources to investments in test scores. This is an efficiency gain because such behavioral responses have no first order positive welfare effect on municipalities (by the envelope theorem) but have a first order positive effect on production. This increase in investments is valued according to the social marginal valuation of investment, ι^m.

Second, the increase in τ leads to a positive income effect on municipalities. As τ increases, the returns to investment increases and the relative price of investing decreases to the municipality. As any price decrease, this relaxes municipalities' budget constraint by $B\tilde{f_{I^m}}$. This increase in municipalities resources is valued by ω^m, which combines both the private gains to municipalities utilities and the gains to production in education.

Third, the increase in τ leads to a negative equity loss from the increase in disparity of passive transfers. Municipalities with inframarginal production above average production $f_{A^m} > F$ gets rewarded with larger passive transfers $B\left(\tilde{f_{A^m}} - 1\right) > 0$, and municipalities with inframarginal production below average production get punished with lower passive transfers, $B\left(\tilde{f_{A^m}} - 1\right) < 0$. The rewards and punishes of passive transfers are weighted by the social marginal valuation of income, ω^m. For central governments with larger distributional concerns, the social marginal valuation of income will be larger for the punished municipalities, implying that $-\int_m B\left(\tilde{f_{A^m}} - 1\right)\omega^m dm > 0$.

The optimality condition from equation 14 clarifies that the changes in municipalities budget constraints has two welfare effects: one via production of education and another via the private utility of municipalities. The relative weight we put into the private utility of municipalities depends on how mayors utilize the transfers. If consumption is interpreted as investments in other sectors or transfers to citizens, we could place a large weight on it. However, if it represents corruption from the mayor, then we may place a lower relative weight. Sections 6.2 and 7 investigate empirically how municipalities use their passive transfers.

Lastly, we show in the appendix H.2 that the empirical estimates from section 4 can be mapped to the substitution effect $\frac{\partial I^{m,h}}{\partial \tau}$ and the income partial $\frac{\partial I^m}{\partial y^m}$ of the model:

Corollary 2. *Assuming we can measure the marginal productivity of investment, z, and the normalized production term $\tilde{f}_{I^m} = \frac{zI^m}{F}$ (see Appendix H.3), the sufficient statistics $\frac{\partial I}{\partial y^m}$ and $\frac{\partial I^h}{\partial \beta}$ can be recovered from the empirical estimates of ρ and γ obtained from equation 9 in Section 4 as follows:*

$$\frac{\partial I_t^m}{\partial y^m} = \frac{\gamma}{z},$$
$$\frac{\partial I^{m,h}}{\partial \tau} = \rho - \frac{\gamma}{z} \tilde{f_{I^m}}.$$

See Appendix H.2 for the proof.

5.2 Discussion

The model clarifies what is first order important to measure in the data: substitution effect on investments, the distribution of transfers in different transfer allocations, the income effect on test scores, and how municipalities use their passive transfers across sectors. The first allows us to assess the efficiency gains from conditioning transfers. The second allows us to assess the disparity in transfers from conditioning transfers. The third allows us to estimate how the disparity in transfers translate to the production of education. The fourth element allows us to assess what the relative social weight we put on municipalities' private utilities.

Importantly, the solution of the welfare optimal transfer depends on estimable parameters from the data. In Appendix H we show how our event study estimates from section 4 can be mapped to substitution and income effects in the model. We also estimate the distribution of the inframarginal production using data on municipalities' performance pre-reform, when they were not incentivized. To assess the relative social weight we put on municipalities' private utilities, we investigate how municipalities use their passive transfers in sections 6.2 and 7. Specifically, we estimate how passive transfers translate across sector expenditures, inputs in education, and corruption findings. This allows the reader to calibrate the model to their preferred social weights.

The model also clarifies what is not first order important, our assumptions, and limitations. From the envelope theorem, we concluded that any behavioral change from municipalities should not have a first-order effect on their utilities. The only first-order effects come from direct changes to their budget constraints. This result could be challenged in two ways. First, the envelope theorem may not hold for large policy changes. Second, the incentivized public good could be multidimensional and lead to multitasking distortions, akin to Holmström and Milgrom [1991]. For example, municipalities may divert resources from non-incentivized subjects to incentivized ones. In section 6.1, we investigate multitasking concerns–both across municipalities sectoral expenditures and non-incentives outcomes within education.

Second, the model also assumes that production of education is only a function of investments in education. However, mayors could manipulate the performance measures and lead to welfare losses. E.g., they may push low performing students from the educational system. We directly test for manipulation concerns in section 6.2.

One less common transfer instrument is a conditional transfer based on changes in performance metrics. Such transfers would eliminate the equity losses we highlight as long as the investment improvements do not depend on municipalities' capacity. However, conditioning transfers on changes would introduce its own set of drawbacks. For instance, in the U.S. context, changes in schools' performance are often noisy, meaning that pay-for-performance based on changes could lead to large arbitrary "rewards for noise." Analyzing the tradeoffs of transfers conditional on levels versus changes is an interesting avenue for future research.

6 Non-Incentivized Outcomes and Manipulation

To assess the welfare implications of each transfer instrument, we first examine their effects beyond the incentivized outcomes. Then, we analyze whether the observed improvements in test scores reflect selection of test-takers and manipulation of performance measures, or genuine learning gains.

6.1 Non-Incentivized Outcomes

Performance-based transfers could impact non-incentivized outcomes in two ways. First, incentive effects may come at the expense of other valuable outputs, creating multitasking distortions (Holmström and Milgrom [1991]). Second, greater disparities in transfers could also spillover to non-incentivized outcomes through passive transfer effects. We begin by examining non-incentivized outcomes within the education system, and latter 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 the incentive and passive transfer effects using the difference-in-differences specification 9 from section 4, including math, language, and natural sciences as dependent variables.

Table 1 reports the results. The first row presents the estimated incentive effects of the performance-based transfer, and the second row reports the passive transfer effects. Columns (1)-(3) show results for natural sciences, mathematics, and Portuguese, respectively. The estimated incentive effect for natural sciences is positive and statistically significant, with a magnitude that lies between the effects observed for the two incentivized subjects. By contrast, the passive transfer effects are indistinguishable from zero across all subjects. Taken together, these findings indicate that the performance-based transfer did not harm achievement in the unincentivized subject, suggesting the absence of multitasking distortions or adverse spillovers from increased transfer disparities.

Table 1: Overall effect of performance-transfers on incentivized and non-incentivized subjects

	(1)	(2)	(3)
	Natural Science	Math	Portuguese
$1(\mathrm{t}=2019)\ \times\beta^m$	0.003**	0.007**	0.003
	(0.002)	(0.003)	(0.003)
$1(\mathrm{t}=2019)\ \times y^m$	0.001	0.000	-0.001
	(0.001)	(0.001)	(0.001)
R^2	0.115	0.135	0.157
Municipal FEs	✓	✓	✓
State-year FEs	✓	✓	✓
T^m-year FEs	✓	✓	✓
N	11078	198850	198919

This 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 (9): $f_{it}^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \rho\left(\Delta\beta^m \cdot Post_t\right) + \gamma_s\left(\Delta y^m \cdot Post_t\right) + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{tS} are state-year fixed effects, $g_t\left(T^m\right)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t=s]$ is a year indicator, and ϵ_{imt} is the residual. The coefficients ρ_s and γ_s capture the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level.

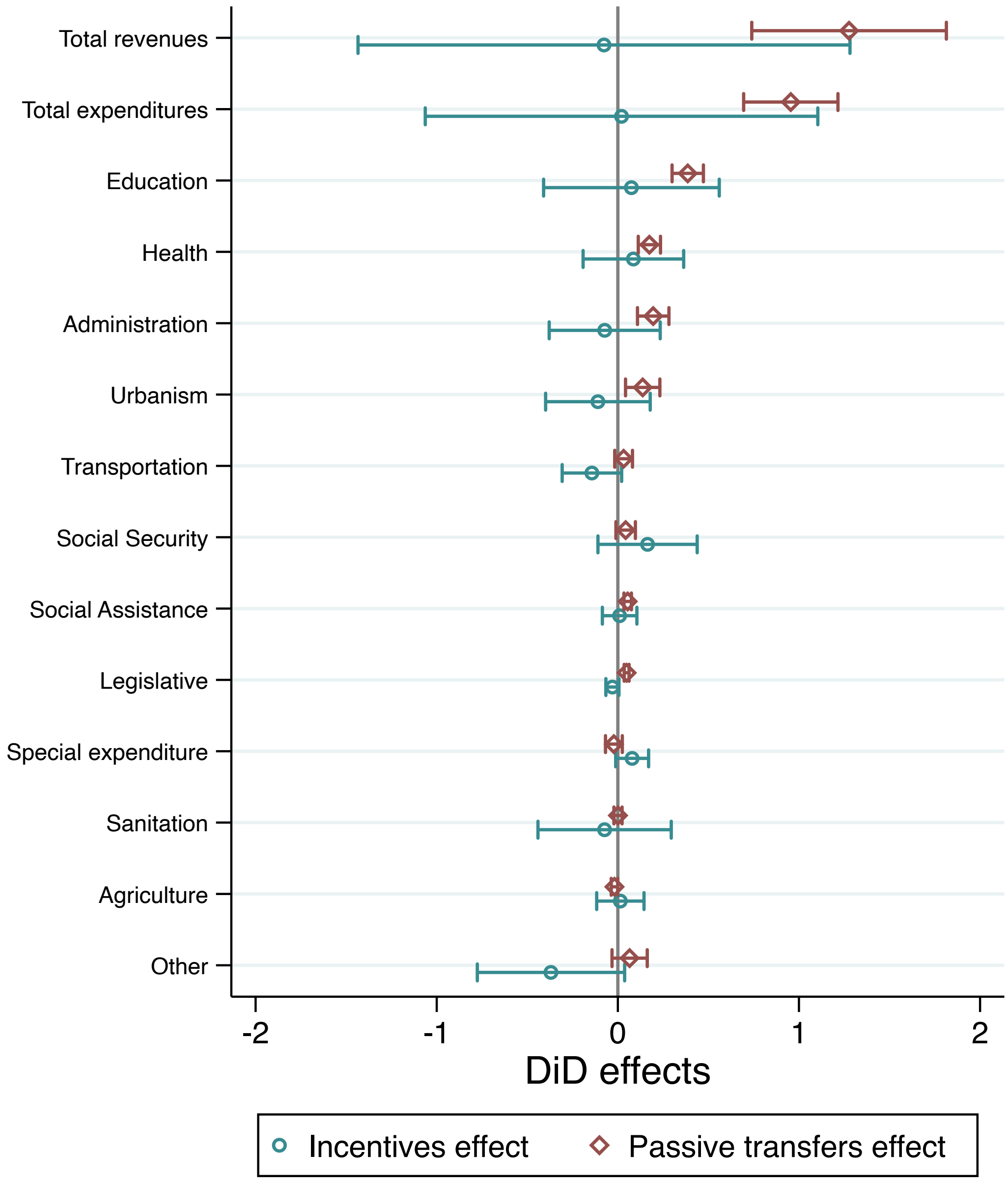
Next, we examine mayors' expenditure choices across sectors. Our analysis focuses on the ten largest spending categories: education, health, administration, urbanism, transportation, social security, social assistance, legislative, sanitation, and agriculture. Together, these sectors account for 92.9 percent of total municipal expenditures (see figure I.1). All remaining sectors represent less than 2 percent of total spending individually and are grouped into a residual category labeled "other sectors."

We estimate sectoral responses to the incentive and passive-transfer components using the extended difference-in-differences specification in equation 9 (section 4). Figure 7 presents the main results, with corresponding event-study estimates reported in Appendix I.1.[22]

The results indicate that, after controlling for changes in passive transfers, the incentive effect had no significant impact on total revenues. By contrast, a one-real increase in passive transfers raised total revenues by 1.28 reais. Moreover, the incentive effect did not significantly alter spending in any sector–including education–suggesting no evidence of multitasking distortions across sectors. In contrast, passive transfers significantly increased expenditures in several areas, with the largest effects observed in education and health. These patterns are consistent with municipalities facing binding legal requirements on minimum spending in these sectors (Section 2) and highlight an important channel for equity losses: disparities in transfers translated into disparities in spending on non-incentivized sectors, especially health.

[22] Appendix I.2 also reports the overall effects on each sector using the specification in equation 4 from Section 3.

Figure 7: Incentive effects and passive transfers on revenues and expenditures



This figure shows the incentive and passive transfer effects, estimated using the difference-in-differences specification from equation 9, $Y_{mt} = \nu^m + \nu_{st} + g_t(T^m) + \rho(\Delta\beta^m \cdot Post_t) + \gamma_s(\Delta y^m \cdot Post_t) + \epsilon_{imt}$ for revenues and expenditures across sectors, Y_{mt}. Theν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $Post_t$ is an indicator equal to one for years after 2007, and ϵ_{mt} is the residual. Standard errors are clustered at the municipality level. Circles represent the incentive effect point estimates, whereas the diamonds represent the passive transfer effects. Horizontal lines denote 95 percent confidence intervals.

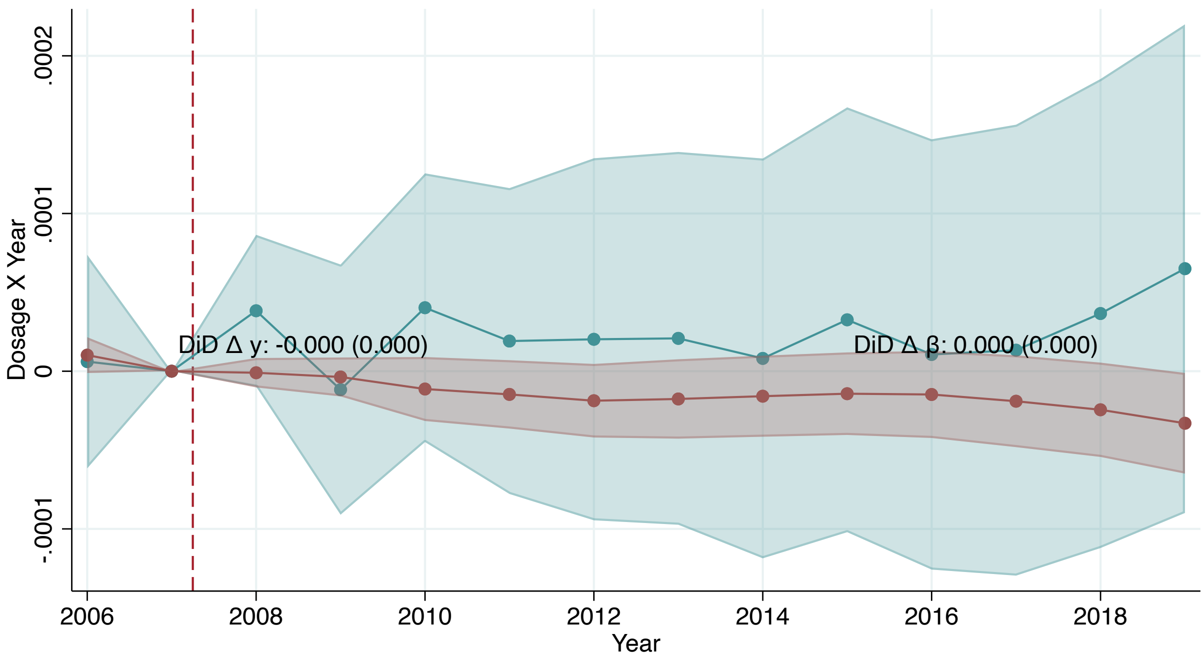
6.2 Manipulation concerns

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 9 from section 4. The findings indicate no significant incentive effect, alleviating concerns about exclusionary manipulation. Moreover, the passive transfer effects was also null, indicating no equity concerns in terms of enrollment.

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



This figure shows the incentive and passive transfer effects on the share of elementary education age population in municipal schools, estimated using the extended event-study specification from equation 8: $Y_{mt} = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} (\rho_s \Delta\beta^m + \gamma_s \Delta y^m) \times 1[t = y] + \epsilon_{mt}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, 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 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.[23]

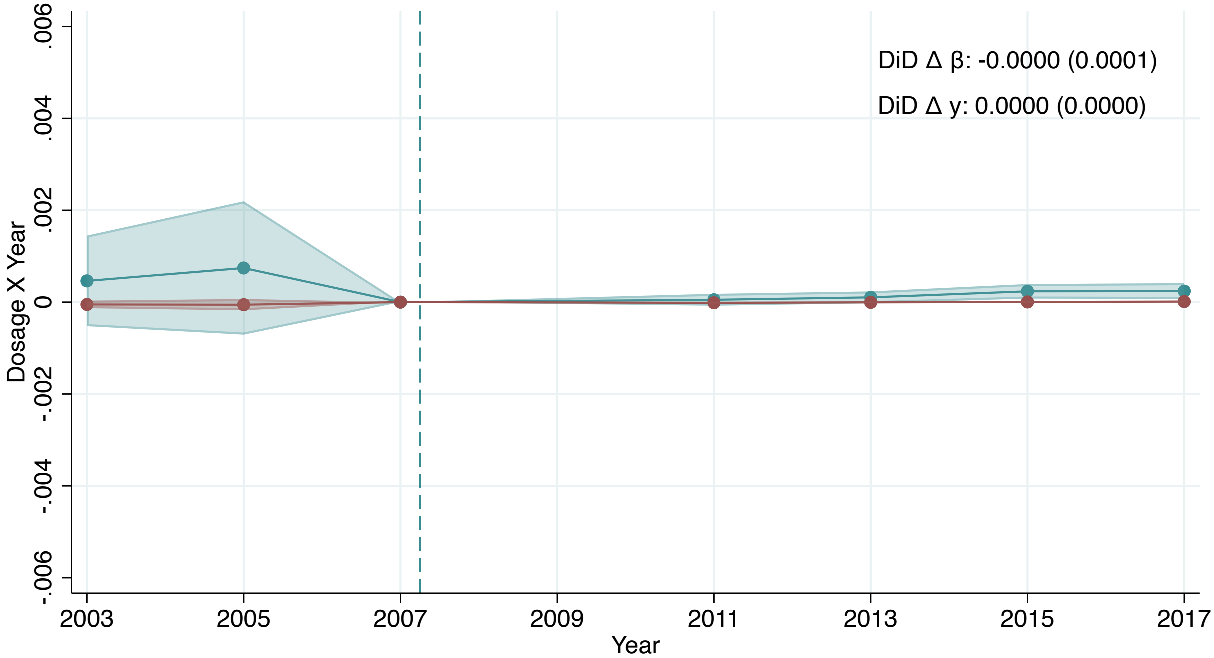
To empirically test for this manipulation, we analyze changes in the composition of students taking the exams following the introduction of performance-based transfers. Specifically, we examine if the students who took exams became predictably better performers. First, we regress test scores from the 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

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

scores for students in all periods. We then estimate equation 9 (Section 4) using these predicted scores as the outcome, allowing us to detect any systematic selection of higher-ability students into test participation

The results are presented in Figure 9. The difference-in-difference estimate for the incentive effect is statistically indistinguishable from zero, indicating that mayors did not exclude predictably lower-performing students following the introduction of performance-based transfers. The event-study estimates show a slight, gradual increase in predicted test scores, but the magnitude is small relative to the overall effect reported in Figure 3 (Section 3). This suggests that any potential manipulation of test participation did not meaningfully contribute to the observed improvements in measured performance. The passive-transfer effects are null in both the event-study and difference-in-differences specifications, supporting our assumption that changes in passive transfers were exogenous to trends in student composition.

Figure 9: Increase in predicted Math test scores is zero or relatively small



This figure shows the incentive and passive transfer effects, estimated using the extended event-study specification from equation 8: $\hat{f}_{it}^{m} = \nu^{m} + \nu_{st} + g_t\left(T^{m}\right) + \sum_{y\neq 2007}\left(\rho_s \Delta\beta^{m} + \gamma_s \Delta y^{m}\right) \times 1[t=y] + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t\left(T^{m}\right)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^{m}$ is the change in per capita bonus pool in municipality m, Δy^{m} is the change in passive transfers, $\mathbf{1}[t=s]$ are year indicators, and ϵ_{imt} is the residual. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. The outcome variable, $\hat{f}_{it}^{m}$, 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. The scale of the plot is set to match the scale of the incentive and passive transfer effects on test scores in figure 5. The results indicate no significant exclusion of predictably lower-performing students following the introduction of performance-based transfers.

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.

7 Mayoral response and input choices

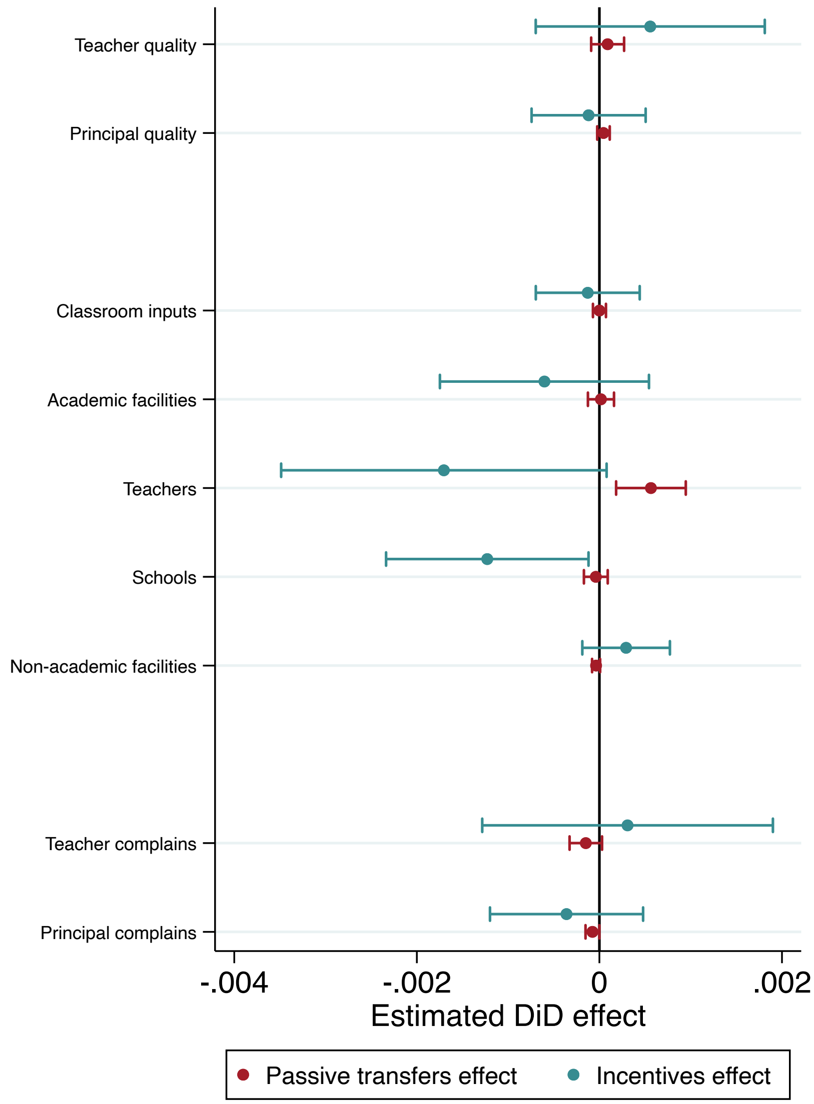
The analyses in section 6 indicate that the incentives improvements in test scores were not driven by an increase in educational expenditures, reallocating efforts to incentivized subjects, or the selection of students. This raises the question of what "hidden actions" by mayors led to these improvements. In this section, we shed light on this by examining their behavioral responses to the reforms. We first examine input decisions within the education system, which was directly incentivized and for which we have detailed input data. We then explore corruption across sectors.

To analyze education inputs decisions, we leverage systematically measured responses 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. Given the extensive number of inputs, we consolidate them into 10 more interpretable indexes, each constructed as an average of the standardized variables within the respective category. Appendix J provides detailed descriptions of the index constructions and results for individual inputs. We then estimate incentive and passive transfer effects on the input indexes the same difference-in-differences specification in equation 9 from section 4.

The estimated incentive and passive-transfer effects on mayors' education input choices are presented in Figure 10. The results reveal that mayors respond in markedly different ways when faced with performance incentives versus additional fiscal resources. The incentive effect led mayors to reduce the number of schools and teachers relative to the school-age population. As discussed in Section 2, consolidating students into better-equipped schools was a strategy first implemented by Ceará's governor during his tenure as mayor of Sobral and later promoted as a best practice for other municipalities. Appendix Figure J.1 provides qualitative evidence that these school closures were politically sensitive and widely debated in local media, consistent with mayors undertaking difficult reforms aimed at improving student performance. In contrast, the passive-transfer effect led mayors to expand staffing by hiring additional teachers.

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 10: Mayors' responses to performance-based transfers: input choices



This figure shows estimates from the difference-in-differences specification in equation 9, $h_{jmt} = \nu^m + \nu_{st} + g_t(T^m) + \rho(\Delta\beta^m \cdot Post_t) + \gamma_s(\Delta y^m \cdot Post_t) + \epsilon_{jmt}$ for various education input indexes. Here, ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in the per capita bonus pool for municipality m, Δy^m is the change in passive transfers, $Post_t$ is an indicator equal to one for years after 2007, and ϵ_{jmt} are the residuals. 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. To facilitate comparison across measures, all education input variables are standardized to have unit standard deviation. 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 J provides detailed descriptions of index construction and presents estimates for individual inputs. Standard errors are clustered at the municipality level. Circles represent the incentive effect point estimates, whereas the diamonds represent the passive transfer effects. Horizontal lines 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.9 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:

$$\begin{aligned}\text{Corruption}_{m,t} = \nu_s + \nu_{g,t} + f(n)_{m,t} + \nu_0 T^m + \nu_1 T^m \cdot \mathbf{1}[t > 2007] + \nu_2 \cdot \Delta\beta^m + \rho \cdot \Delta\beta^m \cdot \mathbf{1}[t > 2007] \\ + \nu_3 \cdot \Delta y^m + \gamma \cdot \Delta y^m \cdot \mathbf{1}[t > 2007] + \varepsilon_{m,t}\end{aligned} \tag{15}$$

where ν_s denotes state fixed effects, $\Delta\beta^m$ is the change in the bonus pool per capita for municipality m, $\mathbf{1}[t > 2007]$ is an indicator variable for post-2007 observations, and Δy^m denotes the change in passive transfers. Geographic region-by-year fixed effects are captured by $\nu_{g,t}$, where we vary the definition of "geographic 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 reported in Table 2. The second row presents the estimated incentive effect, while the fourth row reports the passive-transfer effect. Column (1) shows estimates controlling for 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 results suggest that the incentive effect reduced corruption within the education sector but had no detectable effect elsewhere. Columns (3) and (4) replicate these analyses including treated-by-year fixed effects, yielding similar point estimates. However, once we further include state-by-year fixed effects in columns (5) and (6), the estimates become statistically insignificant. The magnitudes remain economically meaningful: moving from the 25th to the 75th percentile of the per-capita bonus pool distribution implies a reduction of 0.23 corruption cases—about 27 percent of the mean. This attenuation may reflect either state-level trends correlated with the reform or limited statistical power due to the small number of audited municipalities.

Table 2: Mayors' responses to performance-based transfers: corruption

	(1) Education	(2) Not Education	(3) Education	(4) Not Education	(5) Education	(6) Not Education
$\Delta\beta^m$	0.003	-0.003	0.004	-0.005	-0.001	-0.010
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)
1(t > 2007) $\times\Delta\beta^m$	-0.012***	-0.005	-0.014**	-0.002	-0.005	0.006
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Δy^m	0.000	-0.000	-0.000	-0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
1(t > 2007) $\times\Delta y^m$	0.001	0.001	0.001*	0.002*	0.000	0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R^2	0.393	0.366	0.380	0.126	0.480	0.195
# 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	3902	3900	3906	3906	3843	3843

This table presents estimates from the difference-in-differences specification in equation 15: $\text{Corruption}_{m,t} = \nu_s + \nu_{g,t} + f(n)_{m,t} + \nu_0 T^m + \nu_1 T^m \cdot \mathbf{1}[t > 2007] + \nu_2 \cdot \Delta\beta^m + \rho \cdot \Delta\beta^m \cdot \mathbf{1}[t > 2007] + \nu_3 \cdot \Delta y^m + \gamma \cdot \Delta y^m \cdot \mathbf{1}[t > 2007] + \varepsilon_{m,t}$ where ν_s denotes state fixed effects, $\Delta\beta^m$ is the change in the bonus pool per capita for municipality m, $\mathbf{1}[t > 2007]$ is an indicator variable for post-2007 observations, and Δy^m denotes the change in passive transfers. Geographic region-by-year fixed effects are captured by $\nu_{g,t}$, where we vary the definition of "geographic 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. 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.

8 Implications and Conclusion

8.1 Transfer Design Implications

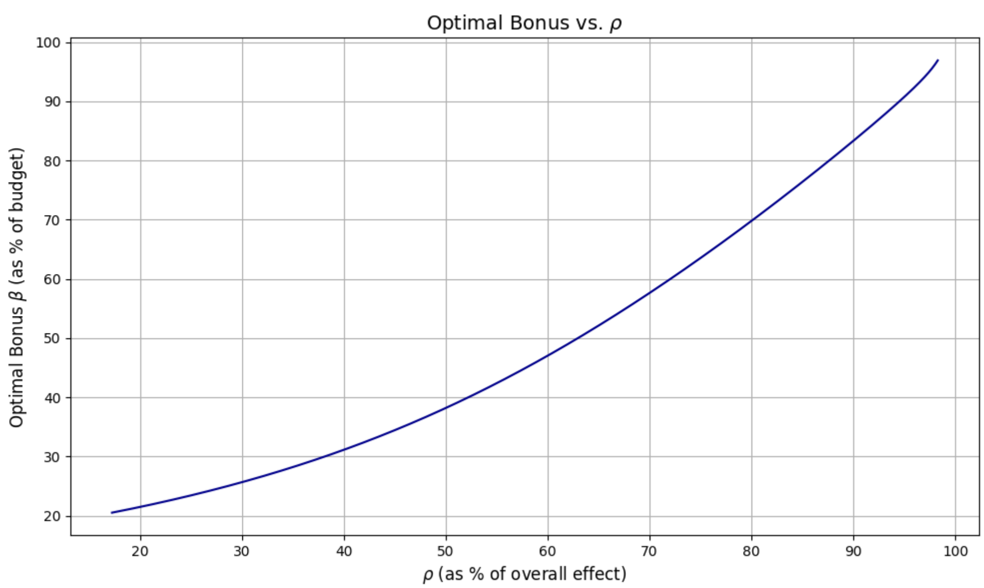
In Section 3, we showed that performance-based transfers generated large overall improvements in education outcomes, though their desirability was ambiguous because they also increased disparities in transfers. Section 4 decomposed these overall effects and showed that the gains are primarily driven by incentive effects, while passive transfer effects are small. Appendix H formalizes how these empirical estimates map to the substitution and income effects of performance transfers, which serve as sufficient statistics for the optimal transfer condition derived in Section 5. Intuitively, stronger incentive effects correspond to larger substitution effects, greater efficiency gains, and thus a higher optimal share of performance-based transfers.

To illustrate these implications, we fix the overall effect of performance-based transfers at the estimated value of 0.003 and simulate the optimal transfer allocation while varying the relative importance of the incentive effect. As shown in Appendix H.1, the overall effect of the bonus pool can be expressed as the sum of the incentive and passive transfer components:

$$\frac{\partial f_t^m}{\partial \beta} = \rho + \gamma \tilde{f_{A^m}}. \tag{16}$$

where $\frac{\partial f_t^m}{\partial \beta}$ is the overall effect of performance-based transfers on test scores, ρ is the incentives effect, γ is the passive transfer effect, and $\tilde{f_{A^m}}$ is the relative inframarginal performance of municipality m. In our simulation, we hold fixed the overall effect of bonus pool at 0.003 and vary the relative importance of the incentives effect to the overall effect, $\frac{\rho}{\rho+\gamma \tilde{f_{A^m}}}$, to see how the optimal transfer allocation changes. Figure 11 shows that as the relative importance of the incentives effect increases, the optimal share of performance-based transfers rises.[24] Given our empirical estimates, the analysis suggests that performance-based transfers should constitute a sizable share of the welfare-optimal transfer mix.

Figure 11: Optimal transfer allocation as a function of the incentives effect's relative importance



Notes: This figure shows how the optimal transfer allocation changes as we vary the relative importance of the incentives effect to the overall effect, $\frac{\rho}{\rho+\tilde{f_{A^m}}}$, while holding fixed the overall effect of bonus pool, 0.003. The y-axis shows the optimal share of the bonus pool, τ, while the x-axis shows the relative importance of the incentives effect. Table H.1 summarizes the other parameters used in the simulation.

[24] Appendix H.3 details the simulation procedure and table H.1 summarizes the other parameters used.

Beyond estimating the globally optimal transfer mix, our framework also allows us to assess whether the observed reform was welfare enhancing and whether marginal increases in the bonus pool are desirable. The optimality condition derived in equation 14 yields sufficient statistics for evaluating the marginal welfare effects of increasing the share of the bonus pool, τ.

In addition to the parameters estimated in Sections 3 and 4, a key remaining object for assessing the equity losses of performance-based transfers is the relative social value of transfers for private utility versus performance gains. In words, this parameter captures how much the central government values additional dollar of municipal spending in terms of direct utility, relative to the social value from education improvements from the same dollar transferred. Using the optimality condition, we can recover the threshold value of this ratio that makes the observed reform welfare enhancing.[25]

The results imply that, as long as the central government does not value the direct utility from an additional dollar of municipal spending more than eighteen times the social value of the education gains produced by that dollar, the reform was welfare improving.

Although the relative social value of municipalities' private utility is subjective, our empirical estimates provide guidance on its magnitude. First, note that the passive transfers effect on education production estimated in section 4 was quite low. This would push towards a large relative value of private utility. Second, note that in section 6 we found that the increase in passive transfers is mostly translated back into education, indicating that the private utility derived from additional spending is in fact limited. The remaining resources were allocated primarily to health, administrative costs, and urbanism. Prior research finds that unconditional transfers in Brazil have modest effects in these sectors and tend to increase corruption (Gadenne [2017]; Caselli and Michaels [2013]; Brollo et al. [2013]).[26] Taken together, this evidence suggests that the relative social value of municipalities' private utility is relatively small. Hence, we conclude the reform was likely welfare enhancing.

8.2 Conclusion

The decentralization of public good provision, widespread across countries, is financed predominantly through intergovernmental transfers. A common design question faced by central governments is whether to allocate transfers unconditionally or to tie them to local policy performance. We have argued that this design choice involves an equity-efficiency trade-off. Conditional transfers can enhance efficiency by incentivizing local governments, but they may also exacerbate inequities by disproportionately benefiting high-capacity municipalities with larger transfers.

We develop a conceptual framework that formalizes the equity-efficiency trade-off between unconditional and performance-based transfers, deriving sufficient statistics for optimal policy design. A central insight is that the welfare implications depend critically on distinguishing between two em-

[25] We fix all other parameters at the values reported in Table H.1.

[26] A notable exception is Litschig and Morrison [2013], who show that unconditional transfers from the FPM improved education outcomes in the 1980s.

pirical effects of performance-based transfers: the incentives effect—arising from changes in marginal returns to improvements—and the passive transfer effect—arising from changes in resources absent behavioral responses.

Exploiting three major reforms to intergovernmental transfers in Brazil, we find that the incentives effect from the bonus pool is far more effective at raising test scores than equivalent increases in passive transfers. Another relevant question for welfare is how the increase in transfer disparities impact non-incentivized sectors and outcomes. We find that the increase in passive transfers is mostly channeled back into education, health, and administrative costs. Interpreted through our model, as long as the other sectors are not immensely valued relative to education, the results imply that performance-based transfers deliver substantial efficiency gains, incur limited equity costs, and should constitute a sizable share of the optimal transfer mix.

We find no evidence of common concerns surrounding performance-based incentives—such as multitasking distortions, selective test participation, or score manipulation. Instead, municipalities appear to respond by improving the quality of educational inputs. We also document suggestive evidence of reduced corruption in the education sector and not in others.

Taken together, our findings suggest that well-designed performance-based transfers can enhance service delivery while minimally undermining equity or other valued public goods. A balanced allocation between unconditional and performance-based transfers can enable central governments to address agency problems while safeguarding redistribution, offering a practical and scalable approach to strengthening local governance.

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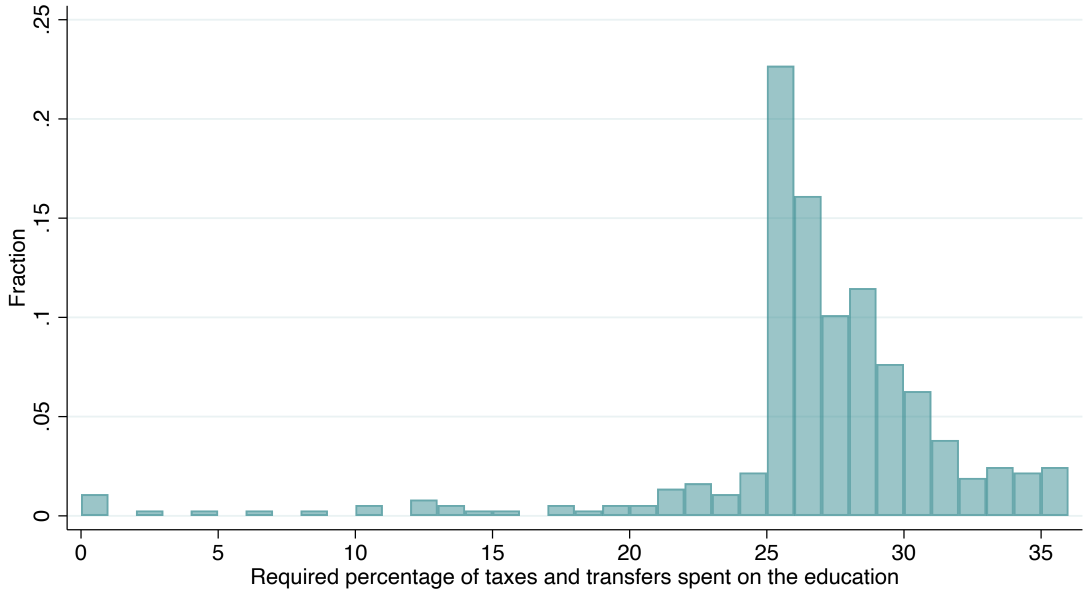
Appendices

A Additional tables and figures

Table A.1: Performance-based transfers around the world

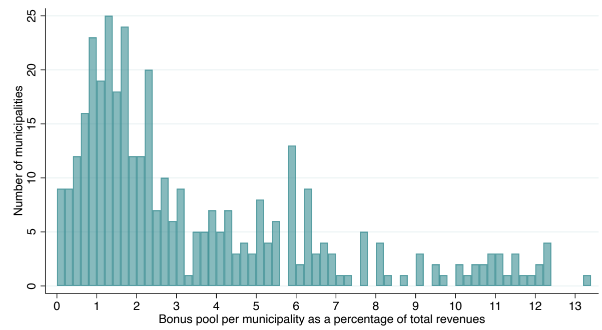
Institution	**Policy**	**Short description**
World Bank	Urban Performance Grants (UPGs)	Fiscal transfers from a higher level of government conditioned on achieving performance in predetermined areas. Over 5 billion between 2013–2020 (41% of the urban portfolio) covering a few thousand local governments.
Brazil	VAT transfers	State-to-municipality transfer conditional on education performance.
Peru	Programa de Incentivos a la Mejora de la Gestión Municipal	Transfers to municipalities relative to their performance in yearly-set indicators.
Argentina	SUMAR program	Transfers from the national government to the provinces conditional on health indicators.
Australia	National Partnership Payments	Payments dependent on the achievement of predetermined milestones or performance benchmarks.
Canada	Canada Health Transfer (CHT)	Federal transfer to provinces for health care. Minimum requirement: access-related conditions (universality, portability, etc.).
Uganda	Local Development Grants	Projects can be rewarded (20%) or punished (20%) based on performance of intermediate outputs.
UK	Local Public Service Agreements	Financial rewards for achieving a set of demanding targets over a three-year period.
US	No Child Left Behind (NCLB)	Required states to punish Title I schools failing to meet Adequate Yearly Progress (AYP) requirements for exam proficiency and graduation rates.
US	Race to the Top	Competitive grant for states that adopted certain education reforms, including performance-based pay for teachers.

Figure A.1: Distribution of the percentage of transfers and taxes spent on education

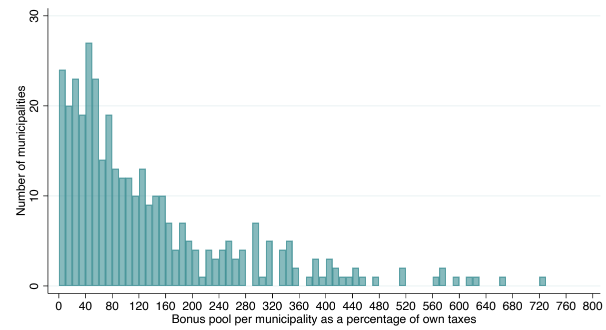


Notes: This figure shows the distribution of the percentage of transfers and taxes spent on education for the states of Ceará and Pernambuco. Municipalities are required by the constitution to spend at least 25% of their revenues on education. The results indicate that this requirement is broadly binding.

Figure A.2



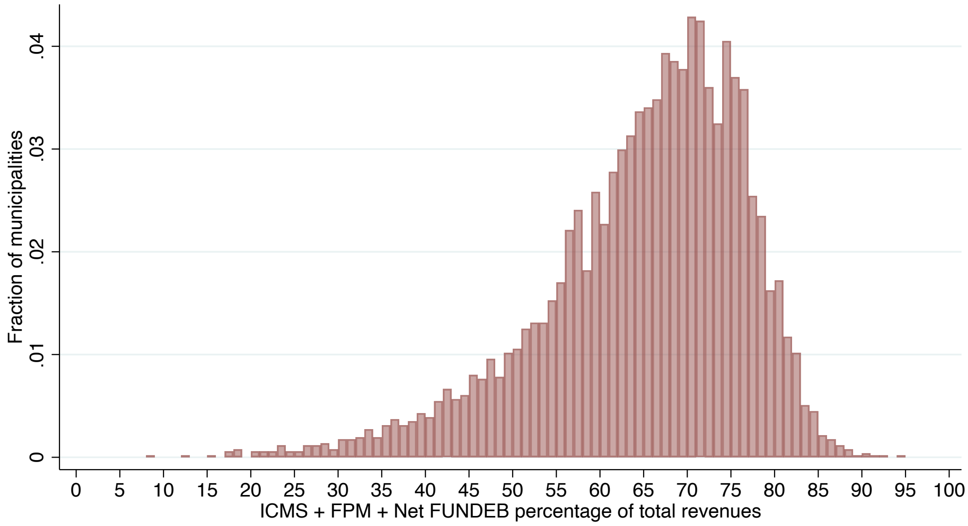
(a) Share of total revenues



(b) Share of total local taxes

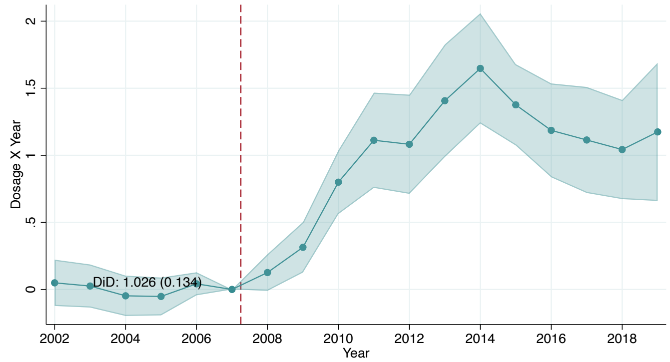
Notes: This figure illustrates the fiscal relevance of the performance-based transfer for municipalities. Panel (a) plots the bonus pool amount per municipality as a share of total municipal revenue; Panel (b) plots it as a share of total local tax revenue. The sample includes municipalities in Ceará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

Figure A.3: Relevance of transfers studied to municipalities' total revenues

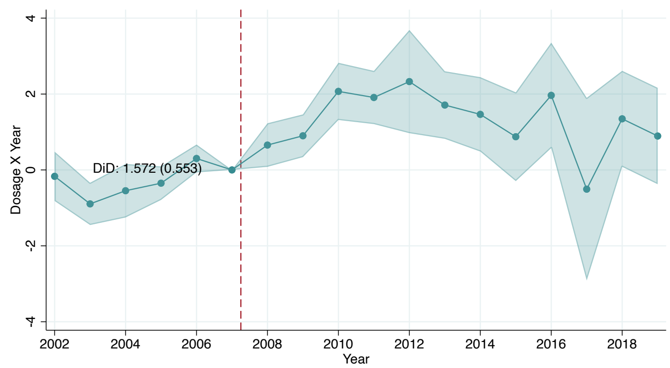


Notes: This figure illustrates the fiscal importance of the transfers studied in this paper. It plots the percentage of total municipal revenue accounted for by the sum of ICMS, FPM, and net FUNDEB in 2007. The sample includes all Brazilian municipalities. On average, these three transfers comprised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

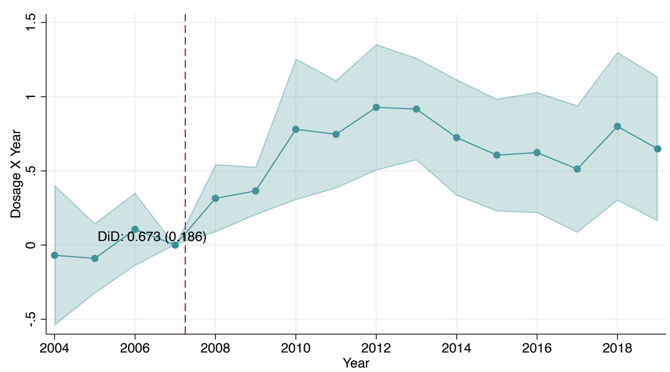
Figure A.4: Overall effects of performance-based transfers



(a) VAT transfers received



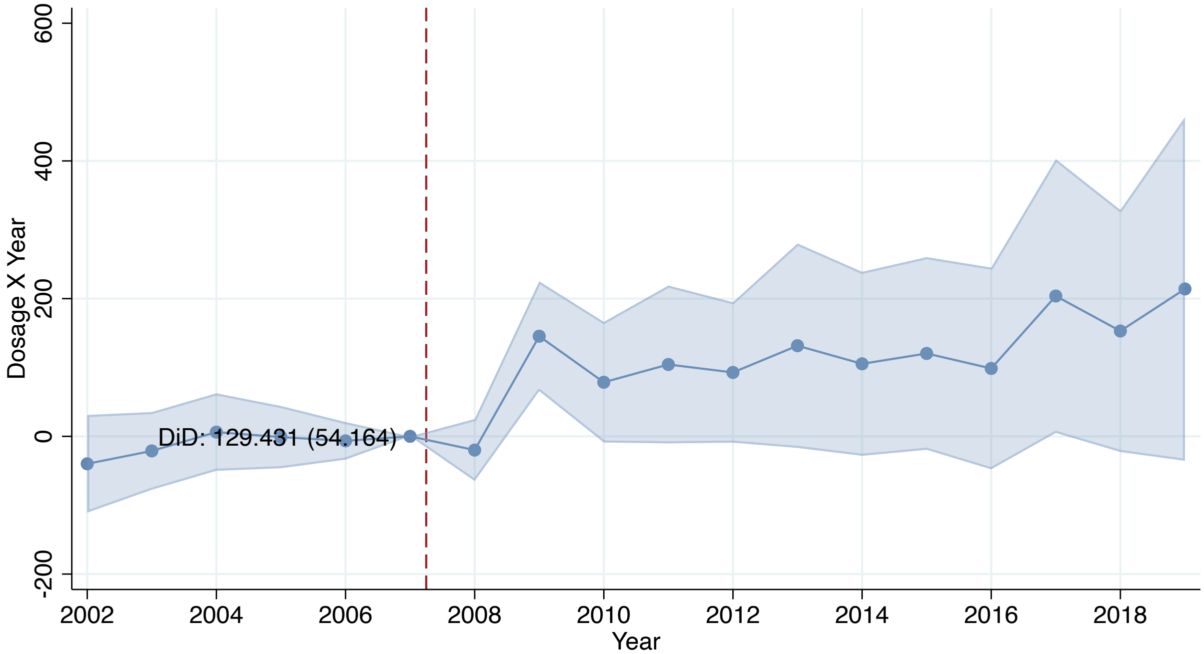
(b) Municipal revenues



(c) Education expenditures

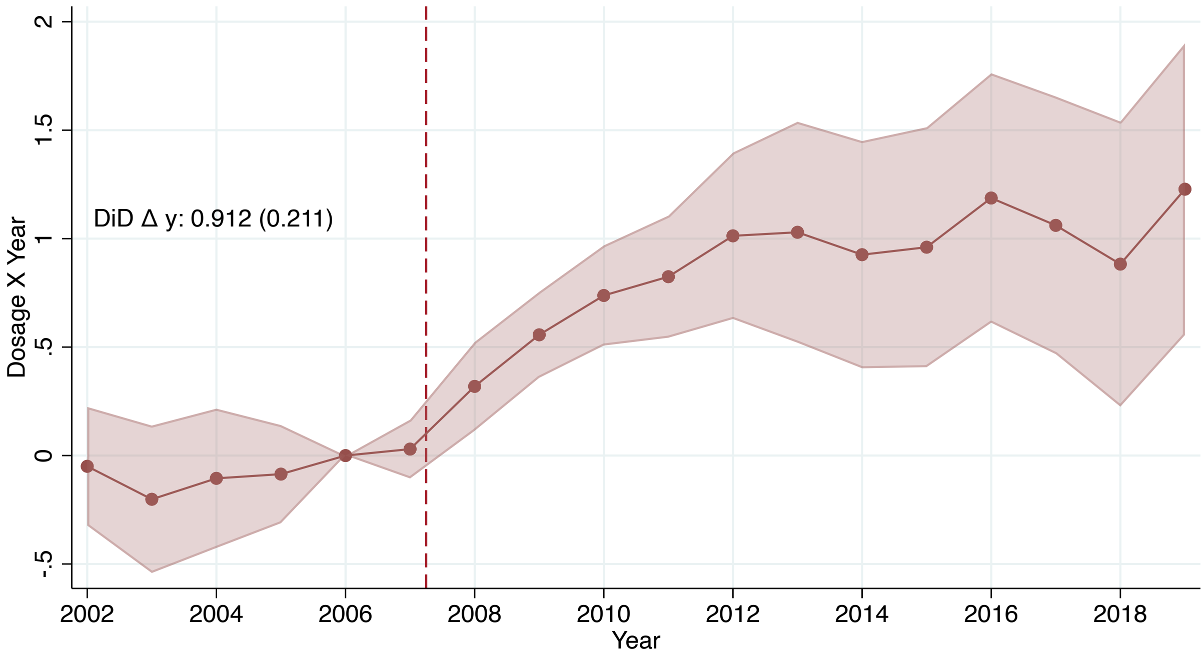
This figure shows the overall effects of performance-based transfers on VAT transfers received, municipal revenues, and education expenditures. Each figure plots the θ_y coefficients from estimating equation 5: $Y_t^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{it}^m$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{it}^m is the residual. The outcome in panel (a) are VAT transfers received, in panel (b) are total municipal revenues, and in panel (c) municipal expenditures in education. Standard errors are clustered at the municipality level, and shaded areas denote 95 percent confidence intervals.

Figure A.5: Transfer changes for municipalities with different government capacity



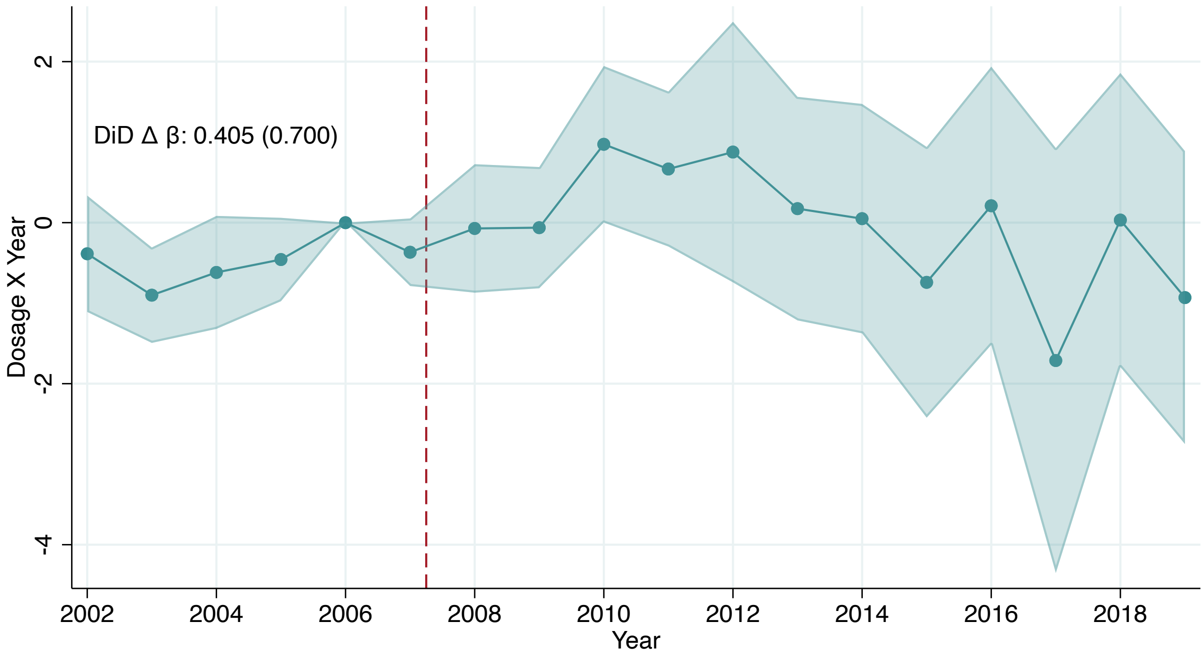
This figure shows the transfer changes for municipalities with different government capacity. Specifically, we plot the θ_y coefficients from estimating equation 5: $Y_t^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \theta_y \tilde{f_{A^m}} \times \mathbf{1}[t=y] + \epsilon_{it}^m$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\tilde{f_{A^m}}$ is the measure of government capacity (baseline relative performance in education), $\mathbf{1}[t=y]$ are year indicators, and ϵ_{it}^m is the residual. The outcome is the VAT transfers received. Standard errors are clustered at the municipality level, and shaded areas denote 95 percent confidence intervals.

Figure A.6: Passive transfers on total municipal revenues



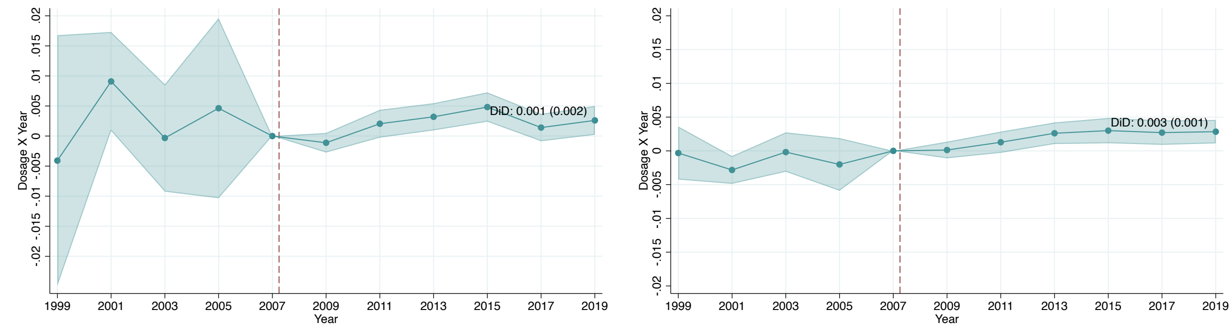
This figure shows the passive transfer effects on total municipal revenues, estimated using the extended event-study specification from equation 8: $Y_t^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} (\rho_s \Delta\beta^m + \gamma_s \Delta y^m) \times 1[t = y] + \epsilon_t^m$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_t^m is the residual. The outcome variable are total municipal revenues for municipality m in year t. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. This figure shows γ_s estimates and Appendix figure A.7 shows the ρ_s estimates. The results confirm that changes in passive transfers increase revenues.

Figure A.7: Incentive on total municipal revenues



This figure shows the incentive effects on total municipal revenues, estimated using the extended event-study specification from equation 8: $Y_t^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} (\rho_s \Delta\beta^m + \gamma_s \Delta y^m) \times 1[t = y] + \epsilon_t^m$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_t^m is the residual. The outcome variable are total municipal revenues for municipality m in year t. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. This figure shows ρ_s estimates and Appendix figure A.6 shows the γ_s estimates. The results confirm that changes to the bonus pool does not impact revenues when conditioned on passive transfers.

Figure A.8: Overall effects of performance-based transfers separabely by state

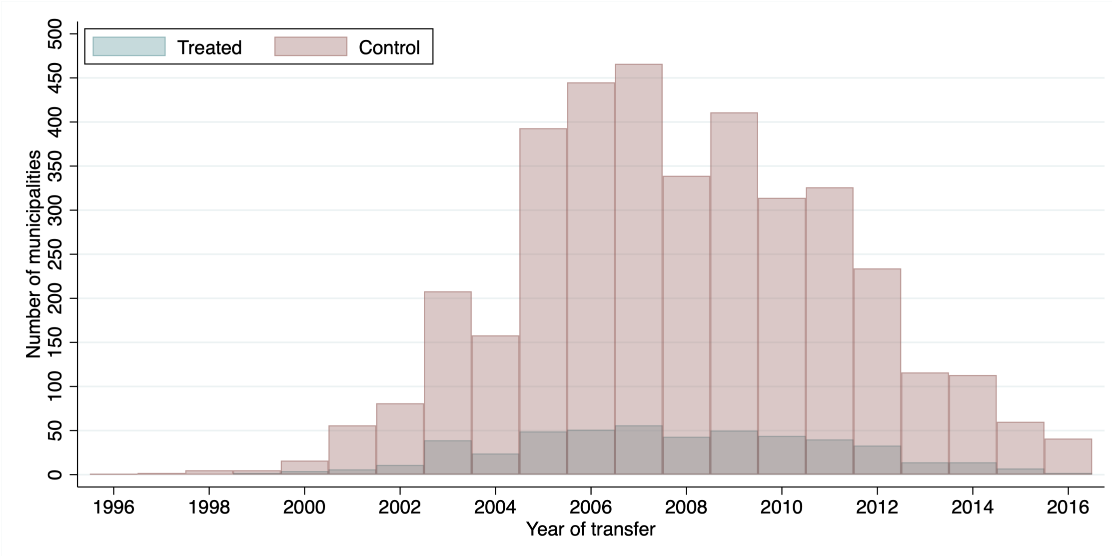


(a) Pernambuco

(b) Ceará

This figure shows the overall effects of performance-based transfers on student test scores. It plots the θ_y coefficients from estimating equation 5: $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{it}^m$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{it}^m 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 students; prior to 2005, the sample comprises random student samples from municipal schools. Panel (a) includes only students from the state of Pernambuco and untreated states; Panel (b) includes only students from the state of Ceará and untreated states. The results combining both states are shown in figure 3.

Figure A.9: Number of municipalities with audited transfers by year



This figure shows the number of municipalities with a transfer audit by year, where the year corresponds to the year in which the transfer was received and not necessarily audited.

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.[27] 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:

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

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

[27] 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 Simulation of Passive Transfer Changes

In this section, we provide additional details on the simulation of passive transfer changes for each of the three reforms described in section 2.

C.1 VAT transfer

As described in section 2 and detailed in section B, the transfer received pre-reform by each municipality,

$$T_{\text{pre}} = \alpha\left(X_{\text{pre}}, \omega_{\text{pre}}\right),$$

dependended on municipal characteristics X_{pre} and policy weights ω_{pre}. The characteristics and policy weights are detailed in tables B.1 and B.2. Crucially, neither of the states conditioned on education outcomes.

The reform updated weights and introduced the bonus:

$$T_{\text{post}} = \alpha\left(X_{\text{post}}, \omega_{\text{post}}\right) + \beta \tilde{f}_{\text{post}}$$

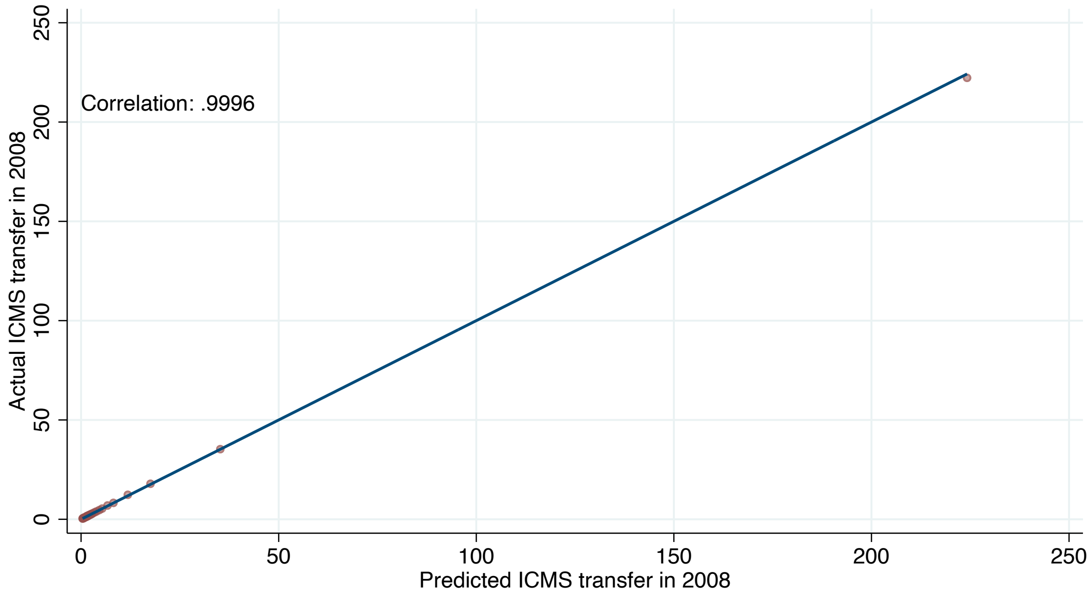
To measure changes in passive transfers, we simulate counterfactual VAT transfers using post-reform policy weights applied to pre-reform municipal characteristics and educational performance:

$$\Delta y_{\text{ICMS}} = \alpha\left(X_{\text{pre}}, \omega_{\text{post}}\right) + \beta \tilde{f}_{\text{pre}} - \alpha\left(X_{\text{pre}}, \omega_{\text{pre}}\right)$$

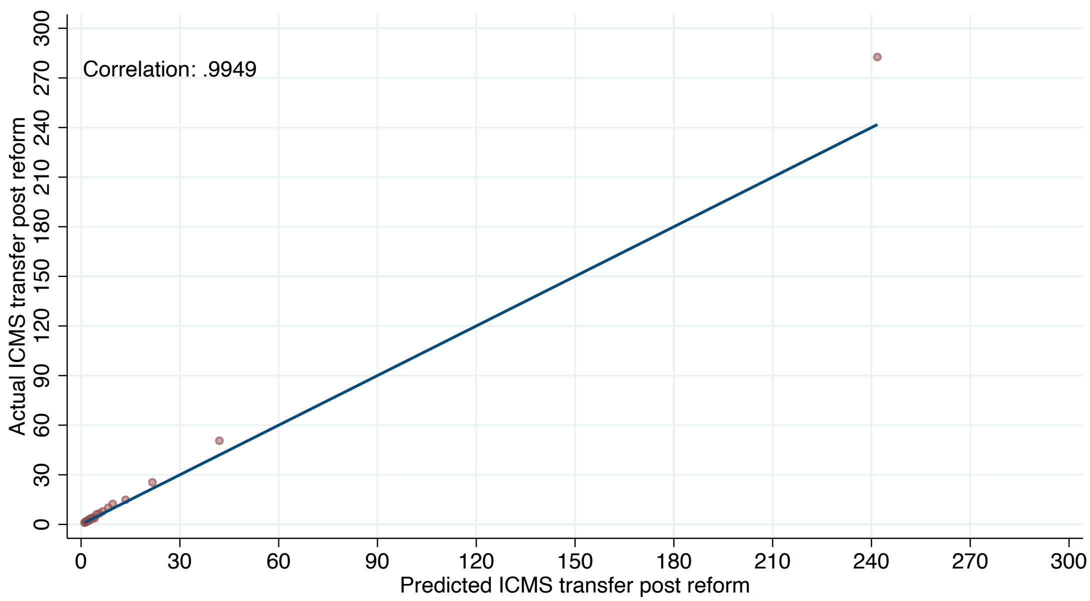
where the pre-reform performance of a municipality is measured using their baseline quality index: $\tilde{f}_{\text{pre}} = \tilde{A}^m$.

These simulation exercises rely on accurately observing municipalities' pre-reform characteristics and correctly interpreting the changes in reform weights. Panel (a) of figure C.1 demonstrates that our predicted VAT, based on pre-reform characteristics and weights, closely matches actual VAT transfers before the reform, exhibiting a correlation of 0.999. Panel (b) further confirms that our predicted VAT using post-reform characteristics and weights similarly predicts actual post-reform transfers effectively.

Figure C.1: Predicted vs reported VAT transfer



(a) Pre-reform



(b) Post-reform

This figure shows binned scatterplots of the predicted vs reported VAT transfers for municipalities in Ceará and Pernambuco. We construct 100 bins using the centiles of the predicted transfers, and plot the average predicted and reported VAT transfers for municipalities in the bin. The correlation reported used all observations. Panel (a) plots predicted transfers based on pre-reform characteristics and weights against reported VAT transfers in the last year pre-reform. Panel (b) plots predicted transfers based on post-reform characteristics and weights against reported VAT transfers in the first year post-reform. The figure confirms our ability to accurately simulate VAT transfers.

C.2 Education Fund transfer (FUNDEB)

As detailed in section 2, the FUNDEB pools funds from all governments and redistributes them to municipal and state governments. The municipalities contribute a share ω of certain transfers received and taxes raised.

Redistribution to municipalities within states occurred equally per student, where students categories c (e.g., students in the first to fourth grades) were weighted according to ω_c.

The net of contributions and transfers received back are thus a function of the share contributed, ω, the weights of the categories, ω_C and municipality characteristics X_{mt} such as the number of high schoolers:

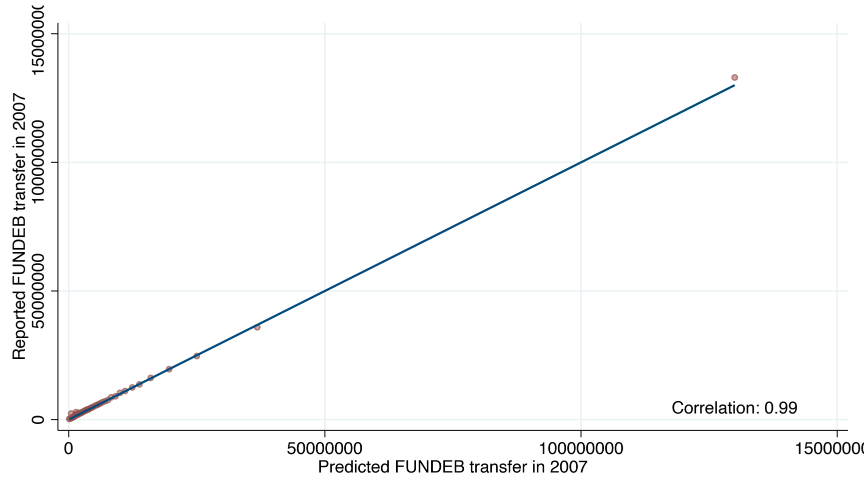
$$\text{Net FUNDEB}_{m,t}(X_{mt}, \omega_t, \omega_{ct})$$

The reform did three things: (i) it increased the share ω from 15 to 20%, (ii) it increased the federal contribution from R$ 1.6 to R$ 5 billion, and it changed the weights of categories w_{ct}. To measure changes in passive transfers, we simulate counterfactual net FUNDEB transfers using post-reform policy weights applied to pre-reform municipal characteristics:

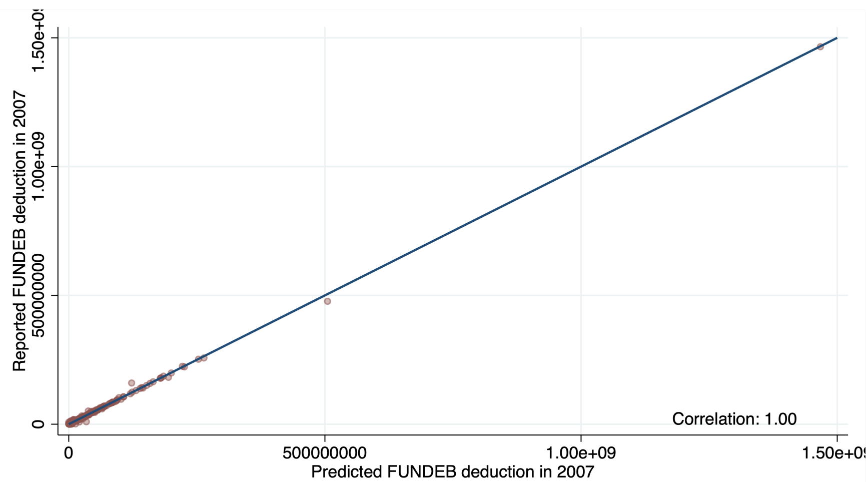
$$\Delta\alpha_{FUNDEB} = \text{Net FUNDEB}_{m,post}(X_{mpre}, \omega_{post}, \omega_{c,post}) - \text{Net FUNDEB}_{m,pre}(X_{mpre}, \omega_{pre}, \omega_{c,pre})$$

The implementation of the reform was phased in over the course of three years (2007-2009). These simulation exercises rely on accurately observing municipalities' pre-reform characteristics and correctly interpreting the changes in reform weights. Panel (a)-(c) of figure C.2 shows the simulated and reported transfers received, contributions, and net FUNDEB using post-reform characteristics and policy weights. The plots confirm that we were able to correctly simulate transfers.

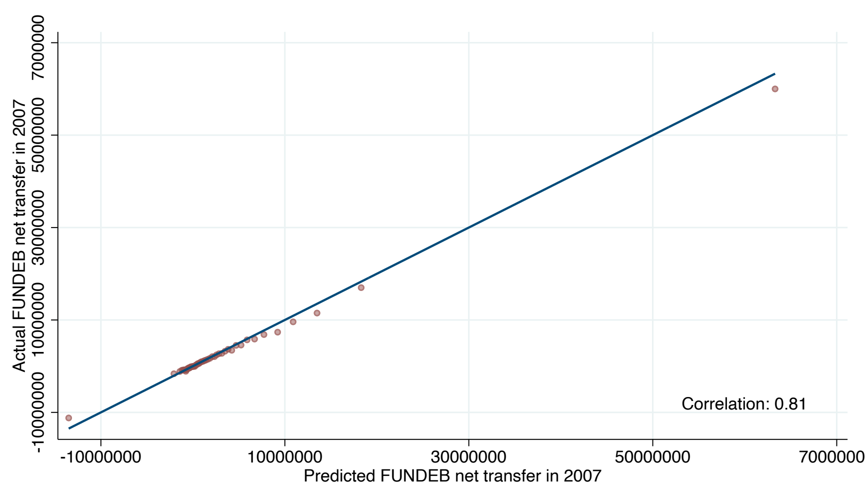
Figure C.2: Predicted vs reported FUNDEB transfer, post-reform



(a) Transfers received



(b) Contributions



(c) Net FUNDEB transfer

This figure shows binned scatterplots of the predicted vs reported FUNDEB transfer components post-reform for all municipalities in Brazil. We construct 100 bins using the centiles of the predicted transfers, and plot the average predicted and reported FUNDEB transfers for municipalities in the bin. The correlation reported used all observations. Panel (a) plots predicted transfers based on post-reform characteristics and weights against reported FUNDEB

C.3 Federal transfer (FPM)

As described in section 2, the allocation of the main federal transfer to municipalities follows two stages. First, a fixed share is assigned to each state based on their population and income per capita. Second, 18 population brackets are defined, each with an associated coefficient.

The amount received by municipality m at year t in state k can thus be described as

$$FPM_{m,t}^{k} = \frac{FPM_{k,t} \times \lambda_{m,t}}{\sum_{m\epsilon k} \lambda_{m,t}}$$

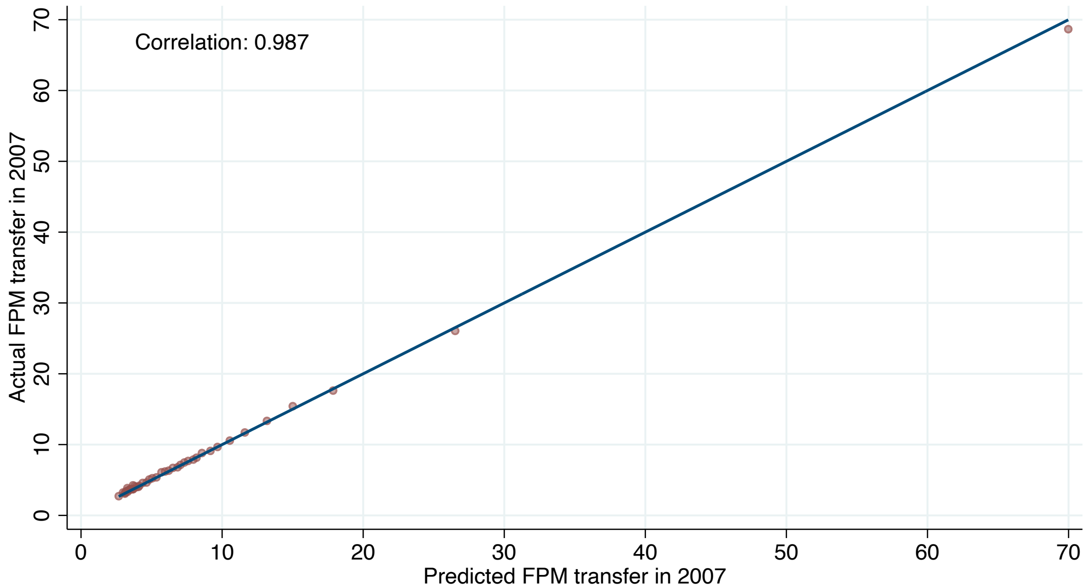
where $FPM_{k,t}$ is the total amount transfered to state k in year t. $\lambda_{m,t}$ is the coefficient associated with municipality m in year t, given by their population size bracket.

Population censuses are conducted every ten years and in inter-censuses periods estimates are used. We leverage the fact that in 2007 a new population count was conducted, leading some municipalities to change their coefficients. To measure the change in passive transfers, we fix total amount transfered to states and isolate the variation to the changes in municipal coefficients coming from the population recount:

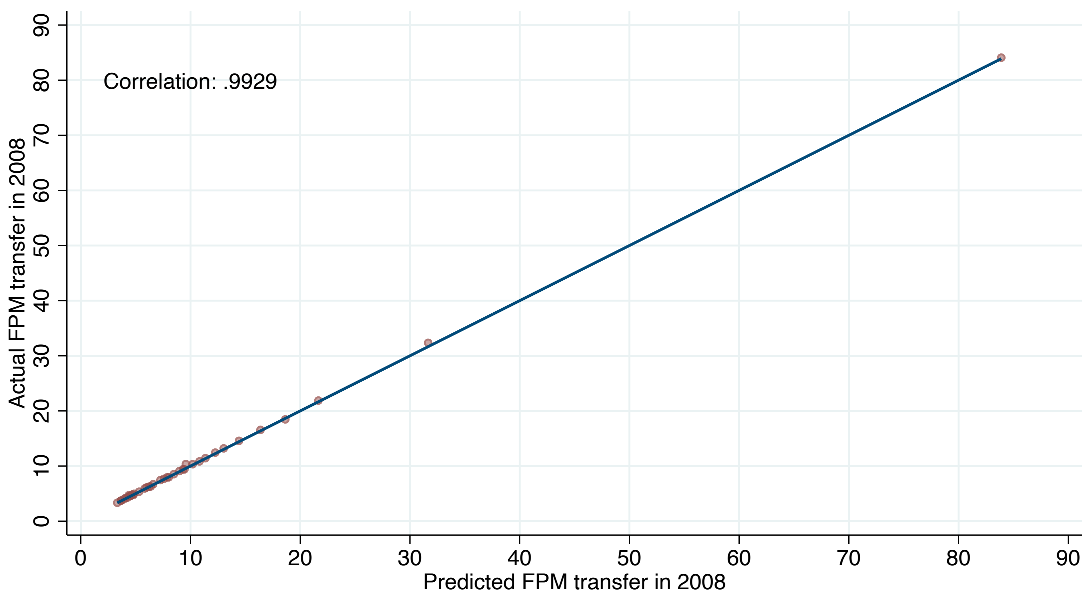
$$\Delta\alpha_{FPM} = \frac{FPM_{k,pre} \times \lambda_{m,post}}{\sum_{m\epsilon k} \lambda_{m,post}} - \frac{FPM_{k,pre} \times \lambda_{m,pre}}{\sum_{m\epsilon k} \lambda_{m,pre}}$$

These simulation exercises rely on accurately observing municipalities' pre-reform characteristics and correctly interpreting the changes in reform weights. Panel (a) of figure C.3 demonstrates that our predicted FPM, based on pre-reform population count and weights, closely matches actual FPM transfers before the reform, exhibiting a correlation of 0.987. Panel (b) further confirms that our predicted FPM using post-reform population count and weights similarly predicts actual post-reform transfers effectively.

Figure C.3: Predicted vs reported FPM transfer



(a) Pre-population count

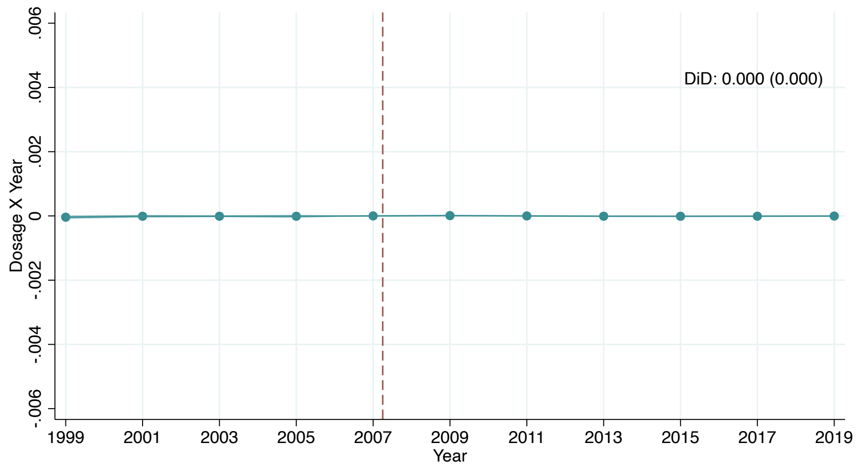


(b) Post-population count

This figure shows binned scatterplots of the predicted vs reported FPM transfers for all municipalities in Brazil. We construct 100 bins using the centiles of the predicted transfers, and plot the average predicted and reported FPM transfers for municipalities in the bin. The correlation reported used all observations. Panel (a) plots predicted transfers based on pre-reform population counts and weights against reported FPM transfers in the last year pre-census. Panel (b) plots predicted transfers based on post-reform population count and weights against reported FPM transfers in the first year post-census. The figure confirms our ability to accurately simulate FPM transfers.

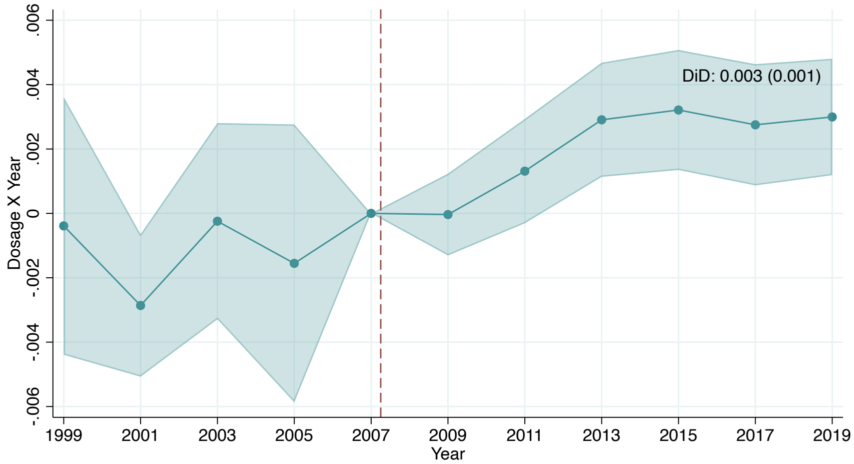
D Transparency of Event Study Estimates

Figure D.1: Event study of the VAT revenues per capita using the control states only



This figure shows the first difference-in-differences from our tripple-difference strategy. Specifically, we show the trends in standardized test scores for municipalities with different values of the per-capita VAT revenues in the pure control group–states that never introduced the performance-based transfers. The figure plots the θ_y coefficients from estimating $f^m_{it} = \nu^m + \nu_{st} + \sum_{y \neq 2007} \theta_y T^m \times \mathbf{1}[t = y] + \epsilon^m_{it}$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, ΔT^m is the value of the per-capita VAT revenues pre-reform, $\mathbf{1}[t = y]$ are year indicators, and ϵ^m_{it} 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 students; prior to 2005, the sample comprises random student samples from municipal schools. Figure 3 shows the overall effect estimates using the tripple-difference strategy.

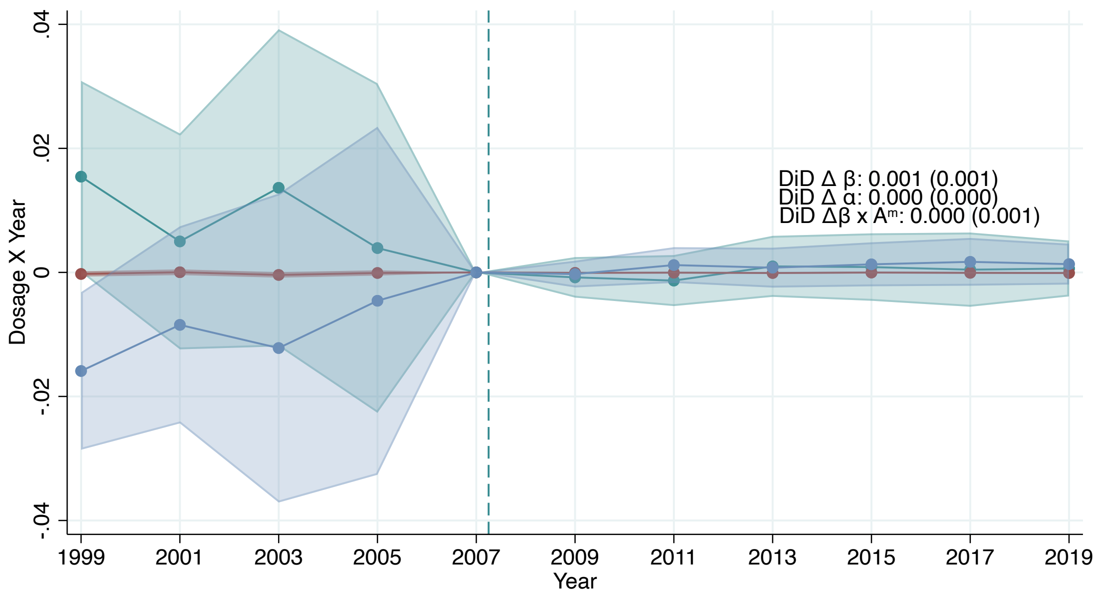
Figure D.2: Event study of the bonus pool using the treatment states only



This figure shows the second difference-in-differences from our tripple-difference strategy. Specifically, we show the trends in standardized test scores for municipalities with different changes in the bonus pool per capita in the treated states. The figure plots the θ_y coefficients from estimating $f_{it}^m = \nu^m + \nu_{st} + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{it}^m$ 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, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{it}^m 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 students; prior to 2005, the sample comprises random student samples from municipal schools. Figure 3 shows the overall effect estimates using the tripple-difference strategy.

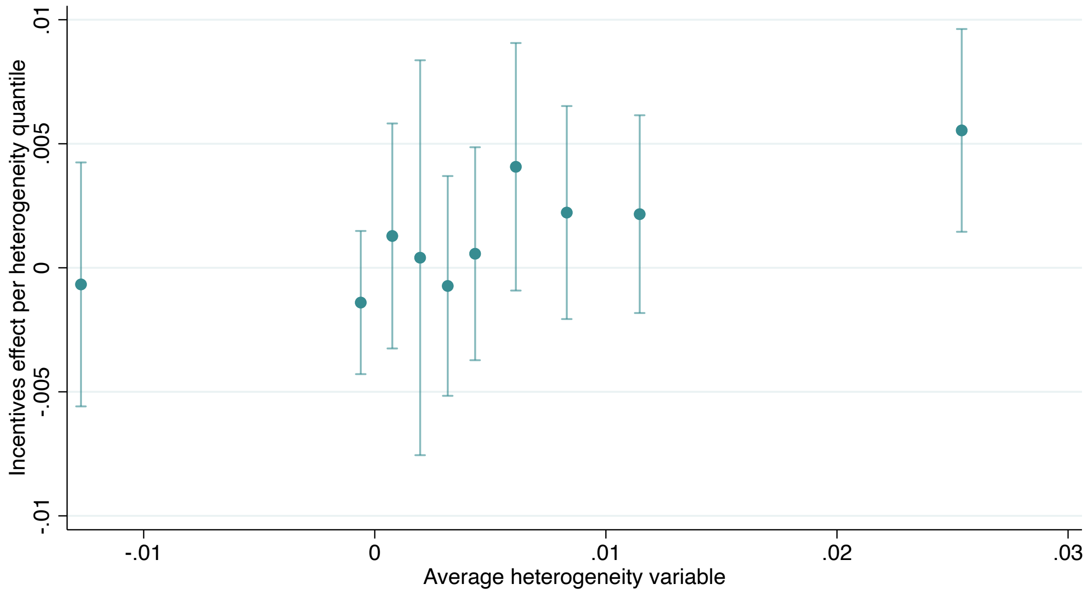
E Heterogeneity Exercises

Figure E.1: Estimates of effects from incentives, unconditional transfers, and transfer conditional on baseline performance



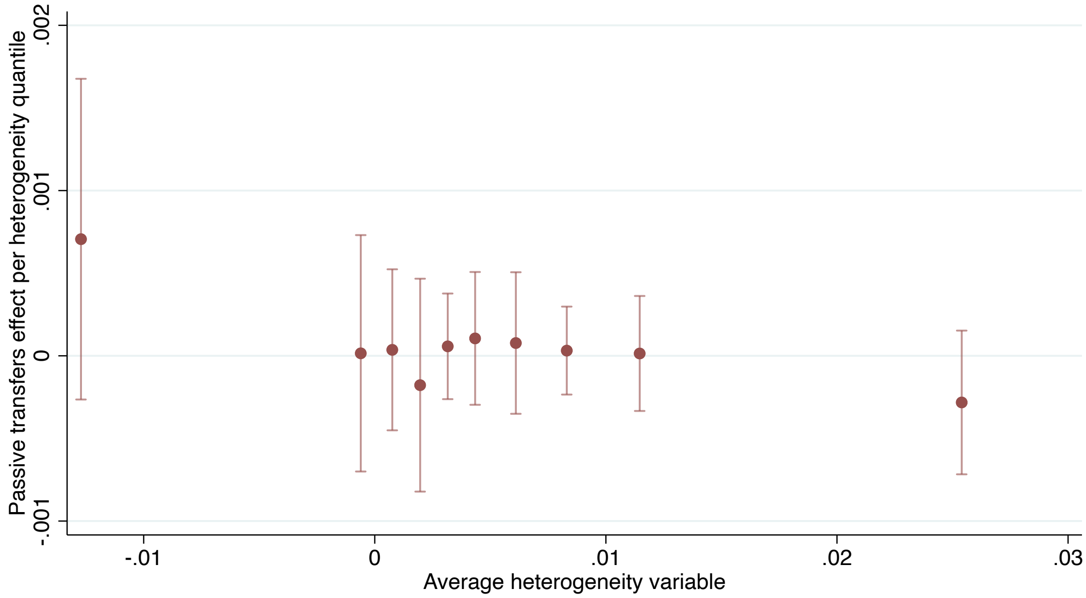
This figure estimates separetly the effect of each component of the passive transfers–unconditional transfers and transfers conditional on baseline performance–and the incentive effect. The figure plots the estimates of ρ_s, γ_s, and η_s from equation $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \left(\rho_s \Delta\beta^m + \gamma_s \Delta\alpha^m + \eta_s \Delta\beta^m \cdot \tilde{f_{A^m}} \right) \times 1[t = y] + \epsilon_{it}^m$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, $\Delta\alpha^m$ is the change in unconditional transfers, $\Delta\beta^m \cdot \tilde{f_{A^m}}$ is the change in transfers conditional on relative baseline performance ($\tilde{f_{A^m}}$), $\mathbf{1}[t = s]$ are year indicators, and ϵ_{it}^m is the residual. The coefficients ρ_s, γ_s, and η_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 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 samples of municipal school students. The resulting estimates are noisy and do not provide clear evidence of differential effects.

Figure E.2: Heterogeneity of the bonus pool effects by baseline performance



This figure estimates the heterogeneity of the incentive effects by baseline performance of municipalities. We divide municipalities into deciles of baseline performance $\tilde{f_{A^m}}$ and plot the ρ_q coefficients estimated with the following specification: $f_{it}^m = \sum_{q \in Q} (\rho_q 1[\text{quantile} = q] \times \Delta\beta^m \times \mathbf{1}[t > 2007] + \gamma_q 1[\text{quantile} = q] \times \Delta y^m \times \mathbf{1}[t > 2007]) +$ [munic FEs] + [state-year FEs] + [quantile-year FEs] + ϵ_{it}^m where $1[\text{quantile} = q]$ are indicators for each decile of baseline performance, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t > 2007]$ is an indicator for post-reform years, and ϵ_{it}^m is the residual. We include municipality fixed effects, state-year fixed effects, and quantile-year fixed effects as controls. The coefficients ρ_q capture the incentive effects for each decile of baseline performance. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. From 2007 onward, the sample includes all students in municipal schools with at least 20 students; prior to 2005, the sample comprises random samples of municipal school students. The result shows that the effects of the bonus pool, $\Delta\beta^m$, are positive only among municipalities with high baseline performance.

Figure E.3: Heterogeneity of the passive transfer effects effects by baseline performance in the control group



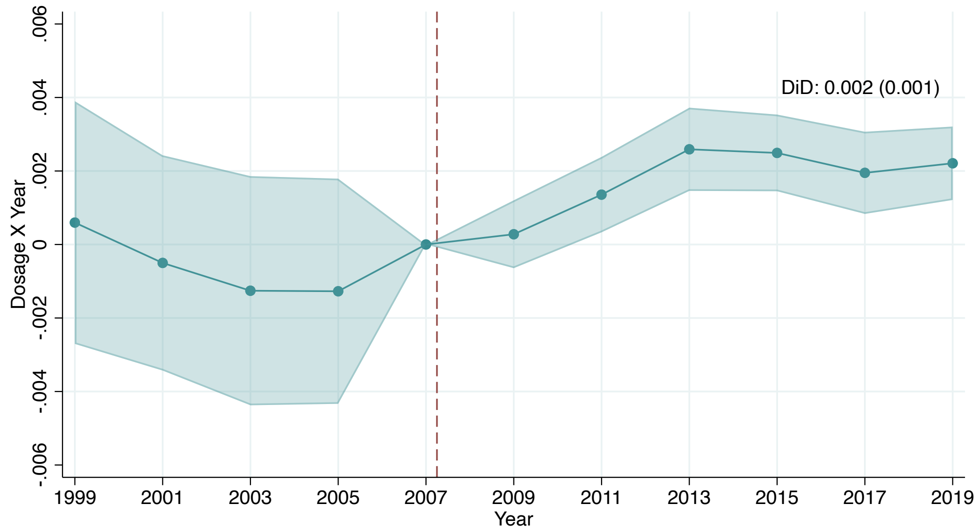
This figure estimates the heterogeneity of the passive transfer effects by baseline performance of municipalities. We divide municipalities into deciles of baseline performance $\tilde{f_{A^m}}$ and plot the γ_q coefficients estimated with the following specification: $f_{it}^m = \sum_{q \in Q} (\rho_q 1[\text{quantile} = q] \times \Delta\beta^m \times \mathbf{1}[t > 2007] + \gamma_q 1[\text{quantile} = q] \times \Delta y^m \times \mathbf{1}[t > 2007]) +$ [munic FEs] + [state-year FEs] + [quantile-year FEs] + ϵ_{it}^m where $1[\text{quantile} = q]$ are indicators for each decile of baseline performance, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t > 2007]$ is an indicator for post-reform years, and ϵ_{it}^m is the residual. We include municipality fixed effects, state-year fixed effects, and quantile-year fixed effects as controls. The coefficients γ_q capture the passive transfer effects for each decile of baseline performance. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. From 2007 onward, the sample includes all students in municipal schools with at least 20 students; prior to 2005, the sample comprises random samples of municipal school students. The result shows that the effects of the passive transfers are positive only among municipalities with low baseline performance.

F Robustness checks

F.1 Main Results Using Portuguese Test Scores

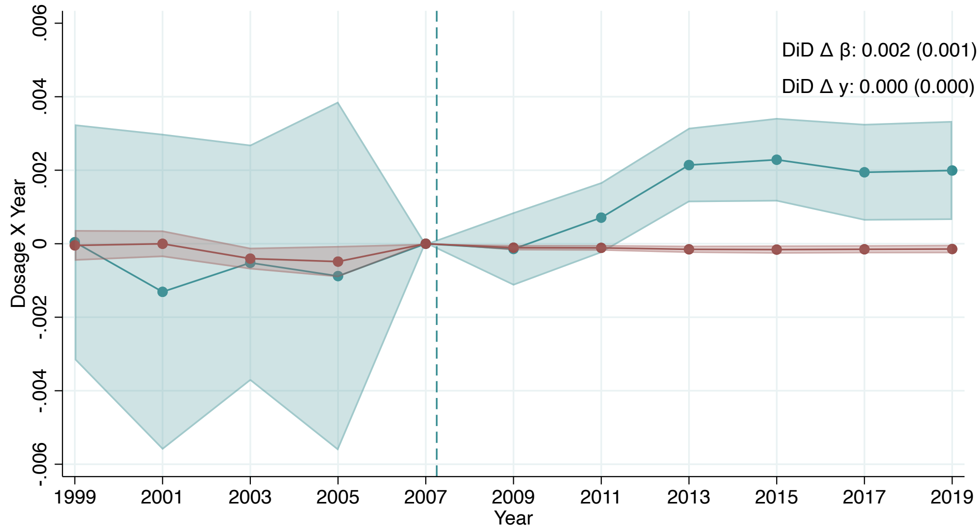
In the main text, we present our main results using standardized math test scores. Here, we replicate these results using standardized Portuguese test scores.

Figure F.1: Overall effects of performance-based transfers



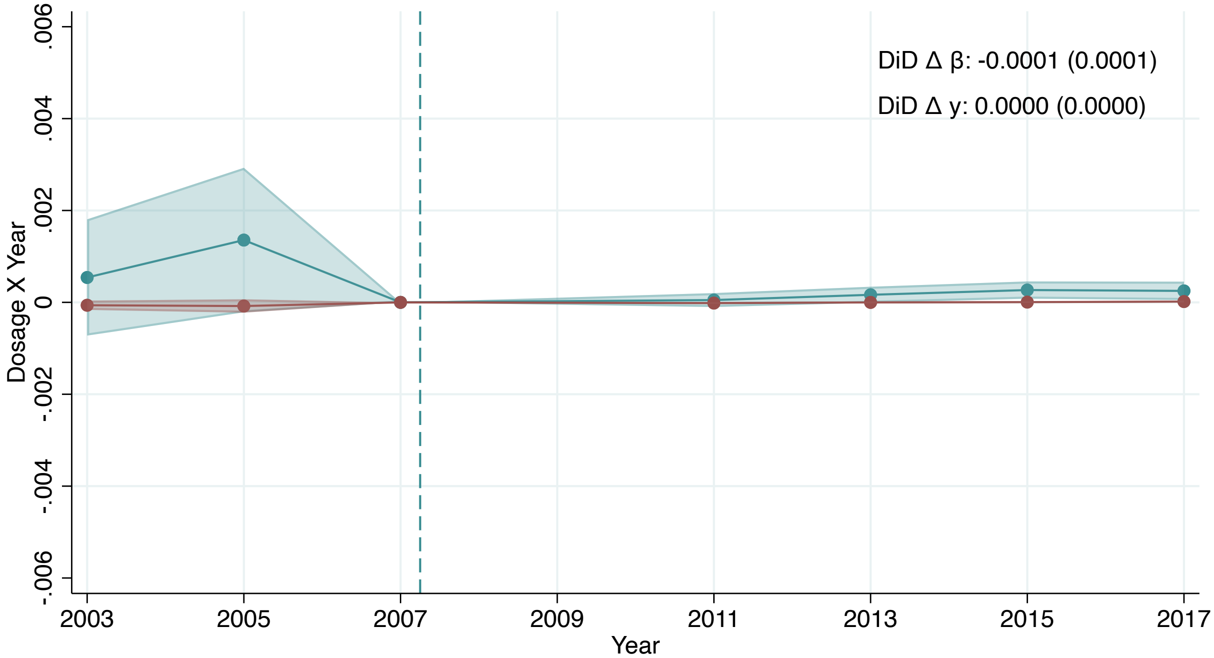
Notes: This figure shows the overall effects of performance-based transfers on student test scores. It plots the θ_y coefficients from estimating equation 5: $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{it}^m$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{it}^m 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 students; prior to 2005, the sample comprises random student samples from municipal schools. Figure 3 shows the equivalent results using math test scores.

Figure F.2: Effects of the bonus pool and investment-independent transfers



Notes: This figure shows the incentive and passive transfer effects, estimated using the extended event-study specification from equation 8: $f_{it}^{m} = \nu^{m} + \nu_{st} + g_t\left(T^{m}\right) + \sum_{y \neq 2007} \left(\rho_s \Delta\beta^{m} + \gamma_s \Delta y^{m}\right) \times 1[t = y] + \epsilon_{it}^{m}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t\left(T^{m}\right)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^{m}$ is the change in per capita bonus pool in municipality m, Δy^{m} is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_{it}^{m} is the residual. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 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 samples of municipal school students. Figure 5 shows the equivalent results using math test scores.

Figure F.3: Increase in predicted Portuguese test scores is zero or relatively small

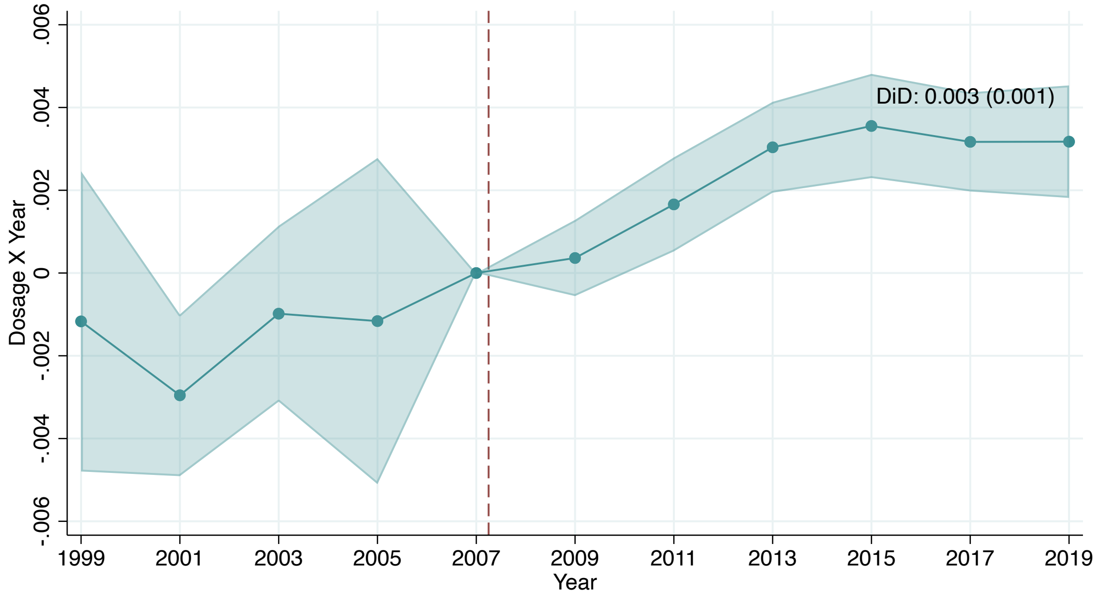


This figure shows the incentive and passive transfer effects, estimated using the extended event-study specification from equation 8: $\hat{f}_{it}^{m} = \nu^{m} + \nu_{st} + g_t\,(T^{m}) + \sum_{y \neq 2007} (\rho_s \Delta\beta^{m} + \gamma_s \Delta y^{m}) \times 1[t = y] + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t\,(T^{m})$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^{m}$ is the change in per capita bonus pool in municipality m, Δy^{m} is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_{imt} is the residual. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. The outcome variable, $\hat{f}_{it}^{m}$, 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. The scale of the plot is set to match the scale of the incentive and passive transfer effects on test scores in figure 5. The results indicate no significant exclusion of predictably lower-performing students following the introduction of performance-based transfers. Figure 9 shows the equivalent results using predicted math test scores.

F.2 Sample selection

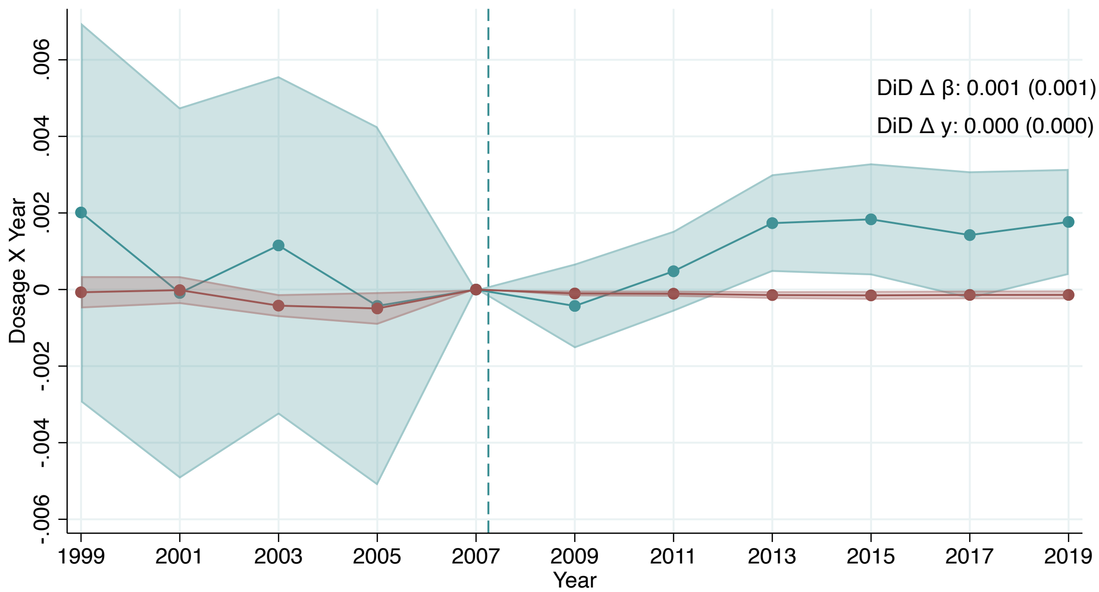
In the main analysis, we did not exclude any municipalities from the sample. Given that the reform was inspired by the municipality of Sobral's education policies and that other municipalities were encouraged to adopt similar strategies, one could argue that the municipality of Sobral should be removed from the analysis. In this appendix, we replicate the main results excluding Sobral and show that the results are robust to its exclusion.

Figure F.4: Overall effects of performance-based transfers excluding the municipality of Sobral



This figure shows the overall effects of performance-based transfers on student test scores. It plots the θ_y coefficients from estimating equation 5: $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{it}^m$ where ν^m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality, $\mathbf{1}[t = y]$ are year indicators, and ϵ_{it}^m 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 students; prior to 2005, the sample comprises random student samples from municipal schools. Figure 3 shows the equivalent results for the sample including the municipality of Sobral.

Figure F.5: Incentive effects and passive transfers excluding the municipality of Sobral



This figure shows the incentive and passive transfer effects, estimated using the extended event-study specification from equation 8: $f_{it}^{m} = \nu^{m} + \nu_{st} + g_t(T^m) + \sum_{y \neq 2007} (\rho_s \Delta\beta^m + \gamma_s \Delta y^m) \times 1[t = y] + \epsilon_{it}^{m}$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_{it}^{m} is the residual. The coefficients ρ_s and γ_s capture the dynamic effects of the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 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 samples of municipal school students. Figure 5 shows the equivalent results for the sample including the municipality of Sobral.

Table F.1: Overall effect of performance-transfers on incentivized and non-incentivized subjects excluding the municipality of Sobral

	(1)	(2)	(3)
	Natural Science	Math	Portuguese
1(t = 2019) $\times \beta^m$	0.003**	0.007**	0.003
	(0.002)	(0.003)	(0.003)
1(t = 2019) $\times y^m$	0.001	0.000	-0.001
	(0.001)	(0.001)	(0.001)
R^2	0.115	0.135	0.157
Municipal FEs	✓	✓	✓
State-year FEs	✓	✓	✓
T^m-year FEs	✓	✓	✓
N	11078	198850	198919

This 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 (9): $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \rho(\Delta\beta^m \cdot Post_t) + \gamma_s(\Delta y^m \cdot Post_t) + \epsilon_{imt}$ where ν_m are municipality fixed effects, ν_{tS} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, Δy^m is the change in passive transfers, $\mathbf{1}[t = s]$ is a year indicator, and ϵ_{imt} is the residual. The coefficients ρ_s and γ_s capture the incentive and passive transfer effects, respectively. Standard errors are clustered at the municipality level. Table 1 shows the equivalent results for the sample including the municipality of Sobral.

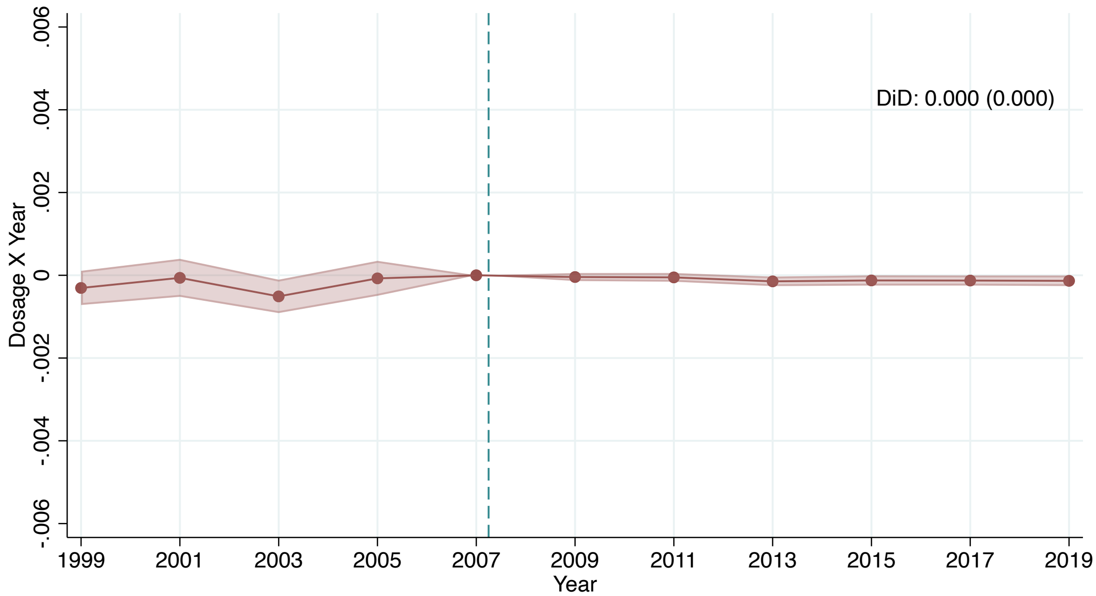
F.3 Passive transfer effects

Recall that the change in passive transfers is given by

$$\Delta y^m = \Delta\alpha^m + \Delta\beta^m \tilde{f_{A^m}}$$

where $\Delta\alpha^m$ is the change in unconditional transfers per capita, $\Delta\beta^m$ is the change in the bonus pool per capita, and $\tilde{f_{A^m}}$ is the relative baseline performance of municipality m. Thus, the null result could represent that the effect of unconditional transfers is 0, or that the effects of the bonus pool are not differential by baseline performance. To investigate this, we estimate the effect of $\Delta\alpha^m$ in the pure control group, where the bonus was never introduced.

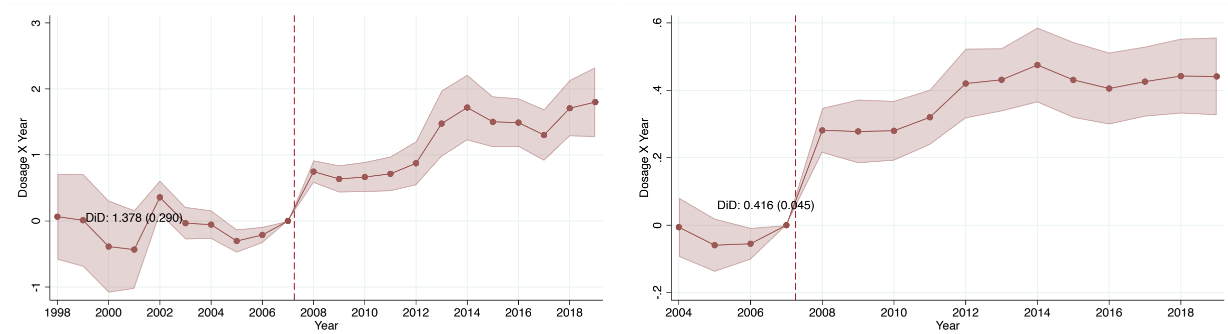
Figure F.6: Passive transfer effects in the control states



This figure shows passive transfer effects, estimated using the extended event-study specification from equation 8: $f_{it}^m = \nu^m + \nu_{st} + g_t(T^m) + \sum_{y\neq 2007}(\gamma_s \Delta\alpha^m) \times 1[t = y] + \epsilon_{it}^m$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t(T^m)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\alpha^m$ is the change in unconditional transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_{it}^m is the residual. The coefficients γ_s capture the dynamic effects of the passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. The sample includes only students in municipalities from the control group–states that never introduced performance-based transfers. 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.

which contrasts to their increase in revenues and expenditures in education:

Figure F.7: Passive transfer effects in revenues and expenditures in education per capita in the control states



(a) Revenues per capita

(b) Expenditures in education per capita

This figure shows passive transfer effects, estimated using the extended event-study specification from equation 8: $Y_t^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \sum_{y \neq 2007}\left(\gamma_s \Delta\alpha^m\right) \times 1[t = y] + \epsilon_t^m$ where ν_m are municipality fixed effects, ν_{st} are state-year fixed effects, $g_t\left(T^m\right)$ are decile-by-year fixed effects of per-capita VAT revenues, $\Delta\alpha^m$ is the change in unconditional transfers, $\mathbf{1}[t = s]$ are year indicators, and ϵ_{it}^m is the residual. The outcome variables are revenues per capita in panel (a) and expenditures in education per capita in panel (b). The coefficients γ_s capture the dynamic effects of the passive transfer effects, respectively. Standard errors are clustered at the municipality level, and shaded areas represent 95 percent confidence intervals. The sample includes only municipalities from the control group–states that never introduced performance-based transfers.

G Model proofs

G.1 Proof of proposition 1

We begin using the problem of the municipality to define the investment Marshallian demand function and Slutsky equation, which will allow us to link changes in the share τ allocated to the bonus pool and the investment-independent transfers (y^m) to the investment decision of municipalities. Next, we use the envelope theorem to consider utility changes from marginal changes to τ. Using both results, we solve the central government's problem to derive the optimal transfers.

In our conceptual framework in section 5, recall that we get the municipality's problem in terms of a simple two-good consumption problem:

$$v(r, y^m) = \max_{C,I} u(C, I)$$

$$\text{s.t. } C^m + (1-r)I^m = y^m$$

where $r = \frac{\tau B z}{F}$ and $y^m = \tau B f_{\tilde{A^m}} + (1-\tau)B$. The Slutsky equation with respect to the price $(1-r)$ is given by the usual

$$\frac{\partial I^m}{\partial(1-r)} = \frac{\partial I^{m,h}}{\partial(1-r)} - \frac{\partial I^m}{\partial y^m} I^m$$

where the $I^{m,h}((1-r), u)$ is the Hicksian supply function. To get the Slutsky equation with respect to τ, we note that

$$\frac{dI^m(1-r, y^m)}{d\tau} = \frac{\partial I^m}{\partial(1-r)} \frac{\partial(1-r)}{\partial \tau} + \frac{\partial I^m}{\partial y^m} \frac{\partial y^m}{\partial \tau}.$$

We can work to obtain each one of the terms from above in terms of τ and y^m. The first term is given by the Slutsky equation with respect to $(1-r)$. Using the chain rule, and noting that $(1-r) = \left(1 - \frac{\tau B z}{F}\right) \implies \frac{\partial(1-r)}{\partial \tau} = -\frac{Bz}{F}$, we can express the Hicksian partial it in terms of τ as:

$$\frac{\partial I^{m,h}(1-r, u)}{\partial(1-r)} = -\frac{F}{Bz} \frac{\partial I^{m,h}}{\partial \tau}$$

and therefore the Slutsky of $(1-r)$ in terms of τ:

$$\frac{\partial I^m}{\partial(1-r)} = -\frac{F}{Bz} \frac{\partial I^{m,h}}{\partial \tau} - \frac{\partial I^m}{\partial y^m} I^m.$$

Combining this result with $\frac{\partial(1-r)}{\partial \tau} = -\frac{Bz}{F}$ and $\frac{\partial y^m}{\partial \tau} = B\left(f_{\tilde{A^m}} - 1\right)$, we can obtain the Slutsky equation for investment in terms of τ:

$$
\begin{aligned}
\frac{dI^m(1-r,y^m)}{d\tau} &= \frac{\partial I^m}{\partial(1-r)}\frac{\partial(1-r)}{\partial\tau} + \frac{\partial I^m}{\partial y^m}\frac{\partial y^m}{\partial\tau} \\
&= \underbrace{\frac{\partial I^{m,h}}{\partial\tau}}_{\text{substitution effect}} + \underbrace{\frac{\partial I^m}{\partial y^m}\left[\frac{Bz}{F}I^m\right]}_{\text{income effect}} + \underbrace{\frac{\partial I^m}{\partial y^m}B\Big(\tilde{f}_{A^m}-1\Big)}_{\text{inframarginal rewards}}
\end{aligned}
$$

The three components of the Slutsky equation are interpreted as follows. The substitution effect has the same meaning and interpretation as usual. Fixing the municipality's utility level, how much does it change in investments due to a change in the return to investments. It is positive and leads to more investments as the share τ increases.

The second component, the income effect, also has the usual interpretation: it captures how much investment changes due to the change in real income caused by a change in the return to investment (price change). As always, we need to scale the income partial, $\frac{\partial I^m}{\partial y^m}$, by the negative of the amount that the expenditure function changes as we change the price of investment, $(1-r)$. A change in the price leads the minimum expenditure to change by I^m. However, since $1-r = 1-\frac{\tau Bz}{F}$, then a change in τ leads to a change of $-\frac{Bz}{F}I^m$ in the minimum expenditure.

The third component captures the rewards/punishments on passive transfers that municipalities receive from their inframarginal relative production $\tilde{f_{A^m}} = \frac{f_{A^m}}{F}$. A decrease in unconditional transfers reduce the passive transfer of all municipalities by $1 \cdot B$. The increase in the bonus pool increases municipalities passive transfers by $\tilde{f_{A^m}}$. Municipalities with inframarginal production above average production $f_{A^m} > F$ get rewarded with larger passive transfers $B\left(\tilde{f_{A^m}}-1\right) > 0$, and municipalities with inframarginal production below average production get punished with lower passive transfers, $B\left(\tilde{f_{A^m}}-1\right) < 0$.

Next, we use the envelope theorem to understand how changes in τ affect the utility of municipalities. Let the Lagrangian of the municipality be given by:

$$
L = u(C^m, I^m) + \lambda\left[y^m(\tau) - C^m - (1-r(\tau))I^m\right].
$$

The first order conditions are given by:

$$
\frac{\partial u}{\partial C^m} = \lambda^*
$$

and

$$
\frac{\partial u}{\partial I^m} = -\frac{Bz}{F}\lambda^*
$$

The envelope theorem gives us that:

$$
\begin{aligned}
\frac{\partial v(r,y^m(r))}{\partial\tau} &= \lambda^*\left[\frac{\partial y^m(\tau)}{\partial\tau} + I^{m*}\frac{\partial r(\tau)}{\partial\tau}\right] \\
&= \lambda^*\left[B\left(\tilde{f_{A^m}}-1\right) + Bf_{I^m}\right]
\end{aligned}
$$

In words, the envelope theorem tells us that a change in the share of transfer via the share to the bonus τ only impacts the utility of municipalities via the budget constraint. The budget constraint is affected in two ways: a change in passive transfers, $\frac{\partial y}{\partial \tau}$, and a change in the price $\frac{\partial r(\tau)}{\partial \tau}$. Both affects matter for the utility of municipalities in as much as consumption matters for their utilities, $\frac{\partial u}{\partial C^m}$. The change in passive transfers creates disparities in resources and therefore in consumption. Municipalities with inframarginal production above average production $f_{A^m} > F$ gets rewarded with larger passive transfers $B\left(\tilde{f_{A^m}} - 1\right) > 0$, and municipalities with inframarginal production below average production get punished with lower passive transfers, $B\left(\tilde{f_{A^m}} - 1\right) < 0$. The effect on prices imply that all municipalities are richer and therefore can consume more. A change in τ leads to a change of $\frac{Bz}{F} I^m$ in the minimum expenditure.

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

$$\max_{\tau} SWF = \int_m \psi^m \left[f^m(r(\tau), y^m(\tau)) + \kappa v\left(r(\tau), y^m(\tau)\right)\right] dm.$$

Using the envelope theorem and the Slutsky equation, the FOC for the central government is

$$\begin{aligned}
0 &= \frac{dSWF}{d\tau} \\
&= \int_m \left(\psi^m z \frac{\partial I^{m,h}}{\partial \tau} + B\tilde{f_{I^m}}\left[\psi^m z \frac{\partial I^m}{\partial y^m} + \psi^m \kappa \lambda^m\right] + B\left(\tilde{f_{A^m}} - 1\right)\left[z\frac{\partial I^m}{\partial y^m} + \kappa\lambda^m\right]\right) dm \\
&= \underbrace{\int_m \iota^m \frac{\partial I^{m,h}}{\partial \tau} dm}_{\text{marginal social benefit - substitution}} + \underbrace{\int_m B\tilde{f_{I^m}}\omega^m dm}_{\text{marginal social benefit - income effect}} = \underbrace{-\int_m B\left(\tilde{f_{A^m}} - 1\right)\omega^m dm}_{\text{marginal social cost - passive transfers}}
\end{aligned}$$

where we defined the social marginal valuation of income as $\omega^m = \psi^m z \frac{\partial I^m}{\partial y^m} + \psi^m \kappa \lambda^m$. This captures how much society values an increase in passive transfers to municipalities. It combines two components: the social marginal valuation of income via production: $\omega_p^m = \psi^m z \frac{\partial I^m}{\partial y^m}$ and the social marginal valuation of private utility: $\omega_u^m = \psi^m \kappa \lambda^m$. The interpretation of the first term is as follows: as passive transfers increase, the municipality increases investment by $\frac{\partial I^m}{\partial y^m}$ and production by $z\frac{\partial I^m}{\partial y^m}$. The central government values this increase in the production of that municipality by $\psi^m \kappa z \frac{\partial I^m}{\partial y^m}$. The interpretation of the second term is as follows: the private marginal utility of passive transfers is λ^m. The central government values that gain in utility by $\psi^m \kappa \lambda^m$.

Alternatively, we can express the condition for optimality as:

$$\underbrace{\int_m \iota^m \frac{\partial I^{m,h}}{\partial \tau} dm}_{\text{marginal social benefit - substitution}} + \underbrace{\int_m B\tilde{f_{I^m}}\omega_f^m\left(1 + \omega_r^m\right) dm}_{\text{marginal social benefit - income effect}} = \underbrace{-\int_m B\left(\tilde{f_{A^m}} - 1\right)\omega_f^m\left(1 + \omega_r^m\right) dm}_{\text{marginal social cost - passive transfers}}$$

H Connecting the model to the data estimates

In this appendix, we start by showing how the overall effect of the bonus pool, estimated in section 3, can be decomposed into the effects of incentives (slope) and passive transfers (intercept), estimated in section 4. Then, we perform simulations of our model from section 5 to analyze the optimal transfer policy. To calibrate the model, we first show how to use the reduced-form estimates from section 4 to back out income and substitution effects of the bonus pool. Then, we use the estimates to perform comparitive statics of the optimal transfer policy.

H.1 Decomposing the Overall Effect into Incentives and Passive Transfers Effects

In this section, we show ho we can decompose the overall effect of the bonus pool estimated in section 3 to incentives (slope) effects and passive transfers (shift) effects of the bonus, estimated in section 4. We begin reminding of the empirical production function for standardized test scores defined in equation 6:

$$f_{it}^m = zI(r_t^m, y_t^m) + A^m + \varepsilon_{it}^m$$

where $I(r_t^m, y_t^m)$ denotes the Marshallian investment demand function, which depends on the return to performance improvements r_t^m and on passive transfers y_t^m, and z is the marginal productivity of investments. The term A^m captures inframarginal productivity differences across municipalities. We assume that A^m is time invariant and that investment decisions do not depend on it, though we relax the latter assumption in heterogeneity analyses in Appendix E. Finally, ε_{it}^mrepresents idiosyncratic shocks to student i outcomes.

If we take differences over time, we obtain:

$$\Delta f_{it}^m = z\Delta I_t^m \left(p, y^m, A^m\right) + \Delta\varepsilon_{it}^m \tag{H.1}$$

Using a first-order approximation, the overall effect of the bonus pool can be written as:

$$\Delta f_{i,t}^m \approx \underbrace{z\left(\frac{\partial I_t^m}{\partial r}\frac{\partial r}{\partial \beta} + \frac{\partial I_t^m}{\partial y^m}\frac{\partial y^m}{\partial \beta}\right)}_{\theta}\Delta\beta^m + \Delta\varepsilon_{it}^m. \tag{H.2}$$

Note that the overall effect of the bonus pool, θ, combines an incentives (slope) effect of the change in the relative price of investing in education, $z\left(\frac{\partial I_t^m}{\partial r}\frac{\partial r}{\partial \beta}\right)$ and an effect of the change in the passive transfers (intercept), $z\left(\frac{\partial I_t^m}{\partial y^m}\frac{\partial y^m}{\partial \beta}\right)$. In section 3, we estimate $\frac{\partial f_t^{m,z}}{\partial \beta} = \theta$ with the following regression from equation 5:

$$f_{it}^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \theta\Delta\beta^m \cdot Post_t + \epsilon_{it}^m$$

To separately estimate the incentives and passive transfers effects, we also allow the unconditional transfers to change, $\Delta\alpha^m$. Then, the empirical production function can be written as:

$$\Delta f_{it}^m \approx z\left(\frac{\partial I_t^m}{\partial z}\frac{\partial z}{\partial \beta}+\frac{\partial I_t^m}{\partial y^m}\frac{\partial y^m}{\partial \beta}\right)\Delta\beta^m + z\frac{1}{\sigma}\frac{\partial I_t^m}{\partial y^m}\frac{\partial y^m}{\partial \alpha}\Delta\alpha^m + \Delta\varepsilon_{it}^m.$$

To simplify the above, note that $\frac{\partial y^m}{\partial \beta} = \tilde{A^m}$ and $\frac{\partial y^m}{\partial \alpha} = 1$. I.e., the change in passive transfers from a change in the bonus is given by the relative baseline production of m, $\tilde{A^m}$, and the change in passive transfers from a change in unconditional transfers is simply 1. Define the change in passive transfers as $\Delta y^m = \tilde{A^m}\Delta\beta^m + \Delta\alpha^m$, and we can rewrite the decomposed effect on production as:

$$\Delta f_{it}^m \approx \underbrace{z\left(\frac{\partial I_t^m}{\partial r}\frac{\partial r}{\partial \beta}\right)}_{\rho}\Delta\beta^m + \underbrace{z\frac{\partial I_t^m}{\partial y^m}}_{\gamma}\Delta y^m + \Delta\varepsilon_{it}^m. \tag{H.3}$$

In section 4, we measure Δy^m and $\Delta\beta^m$ to estimate the passive transfers effect, γ, and the incentives effect, ρ, using the following regression from equation 9:

$$f_{it}^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \rho\left(\Delta\beta^m \cdot Post_t\right) + \gamma_s\left(\Delta y^m \cdot Post_t\right) + \epsilon_{imt}$$

Combining equations H.2 and H.3, and noting that $\frac{\partial y^m}{\partial \beta} = \tilde{A^m}$, we can see that the overall effect of the bonus pool can be decomposed into the estimated incentives (slope) effect, ρ, and a passive transfers (intercept) effect, γ, as follows:

$$\frac{\partial f_t^{m,z}}{\partial \beta} = \rho + \gamma f_{\tilde{A^m}}.$$

H.2 Estimating Income and Substitution Effects

To estimate income and substitution effects from the data, we start from the first-order approximation of the empirical production function which we derived in appendix H.1:

$$\Delta f_{it}^m \approx \underbrace{z\left(\frac{\partial I_t^m}{\partial r}\frac{\partial r}{\partial \beta}\right)}_{\rho}\Delta\beta^m + \underbrace{z\frac{\partial I_t^m}{\partial y^m}}_{\gamma}\Delta y^m + \Delta\varepsilon_{it}^m.$$

where $\Delta y^m = \Delta\alpha^m + \Delta\beta_t^m\tilde{A^m}$ is the change in passive transfers per capita and $\Delta\beta^m$ is the change in the bonus pool per capita. In section 4, we estimate the passive transfers effect, γ, and the incentives effect, ρ, using the following regression:

$$f_{it}^m = \nu^m + \nu_{st} + g_t\left(T^m\right) + \rho\left(\Delta\beta^m \cdot Post_t\right) + \gamma_s\left(\Delta y^m \cdot Post_t\right) + \epsilon_{it}^m$$

To link our estimates of ρ and γ to substitution and income effects, we use $\beta = \tau B$ and fix α to derive a new investment Slutsky equation in terms of the bonus pool:

$$\underbrace{\frac{\partial I^{m,h}}{\partial \tau}}_{\text{substitution effect}} + \underbrace{\frac{\partial I^m}{\partial y^m}\left[\tilde{f_{I^m}}\right]}_{\text{income effect}} + \underbrace{\frac{\partial I^m}{\partial y^m}\tilde{f_{A^m}}}_{\text{inframarginal rewards}} \tag{H.4}$$

Using the Slutsky equation H.4 and $\frac{\partial I^m(1-r,y^m)}{\partial \alpha} = \frac{\partial I^m(1-r,y^m)}{\partial y^m}\frac{\partial y^m}{\partial \alpha} = \frac{\partial I^m(1-r,y^m)}{\partial y^m}$, we can rewrite the empirical production function as:

$$\Delta f_{it}^m \approx \underbrace{z\left(\frac{\partial I^{m,h}}{\partial \tau} + \frac{\partial I^m}{\partial y^m}\tilde{f_{I^m}}\right)}_{\rho}\Delta\beta^m + \underbrace{z\frac{\partial I_t^m}{\partial y^m}}_{\gamma}\Delta y^m + \Delta\varepsilon_{it}^m$$

Assuming we can measure z and the normalized production $\tilde{f_{I^m}} = \frac{zI^m}{F}$ (see the next section H.3), we can back out $\frac{\partial I}{\partial y^m}$ and $\frac{\partial I^h}{\partial \beta}$ as follows:

$$\frac{\partial I_t^m}{\partial y^m} = \frac{\gamma}{z}$$

$$\frac{\partial I^{m,h}}{\partial \tau} = \rho - \frac{\gamma}{z}\tilde{f_{I^m}}$$

H.3 Optimal Transfers Comparitive Statics

To simulate the optimal transfer for different parameter values of the model, we use the expanded optimality condition derived in section 5:

$$\underbrace{\int_m \iota^m \frac{\partial I^{m,h}}{\partial \tau}dm}_{\text{marginal social benefit - substitution}} + \underbrace{\int_m B\tilde{f_{I^m}}\omega_f^m\left(1+\omega_r^m\right)dm}_{\text{marginal social benefit - income effect}} = \underbrace{-\int_m B\left(\tilde{f_{A^m}}-1\right)\omega_f^m\left(1+\omega_r^m\right)dm}_{\text{marginal social cost - passive transfers}}$$

where $\frac{\partial I^{m,h}}{\partial \tau}$ is the substitution effect of investment, $\iota^m = \psi^m z$ is the social marginal valuation of investment, B is the overall budget of the central government, $\tilde{f_{I^m}}\frac{zI^m}{F}$ is the relative investment production, $\omega_f^m = \psi^m z\frac{\partial I^m}{\partial y^m}$ social marginal valuation of income in production, $\omega_r^m = \frac{\kappa\lambda^m}{z\frac{\partial I^m}{\partial y^m}}$ is the relative social value of private utility vs. performance gains, and $\tilde{f_{A^m}} = \frac{f_{A^m}}{F}$ is the relative inframarginal production.

There are several parameters that we need to assume or estimate from the model to perform counterfactuals. To estimate the inframarginal production f_{A^m} of each municipality m, we measure the average test scores of municipalities in the pre-reform period, when they are not incentivized. To estimate the aggregate production F, we sum up the inframarginal production across all municipalities, $F = \int_m f_{A^m}dm$.

The budget B of the central government is given by the total VAT transfers to municipalities per capita from the state of Ceará: R$ 41.

For the marginal productivity of investment, z, we need to assume how a dollar invested in education translates into test score improvements.[28] We take three estimates from the literature. The first is from Jackson and Mackevicius (2021)'s meta-analysis of "all known credibly causal studies" in the U.S. for the effects of increase spending on public K-12 school on test scores. They find that, on average, a $ 1,000 increase in per-pupil public school spending (for four years) increases test scores by 0.044 σ, which we translate to a 0.00001 σ to a R$ 1 per capita increase. There are two issue with these estimates. First, they are based on studies from the United States. Second, spending in public schools may be diverted away and thus not represent an increase in investments. To address these issues, we use the estimates from from Muralidharan and Sundararaman (2011) as an upper bound to z. Their intervention is one of the most cost-effective and strong treatment effect estimated in the literature, and could represent an upper bound to the test score return to investment in education. They find that a performance-based bonus to teachers in Indian state of Andhra Pradesh increased math test scores by as much as 0.27 σ for a cost of Rs.10,000 per school. Using the number of students and the exchange rate, this translates to 0.047σ increase in the test scores for each R$ 1 invested per student. We interpret this as an upper bound on the usage of transfers to improve test scores.

The Pareto weights are of course subjective and depend on the planner's preferences for redistribution. We assume a functional form for the Pareto weights, $e^{-\chi A^m}$, where χ is a parameter that dictates the aversion to inequality of the planner. We chose this functional form to match, at baseline performance, Mirrlees (1971)'s marginal social welfare. We then normalize the pareto weights, $\psi^m = \frac{e^{-\chi A^m}}{\sum_m e^{-\chi A^m}}$, to ensure that they add up to one and facilitate calculations.

We simulate the investment production, $f_{I^m} = I^m(r(\tau), y^m(\tau))z$, for a vector of τ values. We start from the point $\tau = 0$, where $I^m = 0$. Then, for each other τ value, we make a simple linear extrapolation:

$$f_{I^m} = \frac{\partial f^m}{\partial \beta} \underbrace{\cdot B \cdot \tau}_{\Delta\beta} - \frac{\partial f^m}{\partial y^m} \underbrace{\cdot B \cdot (1-\tau)}_{\Delta\alpha}$$

To estimate the two relevant partials from equation **??**, we use the extended event-event study findings from section 4. The effects on standardized test scores are directly estimated as $\frac{\partial f^m}{\partial y} = \gamma$ and the partial $\frac{\partial f^m}{\partial \beta} = \rho$.

The estimates of $\frac{\partial I}{\partial y^m}$, described in appendix H.2, are estimated as $\frac{\partial I_t^m}{\partial y^m} = \frac{\gamma}{z}$. The estimates of $\frac{\partial I^h}{\partial \beta}$, also described in appendix H.2, are estimated as $\frac{\partial I^{m,h}}{\partial \tau} = \rho - \frac{\gamma}{z} \tilde{f_{I^m}}$.

To assess the value of relative social value of private utility vs. performance gains, $\omega_r^m = \frac{\kappa \lambda^m}{z \frac{\partial I^m}{\partial y^m}}$, we make a few remarks. First, note that the passive transfers effect on education production, $z\frac{\partial I^m}{\partial y^m}$, was estimated in section 4 quite low. This would push towards a large ω_r^m. Second, note that in section 6 we found that the increase in passive transfers is mostly translated back into education. This suggests that λ^m is also quite low. The rest of the transfers are spent on health, adminstrative costs, and urbanism. Several studies find that unconditional transfers have disappointing effects

[28] Note that the marginal productivity of investment, z, does not measure how a dollar transferred to a municipality translates into test score improvements ($\frac{\partial f^m}{\partial \alpha}$), as the transfer is not necessarily invested in education.

on these sectors and increase in corruption in Brazil (e.g., Gadenne (2017), Caselli and Michaels (2013), Brollo et al. (2013)).[29] Thus, we think that the relative social value of private utility vs. performance gains, ω_r^m, is likely to be small. Nonetheless, we use a value of 5 in our simulations to be conservative.

Table H.1 summarizes the key parameters we need to estimate to compute the optimal transfer policy and the sources of variation we use to estimate them.

[29] Litschig and Morrison (2013) provide a relevant exception. They find that unconditional transfers from the FPM lead to better education outcomes in the 1980s.

Table H.1: Summary of Key Parameters

Parameter	Description	Source	Values
f_{A^m}	Inframarginal production	Performance in education in the pre-reform period	$A^m \in [-0.52, 0.61]$
F	Aggregate production	Sum of inframarginal production across municipalities	$F = \int_m f_{A^m} dm$
z	Marginal productivity of investment	Backed out from Jackson and Mackevicius (2021) and Muralidharan and Sundararaman (2011)	$z \in [0.00001\sigma, 0.047\sigma]$
B	Central government budget	Total VAT transfers to municipalities per capita from the state of Ceará	R$ 41
ψ^m	Pareto weights	$\psi^m = \frac{e^{-\chi A^m}}{\sum_m e^{-\chi A^m}}$. Functional form chosen to match, at baseline, Mirrlees (1971)'s marginal social welfare	$\chi \in [0, 5]$
$\frac{\partial I}{\partial y^m}$	Change in investment with respect to passive transfers	Extended event-study in Section 4. Detailed in appendix H.2.	$\frac{\partial I_t^m}{\partial y^m} = \frac{\gamma}{z}$
$\frac{\partial I^h}{\partial \beta}$	Substitution effect	Extended event-study in Section 4. Detailed in appendix H.2.	$\frac{\partial I^{m,h}}{\partial \tau} = \rho - \frac{\gamma}{z} \tilde{f_{I^m}}$
f_{I^m}	Production from investment	We evaluate a first-order approximation detailed above.	$f_{I^m} = \frac{\partial f^m}{\partial \beta} \underbrace{\cdot B \cdot \tau}_{\Delta\beta} - \frac{\partial f^m}{\partial y^m} \underbrace{\cdot B \cdot (1-\tau)}_{\Delta\alpha}$
ω_r^m	Relative social value of private utility vs. performance gains	Assumed based on findings from section 6 and discussed above	$\omega_r^m = 5$

We study how the relative importance of the incentives and passive transfers effects alter the optimal transfer allocation. As shown in appendix H.1, the overall effect of the bonus pool can be decomposed into the incentives (slope) effect, ρ, and the passive transfers (shift) effect, γ, as follows:

$$\frac{\partial f_t^m}{\partial \beta} = \rho + \gamma \bar{A}.$$

In figure 11, we hold fixed the overall effect of bonus pool, 0.003, and vary the relative importance of the incentives effect to the overall effect, $\frac{\rho}{\rho+\gamma\bar{A}}$, to see how the optimal transfer allocation changes. The figure shows that as the relative importance of the incentives effect increases, the share of the bonus pool increases, while the share of the unconditional transfers decreases. This motivates the importance of measuring both the income and substitution effects of the bonus pool to understand the optimal transfer allocation.

Second, we study how the central government's aversion to inequality alter the optimal transfer allocation. We picked the functional form of the Pareto weights to match Mirrlees (1971)'s marginal social welfare at baseline production, $\phi^m = \frac{e^{-\chi A^m}}{\sum_m e^{-\chi A^m}}$. The larger is χ, the more averse the central government is to inequality. When $\chi = 0$, the central government is Utilitarian. In figure **??**, we fix the other parameters, such as the incentives and passive transfers effects, to the estimates from the data and vary χ to see how the optimal transfer allocation changes. The figure shows that as the aversion to inequality increases, the share of the unconditional transfers increases, while the share of the bonus pool decreases. Nonetheless, for any given χ, the share of the bonus pool is always substantially large and larger than the current average bonus pool implemented in Brazil. This highlights a key takeaway from our empirical findings: performance-based transfers should constitute a sizable share of the optimal transfer mix, even when the central government is averse to inequality.

I Effects in other sectors

In this Appendix, we first show the incentives and passive transfers effects in the expenditure of other sectors. Then, we analyze the overall effects in these sectors.

We focus our analysis on the following sectors: education, health, administration, urbanism, transportation, social security, social assistance, legaislative, special expenditures, sanitation, and agriculture. As shown in figure I.1, these sectors correspond to 92.9% of the overall expenditures of the municipalities. All other sectors have expenditures below 2% of the overall expenditures, individually. We combine them into a single sector called "other sectors" for the analysis.

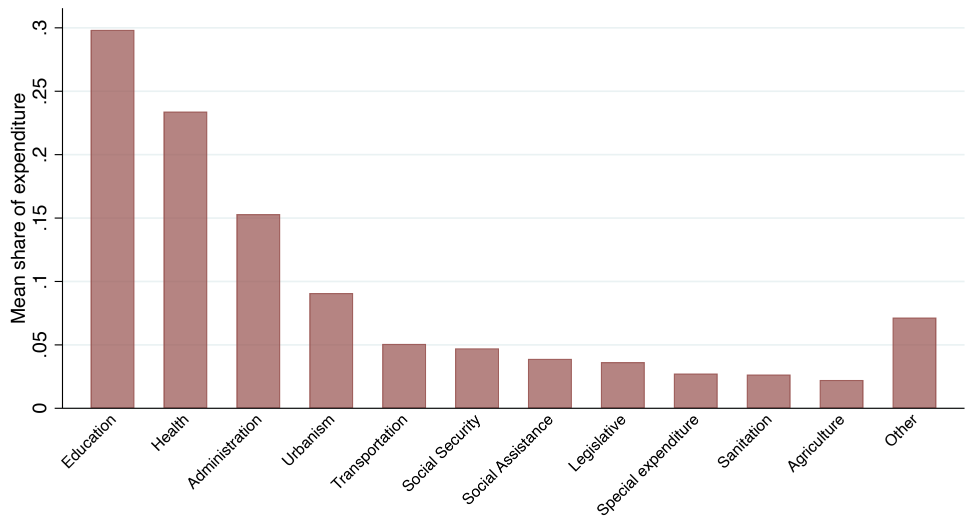


Figure I.1: Mean expenditure shares across sectors pre-reform.

I.1 Incentives and passive transfers effects in other sectors

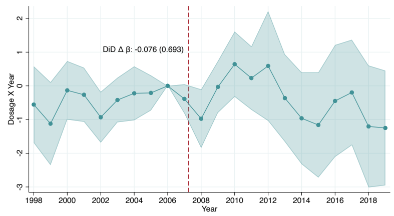
In this section, we present the incentives and passive transfers effects in the expenditure of other sectors. Specifically, we estimate the same equation 8 from section 4, but we use municipalities' revenues and expenditures as the dependent variable. We replicate the equation below, for convenience:

$$Y_{mt} = \nu_m + \nu_{tS} + \sum_{s \neq 2007} (\rho_s \Delta\beta^m + \gamma_s \Delta\hat{y}^m) \times \mathbf{1}[t = s] + \epsilon_{mt} \tag{I.1}$$

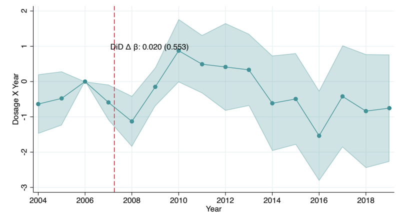
where Y_{mt} is the revenue or expenditure in municipality m at time t. ν_m are municipality fixed effects, controlling for any time-invariant heterogeneity across municipalities. ν_{tS} are state-year fixed effects, controlling for any common shocks within states. $\Delta\beta^m$ is the change in per capita bonus pool in municipality m, and Δy^m is the change in passive transfers for municipality m. The coefficients ρ_s and γ_s estimate the effects of the incentive and the passive transfer effects separately and over time.

Figure I.2 shows the incentives effects on revenues and expenditures across sectors. Figure I.3 shows the passive transfer effects on revenues and expenditures in other sectors. In the main text, figure **??** shows the shows the corresponding effects with difference-in-differences model. We find that the incentives effects did not significantly alter spending in any sector, including education, suggesting that mayors did not reallocate funds away from other areas to improve educational outcomes. In contrast, passive transfers significantly increased expenditures in several sectors, with the largest effects in education and health. These patterns are consistent with municipalities facing binding legal constraints on minimum spending in these areas, as described in Section 2.

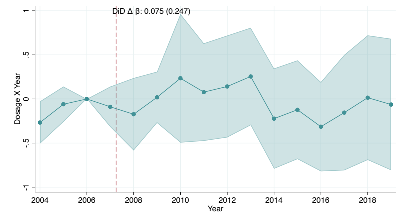
Figure I.2: Extended event study - incentives effects on revenues and expenditures



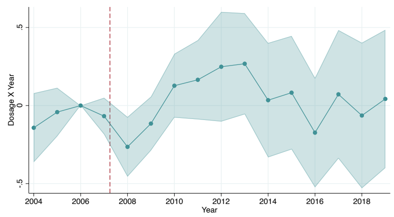
(a) Total revenues



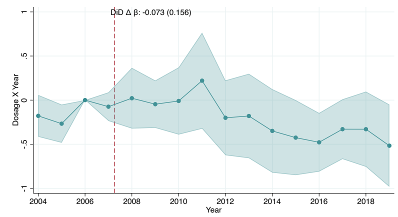
(b) Total expenditures



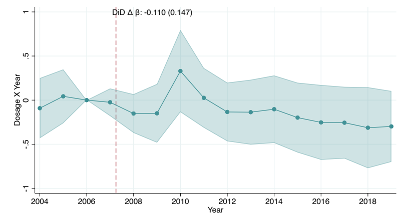
(c) Education



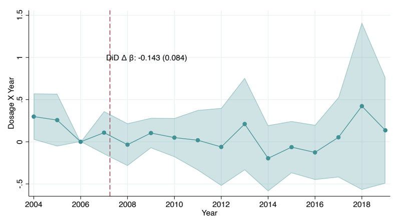
(d) Health



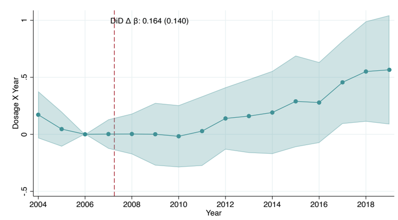
(e) Administration



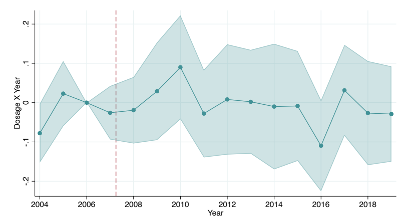
(f) Urbanism



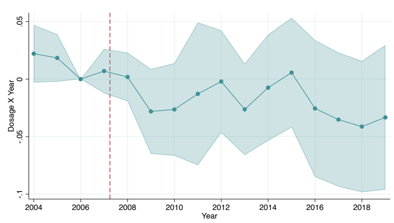
(g) Transportation



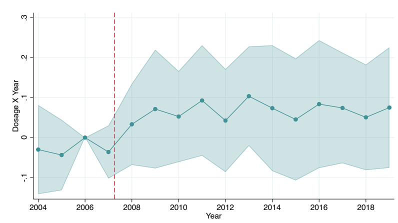
(h) Social security



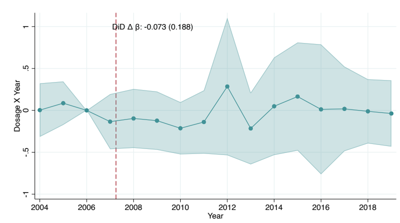
(i) Social assistance



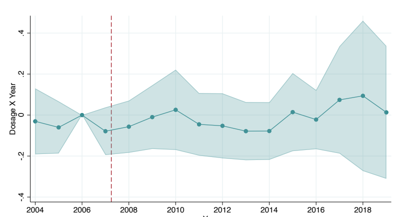
(j) Legislative



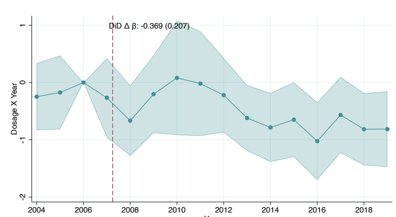
(k) Special expenditures



(l) Sanitation

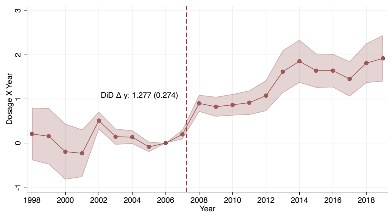


(m) Agriculture

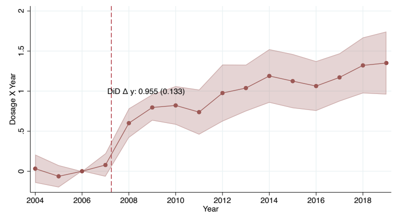


(n) Other sectors

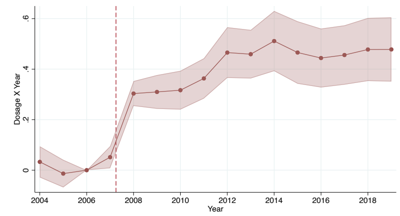
Figure I.3: Extended event study - passive transfer effects on revenues and expenditures



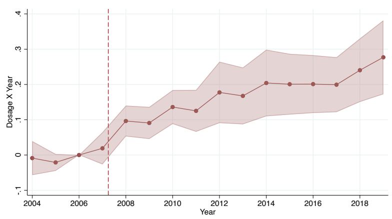
(a) Total revenues



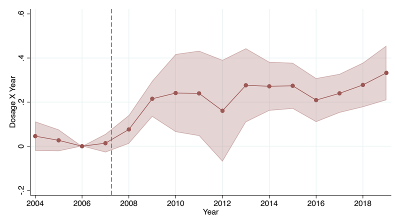
(b) Total expenditures



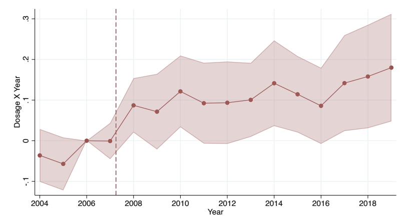
(c) Education



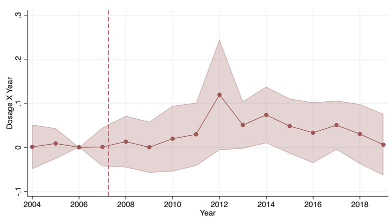
(d) Health



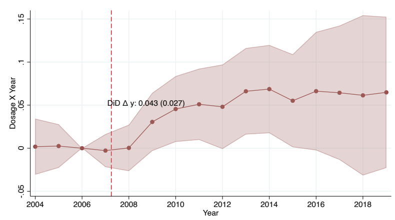
(e) Administration



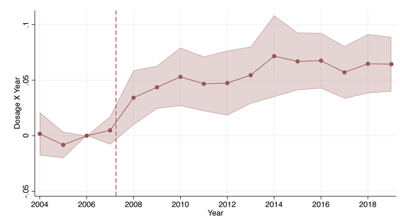
(f) Urbanism



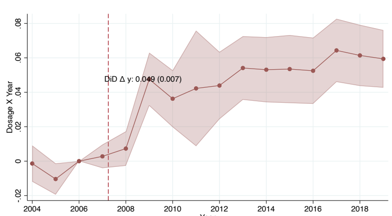
(g) Transportation



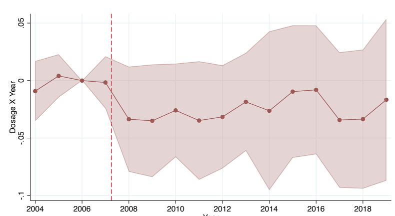
(h) Social security



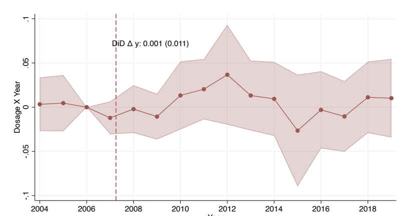
(i) Social assistance



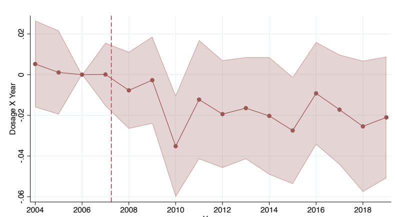
(j) Legislative



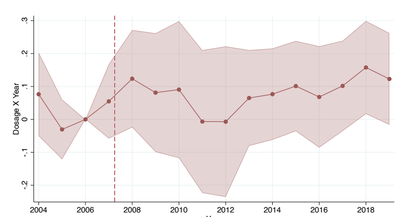
(k) Special expenditures



(l) Sanitation



(m) Agriculture



(n) Other sectors

I.2 Overall effects in other sectors

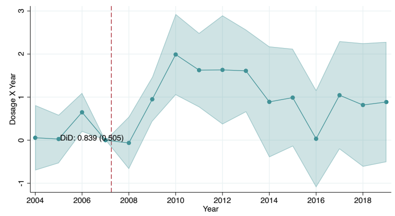
In this section, we present the overall effects in the expenditure across sectors. Specifically, we estimate the same equation 4 from section 3, but we use municipalities' revenues and expenditures as the dependent variable. We replicate the equation below, for convenience:

$$Y_{mt} = \nu_m + \nu_{st} + \sum_{y \neq 2007} \theta_y \Delta\beta^m \times \mathbf{1}[t = y] + \epsilon_{mt} \tag{I.2}$$

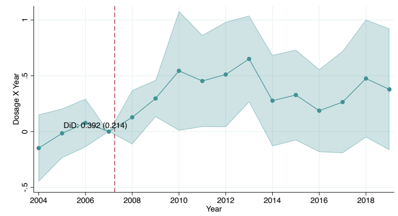
where Y_{mt} is the revenue or expenditure in municipality m at time t. ν_m are municipality fixed effects, controlling for any time-invariant heterogeneity across municipalities. ν_{tS} are state-year fixed effects, controlling for any common shocks within states. $\Delta\beta^m$ is the change in per capita bonus pool in municipality m. The coefficient θ_y estimates the overall effect of the performance-based transfer over time.

Figure I.4: Overall bonus pool effects on revenues and expenditures

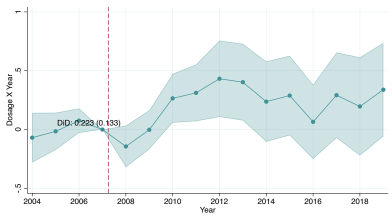
(a) Total revenues



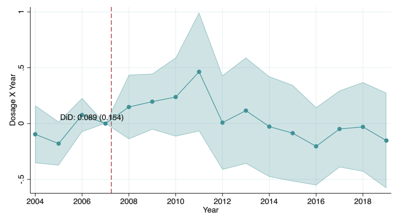
(b) Total expenditures



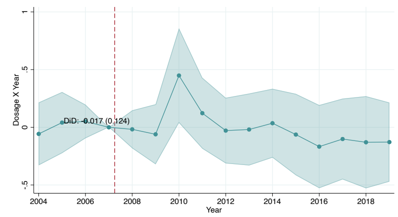
(c) Education



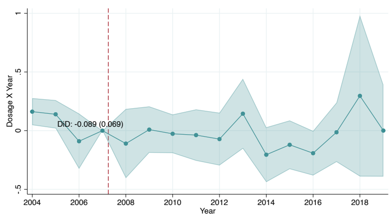
(d) Health



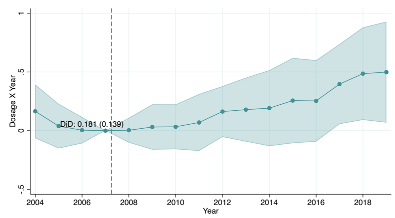
(e) Administration



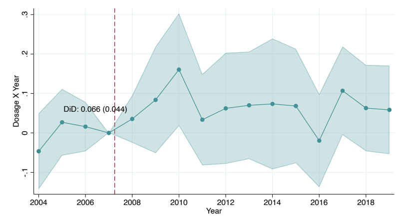
(f) Urbanism



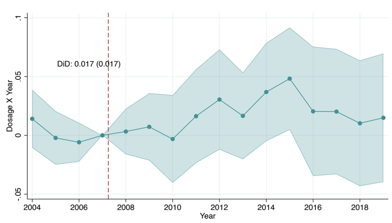
(g) Transportation



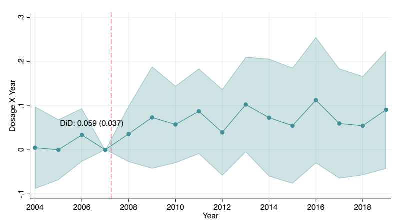
(h) Social security



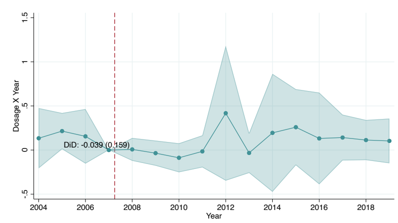
(i) Social assistance



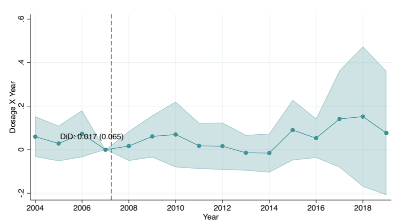
(j) Legislative



(k) Special expenditures



(l) Sanitation



(m) Agriculture

(n) Other sectors

J Details of the Inputs Indices

In section ??, 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 J.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 J.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 J.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
Quantity-related education inputs group		

Table J.1: Indexes constructed for education inputs

Index	**Inputs**	**Sources**
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

Crato fecha 10 escolas e causa protestos de pais

A exclusão das unidades reordena a rede de ensino, a exemplo do que vem sendo feito em outras cidades

Escrito por

28 de Janeiro de 2016 - 01:00

Fechamento de escola gera protesto

Iniciativa teria como objetivo reestruturar o parque escolar por meio da transferência de alunos e professores

Escrito por **Redação** producaodiario@svm.com.br

09 de Fevereiro de 2015 - 01:00

Prefeitura de Cabrobó recebe recomendação do MPPE para suspender nucleação de escolas rurais

Promotores ressaltaram que o fechamento das escolas representa uma violação aos princípios da gestão democrática e da legalidade.

Por G1 Petrolina

05/02/2020 11h45 · Atualizado há 5 anos

Ações do MPCE evitam fechamento de escolas municipais em Lavras da Mangabeira

10 de agosto de 2018

Figure J.1: School closures in the media