Beyond the Flypaper Effect: Crowding-In from Federal Investment in Public Transit

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October 30, 2025

Abstract

I examine how targeted federal grants affect state and local spending on public transit. The analysis uses comprehensive U.S. expenditure data from 2000–2019 and exploits an exogenous shock from the 2009 American Recovery and Reinvestment Act (ARRA). ARRA funds were apportioned to Urbanized Areas through preexisting formula programs, independent of potential changes in transit investment. Using ARRA apportionments as an instrument, I find that each \$1 of exogenous federal grants generates a \$0.20 annual increase in capital transit spending from all sources. This average effect reflects two distinct phases between 2009–2019: an initial rise in federally funded expenditures with no displacement of state or local spending (the flypaper effect), followed by substantial crowding-in of state funding to the same localities. I develop a conceptual model of local officials' investment decisions that distinguishes between guaranteed and flexible funding from each source, the latter requiring costly negotiation. In this framework, the initial flypaper effect arises from the stickiness of guaranteed funds, while the subsequent state crowding-in results from increased negotiation for flexible funding. This negotiation can be driven by two mechanisms: (i) higher returns to additional investment or (ii) lower costs of negotiation. Empirical evidence on the nature of additional spending rejects the first mechanism, while cross-state variation in institutional settings supports the second. Taken together, these results suggest that federal grants empowered local officials to secure additional flexible state funding by reducing the cost of negotiation, leading to a disproportionate and persistent increase in total public transit spending.

JEL: H77, R42

1 Introduction

In the United States, intergovernmental transfers account for more than one-third of both state and local revenues (CRS, 2025). Most transfers are categorical, and their effectiveness depends on how they affect targeted spending. Although one might expect state and local funding in the targeted category to be displaced, empirical studies have found estimates ranging from substantial crowd-out to near dollar-for-dollar pass-through—a phenomenon referred to as the "flypaper effect" (Inman, 2009). However, most of this literature analyzes pairwise governmental relationships at either the federal–state or the state–local level, potentially missing important dynamics. In the context of public transit, I find that the interaction among federal, state, and local governments generates a *crowding-in* effect. Additional federal grants to localities enable them to secure more state funds over time, leading to a cumulative two-to-one increase in targeted spending over eleven years.

Public transit in the U.S. is a prominent case of fiscal intergovernmental relations. While it is administered and largely financed locally, expansions and upgrades rely heavily on transfers from other levels: between 2000 and 2019, federal funds accounted for 41% of capital expenditures, and state funds for 14%. Although funding for transit represents only a modest share of the federal budget, it has fluctuated substantially—such as the 67% increase in 2021.[1] Given the high federal share in capital spending and the volatility of federal funding, this paper provides the first systematic empirical evidence on how changes in federal grants affect state and local spending on transit. Amid ongoing debates about environmental and energy-security policy and the proper role of the federal government, a key policy question is whether federal grants for transit stimulate additional investment or merely displace what state and local governments would have spent otherwise.

In my empirical estimation, I exploit the American Recovery and Reinvestment Act (ARRA) of 2009 (Pub. L. 111-5) as a source of a plausibly exogenous increase in federal funding for transit. ARRA funds were distributed to Urbanized Areas (UZAs) through two preexisting formula programs, the Urbanized Area Formula (UAF) and the Fixed Guideway Modernization (FGM).[2] The amount distributed to each UZA was determined by fixed formula inputs,

[1]On average, the Infrastructure Investment and Jobs Act of 2021 authorizes $21.5 billion per year in guaranteed federal funding for transit over FY 2022–2026. The previous authorization bill, the Fixing America's Surface Transportation Act of 2015, authorized an average of $12.85 billion per year over FY 2016–2021. Mallett (2023)

[2]UAF and FGM were used to distribute roughly 90% of ARRA funding for transit. The rest were distributed to 10 UZAs with eligible shovel-ready projects at the discretion of the Federal Transit Administration. These UZAs are excluded from my analysis.

rather than a competitive process, and did not require local matching. Thus, ARRA provided a source of variation in UZA-specific change in federal spending that was independent of the planned change in spending from state and local sources. This allows me to use ARRA funding amounts as an instrument for the increase in federal grants and estimate their causal effect on state, local, and total transit expenditures.

My analysis reveals a substantial and persistent impact of federal grants. A \$1 increase in federal grants per capita driven by ARRA leads to an additional \$0.2 in annual capital expenditures between 2009 and 2019. Over the eleven years, this implies a cumulative increase of about \$2.30 – more than twice the original federal investment. Extrapolating this causal estimate to the aggregate level suggests that roughly \$6.6 billion in ARRA formula funding generated \$1.4 billion in additional annual expenditures, equivalent to an 8 percent increase over the pre-2009 mean.

The effect has a distinct dynamic pattern. In the first six years after ARRA (2009-2014), spending from federal sources rose by \$0.14 per year without a significant displacement of state or local expenditures. This represents a traditional targeted flypaper effect: federal transfers translated into higher spending rather than displacing funding from other sources. In the subsequent five years (2015–2019), federal spending returned to pre-ARRA levels, but annual state investment increased by \$0.24, replacing and even overcompensating transitory federal support. Localities that initially received larger federal grants due to ARRA later experienced a crowding-in of state funds, producing a disproportionately large overall increase in transit expenditures.

To better understand the novel empirical finding of state funding crowding-in from additional federal grants, I develop a conceptual model in which a local official finances capital transit expenditures using three government sources: federal, state, and local. The key innovation of the model is that funding from each level consists of two components: a guaranteed portion and a flexible portion, the latter requiring costly negotiation by the local official. In this framework, the initial flypaper effect arises from the stickiness of guaranteed funds, while the subsequent crowding-in results from increased negotiation for flexible state funding. Differences in negotiation costs explain why no crowding-in is observed for local or federal sources.

I provide several validations of the model. First, the dynamics of the response to the ARRA shock, along with the differing responses of federal, state, and local spending, naturally give rise to an asymmetric structure of guaranteed and flexible funding, with the cost of the latter varying across sources. Second, I present evidence on the nature of the crowding-in effect. The effect persists within states and does not diminish when other UZAs in the same state receive additional federal grants, indicating that the impact of federal funding operates through local rather than state budgets and is not driven by competition among UZAs. I also find that crowding-in is stronger in states with a higher share of discretionary transit funding and a greater reliance on non-dedicated revenue sources such as general funds—consistent with modeling crowding-in as local officials negotiating for more flexible state funding.

This increased negotiation for state funds can be driven by two potential mechanisms: (i) a higher return to additional investment due to projects initiated with federal funds, or (ii) a lower cost of negotiation for local officials. The first mechanism encompasses cost overruns, economies of scale in capital-intensive projects, and network effects from system expansion. The second involves expertise signaling, learning by doing, and the stickiness of local budgets. I provide empirical evidence to distinguish between these two mechanisms.

To assess the first mechanism, I show that the additional funds were spent primarily on buses and bus facilities, which is inconsistent with the large, long-term projects implied by this channel. Moreover, bus fleets in more affected UZAs did not become larger or newer as a result. This suggests that ARRA funds were directed toward maintenance and incremental upgrades, or toward the purchase of more expensive buses, rather than expanding service or renewing fleets. Such spending aligns with the short ARRA timeline, during which local officials had less than a year to allocate funds to specific projects. Consistent with this interpretation, I find that relative transit service levels in more affected areas remained unchanged, while passenger trips increased only marginally. Because bus-related improvements are not highly capital-intensive and do not exhibit economies of scale, this pattern rules out the possibility that new projects induced additional state contributions in the later period.

I then test the second mechanism by examining cross-state variation in institutional settings. Using survey data from state Departments of Transportation (DOTs) collected by Tomer and Swedberg (2024), I show that crowding-in is stronger in UZAs located in states where local governments have greater autonomy over transportation decisions, yet remains similar across states with different levels of transparency in project selection. This pattern is consistent with the crowding-in of state funds being driven by an improved negotiation position rather than by investment in projects with higher returns. I therefore conclude that federal grants empowered local officials to secure additional flexible state funding by reducing the cost of negotiation.

By documenting both the flypaper effect and the crowding-in of state funds, this paper contributes to the literature on intergovernmental transfers. The translation of grants into spending without substantial displacement of other funds, known as the flypaper effect, was initially viewed as an anomaly (Courant et al., 1979). More recently, it has been documented in several contexts, including federal Medicaid requirements (Baicker, 2001), state education grants (Card and Payne, 2002), and windfall state revenues (Singhal, 2008). In contrast, complete crowding-out has been found in other settings, such as regular federal highway funding (Knight, 2002), Title I federal grants to schools (Gordon, 2004), and state education grants (Lutz, 2010). This paper is the first to document a flypaper effect in the context of public transit.

In contrast to crowding-out and the flypaper effect, crowding-in from federal grants has rarely been documented. The only previous empirical evidence comes from Leduc and Wilson (2017), who – similar to this paper – study the effect of ARRA but in the context of federal highway funding.[3] While Leduc and Wilson (2017) estimate a spending response greater than one, implying crowding-in, they primarily interpret it as evidence of the flypaper effect and do not attempt to explain it further. The standard explanations for the flypaper effect, such as a reluctance to reduce local taxes, can account for the absence of displacement but not for additional spending beyond the grant itself.

I propose a framework in which each level of government provides both guaranteed and flexible funding, allowing the model to accommodate both the flypaper effect and crowding-in. I further identify two mechanisms that could generate crowding-in and provide empirical evidence that, in my setting, it is driven by reduced negotiation costs for flexible funding through the empowerment of local officials. The observed pattern of spending on buses and bus facilities rules out the project-complementarity mechanism of crowding-in suggested by Leduc and Wilson (2017).

The focus on transit funding offers a unique opportunity to study a public good financed by all three levels of government. I find that localities are able to transform a transitory increase in federal grants into a potentially sustained increase in state funding. The possibility of such interaction is largely absent from prior literature and may help explain why crowding-in has rarely been observed. The only other empirical context involving three levels of government is Gordon (2004), who study school funding and find complete crowding-out after three years. An important distinction is that Gordon (2004) examine a permanent increase in

[3] Two other studies provide correlational evidence. Gramlich (1987) documents a reverse form of crowding-in: a decrease in state spending following a decrease in federal grants, which Oates (1999) describes as a "super-flypaper effect." Bernet (2007) finds evidence of crowding-in from federal transfers across public health agencies in Missouri.

federal funding, whereas ARRA was transitory. While the setting of Leduc and Wilson (2017) – highway funding – does not explicitly feature a local level, the Special Interest Groups (SIGs) they consider may play a similar role.[4] Therefore, this paper is the first to document crowding-in from federal grants in a three-level government setting and to explain it through a plausible mechanism.

I also contribute to the understudied question of optimal public transit funding by estimating the effect of a largely unconstrained increase in federal support. While the potential reductions in driving externalities (e.g., Parry and Small, 2009, Anderson, 2014) and other benefits of transit such as access equity (e.g., Glaeser et al., 2008) have been well documented, the literature rarely examines how transit should be financed. An important policy question is which level of government should bear primary responsibility for its funding. I show that federal transfers to localities were highly effective in increasing capital spending by attracting additional state investment, yet the resulting funds were likely directed toward marginal quality improvements rather than expanded service provision. This suggests a limited role for federal transfers in their current form in stimulating transit expansion.

To the best of my knowledge, this paper is the first to estimate the causal effect of transit funding allocated under ARRA and the first to examine its impact on transit-related outcomes.[5] Although transit funding represented a small share of ARRA overall, I find that it was effective in increasing immediate spending, even before accounting for the later crowding-in of state funds. Evidence on the impacts of different ARRA components can help guide the design of future stimulus programs, ensuring that they are effective not only for fiscal stabilization but also as sound public policy.

2 Overview of Public Transit in the U.S.

Public transit in the U.S. is a localized phenomenon, in contrast to intercity rail and buses. It provides services targeted for commute and recreational travel inside and in the near vicinity of cities and towns.[6] Public transit has a minuscule share of land passenger mileage (1%;

[4] Singhal (2008) also attribute the flypaper effect to bargaining with SIGs, but do not find crowding-in. The parallels between local governments and SIGs are a promising avenue for future research.

[5] There is a large literature on the effects of ARRA, mostly focused on employment. See, for example, Chodorow-Reich et al. (2012) and Wilson (2012).

[6] Transit is also provided in many rural areas, but passenger trips in rural areas account for less than 1% of all transit trips in the US. Therefore, rural transit is excluded from my analysis. (Federal Transit Administration, 2019).

Bureau of Transportation Statistics, 2023), but attracts much public attention and a large share of transportation funding (27%; Congressional Budget Office, 2025). One reason for this is a potentially large role of transit in reducing driving externalities (Anderson, 2014), while another is the vital role of transit for poor individuals (Glaeser et al., 2008).

Transit is provided in the form of buses and rail, the latter including heavy (metro/subway) and light (streetcars) rail. Across the US, about half of all transit trips are taken by rail (Federal Transit Administration, 2019). However, when New York City is excluded, this share falls to 34%.[7] Transit in the U.S. is provided by transit agencies, 92% of which are publicly-owned (Federal Transit Administration, 2019). In addition to the revenue from their operations, transit agencies receive substantial funding from local, state, and federal governments.

Despite the localized nature of public transit, when a typical system serves only one metropolitan area, all three governmental levels substantially participate in its funding. On average between 2000-2019, $52 billion was spent annually on transit in the US. Of that, 17% was financed from federal sources, 21% – from state sources, 33% – from local governments, and 29% – from direct revenue. The picture is quite different when looking at capital expenditures, which include spending on vehicles and facilities. Of the $16 billion spent annually on transit capital, 41% was financed by the federal government, 14% by state sources, 40% by local sources, and only 5% by directly-generated revenue (2% if NYC is excluded).

Thus, federal funding plays a large role in financing the expansions and upgrades of transit systems across the US. While operational expenditures (wages, vehicles operation) receive less federal money, they are to a large extent determined by the existing infrastructure, which was built using federal funding. Whether federal funding attracts or displaces funding from state and local sources is the central point of my inquiry.

2.1 Federal Funding

Federal funding for transit is overseen by the Federal Transit Administration (FTA). FTA's programs include formula grants, distributed based on pre-determined criteria, and discretionary grants, awarded competitively for specific projects. Additionally, the FTA is responsible for maintaining the National Transit Database (NTD). To receive federal funding, transportation agencies are requires to submit annual reports to the NTD, detailing their

[7] NYC takes up an enormous share of all national transit. In 2019, every 4.4 out of 10 trips taken and 2.1 out of 10 service miles provided were in the NYC Urbanized Area.

financial operations, service provision, and ridership data.

Formula grants are prevalent in transportation, and particularly in transit funding. Over 2000-2019, between 70-82% of all federal funding for transit was allocated through formula programs (APTA, 2016). Unlike discretionary grants awarded competitively, formula grants distribute funds based on pre-determined calculations outlined in the most recent appropriation act (passed every several years) using data from the NTD and the latest census. Due to the calculation process and data delays, inputs in the current formula apportionment is from three years prior.

For my setting, two formula programs are especially important. The first is the Urbanized Area Formula program (UAF), established in 1974. This program aims to provide reliable streams of funds for capital expenditures on transit in Urbanized Areas (UZAs). As such, it mostly relies on four relatively stable UZA-level inputs: population, population weighted by density, bus vehicle-revenue miles, and fixed-guideway vehicle-revenue miles (VRM).[8]Since its inception, UAF has been the largest federal program for transit, used to distribute around 42-48% of regular federal funding between 2000-2019 (**primer**). It played an especially prevalent role in the emergency ARRA funding in 2009: around 80% of all transit funds distributed to Urbanized Areas were from UAF. The second is the Fixed Guideway Modernization program, which is smaller and aimed at the minority of locations that operate rail transit. It has a complex tier system, with the majority of funds allocated in a pre-determined way based on 1997 inputs. It was used to allocate 10% of ARRA funding.

Importantly, both formula programs and discretionary grants for transit are administered on a reimbursement basis. Formula funds are first apportioned to Urbanized Areas or transit agencies but not drawn from the federal account. Then, funds from available formula amounts and awarded discretionary grants are obligated to eligible projects, which represents a legal promise of the federal government to pay for these expenses. Finally, transit agencies spend money on capital investments and operations and are reimbursed according to obligations.

Apportionments do not always result in outlays by the same UZA to which they were allocated. Most federal funding, including UAF funds, can be moved by the governor between small UZAs (population $\leq 200,000$) inside the same state, while unobligated funds can be also moved between larger UZAs after serval years. I use apportionment amounts as an instrument because apportionment is based on the UAF and FGM formulas and is thus exogenous to a change in capital expenditures. However, I use realized federal outlays (reim-

[8]A detailed breakdown of the formula can be found in Appendix Figure A1.

bursements) as the instrumented treatment because they represent the actual grants moving from the federal account to the local transportation agency.

2.2 Urbanized Areas

The majority of federal transit funding is allocated to UZAs that combine cities with their surrounding suburbs. Unlike Metropolitan Statistical Areas, they do not conform to county or any other administrative borders. This reflects the interconnected nature of metropolitan transportation systems, where travel patterns are determined by living and job arrangements rather than municipal boundaries. The borders of UZAs are updated by the Census Bureau after each decennial census. Following the exact definition, "an urban area will comprise a densely settled core [...] that meet[s] minimum population density requirements, along with adjacent territory". Urbanized Areas (UZAs) are urban areas with 50,000 or more people.

UZAs are a natural level of transit funding analysis. First, they are defined based solely on population patterns, which also determine transit demand and provision. This circumvents potential endogeneity in organizational structures across states. Second, most of of federal funding is allocated to UZAs. Even though individual transit agencies are the ones spending money, they report the primary UZA that they serve. Finally, UZAs consist of Census blocks and multiple statistics that I can use as covariates to improve precision and account for potential confounders are published for this level of aggregation.

2.3 Crowding-Out and Crowding-In

Public transit in the U.S. receives substantial funding from all three levels of government, and the interaction between different sources affects policy design. Given any federal transit policy objective, the degree of displacement (crowding-out) or attraction (crowding-in) of other funding for transit is pivotal for designing the distribution method and the scope of the program. It is intuitive to expect some degree of crowding-out, as an additional grant from the federal government frees some of the money to be spent on other uses or returned to constituents. However, it could also be the case that funding attracts more funding, either because of the increasing value of funds (e.g., concavity in the cost function) or because it becomes easier to bargain for more funds.

This question is closely related to the long-standing literature on the flypaper effect. The classic flypaper effect is defined as higher marginal public spending from intergovernmental grants compared to an increase local income: "money sticks where it hits."[9] More recently, empirical studies have focused on sector-specific crowding-out and flypaper effects. Since most intergovernmental grants are targeted at a specific sector, such as healthcare, education, or transportation, it is of greater importance whether they increase spending within this specific sector rather than public spending in general. Similar to the theoretical arguments about block grants, targeted grants should increase targeted spending only insofar as they increase local income. This would result in a crowding-out of spending from other sources by almost the amount of the grant. The absence of such strong crowding-out or, in the extreme cases, a one-to-one translation of targeted grants to spending is also referred to as the flypaper effect.[10]

In different contexts and using different identification strategies, several studies found a complete crowding-out of targeted intergovernmental grants, in accordance with the representative voter argument: Knight (2002) (federal highway grants to states), Gordon (2004) (Title I federal grants to school districts), and Lutz (2010) (state grants to local schools). On the other hand, similar to the older empirical literature, some studies find evidence of the absence of crowding-out, or the flypaper effect: Baicker (2001) (federal Medicaid requirements), Card and Payne (2002) (state education grants), and Singhal (2008) (state revenue from a settlement). Finally, Leduc and Wilson (2017) document a *crowding-in* of state spending from federal highway grants.

It is not clear based on the evidence from other contexts whether federal transit grants will crowd out, keep unchanged, or crowd in state and local funding. The most similar type of spending are highways, for which Knight (2002) and Leduc and Wilson (2017) find conflicting results. On the other hand, transit draws funds from all three levels of government, more similar to public schools than to state-managed highway construction. Evidence for educational funding varies as well, though with a similar identification strategy to mine,

[9] In a standard representative voter model, an unrestricted block-grant from the federal government is equivalent to an increase in local income and should increase total public spending by only about 5% (Inman, 2009). If the focus is on transit only, the predicted increase is even smaller: approximately the share of transit spending times 5%. Thus, it would crowd-out spending on transit from state and local sources by almost the whole amount of the grant. See Hines and Thaler (1995) and Inman (2009) for conceptual and empirical overviews of the traditional flypaper effect.

[10] Many federal programs include a matching component, which requires recipients to contribute a certain share of their own funds to receive the grant. This makes the absence of a full crowding-out or even a crowding-in more likely. However, as noted by Hines and Thaler (1995), if the local government spends enough to achieve the cap of the matching grant the matching component does not matter. In general, the flypaper effect might also be present for matching grants below the cap (including open-ended grants), but the empirical evidence on this is limited.

Gordon (2004) finds a complete crowd out from an increase in federal grants. One important distinction compared to my setting is that the increase in Gordon (2004) is permanent, whereas I study a transitory shock. This can affect the planning horizon and the capacity of state and local budgets to adjust their funding.

3 Empirical Strategy

To construct an optimal federal transit policy, an important issue is the effect of of additional federal grants on total spending, i.e., the extent of crowding-out or crowding-in. Empirically, federal grants to UZAs are measured as realized spending in a given year, due to the reimbursement nature of federal programs. Following the eligibility requirements for most federal funds and especially ARRA, I focus on capital expenditures. Moreover, the operational expenditures are majorly determined by prior investments. Thus, my main empirical question is how capital spending from federal sources (Cap^{fed}) affect capital state (Cap^{st}), local (Cap^{loc}), and total (Cap) capital spending.

Studying this relation is challenging because spending amounts from all sources are endogenous. Demand for transit and other local characteristics simultaneously affect expenditures from all sources, while available funding from each source affects spending from other sources through strategic decisions. A time-differences approach utilizing a panel structure might still have a similar problem. Local shocks to demand and to available funding affect spending from all sources. Thus, the following regression will be biased:

$$\Delta Cap_i = \alpha + \Delta Cap_i^{fed} + \varepsilon_i \tag{1}$$

, where ΔCap_i is the change in total capital spending and ΔCap_i^{fed} is the change in capital spending from federal sources. In other words, an exogenous variation in federal spending is needed to identify its effect on spending from other sources.

While formula amounts are endogenous and explicitly correlated with the determinants for transit demand, changes in allocation amounts can serve as plausibly exogenous shocks. For example, Gordon (2004) used the Census update as a source of such exogenous variation in formula amounts. In the context of transit, year-to-year changes in formula funding are not large. However, the American Recovery and Reinvestment Act (ARRA) of 2009 presents a unique setting when the response to the national recession created a large transient shock to federal funding for transit, which varied across locations based on a pre-determined formula.

3.1 ARRA as a Source of Exogenous Increase in Funding

The American Recovery and Reinvestment Act of 2009 (ARRA), whose main goal was to facilitate the recovery from the Great Recession, dedicated \$48 billion for transportation, out of which \$8.78 billion was spent on public transit (USDOT, 2017). This constituted a massive increase in federal funding for transit, as regular federal transit programs in that year amounted to just above \$10 billion. ARRA funds were distributed to UZAs using three programs: Urbanized Area Formula (80%), Fixed Guideway Modernization (10%), and Capital Investment Grants (10%).

UAF and FGM are formula programs with predetermined allocation rules and inputs from the 2000 Census and 2006 transit statistic. Capital Investment Grants (CIG) were distributed to 10 UZAs with shovel-ready projects that had the capacity to absorb additional funding. Excluding these 10 UZAs from the analysis due to the potential endogeneity of having a project underway, ARRA funding amounts had a clear formula determination. For UZA i:

$$ARRA_i = f(population_i^{2000}, density_i^{2000}, transit_i^{2006}, e_i^{2006}),$$

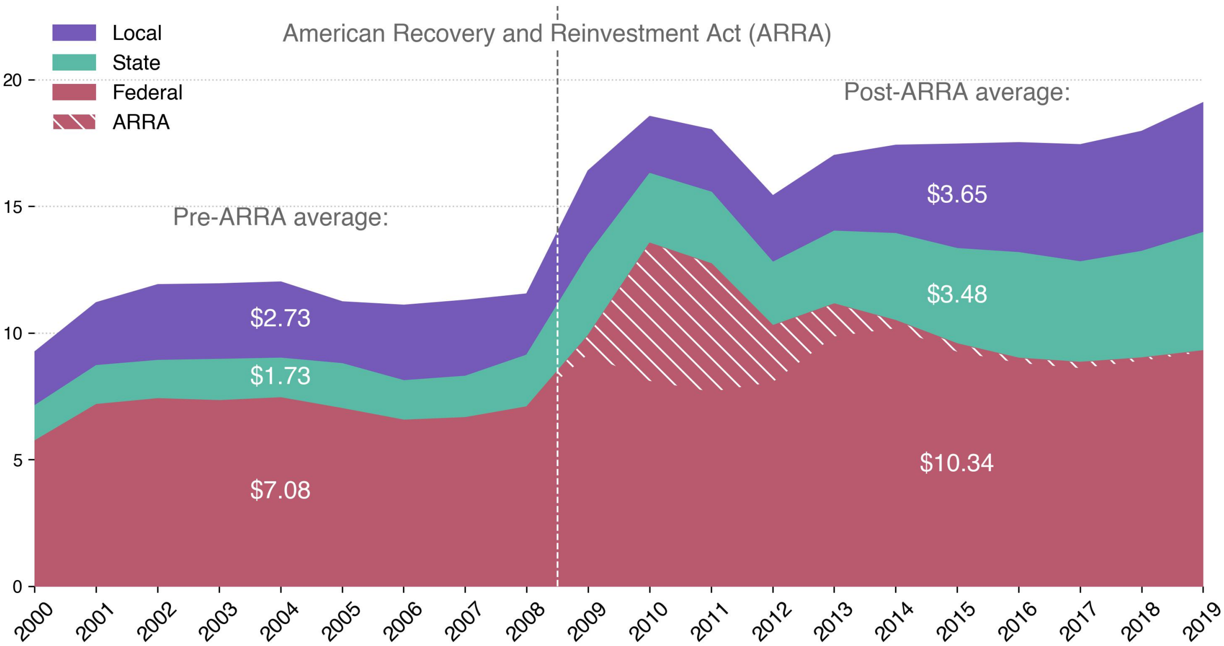
The goal of using a tried-and-true allocation mechanism was to make funds available quickly for spending and support the distressed economy. Additionally, ARRA funds were to be obligated to specific projects before October 2010 (with at least 50% of funds before October 2009) and spent before October 2015. ARRA funds were initially restricted to capital expenditures (infrastructure projects such as building new stations or acquiring new buses), and the restriction was lifted only after most funds were obligated. Unlike regular UAF and FGM programs, ARRA did not require matching with state and local funds. As seen in Figure 1, federally-funded capital expenditures increase immediately after 2009 with no displacement of state and local funds. Later, when federal funds start to return to pre-ARRA levels, state expenditures increase. This is a key motivation for my analysis.

3.2 Estimation

The transit part of ARRA was a large shock to federal funding in 2009. While the amount of ARRA funding ($ARRA_i$) is correlated with the level of capital spending, it is plausibly exogenous from the post-2009 change in it:

$$\Delta Cap_i \perp ARRA_i | X_i,$$

Figure 1: Annual Capital Expenditures by Funding Source Averaged Across UZAs.



All values are in per capita terms and in 2009 constant dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision.

Where $\Delta Cap_i = Avg(Cap_i^{2009-2019}) - Avg(Cap_i^{2000-2008})$. Since $ARRA_i$ has a known functional form, this is equivalent to:

$$\Delta Cap_i \perp population_i^{2000}, density_i^{2000}, transit_i^{2006} | X_i \tag{2}$$

In other words, the expected change in capital spending by a UZA is orthogonal to the lagged formula inputs.

Given this assumption, it is possible to instrument the change in federal grants with ARRA funding and estimate the effect of the former on the change in total capital spending. First Stage:

$$\Delta G_i = \alpha_{FS} + \beta_{FS} ARRA_i + \gamma_{FS,X} X_i + \varepsilon_i, \tag{3}$$

where $\Delta G_i = \underset{\text{09-14}}{\Delta} Cap_i^{fed} = Cap_i^{2009-2014} - Cap_i^{2003-2008}$.[11] Second Stage:

$$\Delta Cap_i = \alpha_{2SLS} + \beta_{2SLS} \widehat{\Delta G_i} + \gamma_{2SLS,X} X_i + \varepsilon_i \tag{4}$$

[11]Even though ARRA funding was allowed to be spent until 2015, small amounts were still spent up to 2019 because of granted exceptions. By 2014, more than 95% of all funding was spent.

To indirectly test the parallel trends assumption and demonstrate the dynamics of the effect, the Event-Study specification is estimated:

$$Cap_{iy} = \sum_{\substack{z=2000 \\ z\neq 2008}}^{2019} \mathbb{1}\{y = z\} \left[\beta_z \widehat{\Delta G}_i + \gamma_{Xz} * X_i\right] + \gamma_i + \gamma_y + \varepsilon_{iy}$$

In such specification, 2008 is normalized to zero and then β_z estimate the effect of $1 of federal grants on capital spending in year y, compared to the 2008 baseline relation. The coefficients fo years 2000-2007 show the absence of pre-treatment trends.

4 Data Description

The primary data source for this project is the National Transit Database (NTD) maintained by the Federal Transit Administration (`https://www.transit.dot.gov/ntd`). Transportation agencies submit regular reports to the NTD, detailing their expenditures and service provided each fiscal year. For this project, the data is aggregated to the level of Urbanized Areas (UZAs) based on the primary UZA reported by each agency (usually the one where they operate most extensively). When one agency serves several UZAs, all its expenditures are attributed to one, primary UZA in the aggregation.

I use only the the lower 48 states, as customary in transportation literature (see Lalive et al. (2013)). I include UZAs that reached the 50,000 population threshold in 2000 or 2010 Census, which allows me to have a full panel for 2000-2019. For my main specifications, I exclude 10 UZAs that received the Capital Investment Grant as part of ARRA.[12] My final dataset contains 473 UZAs, the information on which is presented in Table 1.

The expenditures data includes operational and capital expenditures divided into four main funding sources (federal, state, local, direct). I combine direct and local spending and call them simply "Local." The FTA also reports program apportionments to each UZA, including ARRA funds. Population and population density counts are from the decennial Census. Throughout the paper, I normalize spending and apportionments by 2000 population for each UZA. This approach avoids artificial changes in values when the Census updates population figures. All values are adjusted to 2009 constant dollars for comparability. Using 2009 as

[12]They are: New York-Newark, NY-NJ-CT, Dallas-Fort Worth-Arlington, TX, Denver-Aurora, CO, Eugene, OR, Los Angeles-Long Beach-Santa Ana, CA, Phoenix-Mesa, AZ, Portland, OR-WA, Salt Lake City, UT, Seattle, WA, and Washington, DC-VA-MD.

Table 1: Data Description.

		All UZAs (48 states) Mean (SD)	Excl. NYC Mean (SD)	Sample (No CIG) Mean (SD)
	2000 Pop. (000's)	399.17 (1209.83)	363.07 (914.30)	306.20 (692.78)
	2000 Den. (000's/mile^2)	2.13 (0.89)	2.13 (0.88)	2.10 (0.84)
Per Capita	Total Expenses	73.29 (100.59)	71.45 (92.24)	65.06 (75.68)
	Federal	20.56 (18.74)	20.36 (18.25)	19.21 (15.93)
	State	15.27 (28.10)	14.85 (26.58)	14.20 (25.44)
	Local	37.46 (66.95)	36.24 (61.41)	31.66 (47.67)
	Capital Expenses	17.97 (34.98)	17.44 (33.05)	14.68 (22.75)
	Federal	9.86 (13.35)	9.69 (12.80)	8.81 (10.70)
	State	2.96 (6.74)	2.91 (6.66)	2.65 (6.09)
	Local	5.15 (18.95)	4.85 (17.76)	3.23 (9.23)
	ARRA UAF	19.00 (9.37)	18.90 (9.13)	18.61 (8.86)
	ARRA FGM	0.34 (2.30)	0.31 (2.16)	0.29 (2.17)
	ARRA	19.84 (12.44)	19.68 (11.91)	18.90 (9.73)
	Service Miles	10.58 (10.40)	10.50 (10.25)	10.18 (10.01)
	Bus	6.28 (6.50)	6.26 (6.49)	6.09 (6.41)
	Rail	0.39 (2.32)	0.33 (1.88)	0.25 (1.65)
	Trips	11.98 (19.12)	11.55 (16.62)	10.74 (15.26)
	Bus	9.90 (13.40)	9.78 (13.14)	9.31 (12.70)
	Rail	1.38 (9.28)	1.08 (6.37)	0.77 (5.44)
Dem.	Median Age	34.58 (4.73)	34.58 (4.73)	34.60 (4.76)
	Unemployment Rate	3.83 (1.27)	3.83 (1.27)	3.84 (1.28)
	Non-Labor Force Rate	36.04 (6.12)	36.04 (6.12)	36.12 (6.13)
	College Share	24.64 (9.66)	24.63 (9.66)	24.50 (9.68)
	Poverty Rate	13.40 (5.40)	13.40 (5.41)	13.44 (5.43)
	Average Income (000's)	20.22 (3.98)	20.21 (3.98)	20.14 (3.95)
	Median Income (000's)	40.08 (9.20)	40.06 (9.20)	39.91 (9.18)
G.R.	Median House Value (000's)	117.11 (56.25)	116.91 (56.15)	116.02 (56.07)
	Mortgaged Homes Share	70.26 (8.87)	70.26 (8.88)	70.09 (8.87)
	Share Working in Construction	6.34 (1.80)	6.35 (1.81)	6.34 (1.81)
	Share Working in Finance	6.16 (2.10)	6.15 (2.09)	6.12 (2.09)
	N	483	482	473

Local spending is funded by grants from local governments and directly-generated revenue from service provision.

the base year ensures nominal ARRA amounts reflect their real spending power in the year of apportionment.

I consider three sets of covariates to improve my statistical power and reduce endogeneity concerns. First are demographic covariates: logarithm of population, median age, unemployment, labor force participation, share of people with only a high-school diploma, and poverty rate. They are likely to determine the demand for public transit and are mostly used for statistical power. Second are two income measures: median and average. Third are proxies for the differential impact of the Great Recession: median house value, mortgage share, share of workers in construction and finance. All covariates are taken from the long form of the 2000 Census.

State-level covariates for the study of crowding-in mechanisms are from the 2013 Survey of State Funding by the American Association of State Highway and Transportation Officials.

5 The Effect of Federal Grants on Capital Spending

The main specification estimates the effect of federal transit grants on capital spending from all sources. A negative effect on state- or locally-funded expenditures indicates a crowding-out, while positive – crowding-in. Plausibly-exogenous ARRA funding, which was distributed using preexisting formulas, is used to instrument the change in federal grants. In this section, the instrumented change in federal grants is the average annual increase in capital spending in six years following the passage of ARRA compared to six years prior ($G = \underset{09\text{-}14}{\Delta} Cap^{fed}$). Section 5.4 considers other options. The outcome is the average increase in annual capital spending from different sources in the post- compared to pre-ARRA period ($\Delta Cap, \Delta Cap^{fed}, \Delta Cap^{st}, \Delta Cap^{loc}$).

Results of this estimation are presented in Table 2. The effect of a \$1 of additional federal grants is a \$0.21 annual increase in capital spending on transit. This indicates a large impact of targeted intergovernmental transfers exaggerated by the crowding-in of other funding. Between 2009-2019, each \$1 of federal funds led to \$2.31 cumulative expenditures. While the F-Statistics of the first stage is below the conventional 10, I do extensive checks to verify that the estimates are not biased. Tables B1 and B2 in the Appendix present complimentary results from two other specifications. Tables B1 uses expenditures coming specifically from ARRA grants rather than all federal sources, and Table B2 removes five outliers that make the first stage imprecise. Section 5.1 discusses this issue in more detail, while Section 5.4

Table 2: The Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from Different Sources.

	2009-19	2009-14	2015-19
ΔCap^{fed}	0.11***	0.15***	0.06
	(0.03)	(0.04)	(0.06)
ΔCap^{st}	0.08	-0.04	0.23**
	(0.06)	(0.08)	(0.10)
ΔCap^{loc}	0.02	0.02	0.02
	(0.07)	(0.06)	(0.10)
ΔCap^{tot}	0.21**	0.13	0.31*
	(0.09)	(0.09)	(0.16)
FS F-Stat	6.95	6.95	6.95

The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in capital transit expenditures from the relevant source in the relevant period compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision. Standard errors are in parenthesis: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

presents multiple robustness checks including some that have higher first-stage F-Statistic. Across specifications, the pattern described below holds.

Time dynamics between two parts of the sample, shown in Table 2, reveal an important interaction between federal and state funding. In the first half (2009-14), federal grants lead to more federal spending, which is mostly mechanical. The effect of $1 of federal grants is an annual $0.15 increase or a cumulative $0.9 increase over the period. A difference between $1 and $0.9 suggests that my specification slightly attenuates the estimation of spending.

On the other hand, state and local spending in the first half of the sample are close to zero and insignificant, indicating only a marginal crowding-in. This is an empirical evidence of the transit-specific flypaper effect. ARRA funding came with essentially no strings attached and did not require a local match.[13] State and local governments were free to direct their own

[13]While the maintenance of effort requirement was formally put in place, it was not enforced in practice. See Leduc and Wilson (2017) for a discussion.

funds to other purposes while keeping the investment in transit constant, but they didn't do that. Instead, additional federal grants led to a \$0.78 increase in spending between 2009-14 per each \$1 of funding.

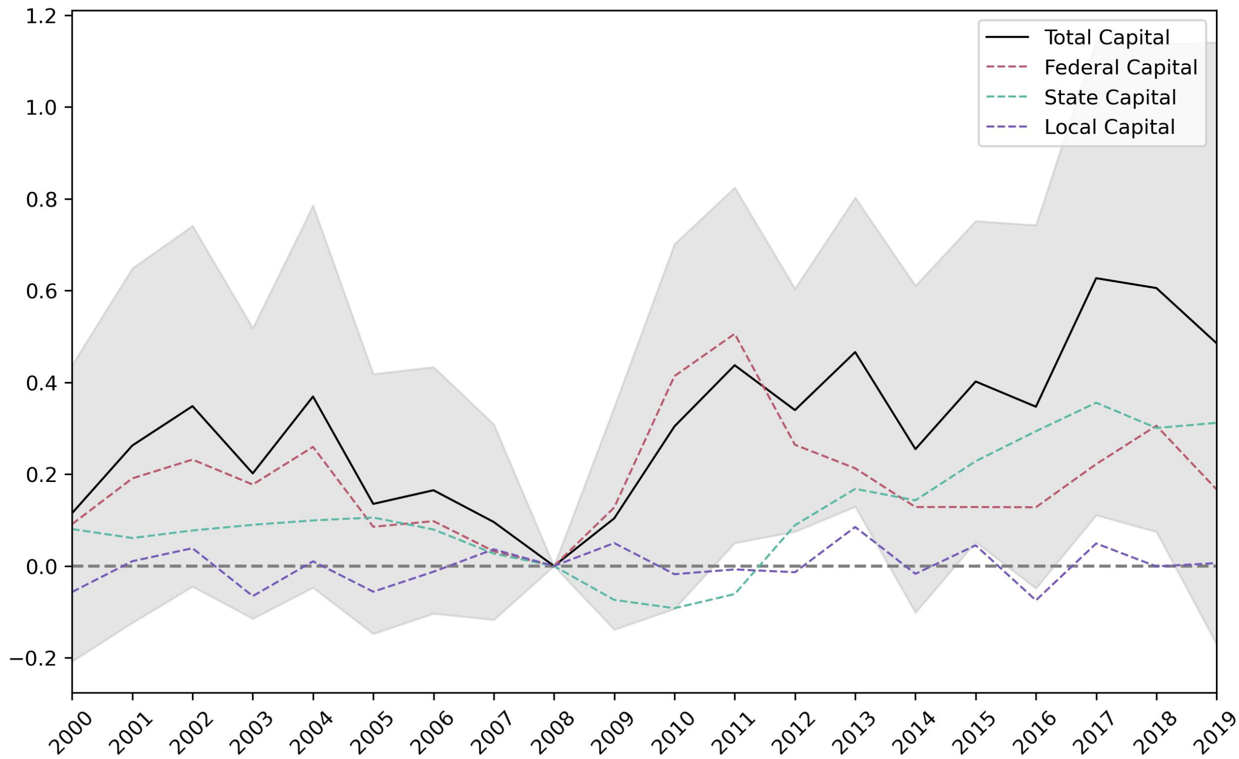
Outside of public transit context, the flypaper effect of a similar magnitude has been documented before. The novelty of the current finding comes in the second part of the sample, after 2015. There, spending from state sources experienced a large increase of \$0.23 in annual or \$1.15 in cumulative terms. This indicates that locations that received more additional federal grants also received from funding from their states later on. Importantly, the effect on the local spending is still insignificant and close to zero, suggesting a state-specific mechanism of crowding-in. The insignificant effect on federal capital expenditures in 2015-19 is comforting from the identification standpoint. It confirms that I am indeed capturing a transitory shock to federal grants from ARRA rather than a permanent change in federal funding due to secular reasons.

Overall, \$1 of additional federal grants in 2009 led to \$0.11 more of federal and \$0.08 more of state annual expenditures in 2009-19, which is a approximately a 72% voluntary match from the state governments. If the state spending increase in the second part of the sample is permanent, the magnitude of the match will keep increasing with the length of the sample under consideration. Such crowding-in has not been empirically observed in many contexts and, to the best of my knowledge, not explained from the theoretical standpoint. I return to the potential mechanisms of this effect in Section 7.2.

An event-study estimation allows me to investigate this dynamic in more detail and simultaneously support my identification assumption by demonstrating the absence of a pre-trend. Coefficients indicate how the difference in expenditures between the current year and the baseline year, 2008 in my case, depend on the cross-sectional change in federal grants instrumented by ARRA funding in 2009. The results of this estimation are presented in Figure 2 and largely paint the same picture as Table 2. Importantly, however, the coefficients before 2008 are indistinguishable from zero, indicating a flat trend in capital expenditures for several years leading up to the ARRA. While the differences in capital expenditures between UZAs with different ARRA apportionment existed, they did not change systematically before 2009. This provides indirect evidence supporting the parallel trends assumption and the causal interpretation of my findings. Any significant change after 2009 that is systematically related to the change in federal grants instrumented by ARRA funding is therefore likely to be driven by the shock.

Right after 2009, capital expenditures increase more in UZAs that increased their federal

Figure 2: Year-by-Year Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Capital Spending from Different Sources.



The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. Dependent variables are capital transit expenditures from the relevant source. The year before treatment, 2008, is excluded. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision. 95% Confidence Interval for the total capital expenditures is depicted.

spending due to ARRA. Expenditures from federal sources follow a clear pattern of a steep increase and a more gradual return to the pre-2009 mean. State spending, after a small initial dip, starts to increase when extra federal spending is waning to keep total expenditures elevated compared to the level before ARRA. They level off after 2016, indicating a permanent effect beyond the sample boundary. Throughout the whole sample, local capital expenditures stay on parallel trends between UZAs with different ARRA funding amounts. The event-study plots for two complimentary specifications with a stronger first stage – using only ARRA-funded expenditures as treatment and excluding a handful of first-stage outliers – are presented in Figures B2 and B3.

5.1 First Stage

The first stage in my analysis identifies the effect of apportioning \$1 of ARRA to a UZA on this UZA's post-2009 change in capital federal spending. In the main specification, the first stage has an F-Statistic of 6.8, which is below the conventional rule-of-thumb of 10. In this section, I describe why ARRA apportionment might be noisy predictor of the change in federal grants and propose to alternative specifications with a strong first stage. The main takeaway is that the estimate is very stable across specifications and unlikely to be biased by the weak first stage.

Apportioned ARRA grants might not systematically translate into an increase in federal spending on capital for two distinct reasons: apportioned funds are not spent and ARRA displaces other federal programs. Apportionments do not translate into spending one-to-one if they are re-distributed. For regular formula programs, the redistribution normally happens only between smaller ($< 200,000$ population) UZAs inside the same state at the discretion of the governor. However, ARRA UAF funds had fewer restrictions and could be re-distributed between same-state UZAs of any size. Additionally, due to the limitations of the data, I attribute all expenditures by a transit agency to its primary UZA. A small portion of expenditures that takes place in the secondary UZA gets attributed wrongly, which can contribute to the discrepancy between apportionments and observed spending.

A increase in funding availability from one federal program might not be fully absorbed into higher federal spending if other programs are being displaced. This can happen if maintaining the level of annual discretionary grants applications is costly or if other programs come with heavy restrictions and overhead costs. Yet, the majority of federal funding comes through formulas and in most cases can be spent flexibly, so much displacement is unlikely. There could be a change in the allocation between operational and capital expenditures. However, 3 shows an even weaker first stage when all federal spending is used. The final reason for a weak first stage in the main specification are local shocks of high magnitude that introduce noise in the estimation.

The first type of issues can be isolated from federal programs displacement and local shocks by using only ARRA-funded expenditures rather than expenditures from all federal sources. The discrepancy between ARRA apportionments and ARRA-funded total spending is still affected by re-distribution and mis-attribution but is immune to interaction with other federal programs. It is also not affected by local shocks because there was no pre-2009 ARRA spending and all funds had to be expended once obligated. Main estimates from this specification are presented in Table B1 and Figure B2. The effect is very similar to the main specification and slightly larger. A strong first stage with an F-Statistic of 20.41 indicates that the relation between ARRA apportionments and the change in federal grants is weakened by the displacement of federal programs and local shocks rather than re-distribution and mis-attribution.

It is straightforward to identify which UZAs have the most (negative) effect on the F-Statistic in the first stage. It turns out that a small number of them has an outsized impact on how precisely the first stage is estimated. At the same time, these first-stage outliers do not change the second stage or the final 2SLS estimate. Durham, NC, Chicago, IL, and Lancaster-Palmdale, CA all experienced a large decrease in federal spending on capital around 2009 despite being apportioned a substantial amount of ARRA funds per capita. The negative change cannot be explained by the effect of ARRA, since a displacement would bring the total change to zero, and are likely driven by coinciding local shocks.

Removing these three UZAs from the regression leads to a virtually unchanged estimate of 0.22*** (0.07) but increases the first stage F-Statistic to 11.04. On the other hand, East Stroudsburg, PA spent no ARRA funds but substantially increased its federal capital expenditures after 2009 (it was smaller than $50,000$ people in 2009 and did not get any apportionment). Removing East Stroudsburg as well brings the F-Statistic to 12.16 without changing the estimate. The sequential removal of 10 UZAs that decrease the F-Statistic the most is presented in Figure B4 in the Appendix. Full estimates after the removal of top-5 are in Table B2 and Figure B3. While the removal of UZAs with local shocks of a specific kind can lead to a bias, the remarkable stability of the estimate makes it unlikely.

5.2 Alternative Treatments and Instruments

Table 3 shows how the estimated effect changes when an alternative instrument or treatment is used. The first four columns keep ΔCap^{fed} as treatment but change the instrument. Changing the instrument changes the set of compliers, which in the continuous case are units that increase treatment when the instrument is increased. Compared to using both formula programs as the total $ARRA$ instrument, using only the Urbanized Area Formula relies more on smaller and less transit-intensive UZAs that don't receive the Fixed-Guideway Modernization grants. Population density in 2000 is the main component determining the per capita Urbanized Area Formula amount. Both of these instruments provide 2SLS estimates that are a little smaller but similar to the main result. Vehicle Revenue Miles in 2006 is

Table 3: The Effect of the Treatment Variable Instrumented by the Instrument on Annual Capital Spending from All Sources.

Treatment:	$\underset{09\text{-}14}{\Delta} Cap^{fed}$	$\underset{09\text{-}14}{\Delta} Cap^{fed}$	$\underset{09\text{-}14}{\Delta} Cap^{fed}$	$\underset{09\text{-}14}{\Delta} Cap^{fed}$	$\underset{09\text{-}14}{\Delta} Tot^{fed}$	ARRA Exp.
OLS	0.16***	0.16***	0.16***	0.16***	0.10***	0.20***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
Instrument:	ARRA	ARRA UAF	Density'00	VRM'06	ARRA	ARRA
2SLS	0.21**	0.19**	0.18*	0.37***	0.18**	0.25*
	(0.09)	(0.08)	(0.10)	(0.14)	(0.08)	(0.14)
First Stage	0.78***	0.79**	0.01**	0.84*	0.92**	0.65***
	(0.30)	(0.31)	(0.00)	(0.45)	(0.38)	(0.14)
FS F-Stat	6.95	6.46	5.66	3.48	5.92	20.41

The treatment variable is the increase in federal grants for capital or total expenditures in 2009-2014 compared to 2003-2008, or total ARRA expenditures. The instrument is 2009 ARRA funding or only the Urbanized Area Formula portion of ARRA. The dependent variable is the difference in total capital transit expenditures in 2009-2019 compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Standard errors are in parenthesis: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

another component of the UAF amount for larger ($\geq 200,000$ population) UZAs. Its effect on the formula funding is more complicated, partly because fixed-guideway VRM and bus VRM have different coefficients and partly because my measure of VRM is the sum of VRM across all agencies for whom the current UZA is primary. Therefore, the F-Statistic of the first stage with this instrument is considerably smaller though the effect is larger, reflecting a more transit-intensive pool of compliers.

An alternative treatment is the change in total federal expenditures in 2009-14 compared to 2003-08, which includes both capital and operational outlays. Including operational expenditures presents a trade-off. They are more determined by outside forces and thus less sensitive to an influx of federal grants, which is reflected in a lower F-Stat. However, including them allows to investigate whether ARRA affected total capital spending through the increase in operational federal spending and thus freeing some of the state and local funds for capital. The estimate is numerically very close to the capital-specific change effect, so this does not seem to be a significant channel. Finally, the structure of my data allows me to isolate expenditures from ARRA funds by each UZA. Using this variable as treatment, I can identify the effect of an additional $1 of ARRA grants rather than of an additional $1 of federal grants brought by it. The effect is somewhat larger but still close to the estimate from the main specification.

5.3 Heterogeneity

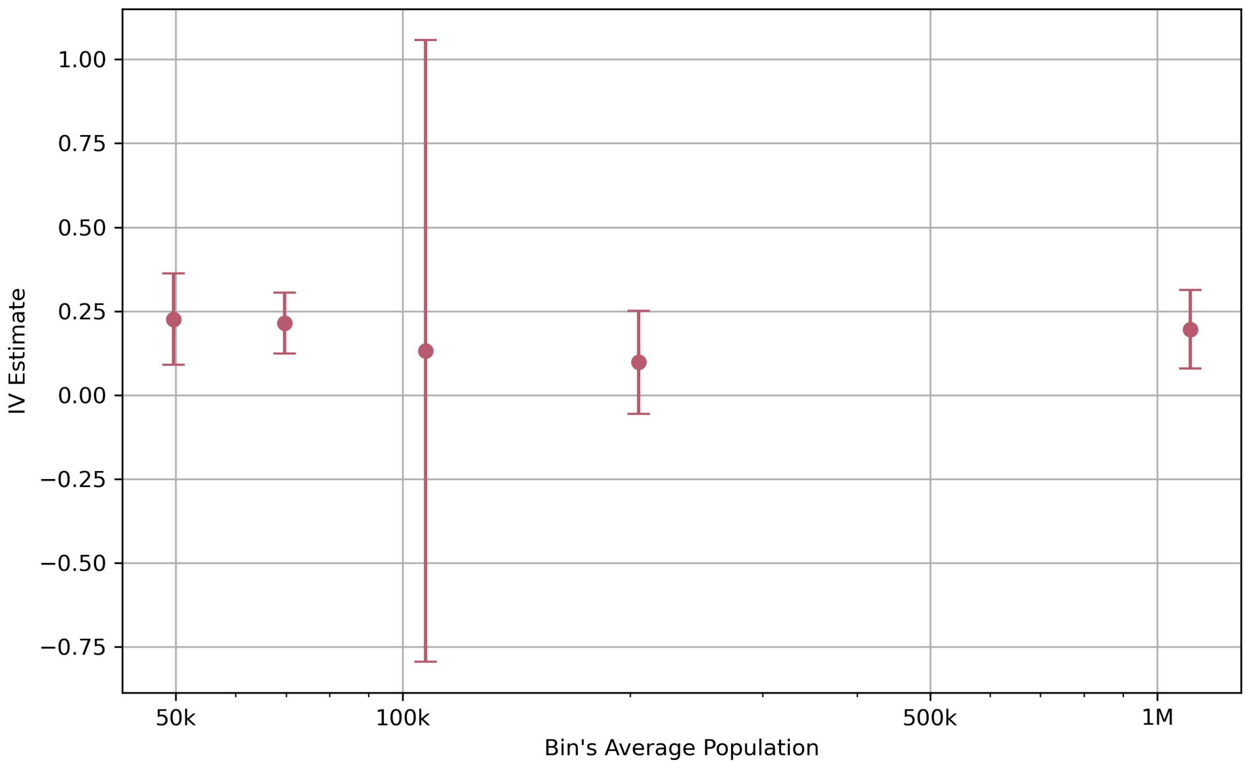
The sample of all national UZAs is diverse. One dimension that captures this diversity pretty well is the population size. Even after translating all outcomes per capita, larger UZAs might be very different than smaller ones. There is an economy of scale in the provision of transit, both in terms of the administration and physical capital. If these differences are only in levels, than the effect of per capita ARRA funding might still be similar across them. However, there are reasons why larger cities might be more or less affected by additional federal funding. First, due to the experience and existing transit infrastructure, they can be in the position to better put additional funds to use. Smaller UZAs might be less able to absorb even the "free" federal money because it requires coordination and political will to propose a project and some initial investment to write an application. On the other hand, larger UZAs might already have excessive funding that they are not able to fully utilize due to bottle-necks in other parts of the process.

To investigate this heterogeneity, in Figure B5 I show the results from the main specification for 5 population groups with equal number of UZAs in each. The estimate for all but one group are similar, despite a substantial difference in sizes. The estimate for the fourth group, with the average population of about 200,000 is negative and far from precisely estimated. This indicates that the first stage in this group is close to zero. However, when excluding the 10 UZAs that decrease the F-Statistic the most (see Appendix Figure B4), the effects between groups are remarkably similar as shown in Figure 3.

5.4 Robustness

The increase in the total spending from additional federal grants is robust to multiple specification changes. Panel A of Table 4 shows several sample modifications. First, I add 10 UZAs that received a Capital Investment Grant through ARRA. Since CIG were explicitly given to shovel-ready projects that were able to absorb more funds, there is an endogeneity concern that these UZAs would have increased their spending regardless of ARRA. Moreover, this list consists of very transit-intensive UZAs including NYC, which is the national outlier by any urban metric. Local shock in these cities may have too much effect on the

Figure 3: The Effect of a $1 Increase in the Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from All Sources by Population Size. First-Stage Outliers Excluded.



The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in capital transit expenditures from all sources in 2009-2019 compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 468 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. 5 UZAs that were decreasing the first-stage F-Statistic the most are excluded: Durham, NC, Danbury, CT-NY, Pittsfield, MA, Chicago, IL-IN, and East Stroudsburg, PA. Population bins contain approximately the same number of UZAs each. 95% Confidence Interval is depicted.

estimate. Indeed, when these UZAs are included, the effect becomes inflated through a large but insignificant increase in local capital spending. The other element of Panel A shows that the exclusion of never-reporting UZAs that likely have no transit service does not change the result much.

Panel B of Table 4 explores the effect of covariates. Consistent with the coinciding influence of the Great Recession, the effect is slightly larger when no covariates or only the demographic covariates are included. An important potential confounder, used in Gordon (2004)'s study of Title I funding, is the update in formula inputs. 2013 was the first year when UAF and other formula programs used the new 2010 Census to calculate the distribution amount for each UZA. If this change is correlated with ARRA funding, this can bias the estimates after 2013. However, including the change in the UAF amount between 2013 and 2012 only increases the estimates.

Finally, Panel C considers changes in the definition of the treatment variable. In the main specification, it is defined as the change between federal capital expenses between 2014-09 and 2003-08. Changes to these windows do not bring significant changes, though there is some trade-off between a slightly larger coefficient and a slightly lower first-stage F-Statistic. Overall, the estimates in the whole table indicate a large increase in capital expenditures driven by larger federal and state spending and no change in local spending.

6 Conceptual Model of Transit Investment

The previous section documents the dynamics of capital spending following an exogenous, transitory shock to federal grants. In the first part of the sample (2009–2014), federally funded expenditures grow without displacing state or local spending. In the second part (2015–2019), federal spending returns to its pre-shock level, while spending from state sources rises. The first period illustrates the flypaper effect, which—once considered an anomaly—has since been attributed to several possible mechanisms (see, e.g., Hines and Thaler (1995)). The crowding-in observed in the later period, however, is a novel finding that lacks a formal explanation in the existing literature. This section develops a conceptual model of transit investment that accounts for both the flypaper effect in the first period and the state-level crowding-in in the second.

Table 4: The Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from Different Sources. Robustness.

	ΔCap^{tot}	ΔCap^{fed}	ΔCap^{st}	ΔCap^{loc}	F-Stat
Main Spec	0.21**	0.11***	0.08	0.02	6.95
	(0.09)	(0.03)	(0.06)	(0.07)	
Panel A: Sample					
+ 10 CIG UZAs	0.30**	0.08**	0.08***	0.13	20.68
	(0.14)	(0.04)	(0.03)	(0.10)	
- 48 Never Reported	0.19*	0.10***	0.07	0.02	5.38
	(0.10)	(0.03)	(0.06)	(0.08)	
Panel B: Covariates					
No Covs	0.31*	0.12**	0.25**	-0.06	2.84
	(0.16)	(0.05)	(0.13)	(0.16)	
Dem Covs	0.22**	0.10***	0.11	0.01	7.17
	(0.10)	(0.03)	(0.07)	(0.08)	
All + 2013 ΔUAF	0.24***	0.13***	0.09*	0.02	9.31
	(0.08)	(0.02)	(0.05)	(0.07)	
Panel C: Treatment					
2013-09 vs 2004-08	0.20**	0.10***	0.08	0.02	9.52
	(0.09)	(0.03)	(0.06)	(0.07)	
2015-09 vs 2002-08	0.23**	0.12***	0.09	0.02	5.40
	(0.11)	(0.02)	(0.07)	(0.08)	
2014-09 vs 2000-08	0.24*	0.12***	0.09	0.02	6.01
	(0.14)	(0.04)	(0.08)	(0.09)	

Except for Panel A, the sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision. Standard errors are in parenthesis: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

6.1 Model Setup

I consider a local official making decisions about transit investment within an Urbanized Area (UZA). I do not take a strong stance on the nature of this official. In practice, such decisions are made collectively by the Metropolitan Planning Organization (MPO) that oversees each UZA. Each MPO comprises local officials and representatives from the transportation agencies operating in the area.[14] The model below treats the outcome of the negotiation process among these representatives as the decision of the local official.

The official chooses the level of capital expenditures, drawing funds from federal, state, and local sources in period t:

$$Cap_t = Cap_t^{fed} + Cap_t^{st} + Cap_t^{loc}.$$

Local official derives utility $U(Cap_t, Cap_{t-1})$ from capital spending. More spending is always better, but decreasingly so: $\partial U/\partial Cap_t > 0$, $\partial^2 U/\partial Cap_t^2 < 0$. Cap_{t-1} reflects unfinished projects from the previous period, economies of scale, and induced transit demand. All of these might explain why previous spending makes present spending more lucrative: $\frac{\partial^2 U}{\partial Cap_t \partial Cap_{t-1}} \geq 0$. The complete fungibility of funds across sources is a simplifying assumption, which can be relaxed by introducing limiting conditions. For example, the required 20% match for regular federal programs would be reflected in the condition $Cap_t^{fed} \leq 4 * (Cap_t^{st} + Cap_t^{loc})$.

The main innovation that allows the model to capture both the flypaper effect and state crowding-in is that funding from each source consists of two components: a guaranteed (passive) part and a flexible (discretionary) part. For federal and state funding, the guaranteed component reflects allocations to UZAs based on formulas and earmarks established by prior legislation. For local funding, the guaranteed component similarly derives from dedicated local taxes for transit provision. The defining feature of guaranteed funding in each case is its stickiness—it is not considered for a change in the short term.

The second part of funding is flexible, and the local official needs to exert effort to acquire it. In case of federal funding, the effort can be in application for discretionary grants to the FTA. On the state level, the process is more resembling a negotiation with the state DOTs for flexible funding on the state level. For local funds, the effort might reflect the marginal

[14] In most cases, a single MPO represents one UZA, though several UZAs may belong to the same MPO. Consequently, between 2011 and 2019 there were 486 UZAs but only 408 MPOs (NTD; FAST, Pub. L. No. 114-94). To the best of my knowledge, cases in which one UZA belongs to multiple MPOs occur only in Florida, where MPOs correspond to counties. A UZA crossing a county boundary thus falls under multiple MPOs.

cost of public funds. Across all three sources, the effort cost is defined as:

$$E^k(Cap_t^k, Cap_{t-1}) = \begin{cases} 0 & \text{if } Cap_t^k \leq P^k \\ e^k\left(Cap_t^k - P^k; Cap_{t-1}\right) & \text{if } Cap_t^k > P^k \end{cases}$$

where P^k is guaranteed (passive) funding. To represent budget scarcity on all levels, $e^k(\cdot)$ is convex. Cap_{t-1} represents that higher capital budget in the previous period can decrease the cost of negotiation for flexible funds through expertise signaling, learning by doing, or aversion to budget contraction: $\frac{\partial^2 e^k}{\partial Cap_t \partial Cap_{t-1}} \leq 0$.

Therefore, local official's problem is

$$\max_{Cap_t^{fed}, Cap_t^{st}, Cap_t^{loc}} U(Cap_t^{fed} + Cap_t^{st} + Cap_t^{loc}, Cap_{t-1}) - \left[E^{fed}(Cap_t^{fed}, Cap_{t-1}) + E^{st}(Cap_t^{st}, Cap_{t-1}) + E^{loc}(Cap_t^{loc}, Cap_{t-1})\right].$$

This problem yields $\forall k \in \{fed, st, loc\}$:

$$E^{k\prime}(Cap_t^{k*}, Cap_{t-1}) \geq U'(Cap_t^*)$$
$$\text{and}$$
$$Cap_t^{k*} \geq P^k.$$

Operational expenditures are omitted from this model. If they are perfectly determined by the size of the current transit system, this can be addressed by adjusting P^k to cover operating costs optimally before choosing the level of capital investment. Alternatively, operating expenditures can be introduced as additional choice variables, though the main conclusions regarding capital spending would remain unchanged.

6.2 Dynamic Response to a Shock

In **period 0**, funding is in the steady state, defined as all funding being passive: $Cap_t^{k*} = P^k \ \ \forall k \in \{fed, st, loc\}$. While this assumption may appear restrictive, it can be justified as follows. In the absence of effort by local officials, flexible funding is distributed randomly across UZAs and does not influence local decision-making. If a UZA persistently secures more flexible funding than others, this may become part of its passive funding through formal earmarking or entrenched intergovernmental relationships.[15] Based on this,

$$\begin{aligned} Cap_0^{fed*} &= P^{fed}, \\ Cap_0^{st*} &= P^{st}, \\ Cap_0^{loc*} &= P^{loc}. \end{aligned}$$

In **period 1**, an exogenous shock increases passive federal funding: $\hat{P}^{fed} > P^{fed}$. The incentives of the local official do not change (Cap_{t-1} is still at the steady state level) and thus spending from each source is at the guaranteed level:

$$\begin{aligned} Cap_1^{fed*} &= \hat{P}^{fed} > Cap_0^{fed*}, \\ Cap_1^{st*} &= P^{st} \quad = Cap_0^{st*}, \\ Cap_1^{loc*} &= P^{loc} \quad = Cap_0^{loc*}. \end{aligned}$$

Due to the shock to federal funding, federal spending increases, but state and local spending is not displaced. Intuitively, this happens because guaranteed funding is "free" and local officials do not have incentives to decrease it, even when the marginal value from investment ($U(\cdot)'$) goes down. Overall capital spending increases one-to-one with the shock: $Cap_1 > Cap_0$.

In **period 2**, the transitory shock passes and guaranteed federal funding returns to the steady state value: $P^{fed} < \hat{P}^{fed}$. The movement of the spending from each source is ambiguous. Since $\frac{\partial^2 U}{\partial Cap_t \partial Cap_{t-1}} \geq 0$ and $\frac{\partial^2 e^k}{\partial Cap_t \partial Cap_{t-1}} \leq 0$ and $Cap_1 > Cap_0$, there may be incentives to increase spending relative to the steady state. Crowding-in from source k happens if marginal cost of negotiation effort is sufficiently low compared to the marginal utility of additional spending: $e^{k\prime}(0, Cap_1) < U'(\sum_k P^k, Cap_1)$.

If the cost of effort for obtaining flexible state funding is low, but too high for federal and local funding, this is sufficient to predict crowding-in of state funds, CI^{st}, without any change

[15] Singhal (2008) proposes an explanation for the flypaper effect based on strategic interactions with SIGs, and Leduc and Wilson (2017) finds empirical support for this mechanism in the context of ARRA highway grants. In my model, a long-term commitment to a local SIG would similarly render a portion of expenditures non-negotiable—that is, passive.

in federal or local spending:

$$
\begin{aligned}
Cap_2^{fed*} &= P^{fed} &&= Cap_0^{fed*}, \\
Cap_2^{st*} &= P^{st} + CI^{st} &&> Cap_0^{st*}, \\
Cap_2^{loc*} &= P^{loc} &&= Cap_0^{loc*}.
\end{aligned}
$$

The relatively small size of local budgets and the limited share of federal transit funds distributed through discretionary grants may explain why the cost of acquiring additional local or federal funding beyond the guaranteed component is high. State transit funding, by contrast, can often be flexed from highway or general funds and is therefore less costly to obtain. Under this assumption, the simple model aligns with the dynamics observed empirically:

$$
\begin{aligned}
Cap_0^{fed*} &< Cap_1^{fed*} &&> Cap_2^{fed*}, \\
Cap_0^{st*} &= Cap_1^{st*} &&< Cap_2^{st*}, \\
Cap_0^{loc*} &= Cap_1^{loc*} &&= Cap_2^{loc*}.
\end{aligned}
$$

6.3 Model Validation

Since the model is not intended to numerically fit local transit investment, its usefulness depends on how well it captures the essence of the investment decision faced by the local official. First, the assumption of fungibility across funding sources is plausible from the perspective of a rational actor. However, the observed responses to a shock differ substantially across federal, state, and local spending, suggesting varying costs of obtaining funds from each source. The model represents these costs with functions e^k.

Second, the distinction between guaranteed and flexible funding naturally arises from the asymmetry in the state response: when federal grants increase, state spending remains unchanged; when federal grants decrease, state spending rises. This pattern suggests that the incentives to reduce versus increase state funding relative to the status quo differ. The model captures this by introducing a kink in the overall cost-of-effort function E^k, such that only increases from the status quo are costly.

Third, I provide two sets of empirical evidence showing that, consistent with the model, state crowding-in is driven by local negotiations over flexible state funding. For the following estimates, I focus on the crowding-in effect—namely, the increase in state funding between

2015 and 2019. From Table 2, this effect corresponds to a \$0.23 increase in state spending for every \$1 of exogenous federal grants. To validate the interpretation of crowding-in as the result of local officials negotiating for flexible state funds, I first isolate within-state variation. Some UZAs in the sample cross state boundaries, so there is no straightforward way to assign them to a single state. The first column of Table 5 estimates the crowding-in effect separately for the 402 UZAs fully contained within one state. The estimated effect, \$0.15, is smaller than in the full sample but remains large and statistically significant.

Table 5: Within-State Interaction of the State Crowding-In from an Increase in Federal Grants.

ΔG	0.15***	0.13**	0.14**	0.15***
	(0.06)	(0.06)	(0.06)	(0.06)
ΔG_{state}			0.11	
			(0.40)	
ΔG_{excl}				0.004**
				(0.002)
Fixed Effects	X	State	X	X

The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008 with the following modifiers: $_{within}$ is with subtracted state mean, $_{state}$ is the state mean, and $_{excl}$ is the sum of all UZAs in the same state (from the sample) excluding current UZAs. The instrument is 2009 ARRA funding also with appropriate modifiers. The dependent variable is the difference in state capital transit expenditures in 2015-2019 compared to 2000-2008 (crowding-in). All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 402 UZAs from the lower 48 states that are fully contained inside one state and did not receive a CIG grant as part of ARRA funding. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

Columns 2–4 of Table 5 account for across-state variation in several ways. Column 2 adds state fixed effects to equations (3) and (4), directly controlling for any changes between 2015–2019 and pre-2009 means that are common to all UZAs within the same state. Similarly, Column 3 controls for the mean change in federal grants across same-state UZAs, which is instrumented in the first stage by mean ARRA funding. Finally, Column 4 includes the mean change in federal grants among UZAs within the same state, excluding the current UZA.

Across all four specifications, the estimate remains stable, indicating that the crowding-in effect is not driven by between-state variation. Within the same state, a UZA receiving \$1 more in exogenous federal grants than another UZA subsequently secures about \$0.13–\$0.15 of additional state funding per year. This supports modeling the crowding-in as driven by local rather than state budgets. Moreover, in Columns 3–4, the coefficient on the state-level increase in federal grants is weakly positive, suggesting that higher state funding does not come at the expense of other UZAs within the same state. This pattern is consistent with UZAs individually negotiating for additional flexible funding rather than state DOTs reallocating a fixed pool among them.

For the second part of the validation, I examine which characteristics of state transit funding are associated with greater crowding-in. To this end, I separate the sample of single-state UZAs using data from a survey by AASHTO (2015). Table 6 estimates the crowding-in effect for UZAs located in states where each characteristic is above the median (Column 1) and below the median (Column 2). The first panel separates states by the share of discretionary transit funding, which closely corresponds to flexible funding in my model. The second panel separates them by the share of funding legislatively restricted to capital expenditures. The third panel separates them by the share of state transit expenditures financed from non-dedicated sources, such as general revenue or bonds rather than gasoline taxes.

Table 6 shows that crowding-in is entirely driven by UZAs in states with a higher share of discretionary funding, a higher share of funding from non-dedicated sources, and a higher share of funds restricted to capital expenditures. The first two findings strongly support the hypothesis that crowding-in arises from flexible state funds that local officials negotiate or apply for. In contrast, the effect in states with relatively low shares of flexible or uncommitted funding is precisely zero, suggesting no state spending response to an exogenous increase in federal grants. The substantial crowding-in of capital spending in states with a larger share of capital-restricted funds further validates the decision to model capital expenditures separately from operating expenditures.

6.4 Two Types of Crowding-In in the Model

In the model, crowding-in is driven by a positive transitory shock in the previous period. This can arise through two distinct channels: (i) an increase in the marginal utility of additional capital, $\frac{\partial U}{\partial Cap} \uparrow$, or (ii) a decrease in the marginal cost of negotiating for flexible funds, $\frac{\partial e^{st}}{\partial Cap} \downarrow$.

The first channel operates through projects initiated with federal funding. If a large project was started due to an increase in federal grants but not completed before those funds were exhausted, finishing it may yield exceptionally high per-dollar utility for the local official. As

Table 6: State-Level Crowding-In from an Increase in Federal Grants Interacted with State Characteristics.

	High	Low
Share Discretionary		
ΔG	0.26**	0.02
	(0.12)	(0.01)
N	249	153
Share Capital-Restricted		
ΔG	0.22**	0.00
	(0.10)	(0.03)
N	210	192
Share Non-Dedicated Sources		
ΔG	0.20**	-0.02
	(0.08)	(0.06)
N	186	216

The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in state capital transit expenditures in 2015-2019 compared to 2000-2008 (crowding-in). The sample consists of 402 UZAs from the lower 48 states that are fully contained inside one state and did not receive a CIG grant as part of ARRA funding. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

a result, the official may be willing to seek additional state funds to complete the project and "unlock" its full service potential. This scenario includes both unintentional cost overruns and projects originally planned for phased completion. Similarly, some large transit projects may exhibit a concave cost structure or require a substantial initial investment. For example, laying new underground rails can be very costly, but once completed, expenditures on trains and stations are relatively modest. Thus, local officials experience high marginal utility from investing in the new line and are willing to incur additional negotiation costs.

Another related concept is the "virtuous cycle of transit": improved service frequency attracts more riders, prompting the transit agency to further increase frequency (Bar-Yosef et al., 2013). If projects completed with federal funds made the transit system more attractive to passengers, the local official's problem may reflect this through a higher marginal utility of investment.

In the following section, I show that the additional funds due to ARRA were spent primarily on buses and bus facilities. This excludes large rail projects, which are more likely to generate additional spending through economies of scale or cost overruns. Moreover, these investments did not expand the size of the bus fleet or increase service provision. Although passenger trips rose marginally in more affected areas, the induced-demand explanation does not appear to hold. Overall, projects initiated with federal funds cannot account for the crowding-in effect I observe.

The second channel directly concerns the negotiation process between localities and states. A locality with a history of higher transit budgets may have a stronger bargaining position for several reasons. First, higher past spending demonstrates the expertise of local bureaucrats in managing large sums while adhering to formal procedures and reporting requirements. State officials are therefore more likely to allocate funds to jurisdictions they believe have sufficient capacity to manage them effectively.

Second, local officials gain additional experience through managing federal funds. This knowledge may help them prepare stronger grant applications or justifications for additional funding, increasing their likelihood of success. Third, state DOTs may be reluctant to reduce local transit budgets, as doing so could result in furloughs and a loss of institutional momentum. This further strengthens the bargaining position of local officials seeking state funds to maintain an elevated budget level.

Importantly, the second channel of mechanisms depends on the overall level of spending rather than on specific projects, and is therefore consistent with the observed spending on buses. In the next section, I present additional analysis that exploits state-level variation and supports this explanation. I thus conclude that an increase in federal grants enhanced local officials' bargaining position, enabling them to negotiate for more flexible state funding.

7 Crowding-in Mechanisms

This section provides evidence to distinguish between the two mechanisms of crowding-in described in the conceptual model: (i) increased attractiveness of additional spending, and (ii) improved bargaining position of local officials. The first subsection shows that the types of expenditures stimulated by additional federal grants do not naturally support continued spending. It also serves an important separate purpose by identifying patterns of spending that follow a large stimulus package implemented under a tight timeline. The subsequent subsection examines state-level heterogeneity consistent with the negotiation channel. Finally, I compare my model and proposed mechanisms with key contributions in the prior literature.

7.1 Additional Money Was Spent on Buses

My main results show a robust and substantial increase in capital transit investment following the 2009 shock. On average, UZAs increased their capital expenditures per capita by $26. According to the estimated crowding-in effect, this led to an additional $60 per capita in capital expenditures over the eleven years between 2009 and 2019. This suggests that ARRA successfully achieved one of its goals—stabilizing public spending and employment. However, the objectives of federal transit policy extend beyond simply increasing spending. The FTA's mandate states that "It is in the national interest ... to encourage and promote the safe and efficient management, operation, and development of resilient surface transportation systems" (*49 U.S.C. Ch. 53* 2023).

Using the same estimation strategy, this subsection examines whether the influx of additional funding produced meaningful changes in transit systems, both in terms of service provision and utilization. The NTD reports expenditures by both source of funds and type of spending, but not their interaction. Therefore, this database alone does not reveal exactly how the additional federal grants or the crowded-in state funding were used.[16] Even if such information were available, it would not capture the total causal effect of the shock if the composition of other funding sources also changed. Instead, the NTD enables me to answer a more meaningful question: how much more did a UZA that received an additional $1 of exogenous federal grants spend on, for example, buses? I will therefore refer to this estimate as if the additional money itself had been spent on buses.

Panel A of Table 7 separates the total increase in capital investment in two dimensions: by type of expenditure and by transit mode. Cap_{roll} includes spending on rolling stock (buses and trains), while Cap_{fac} covers most other infrastructure—stations, buildings, and fixed guideway (rail) (Federal Transit Administration, 2019).The bus category combines standard buses, commuter buses, bus rapid transit, and jitneys; the rail category includes light rail, heavy rail, commuter rail, and other specialized forms of rail. Demand Response refers to

[16] In a related but separate project, I aim to analyze a different dataset to address this question.

vehicles that do not follow a fixed route and/or serve specific populations, such as the elderly, people with disabilities, or employees of large local firms. Although this mode contributes little to the total number of passenger trips, it can account for a substantial share of service in terms of active vehicles and Vehicle Revenue Miles (VRM). Table B3 presents the same effects relative to the pre-2009 mean of each outcome variable.

The additional \$0.22 per capita from the 2009 shock (the \$0.01 difference reflects the use of different data sources within the NTD) was spent predominantly on bus transit (77%), with a small and statistically insignificant portion allocated to rail. Within bus spending, more than half went toward vehicles rather than facilities. This indicates that the predominant use of the additional funding, both from the initial increase in federal grants and the subsequent state crowding-in, was the purchase or rehabilitation of buses. Further analysis sheds light on which of these uses dominated.

The first row of Panel B estimates the effect of additional federal grants on the change in the number of vehicles in service. Each year, transit agencies report the number of active vehicles available for service, without indicating what fraction of these vehicles is newly acquired.[17] Despite spending more money on buses (\$0.09 annually for each \$1 of federal grants), UZAs that received more federal funding experienced a lower annual increase in the number of buses—about 0.86 fewer buses per million people per year. Importantly, this significant negative effect on the rate of change in bus fleet size is not driven by outliers and remains robust to sample adjustments.

While seemingly contradictory, this pattern can be explained by the fact that buses undergoing major repairs are not counted as active vehicles. Thus, if UZAs that received more exogenous federal grants allocated additional resources to repairing existing buses, this could account for the negative effect on fleet size. Additional evidence also suggests that replacing older buses was not the primary use of the new funds. As shown in the second row of Panel B, the average age of the bus fleet decreased—indicating some replacement—but the decline is small and statistically insignificant (0.18% per year; see Table B3). Taken together, these findings are consistent with the additional funds being used primarily for the repair and improvement of existing buses rather than the purchase of new ones.

Across all categories of capital use and service provision, there are no significant changes for rail modes, except for a statistically insignificant but sizable increase in the number of

[17]The NTD defines active vehicles as: "The vehicles available to operate in revenue service at the end of an agency's fiscal year, including spares, vehicles temporarily out of service for routine maintenance and minor repairs, and operational vehicles." Federal Transit Administration (2019)

Table 7: The Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending of Different Types (Panel A) and on Transit Provision and Usage (Panel B).

	Total	Bus	Rail	Demand	Other
Panel A					
ΔCap^{tot}	0.22**	0.17***	0.03	0.01	0.00
	(0.09)	(0.05)	(0.09)	(0.01)	(0.02)
ΔCap^{tot}_{roll}	0.12***	0.09***	0.02	0.01	0.01
	(0.04)	(0.03)	(0.03)	(0.01)	(0.01)
ΔCap^{tot}_{fac}	0.07	0.05	0.03	0.00	-0.01
	(0.08)	(0.03)	(0.08)	(0.01)	(0.02)
ΔCap^{tot}_{other}	0.01	0.02	-0.01	0.01**	0.00
	(0.03)	(0.01)	(0.02)	(0.00)	(0.00)
Panel B					
ΔN vehicles (per 1 mil)	-1.46**	-0.86*	0.01	-0.61**	0.00
	(0.65)	(0.44)	(0.04)	(0.29)	(0.00)
Fleet Age (mos)	0.13	-0.10	-0.13	-0.01	0.04
	(0.21)	(0.19)	(0.26)	(0.20)	(0.14)
Service Miles (VRM)	-0.07	-0.05	0.01	-0.03	-0.00
	(0.07)	(0.05)	(0.00)	(0.04)	(0.00)
Trips	0.07*	0.05	0.02	-0.01	0.00
	(0.04)	(0.03)	(0.01)	(0.01)	(0.00)

The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented with 2009 ARRA funding. In Panel A, dependent variable is the change in capital transit expenditures in 2009-2019 compared to 2000-2008 by the type of spending and transit mode. In Panel B, dependent variables are changes in transit system characteristics. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. Vehicle Revenue Miles (VRM) and Unlinked Passenger Trips are in per capita, the number of new vehicles is per one million. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

vehicles (15%; see Table B3) and an insignificant decrease in the average fleet age. When the estimation is restricted to the 51 UZAs that reported rail service at any point between 2000 and 2019, both the rate of change in the number of vehicles and the fleet age become more negative—although both estimates remain highly insignificant due to the small sample size. Overall, it is unlikely that ARRA spurred a substantial number of new rail projects that could explain state spending crowding-in through economies of scale or a concave cost structure.

This pattern of spending is consistent with the way ARRA funds were distributed. Most allocations had to be obligated to specific projects before October 2009 to avoid reallocation, and all funds had to be obligated by October 2010—less than two years after ARRA's announcement. As a result, transportation agencies and local officials suddenly found themselves with substantial resources that had to be put to use quickly. Repairing or upgrading the bus fleet was among the most straightforward projects to approve and implement. In contrast, trains are typically built to order well in advance, and significant expansions or modifications of existing rail networks require years—if not decades—of planning.

Finally, I examine the implications for transit provision and usage. The supply of transit service is commonly measured in Vehicle Revenue Miles (VRM)—the total number of miles driven by all vehicles while in service. Table 7 shows that transit service was insignificantly lower in UZAs that increased their federal spending more as a result of ARRA. Although this pattern is consistent with a smaller number of active vehicles, the detailed dynamics of these effects suggest distinct mechanisms. While the number of additional vehicles declines around 2012 (Figure B6), the fall in VRM reflects a disruption of the pre-2009 upward trend (Figure B7). More importantly, I find no evidence of an increase in service provision resulting from the additional funds. Although this could reflect the relatively short time horizon, the nature of the spending documented in Panel A makes a subsequent rise in VRM unlikely.

The actual usage of the system can be measured by the total number of passenger trips, where a trip is defined as a passenger boarding a vehicle (Federal Transit Administration, 2019). Despite finding no significant effects on transit service provision, the last row of Panel B shows a significant increase in the number of trips per capita for UZAs that spent more. This suggests that improvements in service quality—such as comfort and reliability—successfully attracted new riders without expanding service provision. For federal transit policy, this is good news: the number of trips is ultimately a more meaningful measure of transit's impact on individuals than the total amount of service supplied.

However, this effect has modest economic significance. Its magnitude is 0.72% of the pre-2009 overall mean, compared to a 1.95% increase in capital spending.[18] Moreover, it is unclear whether the increase in usage driven by improvements to existing buses can be sustained without a continuous inflow of additional funding. Indeed, the event-study plot in Figure B7 supports this intuition: trips in differentially affected UZAs follow parallel trends before 2009, rise after ARRA funding reaches localities, and begin returning to pre-2009 levels by 2019.

In this subsection, I showed that the increase in transit funding was used primarily for buses and, to a lesser extent, for bus facilities. Although data limitations prevent observing the exact nature of spending, I find that fleet size and service provision did not increase, while usage rose only marginally. This pattern is consistent with more affected UZAs allocating additional funds to repairs and improvements of the existing fleet or to the purchase of relatively more expensive buses. Importantly, for understanding the mechanisms behind state crowding-in, these findings rule out explanations based on unfinished projects, economies of scale, or a virtuous cycle of transit.

7.2 Heterogeneity Consistent with Improved Negotiation

To find evidence supporting the negotiation channel of crowding-in, I examine state characteristics from a recent survey by Tomer and Swedberg (2024) on state DOTs.[19] Although the survey covers highways, transit, and other transportation programs funded by states it may still be informative if key funding features are relatively stable over time and consistent across transportation modes supported by state DOTs. Table 8 presents estimates analogous to the earlier analysis, comparing crowding-in for single-state UZAs in states below and above the median for each characteristic.

The results in Table 8 indicate that crowding-in was greater in states with higher local independence. This measure—the share of total DOT funding allocated to local governments for discretionary use—serves as a plausible proxy for the bargaining power of local officials in negotiations with their state DOTs. Although it is impossible to determine whether UZAs in these states *were* more independent prior to the ARRA shock or *became* more independent as a result of it, the finding is consistent with the negotiation channel driving crowding-in

[18]For bus modes only, this ratio is even smaller: a 0.65% increase in trips against a 2.33% increase in capital expenditures. See Tables B3.

[19]One of the recommendations in Tomer and Swedberg (2024) is that "Congress should increase direct formula funding to regional governments, which will address the unequal power dynamics between states and MPOs." This aligns precisely with my empirical findings.

Table 8: State-Level Crowding-In from an Increase in Federal Grants Interacted with State Characteristics.

	High	Low
Local Independence		
ΔG	0.24* (0.14)	0.11** (0.05)
N	203	199
Allocation Decision Quality		
ΔG	0.14 (0.09)	0.14** (0.06)
N	216	186

The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in state capital transit expenditures in 2015-2019 compared to 2000-2008 (crowding-in). The sample consists of 402 UZAs from the lower 48 states that are fully contained inside one state and did not receive a CIG grant as part of ARRA funding. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

in either case. If these localities were already more independent, they were better able to leverage the additional federal grants into greater state funding due to a lower initial cost of negotiation, $e^k(0)$. If not, the observed heterogeneity suggests that crowding-in is associated with an increase in local bargaining power.

The second panel uses the overall rating from Tomer and Swedberg (2024), which measures the transparency of the project selection process based on publicly available data. A high level of project selection transparency indicates stronger alignment between funding decisions and constituency objectives. We would therefore expect UZAs in states with highly transparent transportation funding to achieve investments that better align with the value of additional spending, $U(\cdot)$. However, the similar magnitude of the crowding-in estimate for both high- and low-transparency states suggests that the increase in state funding is not driven by an efficient matching of federal funds. Rather, it appears to result from processes unrelated to efficient project selection, such as negotiation with local officials.

8 Conclusion

This paper provides evidence of a substantial impact of additional federal funding on public transit. Federal grants not only directly increased spending but also attracted additional investment from state governments. This effect is likely driven by a unique interaction among all three levels of government: additional federal grants enabled local officials to secure more state funding over time. The conceptual model presented here explains the flypaper effect through the stickiness of guaranteed funding and the crowding-in effect through a reduced cost of negotiation for flexible funds.

Most previous empirical studies have not documented a crowding-in effect from intergovernmental grants. One possible explanation is that the settings examined rarely involve a three-tiered government structure and therefore lack the specific incentives that generate crowding-in in my context. Gordon (2004) is a notable exception, studying interactions among all three levels of government and finding a crowding-out effect. Notably, my model can accommodate such an outcome as well, if portions of local and state funding are flexible before the shock. Understanding why this difference arises between transit and public education, and exploring its implications for areas like healthcare and public safety, remain important directions for future research.

The single documented exception of crowding-in, Leduc and Wilson (2017), formally considers only the state–federal interaction. However, their proposed mechanism for the flypaper effect—the influence of Special Interest Groups (SIGs)—can operate in a manner similar to the negotiation between states and localities in transit funding. SIGs may be empowered by trickled-down federal funds to advocate for increased state highway spending. The parallels between local officials and localized SIGs present an interesting avenue for future inquiry.

Viewed in light of the findings of this paper, federal fiscal policy is a powerful instrument for shaping public spending beyond its direct effects. However, applying this conclusion to other contexts requires nuance. The unexpected nature of ARRA funding may have played a crucial role in generating the flypaper effect. In contrast, regular federal funding streams may lead state and local planners, over the long term, to reallocate funds originally intended for transit to other purposes, reducing the overall effectiveness of federal investment. Regular grants are more challenging to study empirically, as most identification strategies rely on sudden changes or discontinuities. This underscores the need for further research on the long-term impacts of predictable federal funding.

ARRA was a fiscal stimulus package designed primarily to boost public spending quickly and stabilize the economy. I present evidence that the relatively small portion of ARRA dedicated to public transit was effective in promoting this goal. However, viewed as a targeted transfer for transit investment, its efficiency was limited. Although transit spending increased in response to ARRA, funds were directed toward projects that were easy to implement rapidly—such as bus purchases and improvements—without expanding service. This type of spending is unlikely to have lasting effects or fundamentally transform public transit in the United States. If the federal government seeks to pursue that objective, future funding allocations should differ from an unexpected influx of resources with a short deadline.

References

Anderson, Michael L (2014). "Subways, strikes, and slowdowns: The impacts of public transit on traffic congestion". In: *American Economic Review* 104.9, pp. 2763–2796.

APTA, American Public Transportation Association (2016). *Primer on Transit Funding. TThe Fixing America's Surface Transportation Act and Other Related Laws, FY 2016 Through FY 2020*. Report. URL: https://www.apta.com/wp-content/uploads/Resources/resources/reportsandpublications/Documents/APTA-Primer-FAST-Act.pdf.

Baicker, Katherine (Nov. 2001). "Government decision-making and the incidence of federal mandates". In: *Journal of Public Economics* 82.2, pp. 147–194. ISSN: 0047-2727. DOI: 10.1016/S0047-2727(00)00149-3. URL: https://www.sciencedirect.com/science/article/pii/S0047272700001493 (visited on 08/24/2025).

Bar-Yosef, Asaf, Karel Martens, and Itzhak Benenson (Aug. 2013). "A model of the vicious cycle of a bus line". In: *Transportation Research Part B: Methodological* 54, pp. 37–50. ISSN: 0191-2615. DOI: 10.1016/j.trb.2013.03.010. URL: https://www.sciencedirect.com/science/article/pii/S0191261513000507 (visited on 08/20/2025).

Bernet, Patrick Michael (2007). "Local public health agency funding: money begets money". eng. In: *Journal of public health management and practice: JPHMP* 13.2, pp. 188–193. ISSN: 1078-4659. DOI: 10.1097/00124784-200703000-00016.

Bureau of Transportation Statistics (2023). *U.S. Passenger Miles*. U.S. Department of Transportation. URL: https://www.bts.gov/content/us-passenger-miles (visited on 08/14/2025).

Card, David and A. Abigail Payne (Jan. 2002). "School finance reform, the distribution of school spending, and the distribution of student test scores". In: *Journal of Public Economics* 83.1, pp. 49–82. ISSN: 0047-2727. DOI: 10.1016/S0047-2727(00)00177-8. URL: https://www.sciencedirect.com/science/article/pii/S0047272700001778 (visited on 08/24/2025).

Chodorow-Reich, Gabriel et al. (Apr. 2012). "Does State Fiscal Relief during Recessions Increase Employment? Evidence from the American Recovery and Reinvestment Act". en. In: *American Economic Journal: Economic Policy* 4.3, pp. 118–145. ISSN: 1945-7731. DOI: 10.1257/pol.4.3.118. URL: https://www.aeaweb.org/articles?id=10.1257/pol.4.3.118 (visited on 09/11/2025).

Congressional Budget Office (2025). *Public Spending on Transportation and Water Infrastructure, 1956 to 2023*. Report. Congressional Budget Office. URL: https://www.cbo.gov/publication/60874 (visited on 08/14/2025).

Congressional Research Service (2025). *Impacts of Federal Grants and Other Funds on State and Local Budgets*. CRS Insight, IN12506. Congressional Research Service. URL: https://www.congress.gov/crs-product/IN12506 (visited on 08/15/2025).

Courant, Paul N, Edward M Gramlich, and Daniel L Rubinfeld (1979). "The stimulative effects of intergovernmental grants: Or why money sticks where it hits". In: *Fiscal Federalism and Grants-in-Aid*.

Federal Transit Administration (2019). *National Transit Database*. U.S. Department of Transportation. Data set. URL: https://www.transit.dot.gov/ntd/ntd-data.

Glaeser, Edward L., Matthew E. Kahn, and Jordan Rappaport (Jan. 2008). "Why do the poor live in cities? The role of public transportation". In: *Journal of Urban Economics* 63.1, pp. 1–24. ISSN: 0094-1190. DOI: 10.1016/j.jue.2006.12.004. URL: https://www.sciencedirect.com/science/article/pii/S0094119007000046 (visited on 08/16/2024).

Gordon, Nora (Aug. 2004). "Do federal grants boost school spending? Evidence from Title I". In: *Journal of Public Economics* 88.9, pp. 1771–1792. ISSN: 0047-2727. DOI: 10.1016/j.jpubeco.2003.09.002. URL: https://www.sciencedirect.com/science/article/pii/S0047272703001373 (visited on 08/22/2025).

Gramlich, Edward M. (1987). "Federalism and Federal Deficit Reduction". In: *National Tax Journal* 40.3. Publisher: National Tax Association, pp. 299–313. ISSN: 0028-0283. URL: https://www.jstor.org/stable/41788670 (visited on 08/25/2025).

Hines, James R. and Richard H. Thaler (Dec. 1995). "The Flypaper Effect". en. In: *Journal of Economic Perspectives* 9.4, pp. 217–226. ISSN: 0895-3309. DOI: 10.1257/jep.9.4.217. URL: https://www.aeaweb.org/articles?id=10.1257/jep.9.4.217 (visited on 08/18/2025).

Inman, Robert P. (2009). "Flypaper Effect". en. In: *The New Palgrave Dictionary of Economics*. Palgrave Macmillan, London, pp. 1–6. ISBN: 978-1-349-95121-5. DOI: 10.1057/978-1-349-95121-5_2956-1. URL: https://link.springer.com/rwe/10.1057/978-1-349-95121-5_2956-1 (visited on 08/20/2025).

Knight, Brian (Mar. 2002). "Endogenous Federal Grants and Crowd-out of State Government Spending: Theory and Evidence from the Federal Highway Aid Program". en. In: *American Economic Review* 92.1, pp. 71–92. ISSN: 0002-8282. DOI: 10.1257/000282802760015612. URL: https://www.aeaweb.org/articles?id=10.1257/000282802760015612 (visited on 01/11/2024).

Lalive, Rafael, Simon Luechinger, and Armin Schmutzler (2013). "Does supporting passenger railways reduce road traffic externalities?" In.

Leduc, Sylvain and Daniel Wilson (May 2017). "Are State Governments Roadblocks to Federal Stimulus? Evidence on the Flypaper Effect of Highway Grants in the 2009 Recovery Act". en. In: *American Economic Journal: Economic Policy* 9.2, pp. 253–292. ISSN: 1945-7731. DOI: 10.1257/pol.20140371. URL: https://www.aeaweb.org/articles?id=10.1257/pol.20140371 (visited on 01/11/2024).

Lutz, Byron (May 2010). "Taxation with Representation: Intergovernmental Grants in a Plebiscite Democracy". In: *The Review of Economics and Statistics* 92.2, pp. 316–332. ISSN: 0034-6535. DOI: 10.1162/rest.2010.12258. URL: https://doi.org/10.1162/rest.2010.12258 (visited on 08/24/2025).

Mallett, William J. (2023). *Federal Public Transportation Program: In Brief.* Report R47002. Congressional Research Service. URL: https://crsreports.congress.gov/product/pdf/R/R47002.

Oates, Wallace E. (Sept. 1999). "An Essay on Fiscal Federalism". en. In.

Parry, Ian W H and Kenneth A Small (2009). "Should urban transit subsidies be reduced?" In: *American Economic Review* 99.3, pp. 700–724.

Singhal, Monica (Apr. 2008). "Special interest groups and the allocation of public funds". In: *Journal of Public Economics* 92.3, pp. 548–564. ISSN: 0047-2727. DOI: 10.1016/j.jpubeco.2007.05.005. URL: https://www.sciencedirect.com/science/article/pii/S0047272707000898 (visited on 08/24/2025).

State Highway, American Association of and Transportation Officials (2015). *Survey of State Funding for Public Transportation.* Tech. rep. Item 2371.

49 U.S.C. Ch. 53 (2023). *Title 49, United States Code, Chapter 53: Public Transportation.* United States Code. URL: https://uscode.house.gov/view.xhtml?path=/prelim@title49/subtitle3/chapter53&edition=prelim (visited on 08/15/2025).

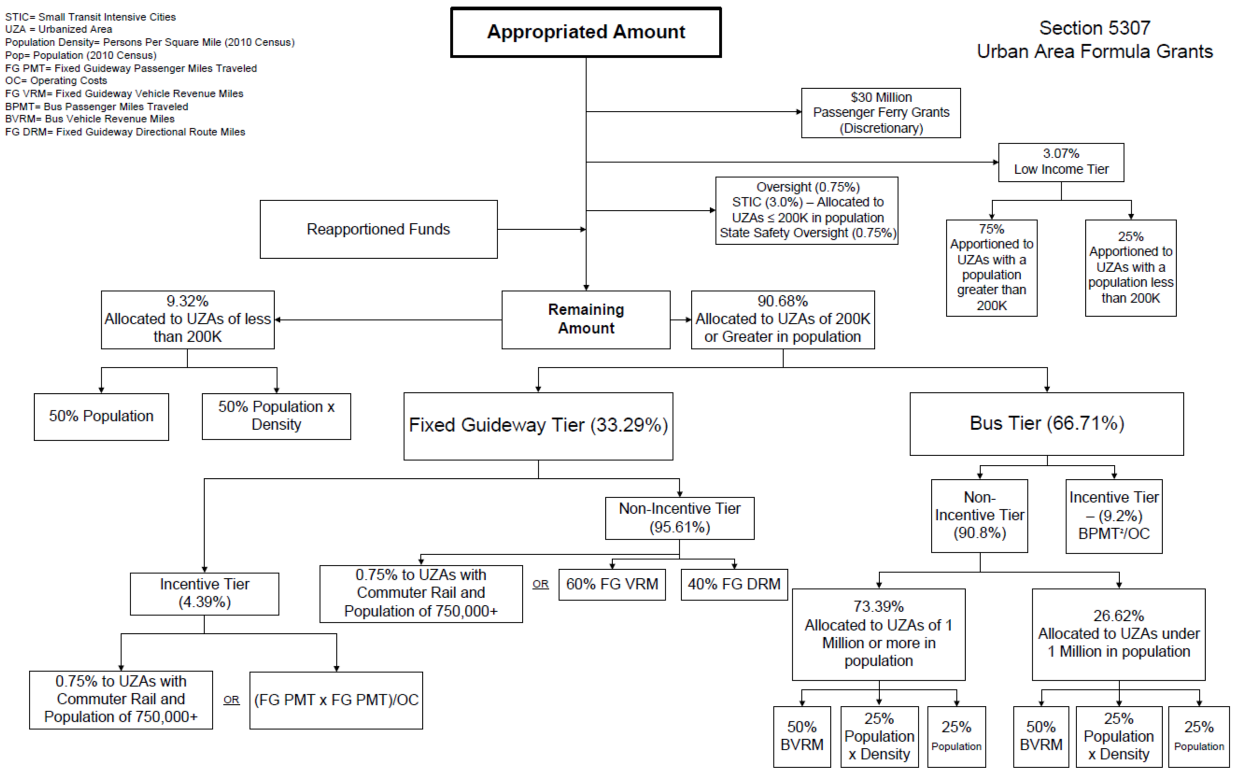
Tomer, Adie and Ben Swedberg (Nov. 2024). *Connecting the DOTs: A survey of state transportation planning, investment, and accountability practices.* en-US. Tech. rep. URL: https://www.brookings.edu/articles/connecting-the-dots-a-survey-of-state-transportation-planning-investment-and-accountability-practices/ (visited on 03/12/2025).

USDOT, U.S. Department of Transportation (2017). *American Recovery and Reinvestment Act Final Report.* Report. URL: https://www.transportation.gov/mission/budget/arra-final-report.

Wilson, Daniel (Apr. 2012). "Fiscal Spending Jobs Multipliers: Evidence from the 2009 American Recovery and Reinvestment Act". en. In: *American Economic Journal: Economic Policy* 4.3, pp. 251–282. ISSN: 1945-7731. DOI: 10.1257/pol.4.3.251. URL: https://www.aeaweb.org/articles?id=10.1257/pol.4.3.251 (visited on 09/11/2025).

A Additional Information

Figure A1: Formula 5307 Allocation Scheme. Source: https://www.transit.dot.gov/



B Additional Results

Table B1: The Effect of a $1 Increase in ARRA Expenditures Instrumented by ARRA Apportionments on Annual Capital Spending from Different Sources.

	2009-19	2009-14	2015-19
ΔCap^{fed}	0.13**	0.18**	0.07
	(0.06)	(0.07)	(0.08)
ΔCap^{st}	0.10	-0.05	0.28***
	(0.07)	(0.09)	(0.10)
ΔCap^{loc}	0.02	0.03	0.02
	(0.09)	(0.07)	(0.12)
ΔCap^{tot}	0.25*	0.16	0.37*
	(0.14)	(0.13)	(0.20)
FS F-Stat	20.41	20.41	20.41

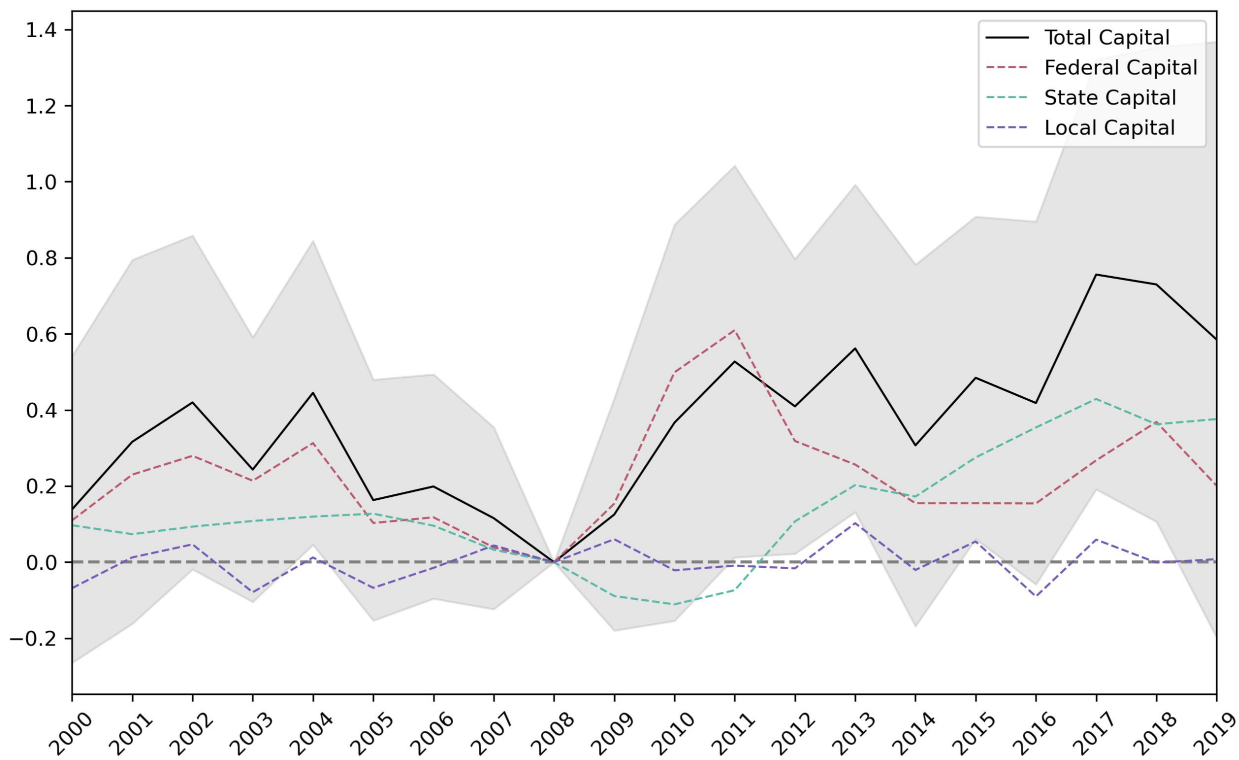
The treatment variable is total spending from ARRA grants. Instrumental variable is the amount of ARRA grants apportioned to UZA by two programs: UAF and FGM. The dependent variable is the difference in capital transit expenditures from the relevant source in the relevant period compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

Table B2: The Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from Different Sources. First-Stage Outliers Excluded.

	2009-19	2009-14	2015-19
ΔCap^{fed}	0.11***	0.14***	0.07
	(0.02)	(0.03)	(0.05)
ΔCap^{st}	0.07*	-0.01	0.18***
	(0.04)	(0.05)	(0.06)
ΔCap^{loc}	0.02	0.02	0.02
	(0.05)	(0.04)	(0.07)
ΔCap^{tot}	0.21***	0.15**	0.28**
	(0.07)	(0.06)	(0.12)
FS F-Stat	16.88	16.88	16.88

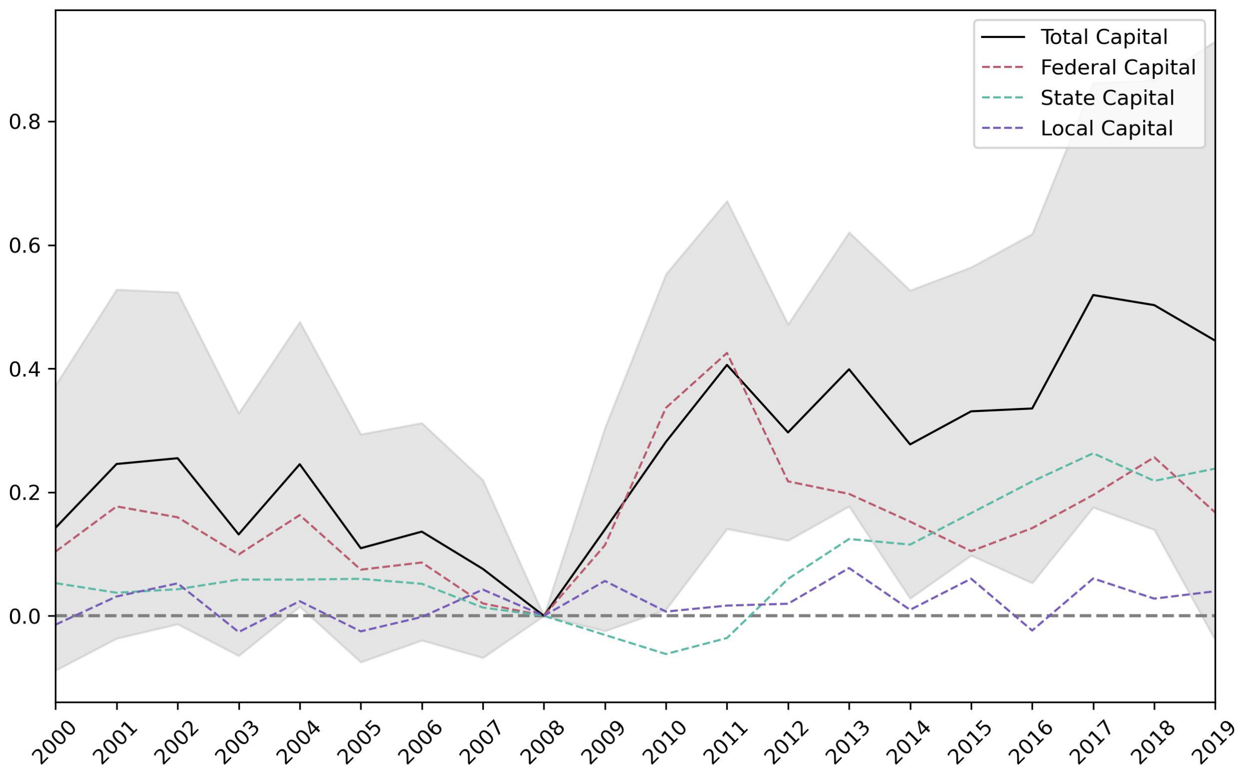
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. Instrumental variable is the amount of ARRA grants apportioned to UZA by two programs: UAF and FGM. The dependent variable is the difference in capital transit expenditures from the relevant source in the relevant period compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 468 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. 5 UZAs that were decreasing the first-stage F-Statistic the most are excluded: Durham, NC, Danbury, CT-NY, Pittsfield, MA, Chicago, IL-IN, and East Stroudsburg, PA. Local spending is funded by grants from local governments and directly-generated revenue from service provision. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

Figure B2: Year-by-Year Effect of a $1 Increase in ARRA Expenditures Instrumented by ARRA Apportionments on Capital Spending from Different Sources.



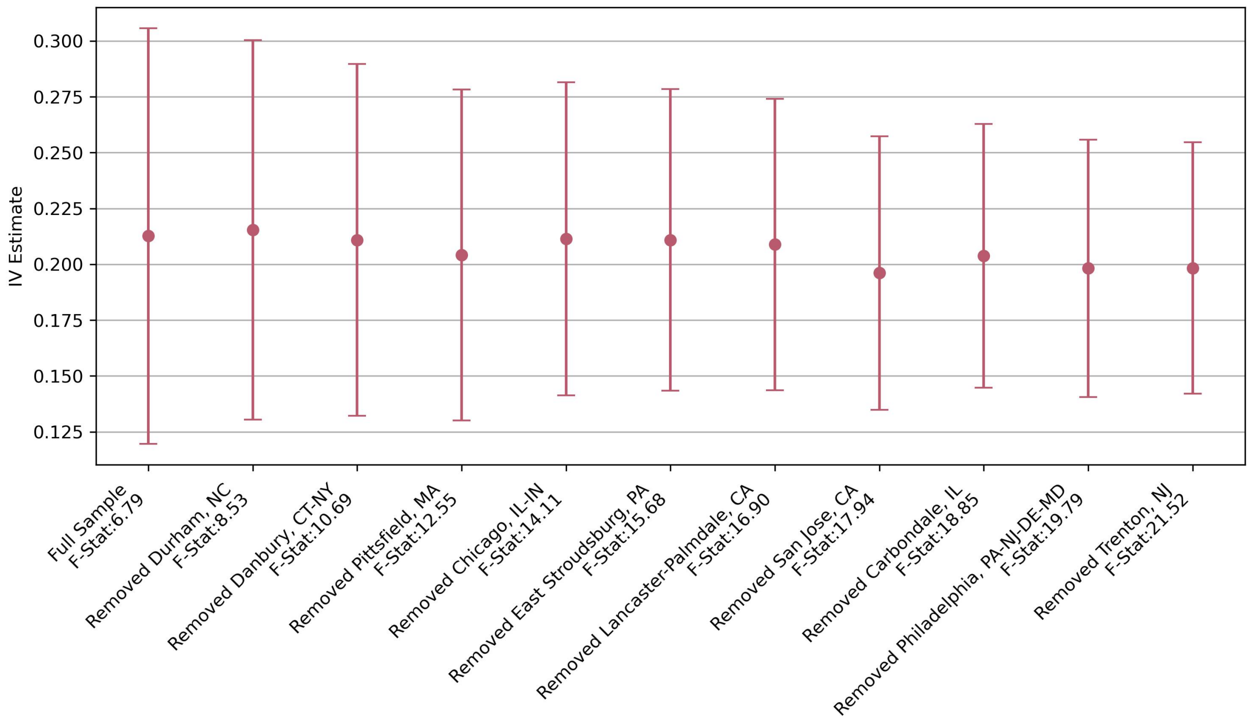
The treatment variable is the increase in expenditures from ARRA grants, instrumented by 2009 ARRA funding. Dependent variables are capital transit expenditures from the relevant source. The year before treatment, 2008, is excluded. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. TThe sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision. 95% Confidence Interval for the total capital expenditures is depicted.

Figure B3: Year-by-Year Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Capital Spending from Different Sources. First-Stage Outliers Excluded.



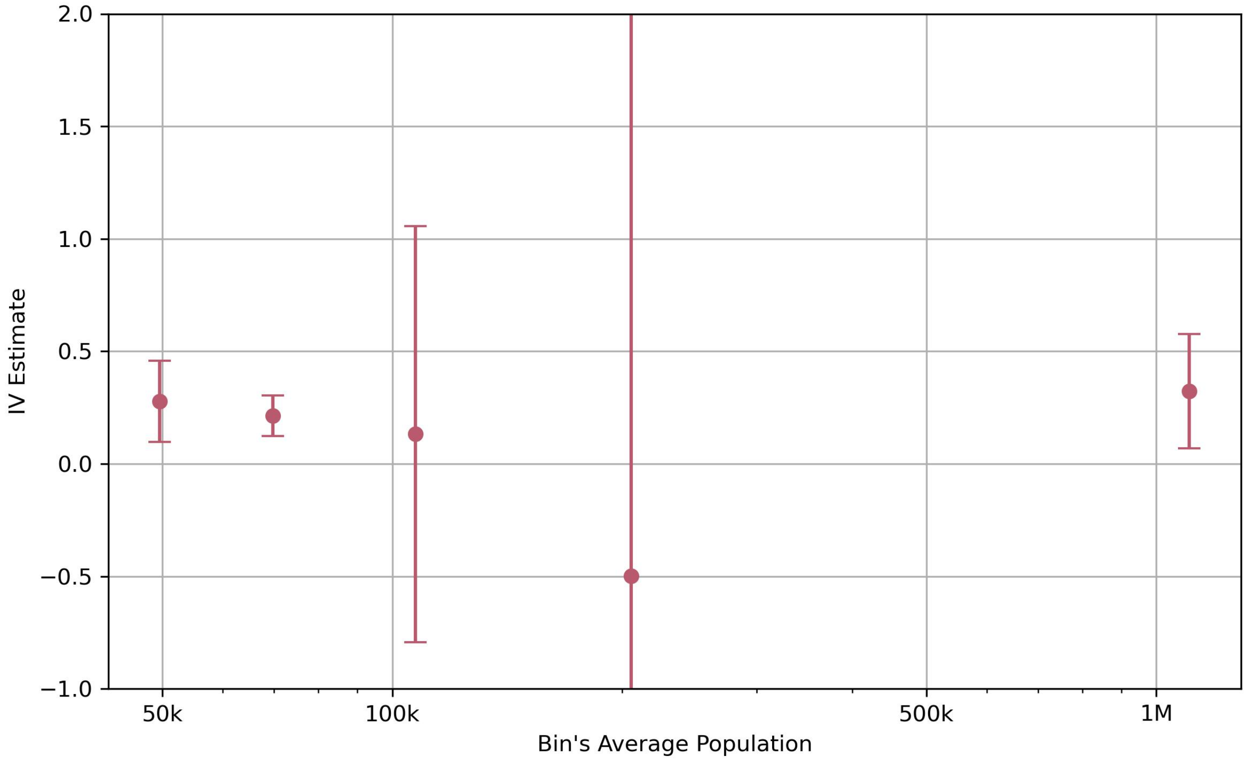
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. Dependent variables are capital transit expenditures from the relevant source. The year before treatment, 2008, is excluded. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 468 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. 5 UZAs that were decreasing the first-stage F-Statistic the most are excluded: Durham, NC, Danbury, CT-NY, Pittsfield, MA, Chicago, IL-IN, and East Stroudsburg, PA. Local spending is funded by grants from local governments and directly-generated revenue from service provision. 95% Confidence Interval for the total capital expenditures is depicted.

Figure B4: The The Effect of a $1 Increase in the Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from All Sources. Sequential Exclusion of First-Stage Outliers.



The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in capital transit expenditures from all sources in 2009-2019 compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The initial full sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. 10 UZAs are excluded in the order of the largest estimated positive effect on the first stage F-Statistic compared to the Full Sample. 95% Confidence Interval is depicted.

Figure B5: The Effect of a $1 Increase in the Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from All Sources by Population Size.



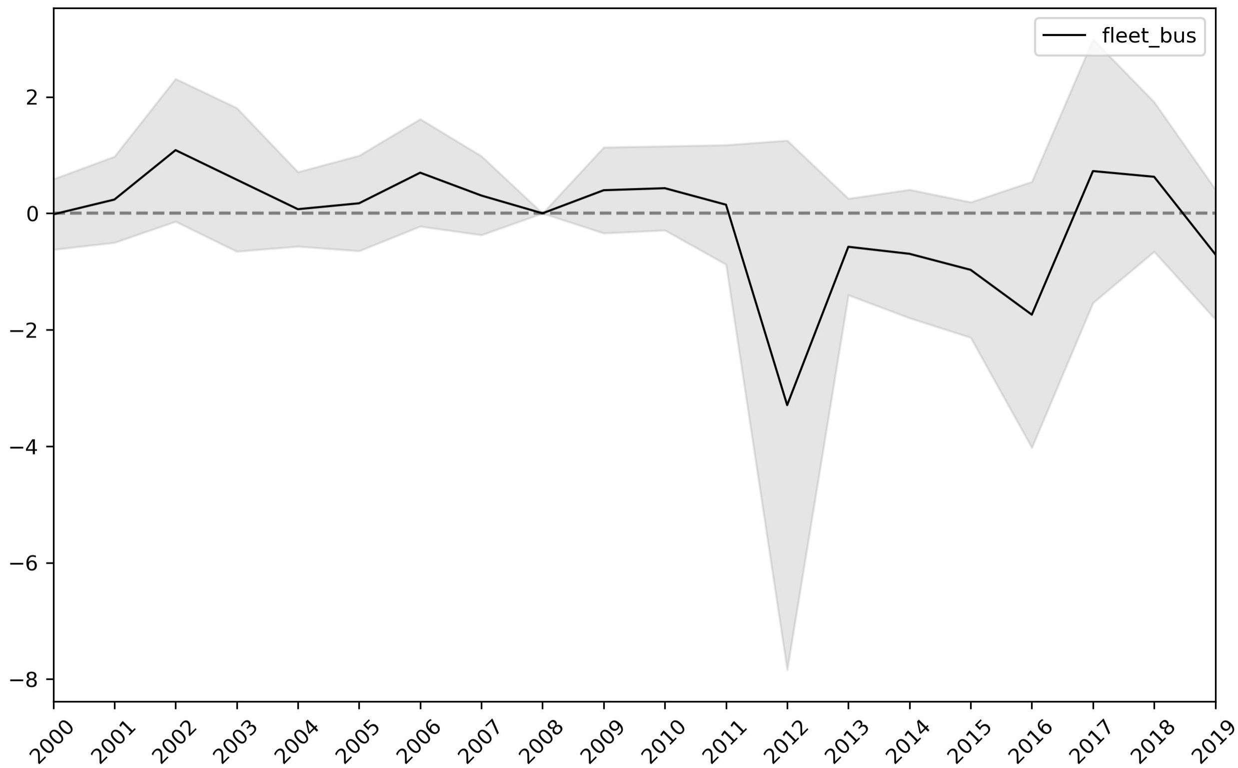
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in capital transit expenditures from all sources in 2009-2019 compared to 2000-2008. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Population bins contain approximately the same number of UZAs each. 95% Confidence Interval is depicted.

Table B3: The Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending of Different Types (Panel A) and on Transit Provision and Usage (Panel B). Percentage Change Relative to the Overall Pre-2009 Mean.

	Total	Bus	Rail	Demand	Other
Panel A					
ΔCap^{tot}	1.95%**	2.33%***	1.29%	1.10%	0.96%
	(0.82)	(0.70)	(3.44)	(1.07)	(17.68)
ΔCap^{tot}_{roll}	2.45%***	2.32%***	3.53%	1.55%	10.11%
	(0.86)	(0.76)	(6.08)	(1.31)	(15.67)
ΔCap^{tot}_{fac}	1.52%	1.92%	1.47%	0.96%	-11.14%
	(1.75)	(1.32)	(4.07)	(2.07)	(27.07)
ΔCap^{tot}_{other}	0.97%	1.72%	-3.06%	4.74%**	5.74%
	(1.76)	(1.33)	(6.38)	(2.30)	(14.85)
Panel B					
ΔN vehicles (per 1 mil)	-11.45%**	-15.22%*	14.68%	-8.75%**	-2.36%
	(5.10)	(7.80)	(38.16)	(4.18)	(-11.86)
Fleet Age (mos)	0.27%	-0.18%	-0.96%	-0.02%	0.77%
	(0.44)	(0.34)	(1.97)	(0.67)	(2.69)
Service Miles (VRM)	-0.90%	-0.92%	2.80%	-1.14%	-2.68%
	(0.91)	(1.07)	(2.13)	(1.45)	(9.93)
Trips	0.72%*	0.65%	3.09%	-1.64%	4.79%
	(0.38)	(0.40)	(1.95)	(1.67)	(7.94)

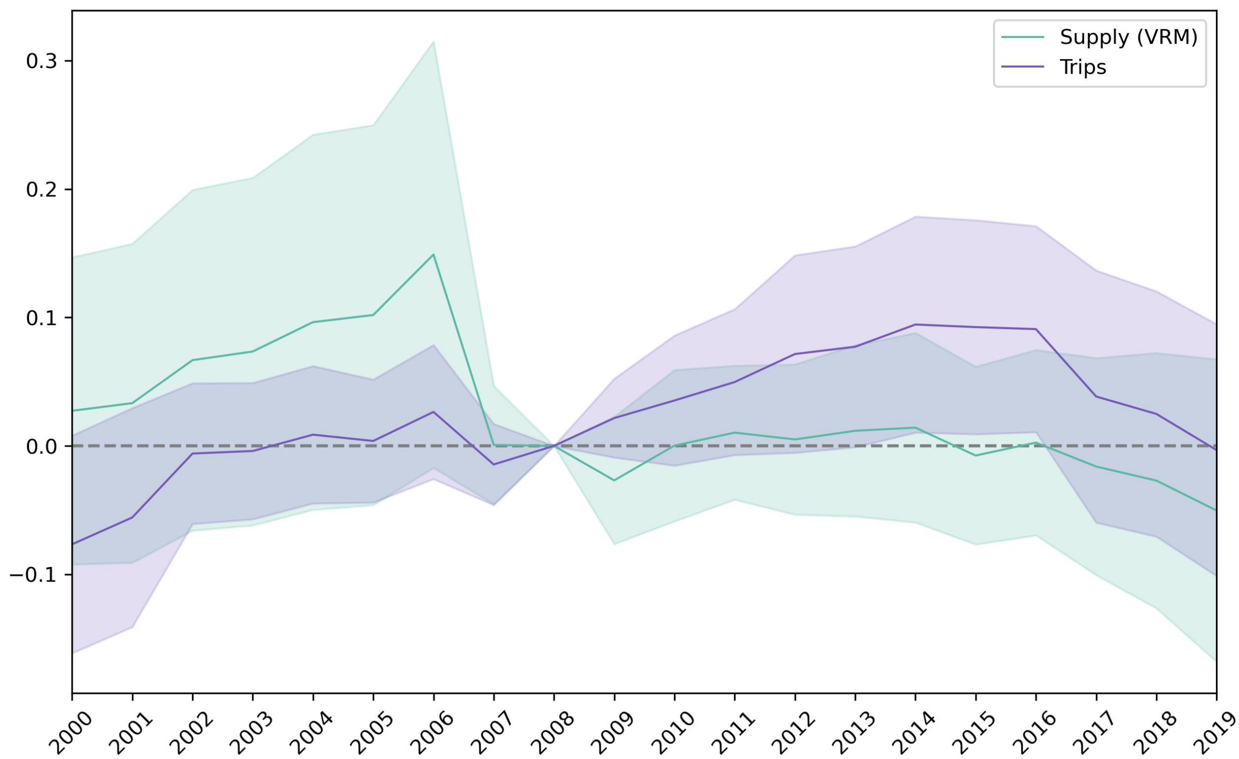
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented with 2009 ARRA funding. In Panel A, dependent variable is the change in capital transit expenditures in 2009-2019 compared to 2000-2008 by the type of spending and transit mode. In Panel B, dependent variables are changes in transit system characteristics. All expenditures and ARRA apportionment are in per capita terms and in real 2009 dollars. Vehicle Revenue Miles (VRM) and Unlinked Passenger Trips are in per capita, the number of new vehicles is per one million. All coefficients are divided by the overall pre-2009 mean of the depenndent varible and multiplied by 100%. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Standard errors are in parenthesis: * p<0.05, ** p<0.01, *** p<0.001

Figure B6: Year-by-Year Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on the Change in Active Bus Vehicles.



The treatment variable is the increase in federal grants for capital expenditures per capita in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding per capita. The dependent variable is the change in the number of active vehicles per capita. The year before treatment, 2008, is excluded. All expenditures and ARRA apportionment are in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. 95% Confidence Interval is depicted.

Figure B7: Year-by-Year Effect of a $1 Increase in Federal Grants Instrumented by ARRA Apportionments on Transit Supply (Vehicle Revenue Miles) and Usage (Trips).



The treatment variable is the increase in federal grants for capital expenditures per capita in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding per capita. Dependent variables are the number of Vehicle Revenue Miles and Trips per capita. The year before treatment, 2008, is excluded. All expenditures and ARRA apportionment are in real 2009 dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. 95% Confidence Interval is depicted.