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

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Abstract

I study how targeted federal grants affect state and local transit spending. My analysis uses comprehensive U.S. expenditure data from 2000–2019 and a plausibly exogenous shock from the 2009 American Recovery and Reinvestment Act (ARRA). ARRA funds were apportioned to Urbanized Areas using pre-existing formula programs, with amounts independent of potential changes in transit investment. Using ARRA apportionments as an instrument, I find that each additional $1 of federal grants generates a $0.21 annual increase in capital transit spending from all sources. This average reflects two distinct phases of the dynamics between 2009 and 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 investments. I find that the additional funds were directed mainly toward upgrading existing buses rather than expanding systems. Consistent with this pattern, Urbanized Areas receiving more federal grants did not experience an increase in transit provision, while ridership rose only marginally. I propose a novel mechanism for the crowding-in of state investment: federal grants empowered local transit agencies, strengthening their ability to negotiate additional state funding. This interpretation is consistent with the crowding-in being confined to state sources and present in spending without economies of scale. Variation in crowding-in strength across states with different institutional characteristics provides further support for this mechanism.

JEL: H77, R42

1 Introduction

In the United States, roughly a third of both state and local budgets is funded by intergovernmental transfers (Congressional Research Service, 2025). Theory predicts that such transfers should primarily reduce local taxes, but empirical studies find that they increase public spending almost one-to-one – a phenomenon known as the flypaper effect (Inman, 2009). Most federal transfers are earmarked for categories such as public transit, and their efficacy depends on how they affect spending within that category rather than public spending overall. While crowding-out would mute their influence, a less explored crowding-in would make federal transfers highly impactful.

Public transit systems in the U.S. are at the center of intergovernmental relations. Although they are administered and primarily financed locally, expansions and upgrades depend heavily on transfers from outside. Between 2000 and 2019, 41% of capital expenditures came from federal funds and 14% from state funds. Given the high federal share in public transit, it is important to understand how changes in federal grants affect spending from other sources. This paper provides the first empirical evidence on this question. While transit represents only a modest share of the federal budget, it is subject to substantial shifts, such as the 67% increase in 2021.[1] Optimal federal policy hinges on whether grants stimulate additional state and local spending on transit or merely displace what those governments would have spent otherwise.

In this paper, I examine how an increase in federal grants affected state and local spending for public transit. I use a comprehensive dataset of all transit spending in the U.S. and a natural experiment from the American Recovery and Reinvestment Act (ARRA) of 2009 (Pub. L. 111-5) to identify the effect. I find that state and local investments were not displaced by the increase in federal funding. In addition to the flypaper effect, I document a crowding-in of state funds to locations that received more federal money. I propose that this voluntary matching operates through an increase in the bargaining power of transit agencies when negotiating more funding from the state officials.

In my empirical analysis, I exploit ARRA as a plausibly exogenous increase in federal funding for transit. ARRA funds were distributed to Urbanized Areas (UZAs) through two pre-existing formula programs, the Urbanized Area Formula (UAF) and the Fixed Guide-

[1] On average, the Infrastructure Investment and Jobs Act of 2021 authorizes $21.5 billion in guaranteed yearly 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)

way Modernization (FGM).[2] The amount distributed to each UZA was determined by fixed formula inputs 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 casual 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 crowding-in triggered by additional federal transfers, I develop a conceptual model in which a local transit agency finances capital expenditures from three government sources: federal, state, and local. The model's innovation is that funding from each level has two components: guaranteed and flexible, the latter requiring costly negotiation by the agency. This framework is able to accommodate both the initial flypaper effect from increased federal grants and the subsequent crowding-in of state funding. In the model, crowding-in arises from increased negotiation for flexible state funding that can be driven by two mechanisms: (i) an increased value of additional funds due to new or expanded transit projects, or (ii) a reduction in negotiation costs. Additional empirical evidence suggests that the second mechanism is more likely, indicating that federal

[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.

grants empower local transit agencies to secure more funding from their states.

I provide several empirical validations of the model. First, federal, state, and local funding respond very differently to the ARRA shock, suggesting that they should be modeled separately. Second, I find that crowding-in is driven by UZAs in states with a higher share of discretionary funding, a higher share of funding devoted to capital expenditures, and a higher share of transit funding coming from non-dedicated sources such as general revenue. This pattern validates the interpretation of crowding-in as arising from local transit agencies drawing more from flexible state funding pools. Third, I show that 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.

To empirically distinguish between the two crowding-in mechanisms, I first show that the additional funds were spent primarily on buses and bus facilities. However, bus fleets in more affected UZAs did not become larger or newer as a result. This indicates that ARRA funds were directed toward maintenance and incremental upgrades, or toward purchasing more expensive buses, rather than accelerating service expansion or fleet renewal. Such spending is consistent with the short ARRA timeline, during which transit agencies had less than a year to allocate funds to specific projects. In line 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 particularly capital-intensive and do not exhibit economies of scale, this pattern rules out the possibility of new projects inducing state contributions in the later period and instead supports the negotiation-cost explanation.

Additionally, using state Department of Transportation survey data from Tomer and Swedberg (2024), I find that crowding-in is driven by UZAs in states where local governments have greater autonomy over transportation decisions, but is similar across states with higher and lower transparency in project selection. This further suggests that state funding crowding-in arises from lower negotiation costs faced by local transit agencies rather than from the projects initiated with additional federal funds. While I cannot pinpoint the exact source of these lower negotiation costs, several plausible explanations exist, including expertise signaling, learning by doing, and the stickiness of local budgets.

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 D. Wilson (2017), who – similar to this paper – study the effect of ARRA but in the context of federal highway funding.[3] While Leduc and D. 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 agencies. The observed pattern of spending on buses and bus facilities rules out the project-complementarity mechanism of crowding-in suggested by Leduc and D. 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 federal funding, whereas ARRA was transitory. While the setting of Leduc and D. Wilson (2017) – highway funding – does not explicitly feature a local level, the special interest groups they

[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.

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%; 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

[4]Singhal (2008) also attribute the flypaper effect to bargaining with special interest groups, but do not find crowding-in. The parallels between local governments and special interest groups is 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 D. J. 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).

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 financial operations, service provision, and ridership data.

[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.

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 (reimbursements) as the instrumented treatment because they represent the actual grants moving

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

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 D. 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 D. Wilson (2017) find conflicting results. On the other hand, localized transit agencies draw funds from all three levels of government, more similar to school districts than to state-managed highway construction. Evidence for educational funding varies as well, though with a similar identification strategy to mine, Gordon (2004) finds a complete crowd out from an increase in federal grants.[11]

[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.

[11]One important distinction compared to my setting is that the increase in Gordon (2004) is permanent.

In a stylized model in Appendix B, I formalize the choice that a transit agency makes when determining spending on capital from each available source. The model considers all three possibilities following a positive shock in federal grants: crowding-out of state and local spending, no impact (flypaper effect), and crowding-in. An important element of the model is that funding from all three levels is split between passive and active. Passive funding is available regardless of agency actions, such as through formulas, and does not react to changes in the availability of funds from other sources. In contrast, active funding needs to be bargained for and takes agency effort.

When experiencing a positive shock to passive federal funding, the agency will chose to exert less effort of acquiring funding from state and local sources, leading to a crowding-out effect. The flypaper effect can arise when the whole (or most) of the funding is passive. On the other hand, crowding-in from federal funding can appear either when marginal utility from capital spending is increasing or when the cost function of acquiring additional funds negatively depends on the spending from other sources. Since previous empirical evidence and my theoretical model suggest any possible effect of federal grants on total spending, this question needs to be answered empirically.[12]

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

This can affect the planning horizon and the capacity of state and local budgets to adjust their funding. However, other differences between education and transit could also be driving the discrepancy in our results.

[12]The model does not explicitly refer to the representative voter but is consistent with the agency maximizing this voter's preferences. My model shares the main idea of fungible public spending that has an economic cost with models trying to explain the transitional flypaper effect, such as Inman (2009). However, the crowding-in elements are transit-specific.

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:

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

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 $\Delta G_i = \underset{09\text{-}14}{\Delta} Cap_i^{fed} = Cap_i^{2009-2014} - Cap_i^{2003-2008}$.[13] Second Stage:

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

[13] 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.[14] 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

[14]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.

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 pre-existing 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 ($G = \underset{\text{09-14}}{\Delta} Cap^{fed}$). 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 C1 and C2 in the Appendix present complimentary results from two other specifications. Tables C1 uses expenditures coming specifically from ARRA grants rather than all federal sources, and Table C2 removes five outliers that make the first stage imprecise. Section 5.1 discusses this issue in more detail, while Section 5.4

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.[15] State and local governments were free to direct their own 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.

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

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 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 C2 and C3.

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 C1 and Figure C2. 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 C4 in the Appendix. Full estimates after the removal of top-5 are in Table C2 and Figure C3. 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 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 C5 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 C4), 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 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 On What Was the Money Spent

My main results show a robust and large increase in capital transit investment following the 2009 shock. The average UZA increase its capital expenditures per capita by \$26. According to the crowding-in effect I estimate, this led to additional capital expenditures of \$60 per capita in the eleven years between 2009-19. This is, perhaps, a good indicator that ARRA achieved one of its goals of stabilizing public spending and employment. The goals of federal transit policy, however, are not simply spending more money on transit. 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). Thus, this sections looks at whether the influx of additional spending brought changes to transit systems, both in terms of service provision and utilization.

Using the same estimation strategy, I first look at how the additional monies were spent. Panel A of Table 5 separates the total increase in capital investment in two ways: by type of expenditure and by transit mode. Cap_{roll} includes spending on the rolling stock (buses and trains) and Cap_{fac} includes most other infrastructure: stations, building, and fixed guideway (rail) (Federal Transit Administration, 2019). The bus category combines normal buses, commuter buses, bus rapid transit, and jitneys; the rail category includes light and heavy rail, commuter rail, and other special forms of rail. Demand Response includes vehicles that don't have a pre-determined route and/or serve special groups of people, such as the elderly or disabled, or employees of a large local firm. The latter mode has a very low contribution to the total number of trips taken but might provide a substantial amount of service in term of active vehicles and Vehicle Revenue Miles (VRM). Table C3 shows the same effects relative to the overall pre-2009 mean of the outcome variable.

The additional \$0.22 dollars from the 2009 shock (the difference of \$0.01 comes from using a different data sources inside the NTD) was predominantly spent on bus transit (77%). Inside the bus spending, more than half was spent on vehicles rather than facilities. This pattern of spending is consistent with the nature of how ARRA funds were distributed. Most of the funds had to be obligated to specific projects before October, 2009 or a reallocation would be triggered. All of them had to be obligated by October, 2010, less than two years after the announcement of ARRA. That meant that transportation agencies and other officials found themselves with a substantial sum of money that had to be quickly put to use. Renewing the current fleet of buses or buying additional ones was one of the most straightforward projects to approve and undertake. In contrast, trains are usually built with an advance order. A significant expansion os the existing rail network, or even a substantial modification of an existing one, also requires years- or even decades-long planning.

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 specifying what fraction of these vehicles is newly acquired.[16]

[16]The definition of active vehicles is: "The vehicles available to operate in revenue service at the end of

Despite spending more money on buses ($0.09 annually for each $1 of federal grants), UZAs that received more federal grants had a lower annual increase in the number of buses (0.86 bus per 1 mil people per year less). This alone does not necessary mean they were buying fewer buses, as they could have been more aggressively replacing the old fleet leading to a decrease in the total number of active vehicles. This significant negative effect on the rate of change in the bus fleet size is not driven by outliers and is robust to sample changes.

Other evidence suggests that the replacement of older buses was not the only use of additional funds. While the average age of the bus fleet decreased, indicating some replacement, this decrease is insignificant and not large in magnitude (0.18% per year, see Table C3). The other possible way of spending funds on buses is to make small improvements and maintenance on existing buses. This type of expenditure is consistent with the decrease in the number of vehicles since buses leave the active fleet while undergoing major maintenance or upgrades. Therefore, existing fleet improvement seems to be the main avenue chosen by transit agencies in spending additional funds received from an increase federal grants and the crowding-in of state funding.

Across all capital uses and service provision, nothing is changing for rail modes except for a statistically insignificant but substantial increase in the number of vehicles (15%, see Table C3) and an insignificant decrease in the average age of the fleet. When the estimation is restricted to 51 UZAs that report rail service at some point between 2000-2019, both the rate of change in the number of vehicles and the fleet age become more negative – though both are highly insignificant because of the small number of observations. Overall, it is unlikely that ARRA spurred many rail projects that could explain state spending crowding-in by the economy of scale or a concave cost function.

Finally, I look at the implications for the provision and usage of transit. The supply of transit is commonly measured in Vehicle Revenue Miles (VRM) – the total number of miles driven by all vehicles while in service. Table 5 indicates that transit service was insignificantly lower for UZAs that increased their federal spending more due to ARRA. Although this is consistent with a decreased number of active vehicles, the granular dynamics of these effects suggest separate mechanisms. While the number of additional vehicles falls around 2012 (Figure C6), the fall in the VRM is a disruption of a pre-2009 relative increasing trend (Figure C7). More importantly, I can rule out an increase in service provision from spending additional funds. While this can be due to a relatively short time horizon, the nature of the

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) spending in Panel A makes a later raise in VRM quite unlikely.

The actual usage of the system can be measured by the total number of passenger trips, where a trip is counted as a passenger boarding a vehicle (Federal Transit Administration, 2019). Despite zero findings for transit service provision, the last row of Panel B indicates a significant increase in the number of trips per capita for UZAs spending more. This indicates that the improvements in service, such as better comport and reliability, were successful in attracting new riders without increasing the provision of service. For the federal transit policy, this is a good news. After all, the number of trips is a better metric of the impact of transit on individuals than the amount of service available.

However, this effect has modest economic significance. Its magnitude is 0.72% of the pre-2009 overall mean, compared to the 1.95% increase in capital spending.[17] Moreover, it is not clear whether increased usage caused by the improving existing buses can be sustained without a constant stream of additional funding. Indeed, the event-study plot in Figure C7 confirms this intuition. Trips in differentially affected UZAs are on parallel trends before 2009, experience an increase after ARRA funding trickles down to transit agencies, and start to return to pre-2009 values by 2019.

7 Mechanisms of Crowding-In

I find that \$1 of additional federal grants attracts, after a six year delay, \$0.23 of annual state investment to the same UZA. ARRA funding that caused the increase in federal grants did not require a local match, so this represents a voluntary matching by the state government. The mechanism of why federal grants might elicit state crowding-in are not well understood, especially in the three-layer interaction when the grant is to a locality. Traditional flypaper effect explanations suggest the stickiness of the current level of spending, not its increase.

My model of the transit agency in Appendix B suggests two possibilities that can lead to crowding-in from an increase in federal funding. The transit agency in the model takes passive state funding (P_i^{st}) as given and chooses the amount of active funding to acquire (A_i^{st}) that maximizes its utility ($U(Cap_i)$) minus the cost of acquiring active funding ($E_i^{st}(A_i^{st})$). Given this setup, the increase in active funding from state sources that I observe can be driven either by the increasing value of additional investment ($U(Cap_i)' \uparrow$) or the decreasing

[17]For only bus modes, this ratio is even worse: 0.65% increase in trips against a 2.33% increase in capital expenditures. See Tables C3.

cost of acquiring additional active funding ($E_i^k(A_i^k)' \downarrow$).

One example of a mechanism of the first type is the "virtuous cycle of transit": improved service frequency attracts more riders, which makes the agency increase frequency even more (Bar-Yosef et al., 2013). However, as I show in the previous section, the service did not increase as part of the effect of additional federal grants. Another possibility is concavity in the cost function, which increases the real output of each dollar spent on transit. For example, after an initial investment in overall infrastructure, it is less costly to scale by increasing the number of vehicles. However, most of the extra funds were spent on improving existing buses. Unlike rail, buses do not experience a strong economy of scale, as the main capital investment is the vehicle itself.

Finally, a major implication of increasing the marginal value of investment in transit is that it should increase local and federal investment as well. While more strict limits on additional federal funds are likely and they do show a positive albeit insignificant increase in 2015-19, the absence of any discernible effect on local spending is not consistent with this explanation of crowding-in. After all, local governments should internalize public transit benefits that their constituents enjoy.

The second type of mechanism decreases the cost of acquiring state-specific funds that transit agencies face. While the exact process of distributing transit funding varies across states, it can be modeled as a bargaining outcome between each agency (or the collection of agencies belonging to the same UZA) with the state Department of Transportation or other representative. With more federal money at hand or already spent, the transportation agency has plausibly more bargaining power in this negotiation. One rationale for this is signaling: more money under management signals more capacity to secure funding, though in this case states have to be ignorant of the essentially-random distribution of ARRA funds. Another is state-level institutional conditions that imply matching, such as formulas. Finally, there could be a purely behavioral reason.

Given the spending pattern of additional funds, improved bargaining power on the state level seems a likely mechanism. An absence of an effect on local or federal spending suggests a state-specific process, while investment in the improvement of existing buses further points at the non-cost-specific direction. I provide an additional analysis that exploits state-level variation in transit funding rules to better understand the nature of state crowding-in in Table 6.

Each estimate in Table 6 is the effect of the change in federal grants instrumented by ARRA apportionments on state spending between 2015-19 compared to 2000-08. In Table 2, this corresponds to the estimate of 0.23. However, only UZAs contained inside one state are used here, of which there are 402. For them, the estimate is smaller than for the whole sample, around \$0.15 annually for each additional \$1 of federal grants. In each of the panels of Table 6, I separate the sample by the median of a state-wide transit funding characteristic. The estimate in the left column is the crowding-in for UZAs in states with a level of the given characteristic higher than the median, while on the left – for UZAs in states with a level below the median.

The first three panels show the influence of the three formal characteristics of transit funding from the 2013 state survey by the American Association of State Highway and Transportation Officials. They show that the result is fully driven by UZAs in states that have a higher share of discretionary funding, higher share of capital-restricted funding, and higher share of funding from non-dedicated sources, such as a general revenue fund or debt. All of these characteristics are consistent with bargaining by localities for additional state funding. The more flexible and uncommitted funding is available, the more influential is bargaining, and the larger is the crowding-in of state spending.

The last two panels use data collected by Tomer and Swedberg (2024) on state DOT policies. They did not differentiate between transit, highways, and other projects, but the legal framework is usually the same for different types of transportation administered by the state DOT. Local Independence is measured as the share of all DOT funding allocated to local governments to be spent at their discretion. It proxies how powerful are local agencies compared to their state DOTs. The results in Table 6 indicate that crowding-in was higher in states with more local independence. Finally, the last panel utilizes the overall rating from Tomer and Swedberg (2024) that measures how well the project selection process is organized at the state level based on publicly-available data. The same estimate for both high- and low-quality states indicates that crowding-in is not driven by states which recognize that matching federal funds is efficient. Instead, it is achieved in a process of bargaining unrelated to efficient project selection.[18][19]

A related question is whether crowding-in operates as a change in the distribution of a fixed

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

[19] I use a cross-sectional post-treatment variation across state funding characteristics for this exercise. One important implicit assumption that I make is that these characteristics were not changed by ARRA. Since most of them are determined by the state legislature and relatively little time has passed, this seems plausible.

amount of transit money across UZAs or an augmentation of state-level transit funding. To test this, Table 7 shows the interactions between different UZAs inside the same state in terms of the crowding-in of state funding. The inclusion of state fixed effects or the state mean in the regression does not change the result much. It stays around $0.14 per year. This indicates that the increase in state funding to a UZA does not come at the expense of other UZAs in the same state. Moreover, the average state-wide increase in federal spending, instrumented by average state-wide ARRA funding, is positive though insignificant. Consistently, the sum of (per-capita) increases in same-state UZAs excluding the current UZA has a positive and significant effect. This mechanism of augmentation is consistent with UZAs improving their bargaining power without affecting the position of other UZAs in the same state.

8 Conclusion

This paper provides evidence of a substantial effect from additional federal funding on public transit. Federal grants not only directly increased spending but also attracted investment from state governments. Viewed in this light, federal fiscal policy is a powerful instrument in directing public spending beyond its direct effect. However, the application of this finding to other contexts might be nuanced.

For instance, the unexpected nature of the ARRA funding likely played a crucial role in generating the flypaper effect. Regular federal funding streams may incentivize state and local planners to divert funds intended for transit to other purposes, making the overall impact on transit investment even less effective. Regular grants are elusive for empirical analysis that often relies on some sudden change or discontinuity, and therefore require more research.

ARRA was a fiscal stimulus package with the main goal to quickly increase public spending and keep the economy afloat. I present evidence that the relatively small portion of ARRA dedicated to public transit was effective in achieving this goal. However, viewed as targeted transfers for public transit, its efficiency was limited. While transit spending was increased in response to ARRA, it went to the type of projects that were easy to implement quickly. The majority of the money went to improving existing buses and did little to increase transit supply. This type of spending is unlikely to have long-lasting consequences necessary to transform public transit in the U.S.

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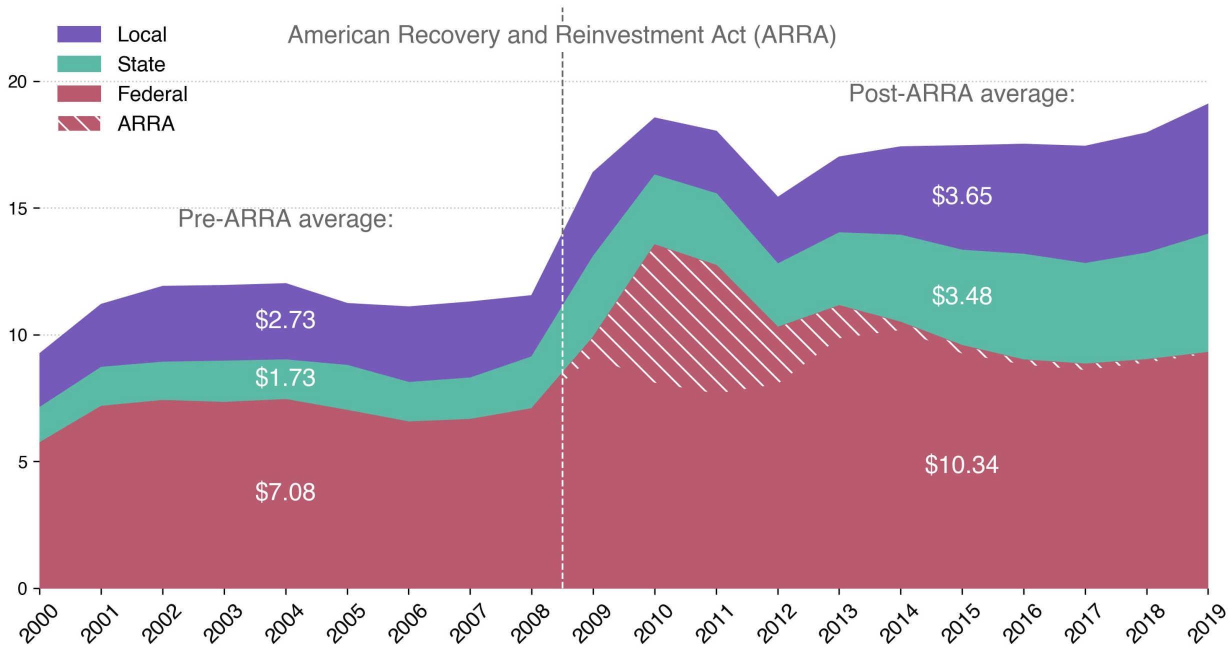
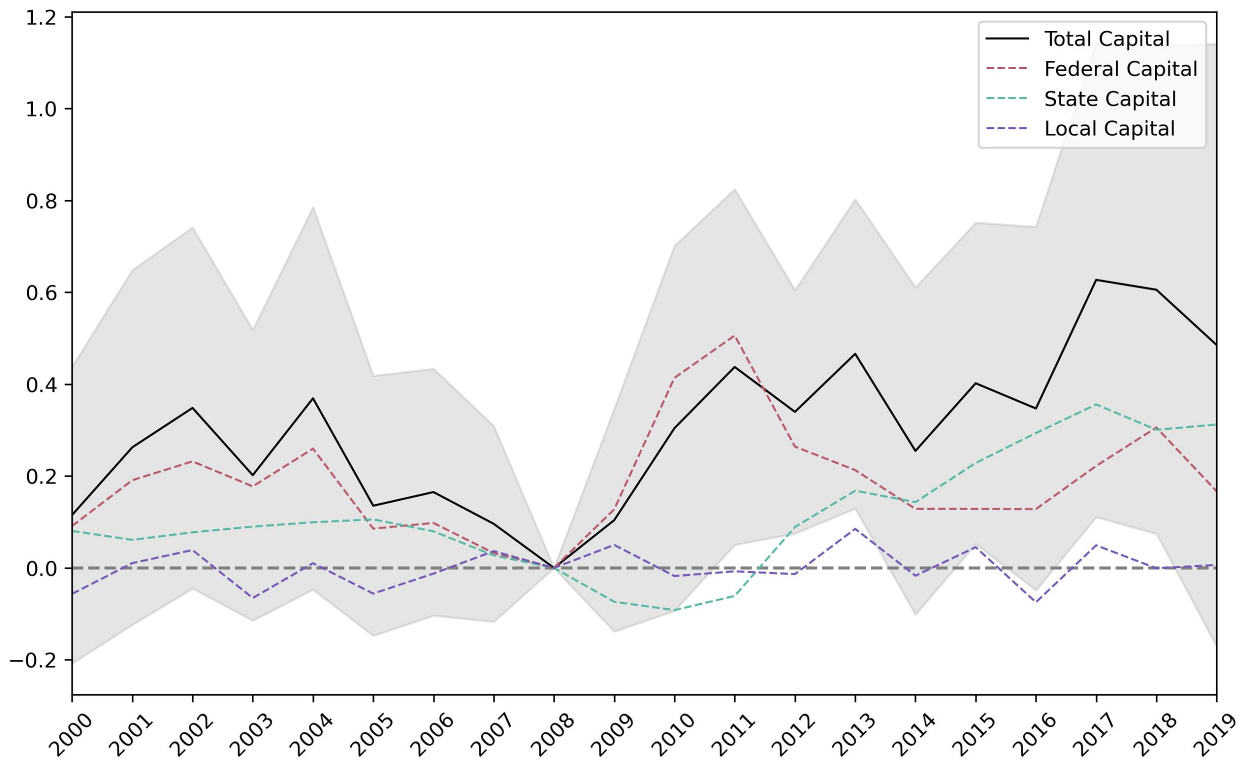
Figure 1: Annual Capital Expenditures by Funding Source Averaged Across UZAs.



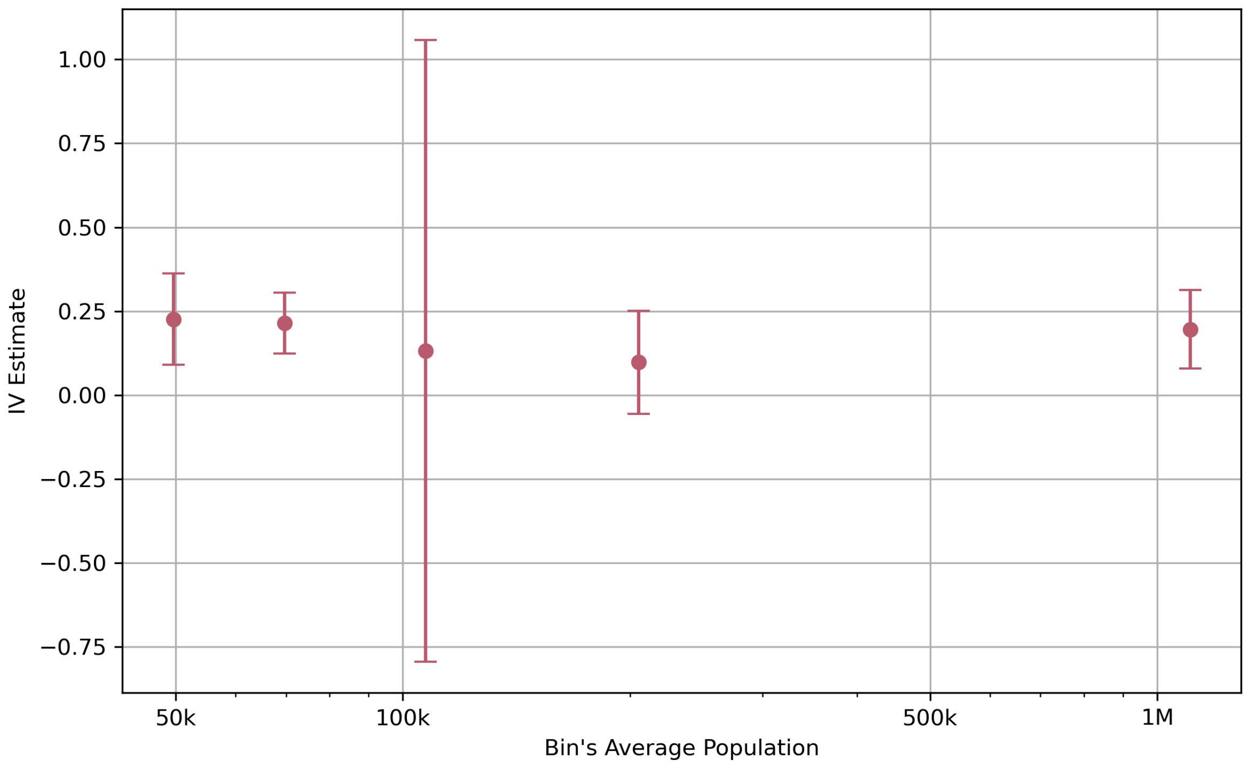
All values are in per capita terms and in 2009 constant dollars. The sample consists of 473 UZAs from the lower 48 states that did not receive a CIG grant as part of ARRA funding. Local spending is funded by grants from local governments and directly-generated revenue from service provision.

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.

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.

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.

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

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*** (0.01)	0.16*** (0.01)	0.16*** (0.01)	0.16*** (0.01)	0.10*** (0.01)	0.20*** (0.04)
Instrument:	ARRA	ARRA UAF	Density'00	VRM'06	ARRA	ARRA
2SLS	0.21** (0.09)	0.19** (0.08)	0.18* (0.10)	0.37*** (0.14)	0.18** (0.08)	0.25* (0.14)
First Stage	0.78*** (0.30)	0.79** (0.31)	0.01** (0.00)	0.84* (0.45)	0.92** (0.38)	0.65*** (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: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

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: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Table 5: 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: * $p<0.05$, ** $p<0.01$, *** $p<0.001$

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
Local Independence		
ΔG	0.24*	0.11**
	(0.14)	(0.05)
N	203	199
Allocation Decision Quality		
ΔG	0.14	0.14**
	(0.09)	(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

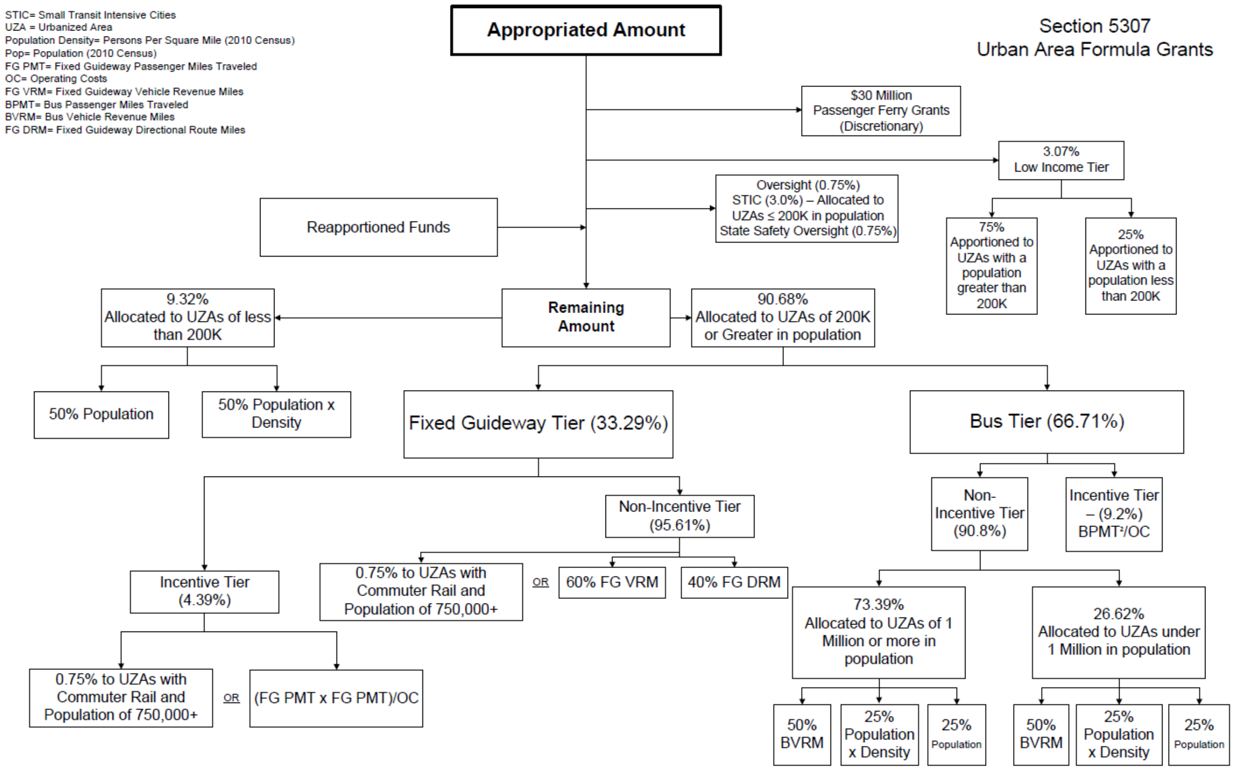
Table 7: Within-State Interaction of the State Crowding-In from an Increase in Federal Grants.

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, $_{s}tate$ is the state mean, and $_{e}xcl$ 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

A Additional Information

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



B Stylized Model of Transit Investment

I consider a representative transit agency that decides on the level of transit investment in its primary UZA i. I abstract from any interactions between agencies serving the same UZA or investments into other UZAs. The agency spends money on capital expenditures from federal, state, and local sources:

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

The fungibility of funds across sources is an assumption, which holds if none of the restrictions on funds usage is binding. For example, federal formula program Section 5310 is directed at older adults and people with disabilities. If eligible investments would have been at least of the same amount without this program, its spending requirement is not binding. The possibility of funding reallocation between agencies inside the same UZA and, to some extent, between UZAs inside the same state makes it quite plausible. The absence of matching requirements is assumed on similar grounds: if the required match is 0.25, as for the UAF funds, then as long as $Cap_i^{fed} \leq 4 * (Cap_i^{st} + Cap_i^{loc})$ the requirement is not binding.

Each source's spending comes from the available (passive) funding that the agency takes as given and the active part, for which the agency has to exert effort:

$$Cap_i^k = P_i^k + A_i^k,\ k \in \{fed, st, loc\}.$$

The passive component P_i^k represents funding that is apportioned regardless of planned projects and agency actions, such as formula programs.[20] The active component A_i^k which will cost the agency effort $E^k(A_i^k)$ includes formal applications for discretionary programs on the federal and state level and bargaining for more funds on the state and local level. Alternatively, the transportation agency and the local government may be closely aligned in which case the active component represents additional taxes or local public funds diverted from other uses. To represent budget scarcity on all levels, $E^k(A_i^k)$ is convex.

The transit agency chooses $A_i^k \geq 0,\ k \in \{fed, st, loc\}$ to solve

$$\begin{aligned} &max\ U_i(Cap_i) - \sum_k E_i^k(A_i^k) \\ &given\ P_i^k, U_i, \end{aligned}$$

where U_i is the measure of the utility from transit investments that includes the demand for transit and the current condition of the transit system in UZA i. From this maximization problem, $\forall k \in \{fed, st, loc\}$:

$$E_i^{k\prime} = U_i'$$
$$\text{or}$$
$$A_i^k = 0 \Rightarrow Cap_i^k = P_i^k.$$

Operational expenditures are omitted from this model. If they are perfectly determined by the size of the current transit system, this is easily resolved by adjusting P_i^k to pay for the operational expenditures in an optimal fashion before deciding on the level of capital invest-

[20] In cases when federal funding can be reallocated (e.g., UAF funding for smaller UZAs), P_i^{fed} is equal to the amount of federal funds the governor is willing to allocate to the current agency before any negotiations take place.

ment. Alternatively, they can be added as more choice variables, but the main conclusions about capital spending will hold. The model also lacks a dynamic component, as it is designed to only handle two states: the steady state with stationary shocks and an immediate effect of a large increase in federal funding.

B.1 Steady State

In the medium-run steady state, both sources of differences across UZAs have a time-constant component and a random stationary shock:

$$U_i(Cap_i) = U_i(Cap_i)(1 + \hat{u}_i),\ \mathbb{E}_i[\hat{u}_i] = 0$$

$$P_i^k = P_i(1 + \hat{P}_i),\ \mathbb{E}_i[\hat{P}_i] = 0.$$

The investment decision is then

$$Cap_i^k = Cap_i^k\left(U_i, \hat{u}_i, P_i^k, \hat{P}_i^k\right) = Cap_i^k\left(\hat{u}_i, \hat{P}_i^k\right),$$

and

$$\mathbb{E}_t[Cap_i^k] = Cap_i^k, \tag{5}$$

which is the parallel trends condition for the steady state.

The average levels Cap_i^k will depend on both U_i and P_i^k:

$$\frac{\delta Cap_i^k}{\delta U_i} > 0, \frac{\delta Cap_i^k}{\delta P_i^k} > 0, \frac{\delta Cap_i^k}{\delta P_i^{k'}} < 0,\ \text{and}\ \frac{\delta Cap_i}{\delta P_i^k} > 0.$$

More transit-intensive UZAs (high U_i) will spend more from all sources, UZAs receiving more passive funding from one source will spend more from that source and less from other sources. Any passive funding increase increases total spending on capital due to the convexity of $E_i^k()$. U_i and P_i^k are likely related. For example, federal programs explicitly allocate more funding to UZAs with higher estimated transit demand based on population, density, and existing transit infrastructure: $Corr_i(U_i, P_i^{fed}) > 0$. Same is plausibly true for state and local passive funding.

This observation represents the first empirical challenge of estimating the effect of federal funding. In a cross-sectional regression of Cap_i on Cap_i^{fed}, the estimate will be biased by the dependency of Cap_i and Cap_i^{fed} on U_i and P_i^k. If all are positively correlated with P_i^{fed}, the bias is positive.

The second empirical challenge arises when the panel structure of the data is utilized. A regression of ΔCap_i on ΔCap_i^{fed} might allow one to get rid of the cross-sectional variation, but both still depend on $\hat{u}_i$ and $\hat{P}_i^k$. Depending on the prevalence of shocks and functional forms, the bias can go either way.

B.2 Shock to Federal Funding

An exogenous shock to passive federal funding can help resolve empirical challenges. Assume that P_i^{fed} exogenously and unexpectedly increases. This will lead to an increase in Cap_i^{fed}, and its effect on total Cap_i can be estimated.

In general, the model predicts

$$\frac{\delta \Delta Cap_i^{st}}{\delta P_i^{fed}} \leq 0, \frac{\delta \Delta Cap_i^{loc}}{\delta P_i^{fed}} \leq 0 \text{ and } \frac{\delta \Delta Cap_i}{\delta P_i^{fed}} \leq 1$$

This is a traditional story of crowding-out, and it's intuitive why it's happening. Due to the decreasing marginal returns to transit investment (U is concave), a positive shock to passive funding decreases the effort agency puts into a acquiring more funding from all sources. In the more traditional public finance sense, an increase in the consumption of capital investment should also increase the consumption of the private good (no effort).

However, the inequality can turn into an equality if the solution is at the corner. If the agency does not exert effort to acquire more state funding, all of its spending is from passive sources, and additional federal funding will not change it. This is one example why the flypaper effect might be observed for transit funding. While seemingly restrictive, the condition of $A_i = 0$ contains various possibilities including many of the previously-suggested mechanisms. In the short term, the budgets are fixed, which would result in all funding becoming passive. Alternatively, bureaucrats can be reluctant to decrease expenditures relative to historical level, and then P_i will absorb all previous funding. Finally, the costs to acquire additional funds can be prohibitively high ($E_i'(0)$ is large) for any action to take place.[21]

The possibility of crowding-in can arise from two distinct channels. First is a nature of U_i

[21] Singhal (2008) proposes an explanation for the flypaper effect based on strategic interaction with special interest groups, and Leduc and D. Wilson (2017) finds some support for it in the context of ARRA highways grants. In the context of my model, a long-term commitment with respect to a local special interest group would also result in a part of the expenditure becoming passive.

Table C1: 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

that makes additional expenditures more attractive. If $U_i'(Cap_i)$ at the pre-shock level is smaller than $U_i'(\overline{Cap}_i)$ at the new value after the shock, it is possible that more effort of acquiring new state funds is induced. Second is the dependency of $E_i^{st}()$ on capital spent from other sources. This might reflect the higher bargaining power of the transit agency that can demonstrate that it successfully manages larger sums of money.

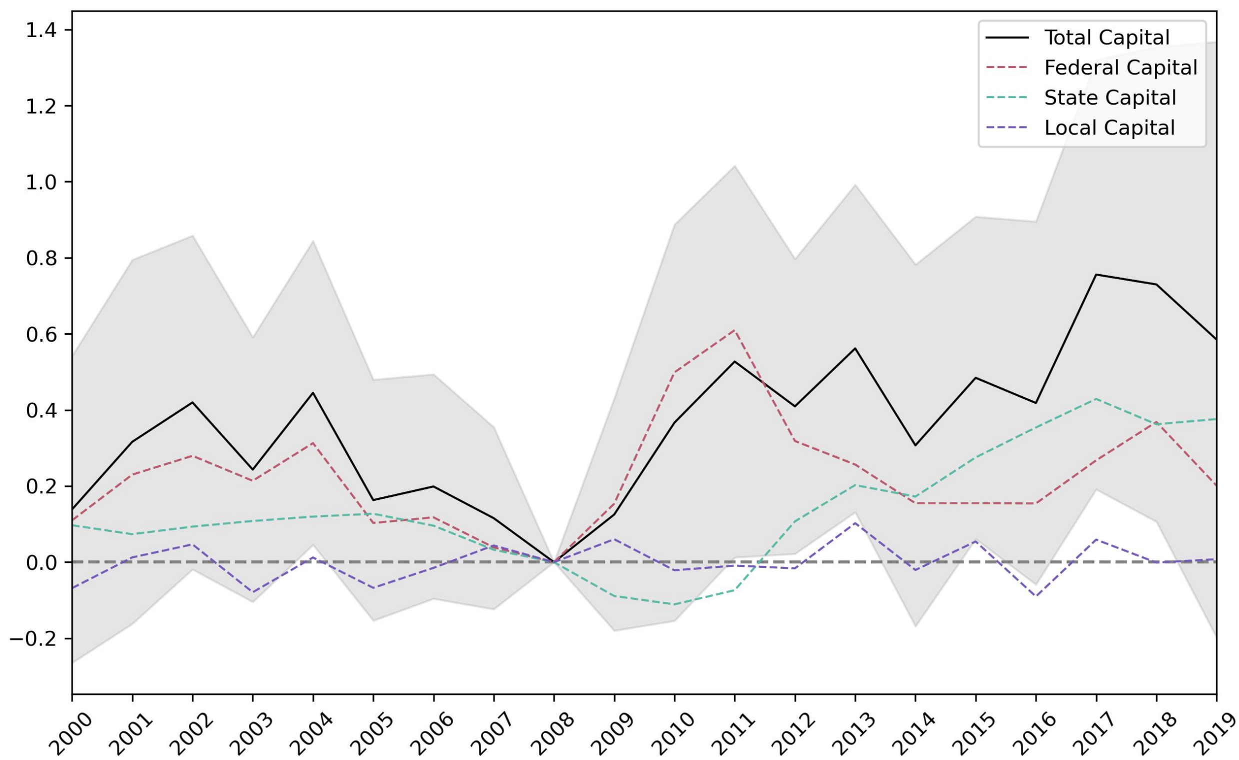
C Additional Results

Table C2: 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

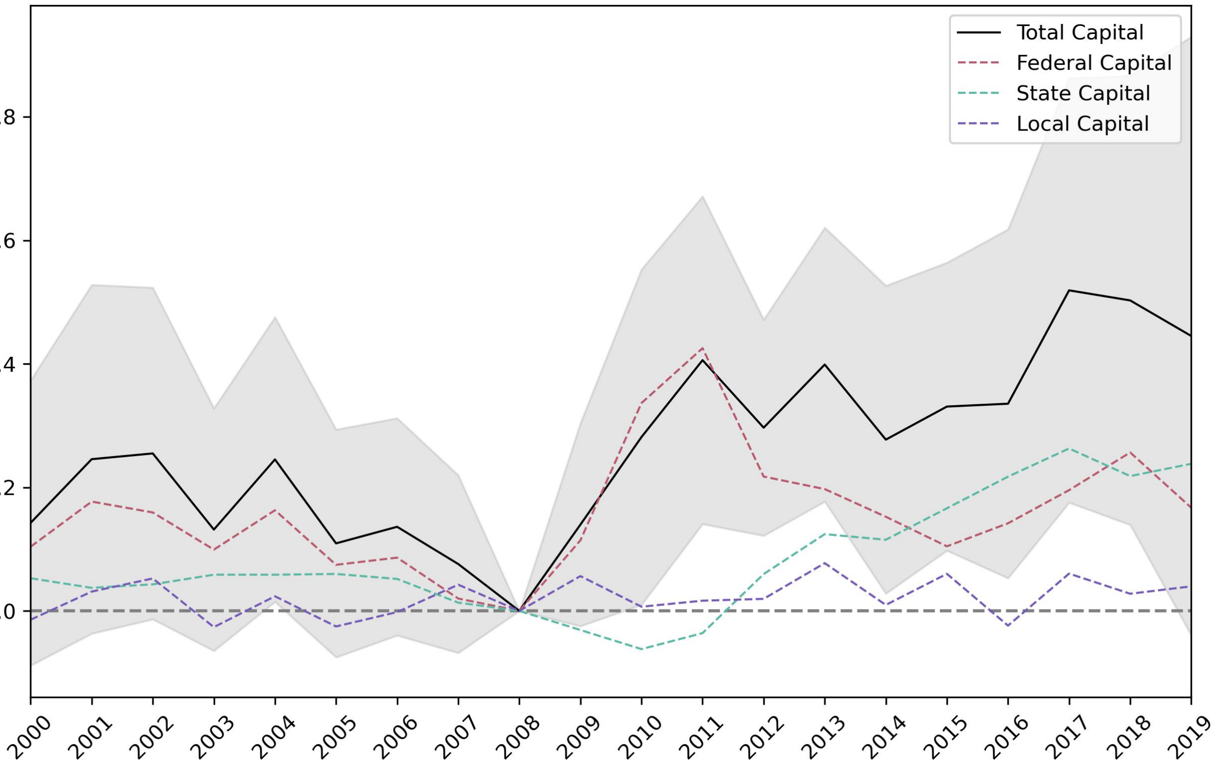
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. Instrumental variable is the amount of ARRA grants apportioned to UZA by two programs: UAF and FGM. The dependent variable is the difference in capital 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 C2: Year-by-Year Effect of a $1 Increase in ARRA Expenditures Instrumented by ARRA Apportionments on Capital Spending from Different Sources.



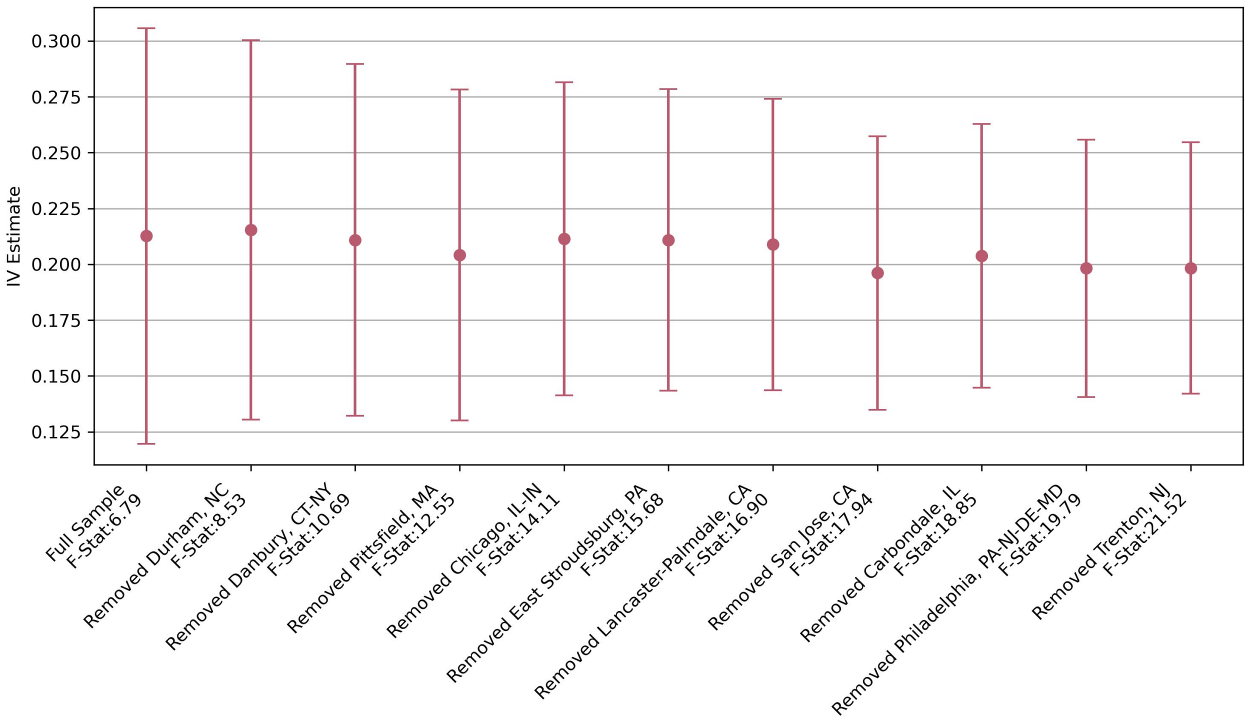
The treatment variable is the increase in expenditures from ARRA grants, instrumented by 2009 ARRA funding. Dependent variables are capital transit expenditures from the relevant source. The year before treatment, 2008, is excluded. All expenditures and ARRA apportionment are in per capita terms and 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 C3: 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.



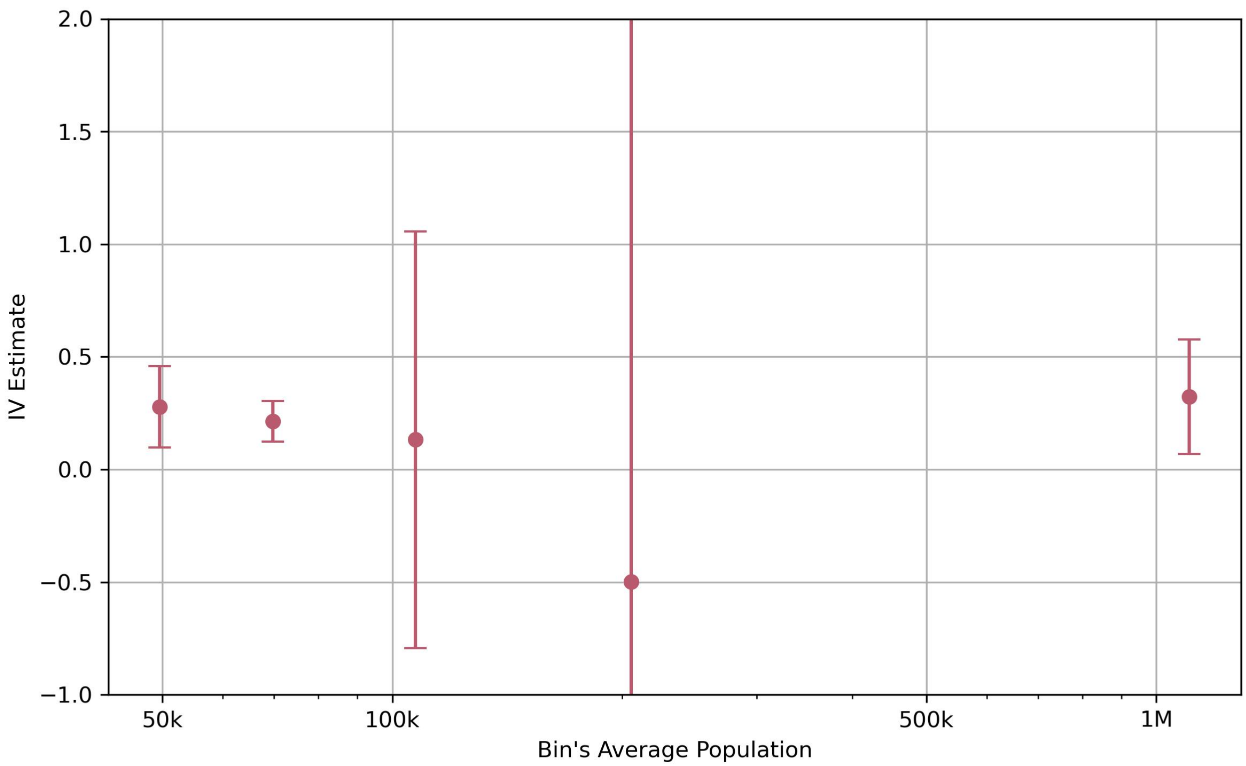
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. Dependent variables are capital transit expenditures from the relevant source. The year before treatment, 2008, is excluded. All expenditures and ARRA 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 C4: 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 C5: The Effect of a $1 Increase in the Federal Grants Instrumented by ARRA Apportionments on Annual Capital Spending from All Sources by Population Size.



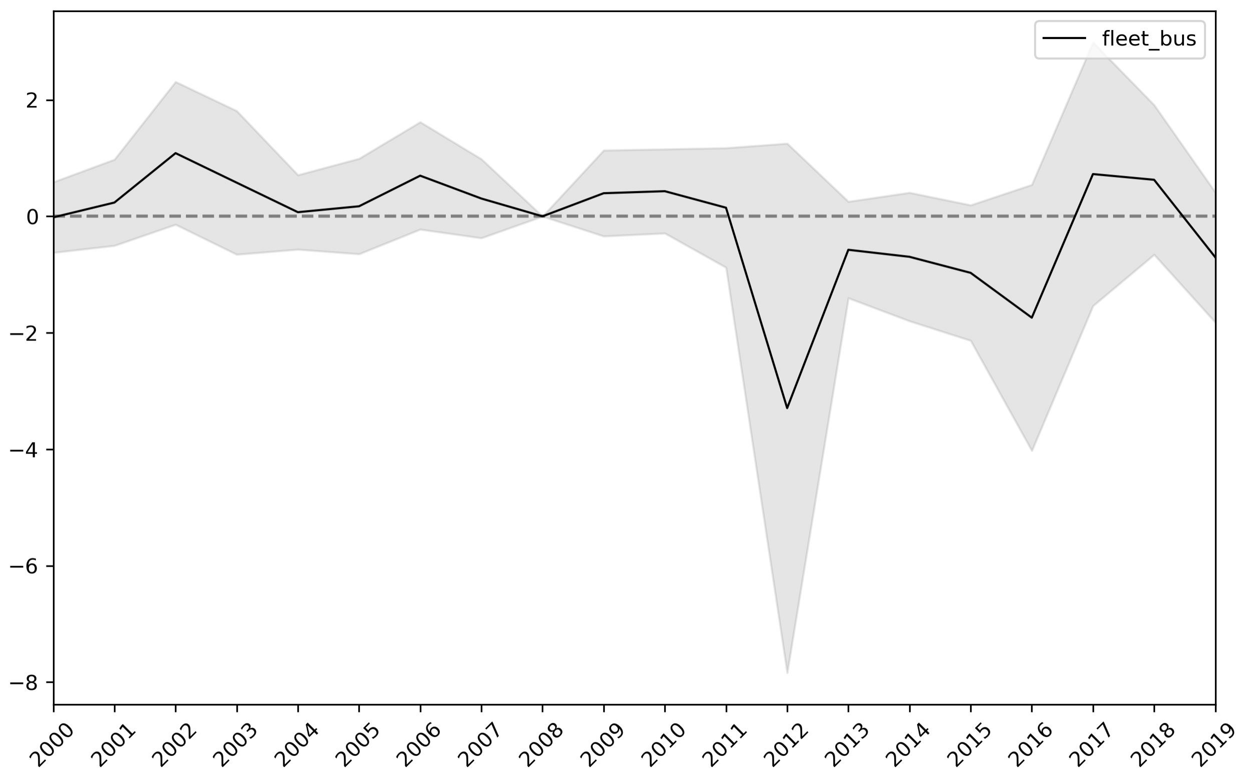
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in capital transit expenditures from all sources in 2009-2019 compared to 2000-2008. All expenditures and ARRA 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 C3: 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)

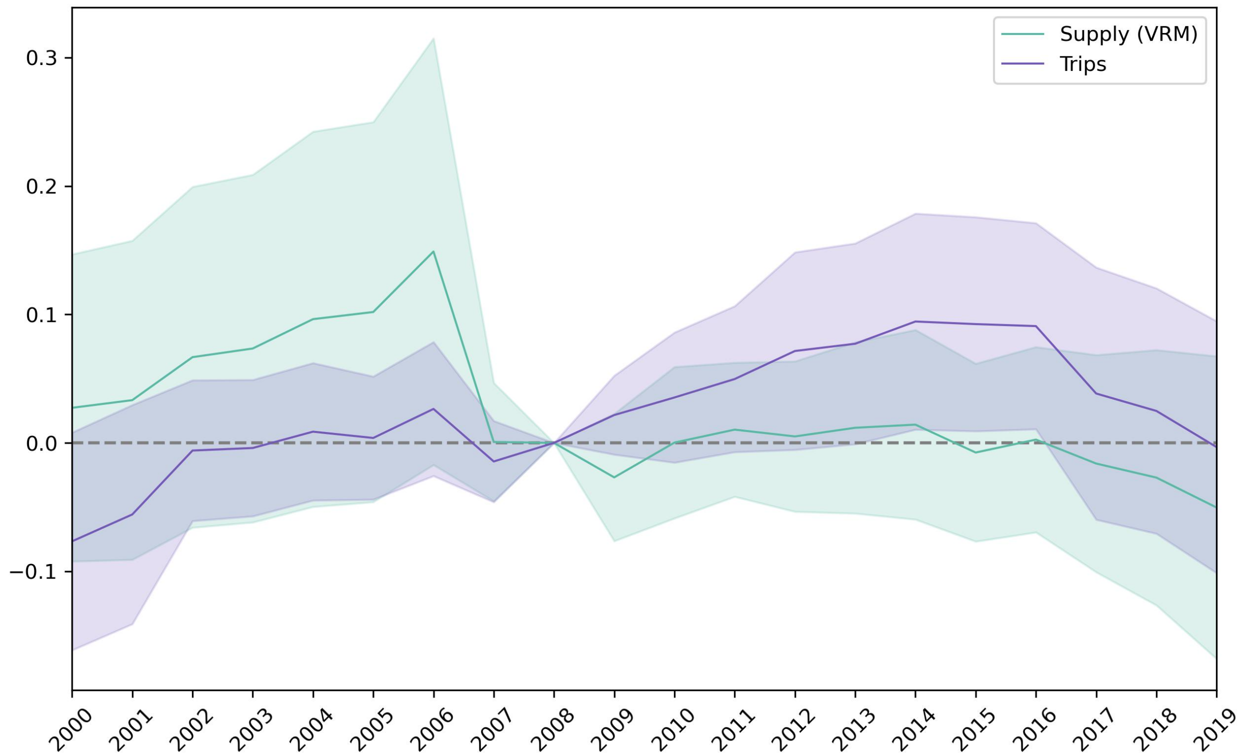
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented with 2009 ARRA funding. In Panel A, dependent variable is the change in capital transit expenditures in 2009-2019 compared to 2000-2008 by the type of spending and transit 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 C6: 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 C7: 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.