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

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Abstract

I examine how targeted federal grants affect spending on public transit in a three-level fiscal system. The analysis uses comprehensive U.S. expenditure data from 2000–2019 and exploits an exogenous shock from the 2009 American Recovery and Reinvestment Act (ARRA). ARRA funds were apportioned to Urbanized Areas through preexisting formula programs, independent of potential changes in transit investment. I find that each $1 of ARRA apportionment led to an additional $1.76 of capital spending from all sources over 2009–2019, or $2.31 when scaled by the first-stage effect on federal capital grants. This reflects two distinct phases: an initial rise in federally funded expenditures with no displacement of state or local spending (the flypaper effect), followed by substantial crowding-in of state funding to the same localities. This additional spending was directed primarily toward maintaining existing bus fleets and did not increase service provision or ridership. Cross-state variation in institutional characteristics points to the negotiation channel as the primary mechanism: ARRA lowered the cost for local officials of securing flexible state funding. In the largest cities, crowding-in may also have been amplified by the attractiveness of continued investment in large ongoing projects.

JEL: H77, R42

1 Introduction

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

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

In my empirical estimation, I exploit the American Recovery and Reinvestment Act (ARRA) of 2009 (Pub. L. 111-5) to estimate the causal effect of federal grants on state, local, and total transit expenditures. The transit portion of ARRA was distributed to Urbanized Areas (UZAs) through two preexisting formula programs, the Urbanized Area Formula (UAF) and the Fixed Guideway Modernization (FGM).[2] The amount distributed to each UZA was

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

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

determined by fixed formula inputs, rather than a competitive process, and did not require local matching. Thus, ARRA was a source of plausibly exogenous variation in federal funding available to UZAs, which I can use for causal identification.

My analysis reveals a substantial and persistent impact of federal grants. Each $1 of ARRA apportionment leads to an additional $0.16 in annual capital expenditures between 2009 and 2019—a cumulative increase of $1.76 over eleven years. Further, using ARRA apportionments as an instrument for the actual change in federal grants, I find that each additional $1 of federal grants generates approximately $0.21 in annual expenditures—a cumulative increase of $2.31 over eleven years, more than twice the original investment. Extrapolating the reduced-form estimate to the aggregate level suggests that $6.6 billion in ARRA formula apportionments generated approximately $1.1 billion in additional annual expenditures, equivalent to roughly a 6 percent increase over the pre-2009 mean.

The effect has a distinct dynamic pattern. In the first six years after ARRA (2009–2014), each $1 of the program apportionment led to a $0.11 increase in annual federal spending on capital 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 $0.18, compensating for the loss of 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.

These effects exhibit substantial heterogeneity by city size: the effect of ARRA funding on total capital spending is positive and precisely estimated for the smallest UZAs and rises again for large metros, but is near zero for the intermediate range. The near-zero effect for mid-sized UZAs reflects that their actual federal grant spending barely moved in response to ARRA apportionments. The crowding-in of state funds also rises steeply with population, with the crowding-in rate exceeding one for the largest metros—pointing to the attractiveness channel amplifying the negotiation effect where the scale of transit investments makes project complementarities most plausible.

The increase in capital spending was directed predominantly toward buses—approximately three-quarters of the total, primarily rolling stock. Despite this increase, bus fleet sizes declined significantly, consistent with the funds being used mainly for the maintenance and repair of existing vehicles rather than new acquisitions. Service provision, measured by Vehicle Revenue Miles, was unchanged, and ridership effects were small and statistically

indistinguishable from zero. The short obligation window imposed by ARRA—most funds had to be committed before October 2009—is consistent with this maintenance-focused pattern: upgrading the existing bus fleet is among the few capital projects that can be approved and implemented quickly. Rail expenditures showed no significant change across any category. Taken together, these findings rule out explanations for the state crowding-in based on unfinished projects, economies of scale, or network externalities from system expansion.

The flypaper phase has a likely transparent explanation: ARRA was an unexpected, one-time shock that landed on top of existing guaranteed budgets rather than displacing them. The delayed crowding-in of state funds during 2015–19 requires a distinct account. Within-state evidence shows that local officials were individually negotiating for flexible state funds rather than competing for a fixed state pool. To distinguish between an *attractiveness channel*—unfinished projects inducing further state investment—and a *negotiation channel*—ARRA experience lowering the cost of obtaining flexible state funds—I consider the effect of state-level institutional characteristics. Crowding-in is concentrated in states where transit funding is more discretionary, sourced from non-dedicated revenues, and subject to local suballocation authority. Combined with the bus-focused spending evidence, which rules out large unfinished projects for the majority of UZAs, these results favor the negotiation channel as the primary driver of the two-phase dynamic. For the largest metros, where ARRA funds were directed toward rail and major facilities, there is evidence of additional amplification from the attractiveness channel.

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

In contrast to crowding-out and the flypaper effect, crowding-in from federal grants has rarely been documented. The only previous empirical evidence comes from Leduc and Wilson (2017), who—similar to this paper—study the effect of ARRA but in the context of federal

highway funding.[3] While Leduc and Wilson (2017) estimate a spending response greater than one, implying crowding-in, they primarily interpret it as evidence of the flypaper effect and do not attempt to explain it further. The standard explanations for the flypaper effect, such as a reluctance to reduce local taxes, can account for the absence of displacement but not for additional spending beyond the grant itself.

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

I also contribute to the understudied question of optimal public transit funding by estimating the effect of a largely unconstrained increase in federal support. While the potential reductions in driving externalities (e.g., Parry and Small, 2009, Anderson, 2014) and other benefits of transit such as access equity (e.g., Glaeser et al., 2008) have been well documented, the literature rarely examines how transit should be financed. An important policy question is which level of government should bear primary responsibility for its funding. I show that federal transfers to localities were highly effective in increasing capital spending by attracting additional state investment, yet the resulting funds were likely directed toward maintaining existing fleets rather than expanding or improving service. This suggests a limited role for federal transfers in their current form in stimulating transit expansion. In a companion paper, I show that the composition of this spending was what mattered for service: quality improvements raised ridership while capacity expansion did not (Braslavskiy, 2026).

To the best of my knowledge, this paper is the first to estimate the causal effect of tran-

[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.

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

sit 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.

The rest of the paper is organized as follows. Section 2 provides background on public transit funding in the U.S., describing the federal formula programs that distributed ARRA funds and the institutional role of Urbanized Areas. Section 3 presents the empirical strategy, detailing how ARRA apportionments serve as an instrument for changes in federal grants and discussing the identifying assumptions. Section 4 describes the data and sample construction. Section 5 reports the main results: the reduced-form estimates of ARRA apportionments on capital spending, the IV interpretation, robustness checks, and heterogeneity by UZA size. Section 6 examines how the additional funds were spent and their effects on transit service. Section 7 investigates the mechanisms behind the crowding-in of state funds, using cross-state variation in institutional settings to distinguish between the project-complementarity and negotiation-cost channels. Section 8 concludes.

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 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, 2019b). However, when New York City is excluded, this

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

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

share falls to 34%.[7] Transit in the U.S. is provided by transit agencies, 92% of which are publicly-owned (Federal Transit Administration, 2019b). 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 required to submit annual reports to the NTD, detailing their financial operations, service provision, and ridership data.

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

[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.

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 (APTA, 2016). 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 several 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 from the federal account to the local transportation agency.

[8]A detailed breakdown of the formula can be found in Appendix Figure A2.

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 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,

[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

empirical studies have focused on sector-specific crowding-out and flypaper effects. Since most intergovernmental grants are targeted at a specific sector, such as healthcare, education, or transportation, it is of greater importance whether they increase spending within this specific sector rather than public spending in general. Similar to the theoretical arguments about block grants, targeted grants should increase targeted spending only insofar as they increase local income. This would result in a crowding-out of spending from other sources by almost the amount of the grant. The absence of such strong crowding-out or, in the extreme cases, a one-to-one translation of targeted grants to spending is also referred to as the flypaper effect.[10]

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

It is not clear based on the evidence from other contexts whether federal transit grants will crowd out, keep unchanged, or crowd in state and local funding. The most similar type of spending are highways, for which Knight (2002) and Leduc and Wilson (2017) find conflicting results. On the other hand, transit draws funds from all three levels of government, more similar to public schools than to state-managed highway construction. Evidence for educational funding varies as well, though with a similar identification strategy to mine, Gordon (2004) finds a complete crowd out from an increase in federal grants. One important distinction compared to my setting is that the increase in Gordon (2004) is permanent, whereas I study a transitory shock. This can affect the planning horizon and the capacity of state and local budgets to adjust their funding.

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.

3 Empirical Strategy

The central empirical question of this paper is how federal grants for transit affect state and local capital spending. The main empirical concern is that funding from different sources is endogenous. Most of transit grants (70-82%) are distributed via formulas, which tend to give more money to larger, denser, more transit-intensive cities. These cities have higher budgets and more sway with their state governors, allowing them to spend more of their own and state money on transit. Other funding, which is distributed via discretionary grants, goes to specific — often large — projects that draw money from various sources. Therefore, a naive comparison between grant and spending amounts across UZAs will likely be biased.

One way to circumvent some of these problems is to utilize a panel structure, which controls for any time-invarying differences between UZAs:

$$\Delta Cap_i = \alpha + \beta \Delta G_i + \gamma X_i + \varepsilon_i, \tag{1}$$

where ΔCap_i is the change in capital spending from state or local sources and ΔG_i is the change in federal formula grants. This way, level differences in size, density, or other characteristics that determine the average funding amount will not confound the relation between grants and spending.

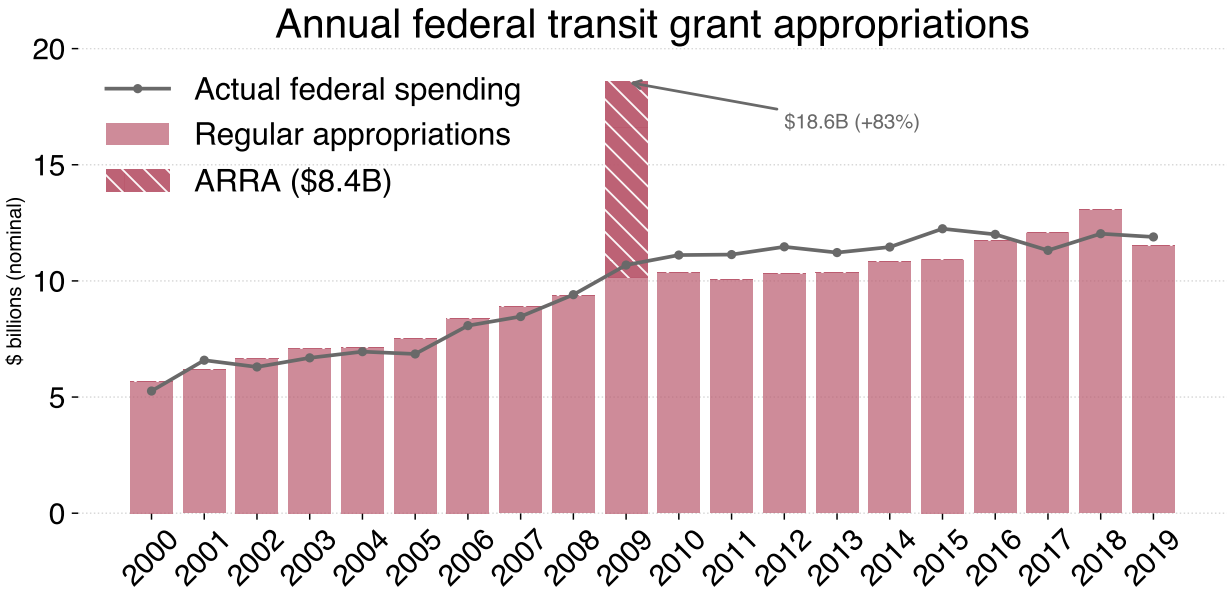
One problem with this approach is that it uses a small part of the overall variation in federal grants (the within-UZA variance of the biggest formula program is about 10% of the total variance). In addition, this residual variation is still subject to the dynamical form of the same endogeneity. A UZA receiving more formula funds from one year to another must have seen an increase in one of the underlying inputs, which can be driven by economic or demographic shifts that independently affect state and local funding. If, however, the change in federal grants is driven by an exogenous shock independent of local conditions, Equation (1) can recover the causal impact of federal grants on capital spending.[11]

[11] Beaudoin and Lawell (2016) and Beaudoin and Lawell (2018) use variation in federal grants for transit as an exogenous instrument for transit supply to identify the effect of transit on congestion and air pollution respectively. They argue that federal funding is unrelated to congestion levels across UZAs. Gordon (2004) uses the decennial Census update as a source of exogenous variation in formula amounts in the context of Title I grants.

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 $8.4 billion was apportioned to public transit (Federal Transit Administration, 2019a). This constituted a massive increase in federal funding for transit, as regular federal transit programs in that year amounted to just above $10 billion (Figure 1). ARRA funds were distributed to UZAs using three existing programs: Urbanized Area Formula (80%), Fixed Guideway Modernization (10%), and Capital Investment Grants (10%).

Figure 1: Annual Federal Transit Grant Appropriations.



Sources: FTA apportionments data; NTD Time Series TS1.1. Amounts are in nominal dollars. In 2009, ARRA added $8.4 billion in transit apportionments on top of the regular $10.2 billion annual appropriation — an 83% increase over baseline. The line shows actual federal transit spending (capital and operating combined) from the NTD.

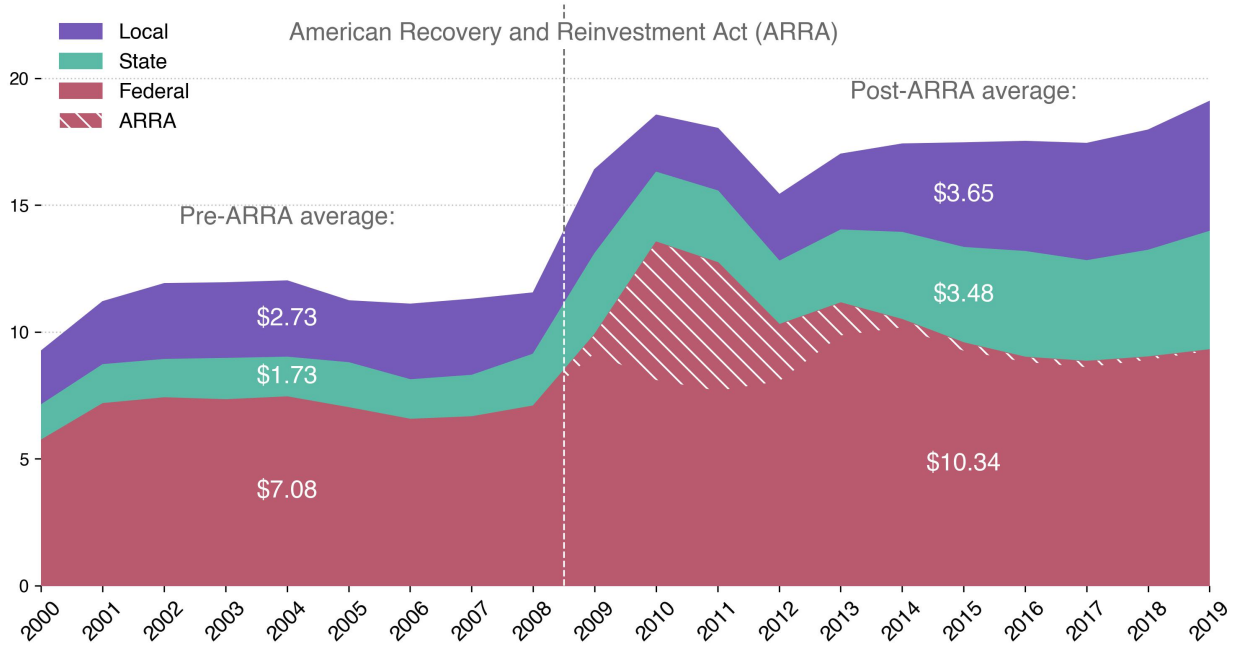
Urbanized Area Formula (UAF) and Fixed Guideway Modernization (FGM) were formula programs with predetermined allocation rules and inputs from the 2000 Census and 2006 transit statistics. Capital Investment Grants (CIG) were distributed to 10 UZAs with shovel-ready projects that had the capacity to absorb 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:

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

where $population_i^{2000}$ and $density_i^{2000}$ are data from the last decennial Census, $transit_i^{2006}$ are several measures of transit supply and, to a much lesser extent, usage from the year two full years before ARRA announcement.[12]

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 allocations, ARRA did not require matching with state and local funds. Therefore, federal money came with few strings attached except for the mandate to be quickly spent on capital improvements. As seen in Figure 2, 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.

Figure 2: 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.

My estimation strategy uses ARRA as a large unexpected shock to estimate the effect of

[12]The formula also includes several state characteristics and the local low-income population, but the impact of these factors is minimal. The full formula is shown in Figure A2.

federal grants on state and local capital spending. The amount of ARRA funding allocated to each UZA ($ARRA_i$) was fixed by a pre-determined formula and lagged inputs, creating a plausibly exogenous variation in federal grants that I exploit. While this amount is correlated with spending *levels* through underlying inputs, it is independent of the *change* in spending:

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

as long as

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

where $\Delta Cap_i = Avg(Cap_i^{2009-2019}) - Avg(Cap_i^{2000-2008})$. In other words, ARRA amount, based on known formula inputs, should not be predictive of the dynamics in capital spending across UZAs. The absence of a differential trend before 2009 will be the main evidence that this assumption is correct.

Given this assumption, Equation (1) can be modified to estimate the causal effect:

$$\Delta Cap_i = \alpha + \beta ARRA_i + \gamma X_i + \varepsilon_i, \tag{2}$$

where $\Delta Cap_i = Avg(Cap_i^{2009-2019}) - Avg(Cap_i^{2000-2008})$. To indirectly test the parallel trends assumption and demonstrate the dynamics of the effect, the Event-Study specification can also be estimated:

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

where 2008 is normalized to zero and β_z estimate the effect of \$1 of ARRA funding on capital spending in year y, compared to the 2008 baseline relation. The coefficients for years 2000-2007 estimate differential pre-treatment trends.

3.2 Instrumental Variable

Under the identification assumption of the independence between ARRA funding and changes in spending, Equation (2) identifies the effect of apportioning an additional dollar of ARRA to a UZA. Yet, a more policy-relevant margin is the effect of an additional dollar of federal funding that reaches the locality. The apportioned money might differ from the one reaching the locality because of two reasons: first, state governors have a legal authority to shuffle

federal transit money between small UZAs ($< 200k$) inside the same state, which was further relaxed to UZAs of any size for ARRA. It is not clear how often they exercise this power. Second reason comes from some degree of interconnectedness between nearby UZAs. While the localized nature of transit makes spillovers much less prevalent than in other forms of infrastructure investment, some transit agencies serve multiple UZAs. Thus, federal money apportioned to a UZA can be spent on capital primarily used in another nearby UZA.

Alternatively, ARRA might have partially crowded-out other federal programs. Discretionary grants applications are costly, while formula programs have matching requirements. Hassle-free ARRA funds with a tight spending deadline were likely to make local officials avoid or postpone using other federal funding. The effect of ARRA funding then underestimates the effect of increasing total available federal grants.

To arrive at the policy-relevant estimate, I use ARRA funding amount as an Instrumental Variable (IV) and the change in federal spending from all programs as an endogenous variable in the Two-Stage Least Squares framework. The first stage shows by how much an additional dollar of ARRA apportionment increases federal spending:

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

where $g_i = \sum_{2009}^{2014} g_i - \sum_{2003}^{2008} g_i$ measures the change in how many federal dollars from all programs actually reach UZA i. The treatment is measured as a cumulative sum rather than an annual average because ARRA disbursement was uneven within the window — some UZAs drew funds early, others later — so only the total injection captures the full treatment dose. The 2009–14 window is chosen because by 2014 more than 95% of all ARRA funding was spent, ensuring the treatment captures virtually the full federal shock without bleeding into the 2015–19 period when state crowding-in was already underway. The 2003–08 window serves as a symmetric six-year pre-ARRA baseline. The second stage then provides the causal coefficient with a relevant interpretation:

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

Equation (2) can be interpreted as the reduced form.

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 lower 48 states, as customary in transportation literature (see Lalive et al. (2013)). I include all UZAs that reached the 50,000 population threshold in either 2000 or 2010 Census, which allows me to have a full panel for 2000-2019. Ending the sample before 2020 allows me to abstract from: a) the devastating effects of the COVID-19 pandemic on public transit and emergency federal funding aimed at keeping it operational; and b) the implications of another Census count for formula funding and UZA border update. For my main specifications, I exclude 10 UZAs that received the Capital Investment Grant as part of ARRA.[13] 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 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

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

Table 1: Data Description.

		All UZAs (48 states)	Excl. NYC	Sample (No CIG)
		Mean (SD)	Mean (SD)	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.

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 (AASHTO, 2015).

5 The Effect of Federal Grants on Capital Spending

The main specification in this section estimates the change in state, local, and total capital spending from a $1 increase in ARRA apportionment. If ARRA crowds out state or local funding sources, the effect on those spending is negative, while the effect on total spending from all sources is less than one. The classical flypaper effect is defined as little or no effect on local and state spending and a direct translation of federal grants into targeted spending at the rate of approximately one-to-one ("money sticks where it hits"). Alternatively, state or local funding can be crowded in, leading to a disproportionately large increase in total capital spending from all sources.

Results of estimating Equation (2) with a varying outcome variable are presented in Table 2. The independent variable is ARRA apportionment throughout the table. Rows indicate different sources of spending used as the dependent variable: federal, state, local, and total (the sum of the three). Columns iterate over post-treatment periods used to calculate the change in capital spending, while the whole pre-treatment period is always utilized. For example, in the second column the outcome is constructed as the UZA-level difference between average spending in 2009-2014 and average spending in 2000-2008. The coefficients can then be interpreted as the additional annual spending from each source and in each specified period resulting from a $1 increase in ARRA apportionment.

The headline result of this estimation is that each $1 of ARRA leads to $0.16 of additional annual capital spending over the whole post-treatment period. Cumulatively, this adds up to $1.76 over 2009-2019, indicating a large impact of targeted intergovernmental transfers exaggerated by crowding-in of other funding. Temporary dynamics reveals individual components of this effect. In the first six years of the post-treatment period (2009-2014), federal grants lead to more spending from federal sources. The effect of $1 of ARRA is an annual $0.11 increase or a cumulative $0.66 increase over the period. For the whole period 2009-

Table 2: Effect of ARRA Apportionments on Annual Capital Spending by Source and Period.

	2009-19	2009-14	2015-19
ΔCap^{fed}	0.08**	0.11**	0.05
	(0.04)	(0.05)	(0.06)
ΔCap^{st}	0.06*	-0.03	0.18***
	(0.04)	(0.04)	(0.05)
ΔCap^{loc}	0.02	0.02	0.01
	(0.04)	(0.03)	(0.06)
ΔCap^{tot}	0.16**	0.10	0.24**
	(0.08)	(0.08)	(0.11)
N	473	473	473

Each cell reports the OLS coefficient from a regression of the change in per capita capital spending from the indicated source on per capita ARRA apportionments, controlling for 2000 Census demographics and Great Recession covariates. The dependent variable is the difference in annual means between the indicated period and 2000–2008. All values are in 2009 dollars. The sample consists of 473 UZAs in the lower 48 states, excluding CIG grant recipients. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

2019, the cumulative effect is $0.88, indicating that ARRA apportionments do translate into higher federal grants in spending but with some reallocation or displacement of other programs. I will use this positive relation as the first stage in the IV specification.

State and local spending don't experience a significant change in the first half of the sample. State funding is slightly crowded out while local — slightly crowded in. Taken together, this is an evidence of a transit-specific flypaper effect: additional federal grants translate into spending without affecting state or local funding. This result is not mechanical. It is plausible to expect localities to channel the federal windfall into existing or planned projects, allowing them to free up state and local money that would have been otherwise spent on them. ARRA funding had little strings attached, and while the maintenance of effort requirement was formally put in place, it was never formalized or enforced. In this case, however, state and local funding (as well as funding from other federal programs) largely stayed unchanged. I explain it by the passive nature of that funding in the short term in which ARRA operated. If the funding is essentially 'free' or guaranteed, there are no incentives for crowding-out.

A more surprising result appears in the second part of the sample, after 2015. Spending from state sources experienced a large increase of $0.18 in annual or $0.9 in cumulative terms. This indicates that locations that received more federal grants also received 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 $0.08 more of federal and $0.06 more of state annual expenditures in 2009-19, which is approximately a 75% voluntary match from the state governments. Extrapolating the per-capita estimates to national dollar magnitudes requires multiplying each coefficient by the total ARRA apportionments received by the relevant set of UZAs. The 473 sample UZAs received approximately $4.0 billion in ARRA funding (UAF: $3.6 billion; FGM: $0.4 billion), which yields $640 million in additional annual capital spending or $7.0 billion cumulatively over 2009–19. The total UAF and FGM apportionments for all lower-48 UZAs, including the ten CIG recipients excluded from the estimation sample, amount to approximately $6.6 billion; applying the same coefficient implies $1.1 billion in additional annual capital per year—roughly a 6 percent increase over the pre-2009 national mean—or $11.6 billion cumulatively over 2009–19. 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.

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. Each coefficient estimates how the UZA-specific difference in expenditures between the current year and the baseline year, 2008 in my case, depends on the cross-sectional variation in ARRA funding. The results of this estimation are presented in Figure 3 and largely paint the same picture as Table 2. Importantly, the coefficients before 2008 are indistinguishable from zero, indicating a flat trend in capital expenditures for several years leading up to the ARRA. While some systematic differences in federal capital expenditures between UZAs with different ARRA apportionment in 2009 exist before 2009, they did not trend upwards. This provides indirect evidence supporting the parallel trends assumption and the causal interpretation of my findings. Any significant change after 2009 is therefore likely to be caused by ARRA funding.

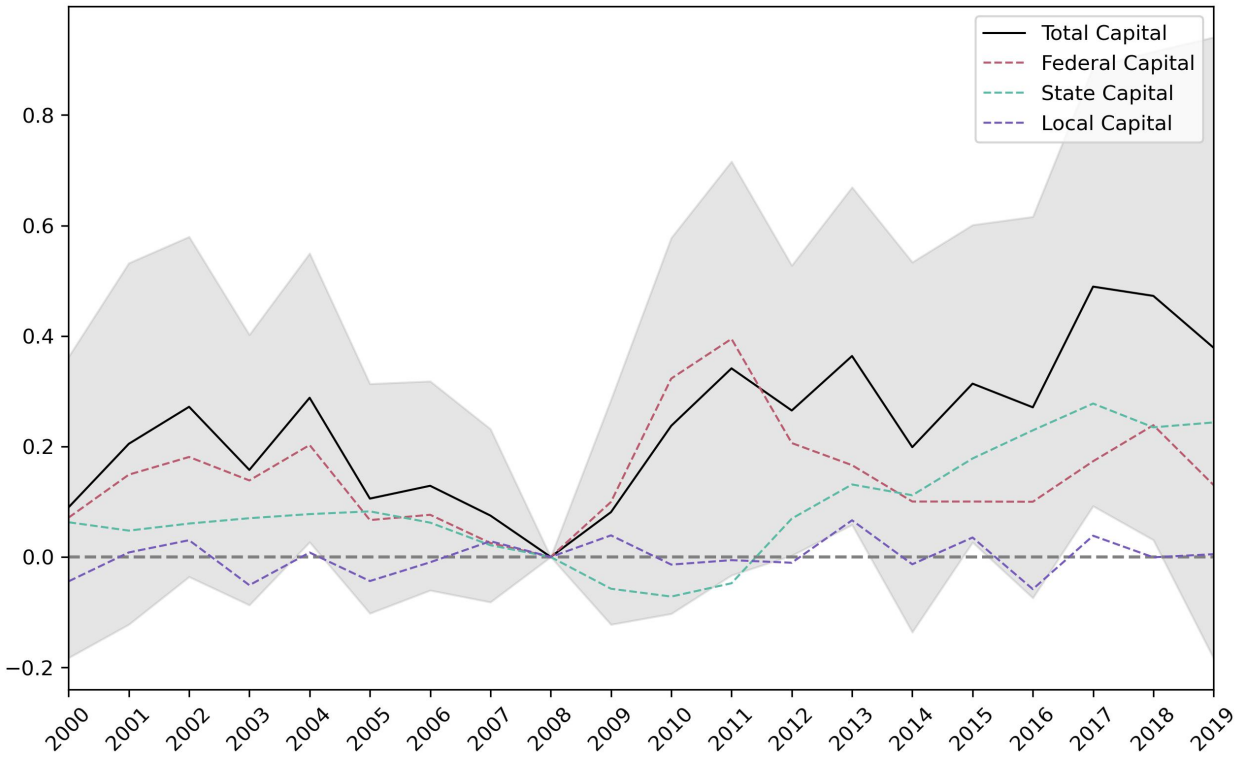
Right after 2009, capital expenditures increase more in UZAs that received more ARRA funding. Expenditures from federal sources follow a clear pattern of a steep increase and a more gradual return to the pre-2009 mean. State spending, after a small initial dip, starts to increase when extra federal spending is waning to keep total expenditures elevated compared to the level before ARRA. They level off after 2016, indicating a sustained effect through the end of the sample. Throughout the whole sample, local capital expenditures stay on parallel trends between UZAs with different ARRA funding amounts.

Although ARRA came as a one-time increase in federal funding in 2009, its effects are evident even ten years later. While the intentional limitation of the sample with 2019 does not allow me to look beyond this period, the dynamic pattern does not indicate that the relative increase in state spending will vanish. It is possible that a one-time infusion of federal money permanently changed the negotiation process between localities and their state counterparts. In this case, cumulative effect of $1.76 per $1 of ARRA apportionment is the lower bound of the permanent increase in state spending in more affected UZAs.

5.1 Instrumental Variable Interpretation

The preceding estimation considers the effect of ARRA funding on spending from different sources. As discussed in Section 3, the Instrumental Variable (IV) approach could be used to answer a more policy-relevant question of the effect of increasing the total value of federal

Figure 3: Event Study: Year-by-Year Effect of ARRA Apportionments on Capital Spending by Source.



Each coefficient represents the OLS effect of per capita ARRA apportionments on the difference in per capita capital spending between year t and the base year 2008, controlling for covariates interacted with year dummies and UZA and year fixed effects. All values in 2009 dollars. Sample: 473 UZAs in the lower 48, excluding CIG recipients. Shaded band is the 95% confidence interval for total capital.

grants on total capital spending. The exogeneity assumption is identical for the already-estimated equation and using ARRA funding as an instrument. The exclusion restriction is plausible since ARRA operated through federal grants. Thus, a Two-Stage Least Squares (2SLS) estimation with ARRA funding as an instrument, the increase in federal spending as an endogenous treatment variable, and the increase in total capital spending as the outcome of interest is well-identified. Through this lens, the estimation in Table 2 is a reduced form.

The endogenous treatment variable measures the cumulative change in federal grants over 2009–14 relative to the symmetric pre-ARRA baseline of 2003–08. Using cumulative rather than annualized spending is appropriate because ARRA disbursement was uneven within the window — some UZAs drew funds quickly, others more slowly — so only the total injection captures the full treatment dose received by each UZA. The 2009–14 window is chosen because more than 95% of ARRA funds were spent by the end of 2014, ensuring that the treatment variable reflects virtually all of the federal shock without bleeding into the 2015–19 period when state crowding-in was already underway. IV estimates using ARRA funding as the instrument and varying treatment definitions are presented in Table 3.

Table 3: IV Interpretation: OLS, First Stage, and 2SLS Estimates of the Effect of Federal Grants on Total Capital Spending.

	Expenditures used as the endogenous treatment:			
	ARRA	Fed.	Cap Fed	Cap Fed (no outliers)
OLS	0.20***	0.10***	0.16***	0.15***
	(0.04)	(0.01)	(0.01)	(0.01)
First Stage	0.65***	0.92**	0.78***	1.15***
	(0.14)	(0.38)	(0.30)	(0.28)
2SLS	0.25*	0.18**	0.21**	0.21***
	(0.14)	(0.08)	(0.09)	(0.07)
F-Stat	20.41	5.92	6.95	16.88
AR 95% CI	[0.02, 0.49]	[0.02, 1.14]	[0.03, 0.53]	[0.10, 0.36]
N	473	473	473	468

The instrument is per capita ARRA apportionments. The dependent variable is ΔCap^{tot} (2009–19 vs. 2000–08). Treatment definitions vary by column: (1) actual ARRA expenditures received; (2) change in total federal spending 2009–14 vs. 2003–08; (3) change in federal capital grants 2009–14 vs. 2003–08; (4) same as (3), excluding five first-stage outlier UZAs ($N = 468$). All values in per capita 2009 dollars. Sample: 473 UZAs in the lower 48, excluding CIG recipients. Anderson–Rubin 95% confidence interval reported. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3 shows OLS, first-stage, and 2SLS estimates for four treatment definitions. The 2SLS estimates range between \$0.18 and \$0.25 per dollar of federal grants, well above the OLS range of \$0.10–\$0.20. This indicates that the OLS result is biased downward: spending from federal sources grows faster where spending from other sources declines. The first stage shows how ARRA apportionment translates into relevant federal grants. Using actual ARRA expenditures as the treatment (Column 1) yields a 2SLS estimate of \$0.25, supported by a fairly strong first stage ($F = 20.41$): UZAs that were apportioned more received more and spent more of it.

Using total federal grants from all programs as treatment gives a lower estimate of $0.18 (Column 2). However, including operational support in the pool of government grants misses policy relevance: the goal of most federal programs for transit is to invest in capital, and including federal operating grants in the treatment conflates two channels that operate through different mechanisms. Thus, in Column 3 I use only federal grants that were used on capital projects, which produces a 2SLS estimate of $0.21. The first-stage F-statistics in Columns 2 and 3 (5.92 and 6.95, respectively) fall below the conventional threshold of 10. For the capital specification (Column 3), a small number of UZAs — Durham, NC, Chicago, IL, and Lancaster-Palmdale, CA among them — received substantial ARRA apportionments but saw federal capital spending fall around 2009, reflecting coincident local shocks unrelated to ARRA. These observations compress the first-stage estimate without affecting the second stage. Column 4 removes the five UZAs with the largest sequential contributions to first-stage imprecision for the capital specification (Appendix Figure B1 plots the sequential path through ten exclusions); the point estimate remains $0.21 while the F-statistic rises to 16.88 and the Anderson–Rubin 95% confidence interval narrows to [0.10, 0.36].

5.2 Robustness

Table 4 confirms that the main findings of this section are robust. Panels A and B show robustness of the effect of ARRA on capital spending (reduced-form result). Panel C then uses the IV framework to verify that the causal interpretation is not an artifact of the particular instrument choice.

Panel A 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, including demographic covariates alone produces a similar estimate, while omitting covariates entirely yields a slightly smaller total effect but a larger state

Table 4: Reduced-Form Effect of ARRA Apportionments on Annual Capital Spending by Source. Robustness.

	ΔCap^{tot}	ΔCap^{fed}	ΔCap^{st}	ΔCap^{loc}	N	F-Stat
Main Spec (RF)	0.16**	0.08**	0.06*	0.02	473	
	(0.08)	(0.04)	(0.04)	(0.04)		
Main Spec (IV)	0.25*	0.13**	0.10	0.02	473	20.41
	(0.14)	(0.06)	(0.07)	(0.09)		
Panel A: Sample						
+ 10 CIG UZAs	0.34***	0.09***	0.09***	0.15***	483	
	(0.08)	(0.03)	(0.03)	(0.05)		
- 48 Never Reported	0.15*	0.08*	0.06	0.01	425	
	(0.08)	(0.05)	(0.04)	(0.04)		
Panel B: Covariates						
No Covs	0.15**	0.06	0.12***	-0.03	473	
	(0.07)	(0.04)	(0.03)	(0.03)		
Dem Covs	0.17**	0.08*	0.08**	0.01	473	
	(0.08)	(0.04)	(0.04)	(0.04)		
All + 2013 ΔUAF	0.25***	0.13***	0.10***	0.02	473	
	(0.08)	(0.04)	(0.04)	(0.04)		
Panel C: Alt. Instruments						
ARRA UAF (IV)	0.23*	0.13**	0.07	0.03	473	19.24
	(0.12)	(0.06)	(0.06)	(0.07)		
Density'00 (IV)	0.29	0.07	0.21**	0.01	473	16.55
	(0.19)	(0.10)	(0.08)	(0.13)		
VRM'06 (IV)	0.35***	0.09	0.15***	0.11*	473	35.62
	(0.12)	(0.06)	(0.05)	(0.06)		

The first two rows show the main specification as a reduced form (RF: OLS of outcome on ARRA apportionments) and as 2SLS (IV: ARRA apportionments as instrument for ARRA expenditures). Panels A and B repeat the RF specification — varying the sample and covariate set, respectively — and do not use IV. Panel C uses the IV specification (ARRA expenditures as treatment) with three alternative instruments: ARRA UAF (urbanized area formula only), population density in 2000, and vehicle revenue miles in 2006. Except for Panel A, the sample consists of 473 UZAs in the lower 48, excluding CIG recipients. All values in 2009 dollars. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

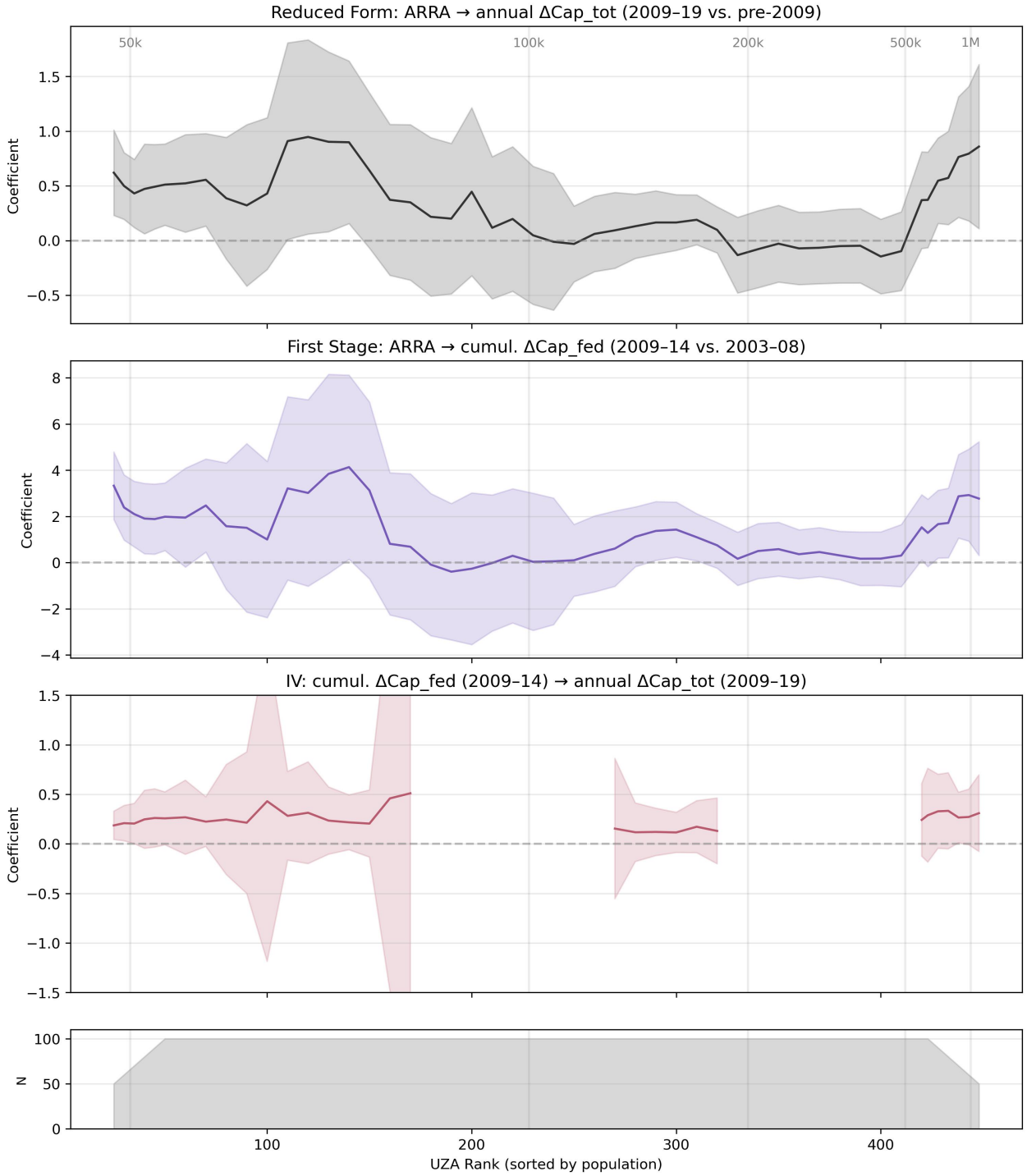
capital coefficient. An important potential confounder, used in Gordon (2004)'s study of Title I funding, is the update in formula inputs. 2013 was the first year when UAF and other formula programs used the new 2010 Census to calculate the distribution amount for each UZA. If this change is correlated 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.

Panel C moves to the IV specification and tests robustness to the instrument choice. Keeping ARRA expenditures as the treatment variable, I replace total ARRA apportionments with three alternative instruments in turn: only the UAF component of ARRA, 2000 population density, and 2006 vehicle revenue miles. The ARRA UAF estimate ($0.23) is slightly below the main specification, while the density and VRM estimates ($0.29 and $0.35, respectively) are somewhat larger. This pattern reflects differences in complier populations: UAF apportionments generate relatively more variation across smaller UZAs, whereas density and VRM identify larger, more transit-intensive cities that respond more strongly to additional federal funding. All three instruments yield strong first stages. 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.

5.3 Heterogeneity

The main results establish a substantial effect of ARRA funding on federal grants and total capital spending, including a state crowding-in. However, these effects can vary significantly with city size, even when considering per-capita levels of spending. Larger UZAs tend to have more developed transit networks and may benefit from the economies of scale, while smaller UZAs have smaller burden of administrative capacity. To assess this, I sort UZAs by 2000 Census population and run the main OLS specifications on rolling windows of 100 UZAs, stepping by 10 UZAs at a time; windows shrink symmetrically at both tails of the distribution to maintain coverage. Each window yields a coefficient plotted at the window's median population rank, producing a continuous picture of how the estimates move across the size distribution. Figure 4 reports the reduced-form effect on total capital, the first stage, and the Wald IV for each window; Figure 5 separates the flypaper phase (ARRA $\rightarrow$ federal spending 2009–14) from the crowding-in phase (ARRA $\rightarrow$ state spending 2015–19) and plots their ratio as the crowding-in rate.

Figure 4: Rolling-Window Estimates: Reduced Form, First Stage, and IV

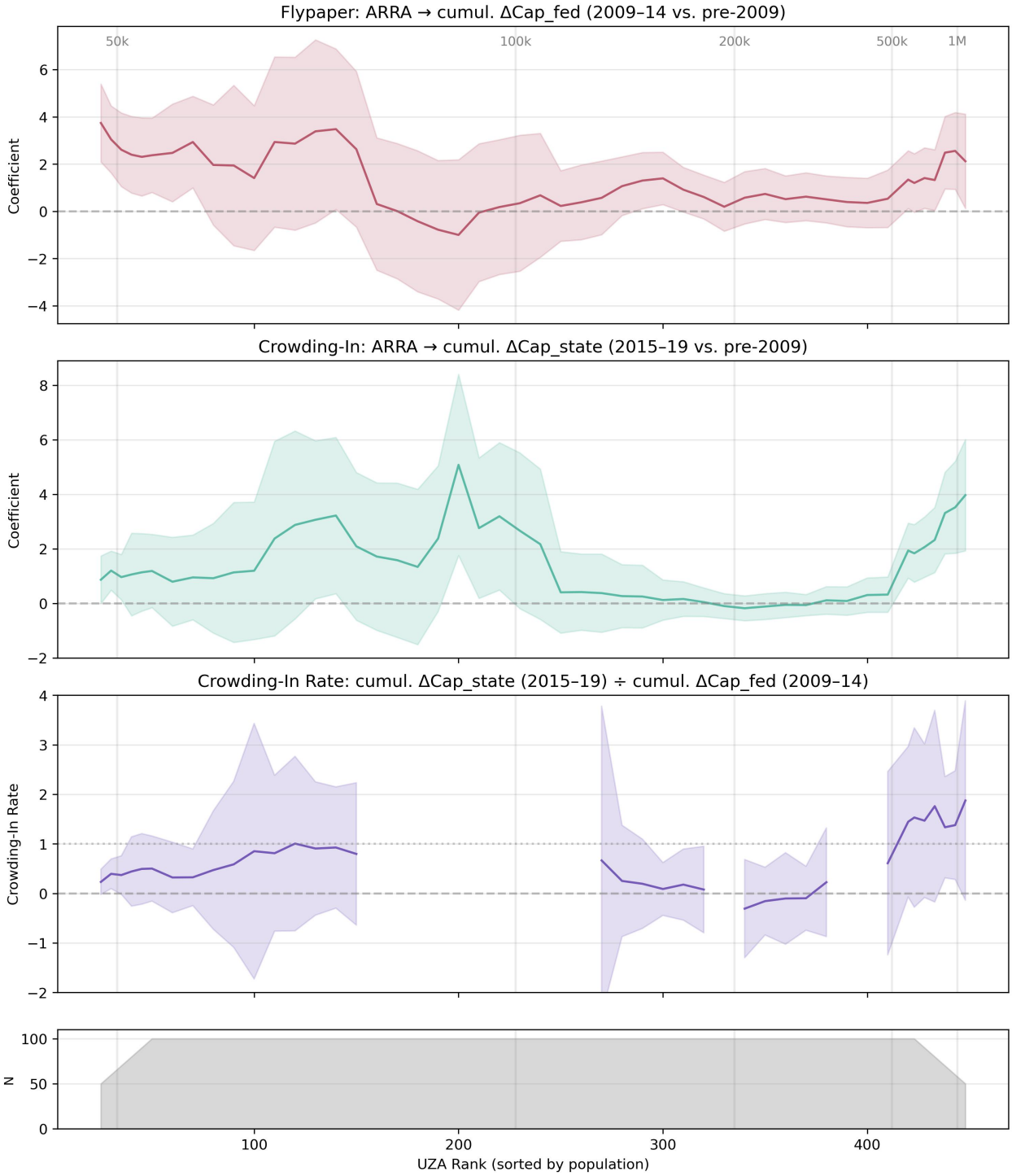


Each panel shows a rolling-window regression (window ≤ 100 UZAs sorted by 2000 Census population, step size 10, shrinking at tails). *Top*: reduced-form effect of ARRA apportionments on mean annual ΔCap^{tot} (avg. 2009–19 vs. pre-2009). *Middle*: first-stage effect on cumulative ΔCap^{fed} (sum 2009–14 vs. 2003–08 baseline). *Bottom*: Wald IV estimate (reduced form ÷ first stage); because the RF is an annual change and the FS is a cumulative sum, the IV coefficient is in units of annual dollars of total capital per dollar of cumulative federally-induced capital. Suppressed where $\hat{\beta}_{FS} < 0.5$. All specifications include 2000 Census demographic and Great Recession covariates. Pale vertical lines mark population thresholds. Shaded bands are 95% confidence intervals.

Figure 4 reveals a non-monotonic pattern. The reduced-form effect of ARRA funding on total capital spending is positive and precisely estimated for the smallest UZAs (below roughly 100,000 population) and rises again for large metros (above 500,000), but is near zero and statistically indistinguishable from zero for the intermediate range of 100,000–300,000. The first stage mirrors this shape. Together, this indicates that mid-size UZAs failed to translate higher ARRA apportionments into more federal grants, and thus more capital spending from all sources. Because the Wald IV divides the reduced form by the first stage, it is suppressed where the first stage falls below 0.5; where it is identified, the IV estimate is stable at approximately \$0.2 of annual total capital per dollar of cumulative federal capital across the full distribution.

The heterogeneity in the aggregate effect therefore reflects differences in first-stage take-up rather than differences in the rate of return on induced federal spending. One interpretation is that small UZAs could quickly redirect apportionments toward bus purchases and routine fleet work—projects that require minimal planning and could meet ARRA's tight obligation deadlines—while large metros had existing project pipelines and dedicated capital staff that made rapid obligation equally feasible. Mid-size UZAs occupy an awkward middle ground that drives the inability to absorb additional funding: too large and complex for a straightforward bus procurement, yet lacking the institutional infrastructure of a major transit authority to advance a major capital project on short notice.

Figure 5: Rolling-Window Estimates: Flypaper Effect and Crowding-In Rate



Each panel shows a rolling-window OLS regression (window ≤ 100 UZAs sorted by 2000 Census population, step size 10, shrinking at tails). *Top*: reduced-form effect of ARRA apportionments on cumulative federal capital ($\overline{\Delta}_{09\text{-}14} \times 6$), measuring the flypaper lock-in of stimulus funds. *Middle*: same specification for cumulative state capital ($\overline{\Delta}_{15\text{-}19} \times 5$), measuring the delayed crowding-in response. *Bottom*: crowding-in rate (cumulative state ÷ cumulative federal); a rate of 1 indicates dollar-for-dollar state matching of federal capital. Suppressed where $\hat{\beta}_{fed} < 0.5$. All specifications include 2000 Census demographic and Great Recession covariates. Shaded bands are 95% confidence intervals.

Figure 5 shows that both phases of the two-phase dynamic are present across the population distribution, but their relative magnitude shifts with city size. The flypaper effect—the lock-in of ARRA apportionments into federal capital during 2009–14—is positive and broadly similar across the distribution. This uniformity is consistent with a mechanism that operates through the stickiness of guaranteed funding: because state and local guaranteed contributions are committed at a fixed level in the short run, local officials have no reason to reduce them when additional federal transfers arrive. The crowding-in of state capital during 2015–19, by contrast, rises steeply with population: the crowding-in rate is roughly 0.5 for the smallest UZAs and exceeds 1 for large metros, implying that state governments more than matched the cumulative federal investment in the largest cities. Two mechanisms contribute to this gradient. First, a successful ARRA grant lowers the cost of future negotiations between local and state officials for all UZAs, generating a crowding-in effect that operates broadly across the size distribution. Second, in large metros where federal funds anchor rail corridors or major facilities, the scale and complementarity of subsequent investments make additional state spending particularly attractive—a channel that amplifies crowding-in at the top of the distribution. The mechanics of both channels are developed further in Section 7.

6 How the Money Was Spent and the Real Effects

My main results show a robust and substantial increase in capital transit investment following the 2009 shock. This suggests that ARRA successfully achieved one of its goals—stabilizing public spending and employment. However, the objectives of federal transit policy extend beyond simply increasing spending. The FTA's mandate states that "It is in the national interest ... to encourage and promote the safe and efficient management, operation, and development of resilient surface transportation systems" (*49 U.S.C. Ch. 53* 2023).

Using the same estimation strategy, this subsection examines whether the influx of additional funding produced meaningful changes in transit systems, both in terms of service provision and utilization. The NTD reports expenditures by both source of funds and type of spending, but not their interaction. Therefore, this database alone does not reveal exactly how the additional federal grants or the crowded-in state funding were used. A companion paper takes up this question for the ARRA funds directly, using a large language model to classify the individual projects each award financed from the text of the grant filings (Braslavskiy, 2026). It finds that 22 percent of the funded projects added service capacity, 30 percent improved the quality of existing service, and 48 percent maintained it, and that this composition shaped

outcomes: areas that directed their ARRA funds toward quality improvement provided more service afterward, whereas capacity expansion did no more for service than maintenance did. Even this project-level composition, however, would not capture the total causal effect of the shock if the composition of other funding sources also changed. Instead, the NTD enables me to answer a more meaningful question: how much more did a UZA that received an additional $1 of exogenous federal grants spend on, for example, buses? I will therefore refer to this estimate as if the additional money itself had been spent on buses.

Panel A of Table 5 separates the total increase in capital investment in two dimensions: by type of expenditure and by transit mode. Cap_{roll} includes spending on rolling stock (buses and trains), while Cap_{fac} covers most other infrastructure—stations, buildings, and fixed guideway (rail) (Federal Transit Administration, 2019b). The bus category combines standard buses, commuter buses, bus rapid transit, and jitneys; the rail category includes light rail, heavy rail, commuter rail, and other specialized forms of rail. Demand Response refers to vehicles that do not follow a fixed route and/or serve specific populations, such as the elderly, people with disabilities, or employees of large local firms. Although this mode contributes little to the total number of passenger trips, it can account for a substantial share of service in terms of active vehicles and Vehicle Revenue Miles (VRM). Table B1 presents the same effects relative to the pre-2009 mean of each outcome variable.

The additional $0.17 per capita from the 2009 shock (the $0.01 difference reflects the use of different data sources within the NTD) was spent predominantly on bus transit—about three-quarters of the total—with a small and statistically insignificant portion allocated to rail. Within bus spending, roughly two-thirds went toward rolling stock and one-third toward facilities, though only the rolling stock component is precisely estimated. Further analysis sheds light on how the bus capital was used.

The first row of Panel B estimates the effect of additional federal grants on the change in the number of vehicles in service. Each year, transit agencies report the number of active vehicles available for service, without indicating what fraction of these vehicles is newly acquired.[14] Despite the increase in bus capital spending (roughly $0.07 per $1 of apportionments), UZAs that received more federal funding experienced a significant decline in bus fleet size—about 0.67 fewer buses per million people. A similar, marginally significant decline of 0.48 vehicles per million appears for demand response modes. These negative effects on fleet size are not driven by outliers and remain robust to sample adjustments.

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

Table 5: Reduced-Form Effect of ARRA Apportionments on Capital Spending by Type and Mode (Panel A) and on Transit Provision and Usage (Panel B).

	Total	Bus	Rail	Demand	Other
Panel A					
ΔCap^{tot}	0.17**	0.13***	0.03	0.01	0.00
	(0.08)	(0.05)	(0.06)	(0.01)	(0.01)
ΔCap^{tot}_{roll}	0.10***	0.07***	0.01	0.01	0.01
	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)
ΔCap^{tot}_{fac}	0.05	0.04	0.02	0.00	-0.01
	(0.05)	(0.04)	(0.04)	(0.01)	(0.00)
ΔCap^{tot}_{other}	0.01	0.01	-0.01	0.00*	0.00
	(0.02)	(0.01)	(0.01)	(0.00)	(0.00)
Panel B					
ΔN vehicles (per 1 mil)	-1.14***	-0.67***	0.01	-0.48*	0.00
	(0.34)	(0.21)	(0.03)	(0.25)	(0.00)
Fleet Age (mos)	0.10	-0.07	-0.10	-0.00	0.03
	(0.25)	(0.17)	(0.18)	(0.36)	(0.10)
Service Miles (VRM)	-0.05	-0.04	0.00	-0.02	-0.00
	(0.07)	(0.04)	(0.00)	(0.05)	(0.00)
Trips	0.05	0.04	0.02*	-0.01	0.00
	(0.04)	(0.03)	(0.01)	(0.01)	(0.00)

Each cell reports the OLS coefficient from a regression of the change in the indicated outcome (2009–19 vs. 2000–08) on per capita ARRA apportionments, controlling for covariates. Panel A: capital spending by type (rolling stock, facilities, other) and transit mode (bus, rail, demand response, other). Panel B: transit system characteristics. All expenditures in per capita 2009 dollars. VRM and UPT are per capita; fleet is per million. Sample: 473 UZAs in the lower 48, excluding CIG recipients. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

While seemingly contradictory, this pattern can be explained by the fact that buses undergoing major repairs are not counted as active vehicles. Thus, if UZAs that received more exogenous federal grants allocated additional resources to repairing existing buses, this could account for the negative effect on fleet size. Additional evidence also suggests that replacing older buses was not the primary use of the new funds. As shown in the second row of Panel B, the average age of the bus fleet decreased—indicating some replacement—but the decline is small and statistically insignificant (0.14%; see Table B1). Taken together, these findings are consistent with the additional funds being used primarily for the maintenance and repair of existing buses rather than the purchase of new ones.

Across all categories of capital use and service provision, there are no significant changes for rail modes, except for a statistically insignificant but sizable increase in the number of vehicles (11%; see Table B1) and an insignificant decrease in the average fleet age. When the estimation is restricted to the 51 UZAs that reported rail service at any point between 2000 and 2019, both the rate of change in the number of vehicles and the fleet age become more negative—although both estimates remain highly insignificant due to the small sample size. Overall, it is unlikely that ARRA spurred a substantial number of new rail projects that could explain state spending crowding-in through economies of scale or a concave cost structure.

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

Finally, I examine the implications for transit provision and usage. The supply of transit service is commonly measured in Vehicle Revenue Miles (VRM)—the total number of miles driven by all vehicles while in service. Table 5 shows that transit service was insignificantly lower in UZAs that increased their federal spending more as a result of ARRA. Although this pattern is consistent with a smaller number of active vehicles, the detailed dynamics of these effects suggest distinct mechanisms. While the number of additional vehicles declines around 2012 (Figure B2), the fall in VRM reflects a disruption of the pre-2009 upward trend (Figure B3). More importantly, I find no evidence of an increase in service provision resulting

from the additional funds. Although this could reflect the relatively short time horizon, the nature of the spending documented in Panel A makes a subsequent rise in VRM unlikely.

The actual usage of the system can be measured by the total number of passenger trips, where a trip is defined as a passenger boarding a vehicle (Federal Transit Administration, 2019b). The last row of Panel B shows a positive but statistically insignificant total effect on trips per capita. The only mode-level exception is rail, where ridership rose by 2.41% relative to the pre-2009 mean—a marginally significant effect (Table B1). Bus ridership shows no significant change despite the capital increase. Even taken at face value, the total effect is modest: 0.57% of the pre-2009 mean, against a 1.53% increase in capital spending.[15] The event-study plot in Figure B3 further suggests the effect is transitory: trips in differentially affected UZAs follow parallel trends before 2009, rise modestly after ARRA funding reaches localities, and begin returning to pre-2009 levels by 2019.

In this subsection, I showed that the increase in transit funding was used primarily for bus rolling stock, with smaller and imprecisely estimated effects on facilities. Although data limitations prevent observing the exact nature of spending, fleet size and service provision did not increase, and usage effects were small and statistically indistinguishable from zero at conventional levels. This pattern is consistent with more affected UZAs directing additional funds toward the maintenance and repair of existing buses rather than their replacement. Importantly, for understanding the mechanisms behind state crowding-in, these findings rule out explanations based on unfinished projects, economies of scale, or a virtuous cycle of transit.

7 Mechanisms of Crowding-In

The flypaper effect—the full pass-through of ARRA apportionments into federal capital with no displacement of state or local spending—has long been considered an anomaly in the intergovernmental transfers literature. In this setting, however, the mechanism is unusually transparent. ARRA was an unexpected, one-time shock whose scale was unknown before enactment. This gave state and local governments essentially no time to adjust their existing, planned spending commitments. As the conceptual model in Appendix C formalizes, the bulk of state and local transit budgets consists of guaranteed (passive) components—dedicated local taxes, formula-driven state allocations, and intergovernmental commitments established

[15] For bus modes only, the disproportion is similar: a 0.50% change in trips against a 1.82% increase in capital expenditures. See Table B1.

well in advance. Because ARRA arrived too quickly for these slow-moving funding streams to be renegotiated downward, the shock landed on top of existing commitments rather than displacing them. The marginal cost of maintaining the guaranteed baseline was zero; local officials had no incentive to reduce it even as the marginal value of additional capital declined. What is harder to explain is the delayed crowding-in of state capital during 2015–19, after federal funding had returned to its pre-shock level. The remainder of this section examines how it arose.

A natural question is whether the increase in state capital reflects a response by state governments to aggregate transit needs—federal funding made transit more salient at the state level, and states raised allocations uniformly—or whether it reflects local officials within each state successfully leveraging their ARRA-era record to claim additional flexible state funds. Table 6 distinguishes between these alternatives. Restricting the sample to the 402 single-state UZAs and absorbing state fixed effects (Column 2), the crowding-in estimate remains large and statistically significant at approximately \$0.16–0.18 per dollar of exogenous federal grants. The coefficient on the mean ARRA apportionment of other UZAs in the same state (Columns 3–4) is weakly positive rather than negative, ruling out the hypothesis that state funds were reallocated away from neighboring UZAs. Within the same state, a UZA that received more ARRA funding subsequently secured more state capital than its neighbors—not at their expense. This pattern is consistent with individual UZAs negotiating separately for flexible state funds rather than competing for a fixed state pool.

The appendix model identifies two distinct channels through which higher capital spending during 2009–14 could generate additional state investment in 2015–19. The first is an *attractiveness channel*: if federal funds initiated large projects that were not yet complete, the remaining scope may carry exceptionally high marginal utility—finishing a rail corridor or a major intermodal facility unlocks the full service value of the prior investment, making further state spending highly attractive to the local official. The second is a *negotiation channel*: a locality with a higher past capital budget signals administrative capacity and project-management credibility to its state DOT, reducing the cost of obtaining flexible state funds through stronger grant applications, demonstrated compliance, or the simple reluctance of state officials to cut a budget they have previously supported (see Appendix C for the formal treatment). The two channels carry different empirical predictions. The attractiveness channel requires specific unfinished large-scale projects—most naturally rail or major guideway infrastructure. The negotiation channel depends on the overall level of prior spending, regardless of how it was used. The findings of Section 6 favor the negotiation channel for the majority of UZAs: additional federal funds were spent primarily on bus

Table 6: Reduced-Form Effect of ARRA Apportionments on State Capital Spending (2015–19): Within-State Variation.

	(1)	(2)	(3)	(4)
$ARRA_i$	0.16***	0.18***	0.17**	0.16***
	(0.06)	(0.06)	(0.07)	(0.06)
$ARRA_{state}$			-0.02	
			(0.11)	
$ARRA_{excl}$				0.004***
				(0.002)
Fixed Effects	X	State	X	X

Each column is an OLS regression with ΔCap^{st} (2015–19 vs. pre-2009) as the outcome. $ARRA_i$ is per capita ARRA apportionments. $ARRA_{state}$ is the state mean of $ARRA_i$; $ARRA_{excl}$ is the sum of $ARRA_i$ for all same-state UZAs excluding the current one. Column 2 adds state fixed effects. All values in per capita 2009 dollars. Sample: 402 single-state UZAs in the lower 48, excluding CIG recipients. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

rolling stock and repairs, did not expand the fleet, and did not increase service provision or ridership. Bus refurbishment is not the kind of spending that creates unfinished projects or scale economies that would make further state investment unusually valuable.

Figure 6 provides direct support for the negotiation channel by exploiting variation in the flexibility and institutional accessibility of state transit funding. Using data from the 2013 AASHTO State Transit Funding Survey (AASHTO, 2015) and from Tomer and Swedberg (2024), I split the sample at the median of five state-level characteristics and estimate the crowding-in coefficient separately for each half. Three AASHTO characteristics measure the share of state transit funding that is discretionary, capital-restricted, or sourced from non-dedicated funds (general revenue or bonds rather than gas taxes). Two Brookings characteristics capture local independence—the share of DOT funds suballocated to local governments—and the quality of allocation decisions.[16] Crowding-in is concentrated in states where discretionary and non-dedicated funding are above the median: in states with rigid, formula-driven transit budgets, the crowding-in estimate is near zero. The local independence result mirrors this pattern. Where there are flexible funds to negotiate for, local

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

officials with elevated ARRA-era budgets can obtain them; where no such funds exist, there is nothing to negotiate.

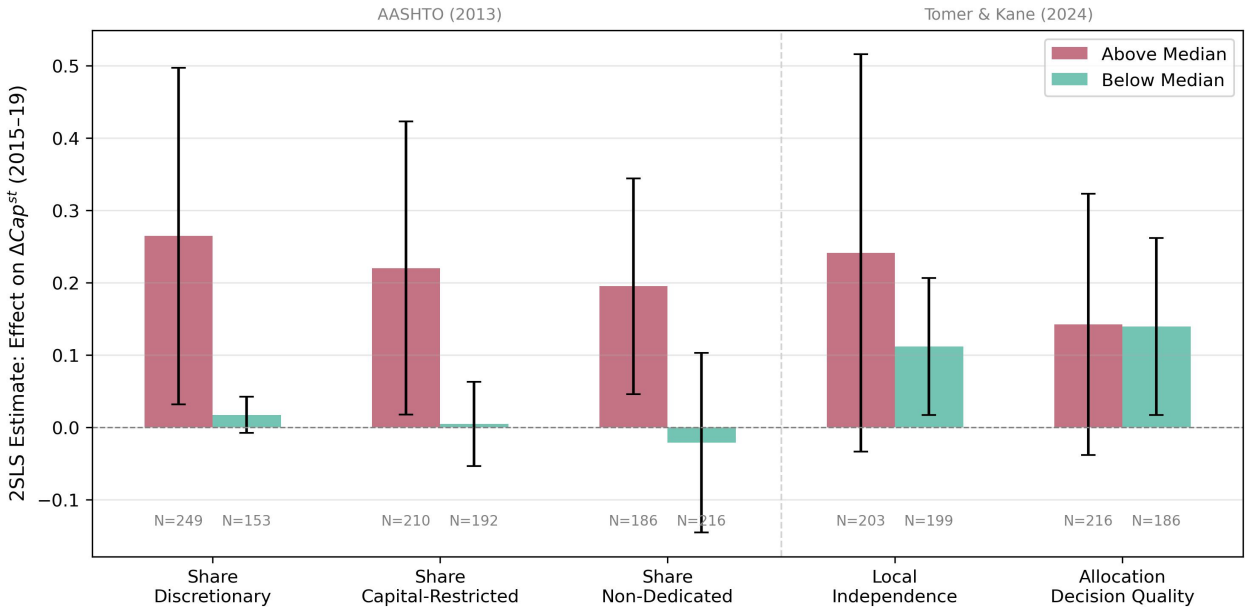


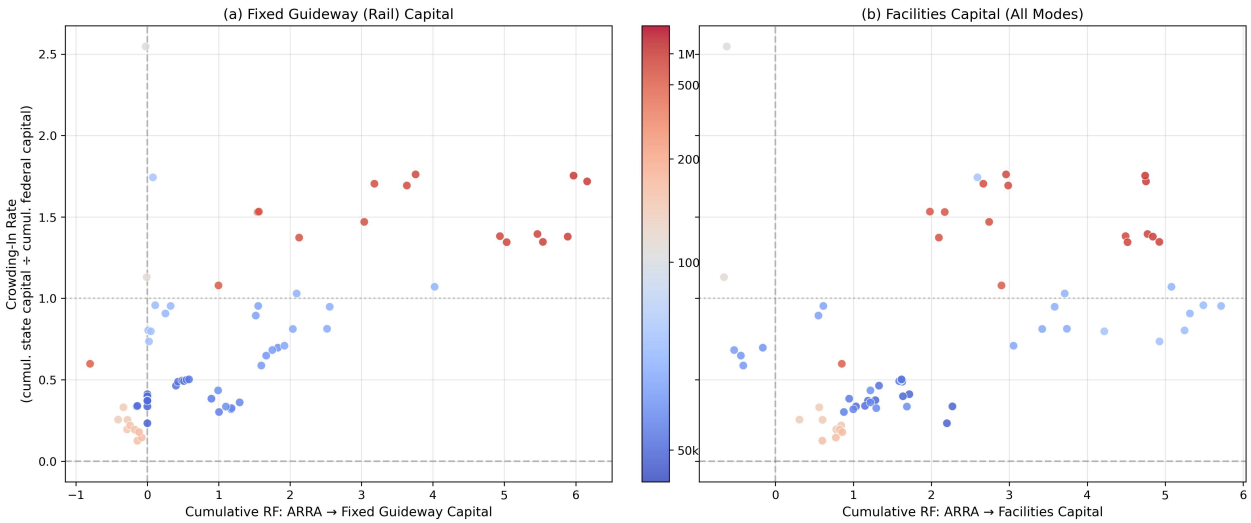
Figure 6: 2SLS Estimates of the Effect of Federal Grants on State Capital Spending (2015–19), by State Characteristics Above and Below Median.

Notes: Each pair of bars shows 2SLS estimates of the effect of a $1 increase in federal capital grants on state capital spending in 2015–19 for single-state UZAs in states above (dark) and below (light) the median for each characteristic. The first three characteristics are from the 2013 AASHTO State Transit Funding Survey: share of discretionary state transit funding, share restricted to capital expenditures, and share from non-dedicated sources (general revenue or bonds). The last two are from Tomer and Swedberg (2024): local independence (share of DOT funds suballocated to local governments) and allocation decision quality. Error bars show 95% confidence intervals. Sample: 402 single-state UZAs in the lower 48 excluding CIG recipients. All values in per capita 2009 dollars.

Figure 7 brings together both channels by plotting the crowding-in rate against the reduced-form effect on fixed-guideway (rail) and facilities capital across rolling windows of UZAs sorted by population. For windows covering small and mid-size UZAs, the crowding-in rate is positive and broadly stable regardless of capital composition, consistent with a negotiation channel that operates through budget credibility rather than through specific project types. For windows covering the largest metros, however, the crowding-in rate rises steeply with rail and facilities spending. These are the UZAs with the institutional capacity to plan and execute major infrastructure—precisely the setting where the attractiveness channel is most plausible. A large metro that used ARRA funds to anchor a new light-rail segment or expand a major station complex may have faced both unfinished projects and scale-complementary investment opportunities in 2015–19, amplifying the crowding-in through both channels simultaneously. The two mechanisms are therefore not mutually exclusive: the evidence suggests the negotiation channel operates broadly across the size distribution,

while the attractiveness channel provides additional amplification at the top.

Figure 7: Crowding-In Rate and Capital Composition by Population Window



Each point represents a rolling window of up to 100 UZAs sorted by population. The y-axis is the crowding-in rate (cumulative state capital ÷ cumulative federal capital). The x-axis is the cumulative reduced-form effect of ARRA apportionments on (a) fixed guideway (rail) capital or (b) facilities capital, 2009–19. Color indicates median population of the window. Windows where $\hat{\beta}_{fed} < 0.75$ are excluded. All regressions include covariates.

8 Conclusion

This paper provides evidence of a substantial impact of additional federal funding on public transit. A positive shock from ARRA not only directly increased spending but also attracted additional investment from state governments. This effect is likely driven by a unique interaction among all three levels of government: additional federal grants enabled local officials to secure more state funding over time.

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

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

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

ARRA was a fiscal stimulus package designed primarily to boost public spending quickly and stabilize the economy. I present evidence that the relatively small portion of ARRA dedicated to public transit was effective in promoting this goal. However, viewed as a targeted transfer for transit investment, its efficiency was limited. Although transit spending increased in response to ARRA, funds were directed toward projects that were easy to implement rapidly—such as bus purchases and maintenance—without expanding service. A companion paper that classifies these projects individually locates the shortfall in allocation rather than amount: the share of spending that improved service quality did raise ridership, while the share that added capacity did not, so a portfolio tilted toward quality would have yielded more service from the same funds (Braslavskiy, 2026). This type of spending is unlikely to have lasting effects or fundamentally transform public transit in the United States. If the federal government seeks to pursue that objective, future funding allocations should differ from an unexpected influx of resources with a short deadline.

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A Additional Information

Figure A1: Urbanized Areas (UZAs) in the New York City Region. Each colored cluster is a distinct UZA as defined by the 2000 U.S. Census Bureau. The large central cluster is the New York–Newark, NY–NJ–CT UZA; smaller UZAs in New Jersey, Long Island, Connecticut, and Pennsylvania are visible around it. The unit of observation in this paper is the UZA. Source: U.S. Census Bureau.

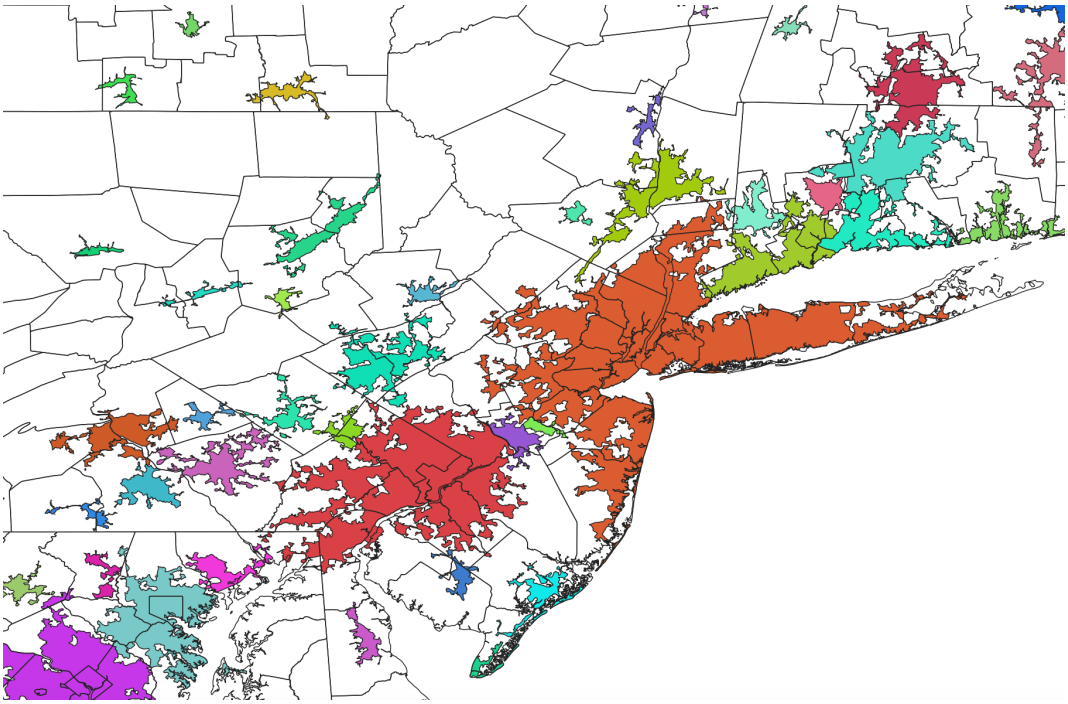
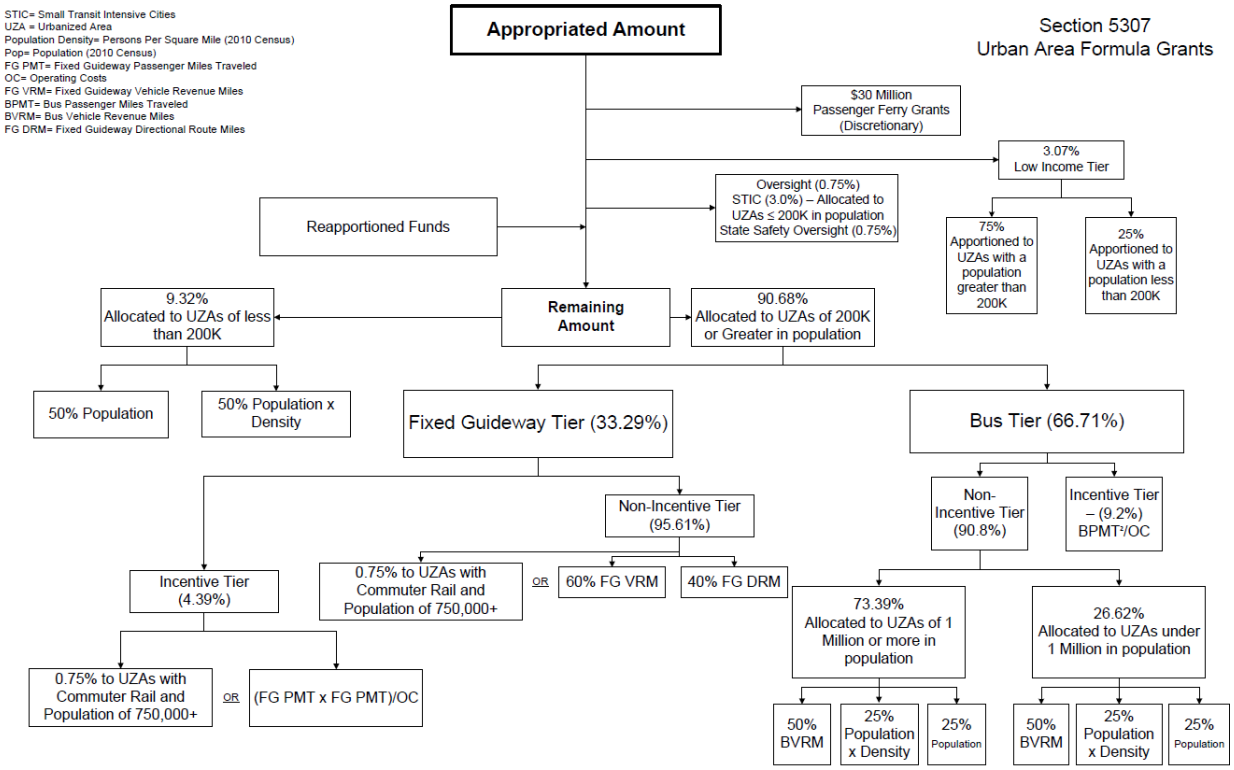
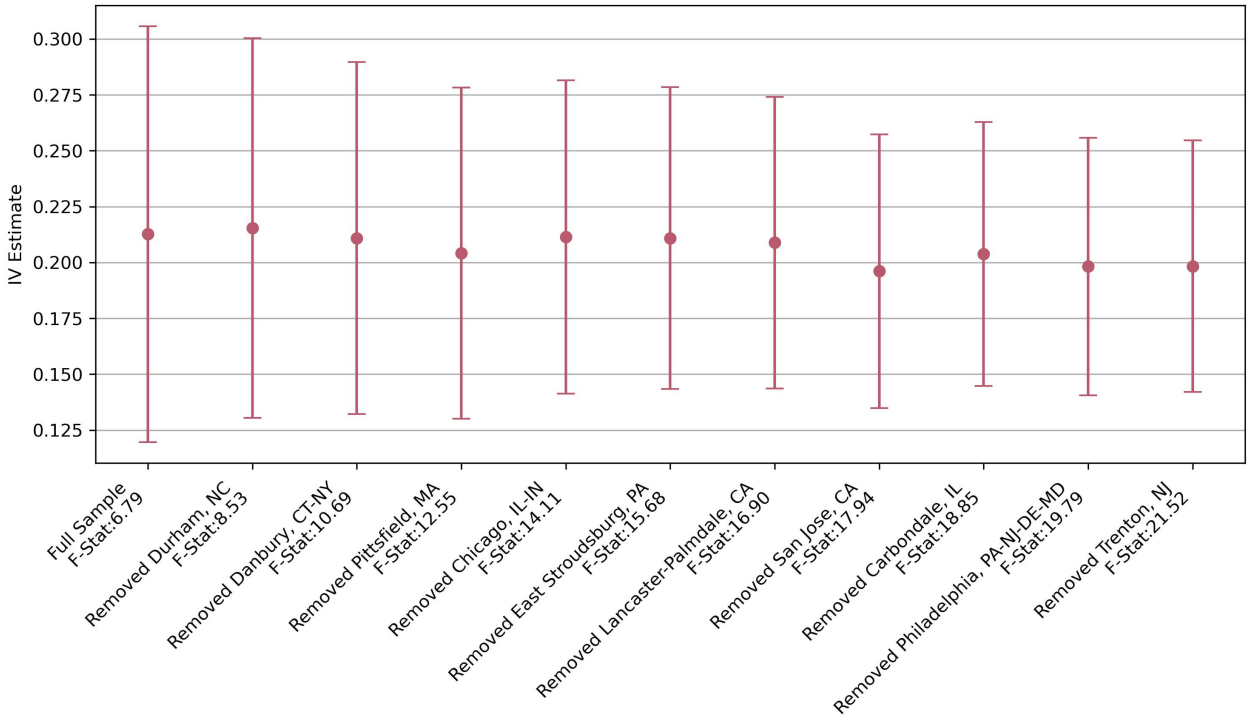


Figure A2: Formula 5307 Allocation Scheme. Source: https://www.transit.dot.gov/



B Additional Results

Figure B1: 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.



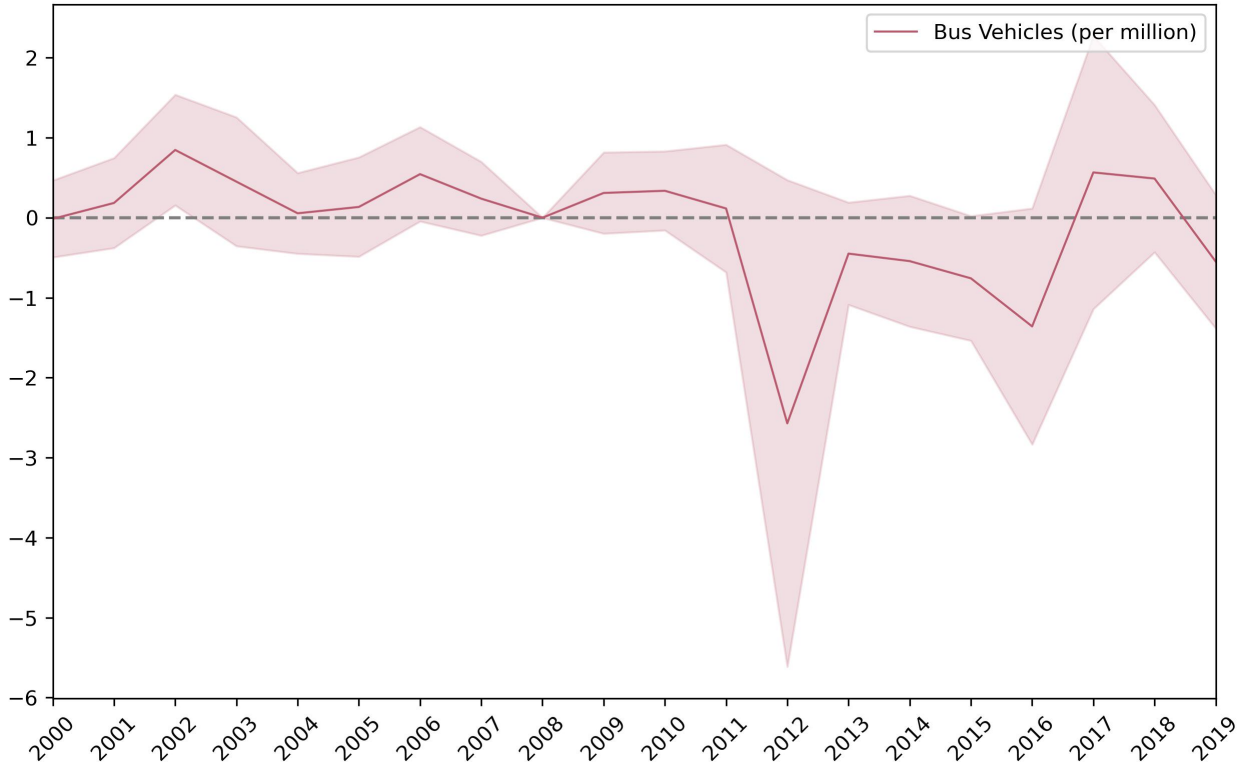
The treatment variable is the increase in federal grants for capital expenditures in 2009-2014 compared to 2003-2008, instrumented by 2009 ARRA funding. The dependent variable is the difference in capital transit expenditures from all sources in 2009-2019 compared to 2000-2008. All expenditures and ARRA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

Table B1: Reduced-Form Effect of 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}	1.53%**	1.82%***	1.01%	0.86%	0.75%
	(0.69)	(0.69)	(2.10)	(1.17)	(8.23)
ΔCap^{tot}_{roll}	1.91%***	1.81%***	2.75%	1.21%	7.89%
	(0.64)	(0.65)	(3.50)	(1.24)	(11.40)
ΔCap^{tot}_{fac}	1.19%	1.50%	1.15%	0.75%	-8.70%
	(1.17)	(1.48)	(2.21)	(2.16)	(7.89)
ΔCap^{tot}_{other}	0.75%	1.34%	-2.39%	3.70%*	4.48%
	(1.40)	(0.96)	(4.72)	(1.98)	(7.42)
Panel B					
ΔN vehicles (per 1 mil)	-8.94%***	-11.88%***	11.46%	-6.83%*	-1.84%
	(2.63)	(3.70)	(31.25)	(3.54)	(-11.69)
Fleet Age (mos)	0.21%	-0.14%	-0.75%	-0.01%	0.60%
	(0.53)	(0.30)	(1.37)	(1.21)	(1.91)
Service Miles (VRM)	-0.70%	-0.72%	2.19%	-0.89%	-2.09%
	(0.85)	(0.76)	(1.73)	(1.97)	(18.52)
Trips	0.57%	0.50%	2.41%*	-1.28%	3.74%
	(0.39)	(0.41)	(1.25)	(1.85)	(5.47)

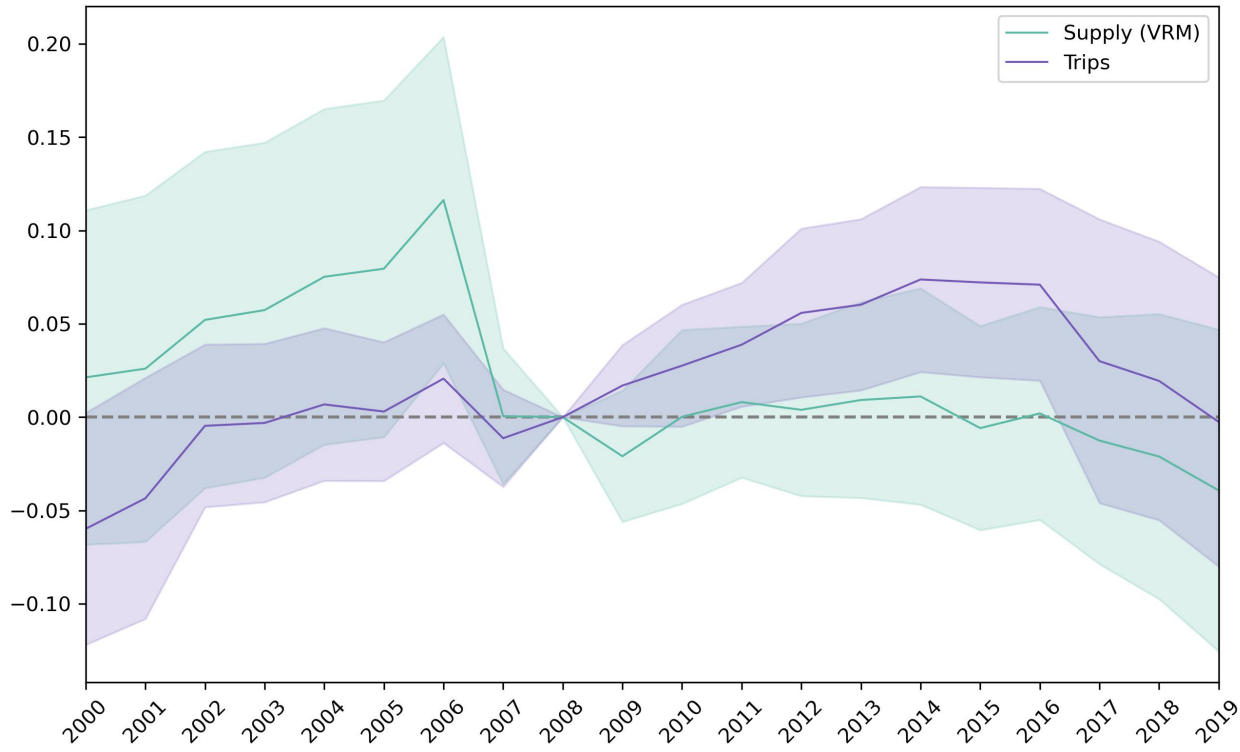
Each cell reports the OLS coefficient from a regression of the change in the indicated outcome (2009–19 vs. 2000–08) on per capita ARRA apportionments, divided by the overall pre-2009 mean of the dependent variable and multiplied by 100%. Panel A: capital spending by type and transit mode. Panel B: transit system characteristics. All expenditures in per capita 2009 dollars; VRM and UPT per capita; fleet per million. Sample: 473 UZAs in the lower 48, excluding CIG recipients. Standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure B2: Reduced-Form Event Study: Year-by-Year Effect of ARRA Apportionments on the Change in Active Bus Vehicles.



Each coefficient represents the OLS effect of per capita ARRA apportionments on the change in active bus vehicles per million between year t and the base year 2008, controlling for covariates. ARRA apportionments are in real 2009 dollars per capita. Sample: 473 UZAs in the lower 48, excluding CIG recipients. Shaded band is the 95% confidence interval.

Figure B3: Reduced-Form Event Study: Year-by-Year Effect of ARRA Apportionments on Transit Supply (Vehicle Revenue Miles) and Usage (Trips).



Each coefficient represents the OLS effect of per capita ARRA apportionments on the change in Vehicle Revenue Miles and Trips per capita between year t and the base year 2008, controlling for covariates. ARRA apportionments are in real 2009 dollars per capita. Sample: 473 UZAs in the lower 48, excluding CIG recipients. Shaded band is the 95% confidence interval.

C Conceptual Model of Transit Investment

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

C.1 Model Setup

I consider a local official making decisions about transit investment within an Urbanized Area (UZA). I do not take a strong stance on the nature of this official. In practice, such decisions are made collectively by the Metropolitan Planning Organization (MPO) that oversees each UZA. Each MPO comprises local officials and representatives from the transportation agencies operating in the area.[17] The model below treats the outcome of the negotiation process among these representatives as the decision of the local official.

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

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

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

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

the required 20% match for regular federal programs would be reflected in the condition $Cap_t^{fed} \leq 4 * (Cap_t^{st} + Cap_t^{loc})$.

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

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

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

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

Therefore, local official's problem is

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

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

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

Operational expenditures are omitted from this model. If they are perfectly determined

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

C.2 Dynamic Response to a Shock

In **period 0**, funding is in the steady state, defined as all funding being passive: $Cap_t^{k*} = P^k \ \ \forall k \in \{fed, st, loc\}$. While this assumption may appear restrictive, it can be justified as follows. In the absence of effort by local officials, flexible funding is distributed randomly across UZAs and does not influence local decision-making. If a UZA persistently secures more flexible funding than others, this may become part of its passive funding through formal earmarking or entrenched intergovernmental relationships.[18] Based on this,

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

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

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

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

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

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

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

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

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

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