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

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Abstract

The efficacy of targeted intergovernmental transfers depends on whether they displace or attract other funds. This paper examines the impact of federal grants for public transit on state and local government spending decisions in the United States. Leveraging the 2009 American Recovery and Reinvestment Act (ARRA) as a natural experiment, I employ a Difference-in-Differences approach with continuous treatment. I find that each \$1 of ARRA transit funding generated \$3.9 of additional capital expenditures over the subsequent eleven years. This increase operates through two key channels: an initial increase in federally-funded expenditures with no displacement of existing state and local funds (a phenomenon known as the flypaper effect), followed by a significant crowding-in of additional state and local investment beyond that. Crowding-in is more pronounced in larger Urbanized Areas and those with existing rail systems, suggesting potential roles for political influence, large upfront costs, and cost overruns in driving this effect.

JEL: H77, R42

1 Introduction

Intergovernmental transfers are an essential element of the U.S. federalist system. Federal transfers fund approximately 26% of all public goods and services provided by state and local governments.[1] These transfers primarily aim to influence spending allocation and each is designated for a specific purpose, such as education, healthcare, or transportation. The efficacy of such targeted transfers depends on whether they displace existing state and local funding (crowding-out) or attract more of it (crowding-in). Under basic assumptions of rational fiscal behavior, federal transfers should replace at least some of the state and local funds that would have been otherwise spent on the targeted category (Bradford and Oates, 1971a; Bradford and Oates, 1971b). Analyzing an unexpected one-time increase in federal transfers for public transit, I document contrasting empirical evidence of crowding-in.

Locally-administered public transit systems in the U.S. heavily rely on intergovernmental transfers, receiving funding from both federal, state, and local sources. In particular, capital expenditures (facilities, rail infrastructure, and rolling stock) in 2019 were funded with 45% of federal funds, 23% of state funds, and 32% of local funds.[2] The significant role of federal funding raises the question of how these transfers affect spending decisions by state and local governments. The recent 67% increase in federal funding for public transit in 2021, coupled with ongoing debates about federal spending, makes this question particularly relevant.[3]

I exploit the American Recovery and Reinvestment Act (ARRA) of 2009 (Pub. L. 111-5) as a source of an unexpected increase in federal funding for public transit. ARRA funds dedicated to transit were largely distributed through the pre-existing Urbanized Area Formula (UAF) program. This program allocates funds to Urbanized Areas (UZAs), defined as densely populated areas with a population of at least 50,000. The formula used for allocation relies on relatively stable local inputs, such as population, population density, and measures of existing transit service. The monies were meant to be obligated quickly and did not require local matching. These characteristics of ARRA funding allows for a causal analysis using a Difference-in-Differences (DiD) approach with ARRA funding as a continuous treatment variable.

[1]Data from the National Income and Product Accounts series published by the Bureau of Economic Analysis. Tables 3.(1-3).

[2]The sample includes the 48 contiguous U.S. states and the District of Columbia. Data for New York City are excluded due to the extreme relative size of its transit system.

[3]On average, the Infrastructure Investment and Jobs Act of 2021 authorizes $21.5 billion of guaranteed yearly funding for transit over FY 2022-26. The previous authorization bill – the Fixing America's Surface Transportation Act of 2015 – authorized, on average, $12.85 billion in yearly funding over FY 2016-21. Source: Mallett (2023).

My analysis reveals a substantial and persistent impact of the increase in federal transit grants. I find that each $1 of transit funding from ARRA generated $3.9 of additional capital expenditures over the subsequent eleven years. This effect operates through two key channels: an initial increase in federally-funded expenditures with no displacement of existing state and local funds (a phenomenon known as the flypaper effect), followed by a significant crowding-in of additional state and local investment beyond that.

Previous research has investigated the effects of federal grants on highway spending, including analyses of ARRA funding (Knight, 2002; Leduc and Wilson, 2017; Campbell and Shirley, 2021). This study provides crucial empirical evidence specific to public transit. Public transit funding involves a more complex interplay between federal, state, and local governments. Highways are primarily managed at the state level with little involvement from local governments. The difference in intergovernmental involvement may explain why I find a more pronounced crowding-in effect than that documented in the closest highway-related paper, Leduc and Wilson (2017). To investigate the sources of crowding-in and potential mechanisms, I provide a more detailed analysis of different funding sources and consider the impact of local characteristics.

A plausible initial hypothesis is that an influx of federal funds would enable the initiation of transit projects previously postponed due to local budget limitations. My findings, however, do not support this explanation. I observe no significant crowding-in effect in smaller Urbanized Areas (UZAs) with tighter budgets. Instead, the crowding-in effect is more pronounced in larger UZAs and in those with existing rail transit systems. This observation points to the potential roles of political influence and the unique cost structure of rail projects. Larger UZAs, with their greater lobbying power and established political connections, may be more adept at leveraging initial federal investments to secure additional funding from state and local sources. Furthermore, rail projects, often characterized by substantial upfront costs and potential for cost overruns, could necessitate continued investment beyond the initial federal grant.

The rest of the paper is organized as follows. Section 2 describes the funding for public transit in the US, including the influx of funds from ARRA. Section 3 introduces my estimation strategy and the assumptions needed for causal interpretation of my estimates. Section 4 discusses the data used and Section 5 presents the results. Finally, Section 6 concludes.

2 Public Transit in the US

Funding for public transit in the Unites States comes from four sources: federal, state, local (county/municipality), and directly generated revenue. Federal and state funds are clearly identifiable, as they come directly from the corresponding level of government. Distinguishing between local and directly generated funds can be more challenging. For instance, a dedicated transit tax might be categorized as either local or directly generated depending on the specific administrative structure. Consequently, I combine these two categories.

National transit is overseen by the Federal Transit Administration (FTA), an agency within the Department of Transportation. The FTA manages a variety of federal programs that provide financial assistance to public transit agencies. These programs encompass both 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 – both private and public – are requires to submit annual reports to the NTD, detailing their financial operations, service provision, and ridership data. This data serves a dual purpose: informing funding allocation through formula programs and providing a comprehensive national picture of the public transit landscape.

Formula grants are a common funding mechanism used across various government sectors, but they are particularly prevalent in transportation. In 2019, approximately 78% of all federal transit funding was allocated through formula programs (APTA (2016)). Unlike discretionary grants awarded competitively, formula grants distribute funds based on predetermined calculations outlined in the most recent appropriation act (passed every several years) using data from the NTD and the latest census. Formula programs ensure a more equitable distribution of funds across locations. However, the lack of discretion in allocating funds can potentially lead to inefficiencies.

The Urbanized Area Formula program (UAF), also known as Formula 5307, was established in 1974 as the first federal formula program for transit. This program aims to provide reliable streams of funds for capital expenditures on transit in Urbanized Areas (UZAs). Formula 5307 quickly became the largest federal transit program, and in 2019 distributed approximately 43% of all federal funding for transit (APTA (2016)). In its current form, Formula 5307 funding is mostly determined by four UZA-level inputs: population, population weighted by density, bus vehicle-revenue miles, and fixed-guideway vehicle-revenue miles (VRM). A detailed breakdown of the formula can be found in Appendix Figure 5. It's important to note that due to the funding timeline, data used in the formula for each UZA is taken from two years prior to the actual allocation.

Historically, transit funding was organized on the level of UZAs that combine cities with their surrounding suburbs. This reflects the interconnected nature of metropolitan transportation systems, where travel patterns are determined by living and job arrangements rather than municipal boundaries. The importance of UAF only solidifies this approach. 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. Hence in most cases, a UZA indeed corresponds to a city with surrounding suburbs. For the map of all UZAs defined in the 2020 Census see Figure 6. For a zoomed-in map of UZAs in the DMV area see Figure 7

After federal funds are made available, they need to be awarded to a specific project. For formula funds, awards are automatic as long as the project is eligible and the UZA has sufficient funds from recent apportionments (e.g., Formula 5307 requires funds to be used within 5 years). Discretionary grants, on the other hand, require a competitive application process managed by the FTA. On the recipient side, projects are overseen by Metropolitan Planning Organizations (MPOs). Each MPO consists of local officials and representatives from transportation agencies operating in the area. In most cases, a single MPO represents one UZA, though sometimes several UZAs belong to one MPO. Consequently, in 2011-2019 there were 486 UZAs but 408 MPOs (NTD; FAST, Pub. L. No. 114-94).[4]

2.1 ARRA

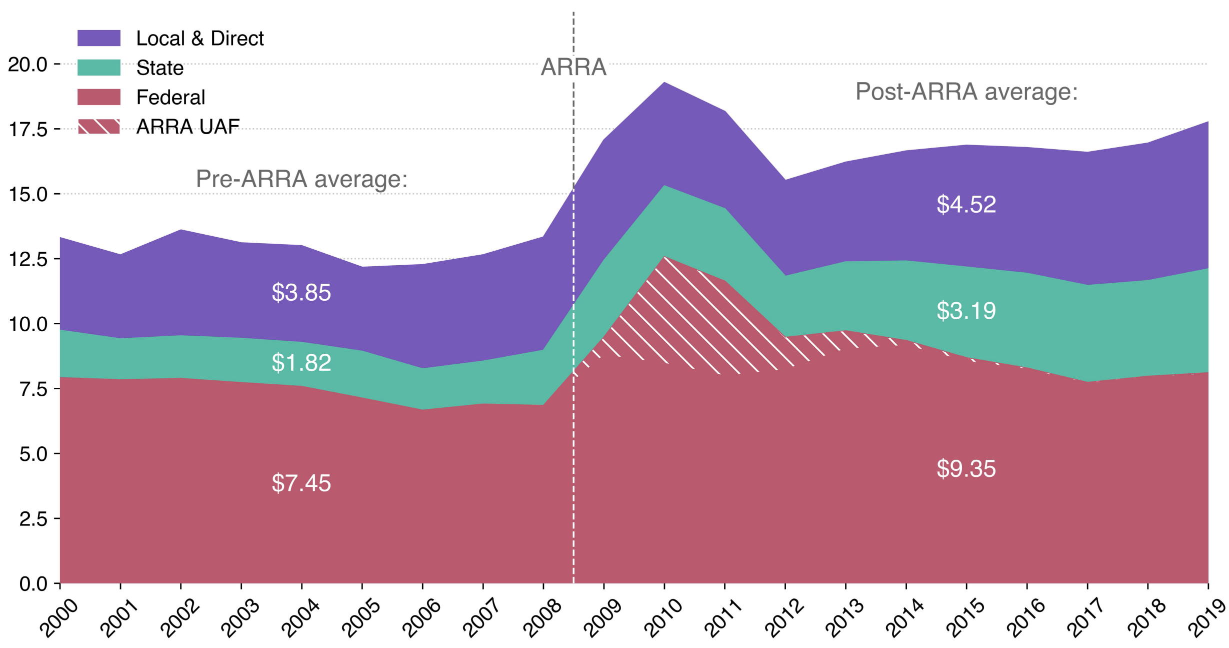
The American Recovery and Reinvestment Act of 2009 (ARRA) dedicated $48 billion for transportation, out of which $8.78 billion was spent on public transit (USDOT (2017)). This constituted a massive increase in federal funding for transit, as all other programs amounted to just above $10 billion. In my analysis, I use funds distributed via the pre-existing Urbanized Areas Formula program, used to allocate $6 billion of all ARRA transit funding. The goal of using a tried-and-true 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

[4] To the best of my knowledge, the cases when one UZA belongs to multiple MPOs are only present in Florida. There, MPOs correspond to counties, and thus a UZA that crosses a county boundary belongs to both MPOs.

2009) and spent before October 2015. Due to the funding timeline, the formula amounts for the ARRA were calculated using input values recorded in 2006.

ARRA funds were initially restricted to capital expenditures (infrastructure projects like building new stations or acquiring new buses), and the restriction was lifted only after most funds were obligated. Unlike regular UAF program, ARRA UAF did not require matching with state and local funds. As seen in Figure 1, federally-funded capital expenditures increase immediately after 2009 with no displacement of state and local funds. Later, when federal funds start to return to pre-ARRA levels, state- and locally-funded expenditures increase. This is a key motivation for my analysis. In the next section, I describe the empirical strategy for estimating the effect of ARRA funding.

Figure 1: Annual Capital Expenditures by Funding Source (UZA average; per capita; 2009$)



UZAs from 48 lower states + DC are included, except for New York City UZA.

3 Empirical Strategy

This paper leverages the American Recovery and Reinvestment Act (ARRA) as a unique setting to explore how federal grants impact local transit spending decisions. By comparing Urbanized Areas (UZAs) that received different amounts of ARRA Formula 5307 funds, I can estimate the marginal effect of distributing an additional dollar from the federal budget.[5]

However, a straightforward comparison of expenditures between UZAs would likely produce a biased estimate due to correlations between ARRA funding amounts and pre-existing spending patterns. To address this endogeneity concern and obtain a robust causal estimate, I use the fact that about 70% of ARRA funding spent on transit was distributed via Formula 5307 (APTA (2012)). This ensured that the amount of funds available to each UZA was determined by nearly-fixed local characteristics rather than contemporaneous need for additional funding.

Local characteristics used to calculate ARRA amounts (e.g., population density, existing public transit infrastructure) are certainly important for the *level* of transit expenditures. After all, Formula 5307 aims to distribute funds according to spending needs. However, these characteristics are relatively stable over time: regular Formula 5307 amounts per capita exhibit within-group variation of only 9.7%. This essentially means that values of formula inputs recorded in 2006, and thus ARRA amounts calculated based on them, were mostly determined by inherent differences between UZAs rather than the outcomes of that specific year (including trends related to the upcoming recession). This allows treating ARRA amounts as exogenous to *changes* in transit expenditures, which are driven by local shocks.

In addition to the nature of funds distribution, the other useful feature of the ARRA is its unexpected nature. Neither the timing nor scope of the Great Recession, let alone the government's response, could have been anticipated. Infrastructure projects generally operate on the horizon of multiple years, making it unlikely that local authorities and transit agencies could have adjusted their behavior in anticipation of the ARRA.

These two observations allow for the application of Difference-in-Differences (DiD) with continuous treatment to estimate the causal effects of ARRA funds. The standard parallel trends assumption translates into the following (see Callaway et al. (2024)): in the absence of treatment (ARRA), the evolution of outcomes (expenditures per capita) would be independent of the intensity of treatment (ARRA funds per capita). Under this assumption, the causal treatment effect is estimated by comparing the change in the relationship between outcomes and treatment intensity after the ARRA, relative to this relationship before the ARRA. If ARRA funding was binary (high vs low), the estimation would simplify to subtracting the difference between high- and low-ARRA UZAs in expenditures per capita before the ARRA

[5]Several studies estimate the effect of the ARRA on multiple outcomes or use the ARRA as a setting to study a more general phenomenon. To the best of my knowledge, this paper is the first to estimate the causal effect of transit funding allocated by ARRA and is also the first one to consider the effect of the ARRA on transit-related outcomes.

from the difference between them after the ARRA.

For simplicity, suppose that Formula 5307 amount is a linear combination of several indicators (a large portion of the actual formula is linear):

$$ARRA_i = \sum_{j=1}^{J} \alpha_j * k_{ij}^{2006}$$

Where $ARRA_i$ is the amount of ARRA Formula 5307 funding per capita received by UZA i, α_j are a set of coefficients common for all UZAs and k_{ij}^{2006} are UZA-level characteristics such as population density, bus Vehicle-Revenue Miles (VRM), etc. reported in 2006. Under the assumption that k_{ij} are independent of the idiosyncratic changes in expenditures, the following equation identifies the causal parameters of interest:

$$Y_{iy} = \sum_{z=2009}^{2019} \beta_z * ARRA_i + \left[\sum_{z=2000}^{2007} \beta_z * ARRA_i \right]^{ES} + \sum_{\substack{z=2000 \\ z \neq 2008}}^{2019} \gamma_{Xz} * X_i + \gamma_i + \gamma_y + \varepsilon_{iy} \quad (1)$$

where X_i are time-invariant covariates allowed to flexibly affect expenditures, γ_i and γ_y are UZA and year fixed effects.[6]

Years 2000-2007 are only included in the Event Study specification to show the absence of pre-treatment trends. In such specification, 2008 is normalized to zero and then β_y estimate the effect of $1 of additional ARRA funding on an outcome in year y, compared to the 2008 baseline relation. Cumulative effect on expenditures is estimated as the sum of post-treatment coefficients in a standard DiD specification, when all years 2000-2008 are taken as the baseline.

4 Data

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

[6]Alternatively, coefficients β_y can be estimated from a series of First Difference regressions, as in Lalive et al. (2013). This produces identical point estimates with potentially different standard errors.

where they operate most extensively). When one agency serves several UZAs, all its expenditures are attributes to one, primary UZA in the aggregation. Since agencies are more likely to consider a relatively larger UZA as their primary, this approach overestimates and underestimates expenditures in larger and smaller UZAs respectively.

I use only the 48 lower states and the District of Columbia, as customary in transportation literature (see Lalive et al. (2013)). I remove the New York City UZA, an extreme outlier in terms of funding. I also include UZAs from 2010 Census that were below the 50,000 threshold in the 2000 Census, and vice versa. This allows me to have a full panel for 2000-2019. After these manipulations, my dataset contains 471 UZAs.

The expenditures data includes operational and capital expenditures divided into four main funding sources (federal, state, local, direct). The FTA also reports program apportionments to each UZA, including ARRA funds. Population and population density counts for each UZA are reported in each decennial Census. Throughout the paper, I normalize spending and apportionments by population for each UZA, using a linear extrapolation between decennial Censuses to ensure a smooth trend. This approach avoids artificial changes in values when the Census updates population figures. When I categorize UZAs by size, I use 2019 population counts to keep the categories constant through time. All values are adjusted to 2009 constant dollars for comparison purposes. Using 2009 as the base year ensures nominal ARRA amounts reflect their real spending power in the year of apportionment.

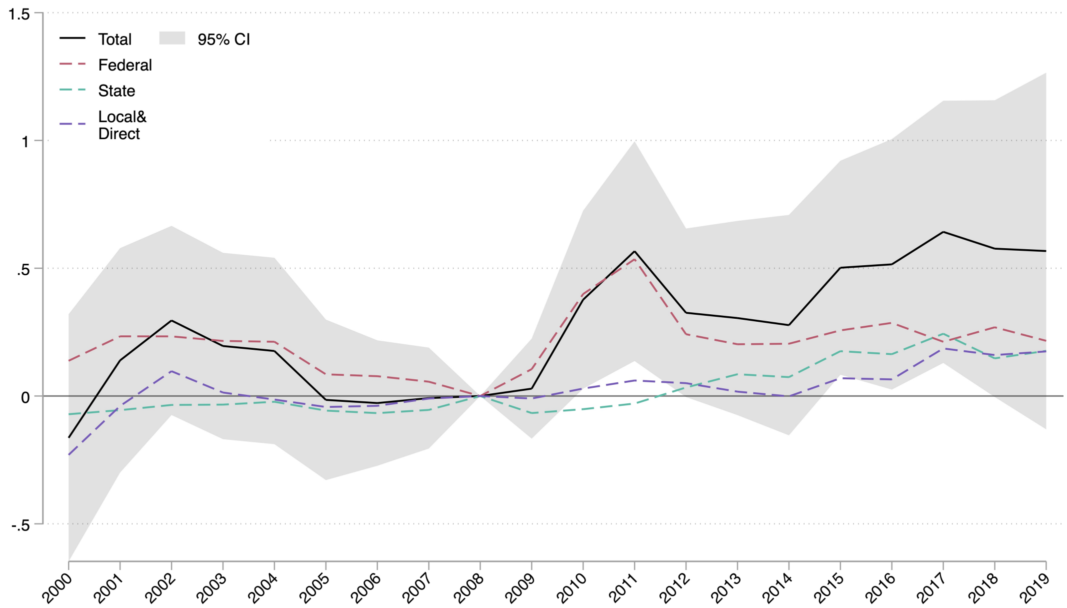
I consider three sets of covariates to improve my statistical power and reduce endogeneity concerns. First are demographic covariates: logarithm of population, median age, unemployment, labor force participation, and poverty rates, high-school share. They are likely to determine the demand for public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

5 Results

The estimated β_y from Equation (1) for total expenditures in all UZAs are shown in Figure 2. Only demographic covariates are used for the Event Study estimation, though other combination of covariates produce similar coefficients. I normalize the coefficient to zero in

2008, the last year before the treatment. Therefore, the figures show the differential relation between capital expenditures and ARRA funding relative to year 2008, after year fixed effects are taken into account.

Figure 2: Annual Effect of $1 of ARRA Funding on Capital Expenditures



This figure shows the result of an event study estimation for the effect of 2009 ARRA UAF funding on capital transit expenditures across all UZAs from 48 lower states + DC, excluding New York UZA. Each coefficient represents how expenditures in that year depend on ARRA funding, relative to the same relation in 2008. Both funding and expenditures are expressed in per-capita 2009 dollars terms. Demographic covariates and UZA and year fixed effects are included. Standard errors are clustered at the UZA level.

The coefficients before 2008 are indistinguishable from zero, indicating a flat trend in capital expenditures for several years leading up to the ARRA. This provides indirect evidence supporting the parallel trends assumption. A strong and persistent positive effect emerges from 2010 onward, with coefficients indicating approximately $0.5 in additional expenditures per year. Importantly, this initial increase is driven solely by the rise in federally-funded expenditures, with no displacement of state and local funds. This observation provides strong evidence of a flypaper effect. Around 2015, as the impact of federal funds begins to taper off, state- and locally-funded expenditures increase. This crowding-in of other funds goes beyond the standard flypaper effect.

Table 1 presents the cumulative effects of ARRA funding on capital expenditures. My preferred specification (Column 2) reveals a substantial multiplier effect: each dollar of ARRA funding generated a $3.86 increase in total capital expenditures over the subsequent eleven years. This estimate proves robust to the inclusion of additional covariates. Notably, Column 4 demonstrates that the differential impact of the Great Recession across UZAs does not account for this observed effect.

Table 1: Cumulative Effect of $1 of ARRA Funding on Capital Expenditures

	(1)	(2)	(3)	(4)
ARRA	3.517**	3.864***	3.512***	3.410***
	(1.403)	(1.228)	(1.179)	(1.200)
Demographic Covariates		X	X	X
Income Covariates			X	X
GR Covariates				X

This table shows the sum of 2009-2019 coefficients from the Difference-in-Differences specification (*DiD Estimate*) for capital transit expenditures. The estimates represent the cumulative effect of ARRA UAF funding on expenditures across all UZAs from 48 lower states + DC, excluding New York UZA. Both funding and expenditures are expressed in per-capita 2009 dollars terms. Standard errors are clustered at the UZA level.

Table 2 provides a detailed breakdown of the impact of ARRA funding on cumulative capital expenditures, categorized by funding source (federal, state, and local) and time period. This analysis confirms that the initial effect is driven by the direct infusion of federal funds. However, a larger, sustained increase in capital expenditures emerges later, primarily due to the crowding-in of state and local funds. Furthermore, Table 2 disaggregates federal funding by program, offering insights into the specific sources driving the increase in federal investment.

5.1 Mechanisms

The observed crowding-in effect may stem from several mechanisms. If federal funds primarily alleviate local budget constraints, we should expect a stronger crowding-in effect in smaller UZAs facing tighter financial limitations. Conversely, if the effect is driven by establishing political connections with the state government, larger, more independent UZAs should demonstrate greater crowding-in. To investigate this, I compare the annual effect for two groups of UZAs, those above and below 200,000 population (Figure 3). While both groups initially exhibit a similar increase, the sustained crowding-in effect is only evident in larger UZAs. This finding points towards political connections as the more likely mechanism.

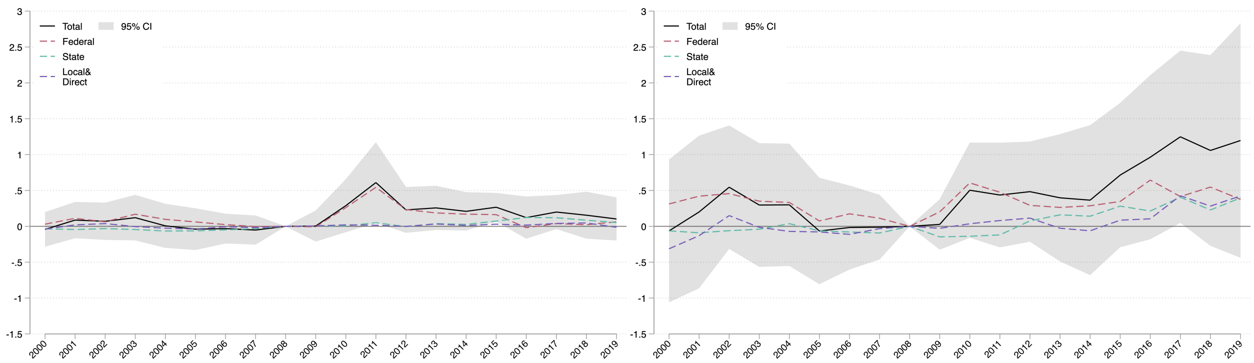
Alternatively, the observed crowding-in effect could be attributed to the substantial upfront costs associated with many transit projects, or to cost overruns exceeding initial budget projections. These factors might necessitate additional funding from state and local sources to ensure project completion. To explore this possibility, I use the presence of rail transportation within an UZA as a proxy for projects with high upfront costs or potential cost overruns. Figure 4 reveals a significantly larger crowding-in effect in UZAs with rail trans-

Table 2: Disaggregated Cumulative Effect of $1 of ARRA Funding on Capital Expenditures

	2009-14	2015-19	2009-19
Total	1.433*	2.431**	3.864***
	(0.743)	(0.957)	(1.108)
Local&Direct	0.276	0.764	1.040
	(0.595)	(0.761)	(0.894)
State	0.303	1.122*	1.425**
	(0.510)	(0.581)	(0.718)
Federal	0.854	0.545	1.399**
	(0.526)	(0.538)	(0.643)
Federal:			
ARRA	0.630*	0.029	0.659*
	(0.374)	(0.148)	(0.379)
Capital Program	0.185	0.349	0.534
	(0.420)	(0.574)	(0.664)
Regular UAF	0.325	0.429	0.754
	(0.364)	(0.356)	(0.469)
Other Federal	-0.286	-0.261	-0.548
	(0.427)	(0.430)	(0.599)

This table shows the sum of 2009-2014, 2015-2019, and 2009-2019 coefficients from the Difference-in-Differences specification (*DiD Estimate*) for capital transit expenditures. The estimates represent the cumulative effect of ARRA UAF funding on expenditures across all UZAs from 48 lower states + DC, excluding New York UZA. Both funding and expenditures are expressed in per-capita 2009 dollars terms. Demographic covariates and UZA and year fixed effects are included. Standard errors are clustered at the UZA level.

Figure 3: Annual Effect of $1 of ARRA Funding on Capital Expenditures for Small and Large UZAs



(a) UZAs with population $< 200,000$ (N = 324) (b) UZAs with population $\geq 200,000$ (N = 147)

This figure shows the result of an event study estimation for the effect of 2009 ARRA UAF funding on capital transit expenditures for large ($\geq 200,000$) and small ($< 200,000$) UZAs. All UZAs from 48 lower states + DC, excluding New York UZA, are considered. Each coefficient represents how expenditures in that year depend on ARRA funding, relative to the same relation in 2008. Both funding and expenditures are expressed in per-capita 2009 dollars terms. Demographic covariates and UZA and year fixed effects are included. Standard errors are clustered at the UZA level.

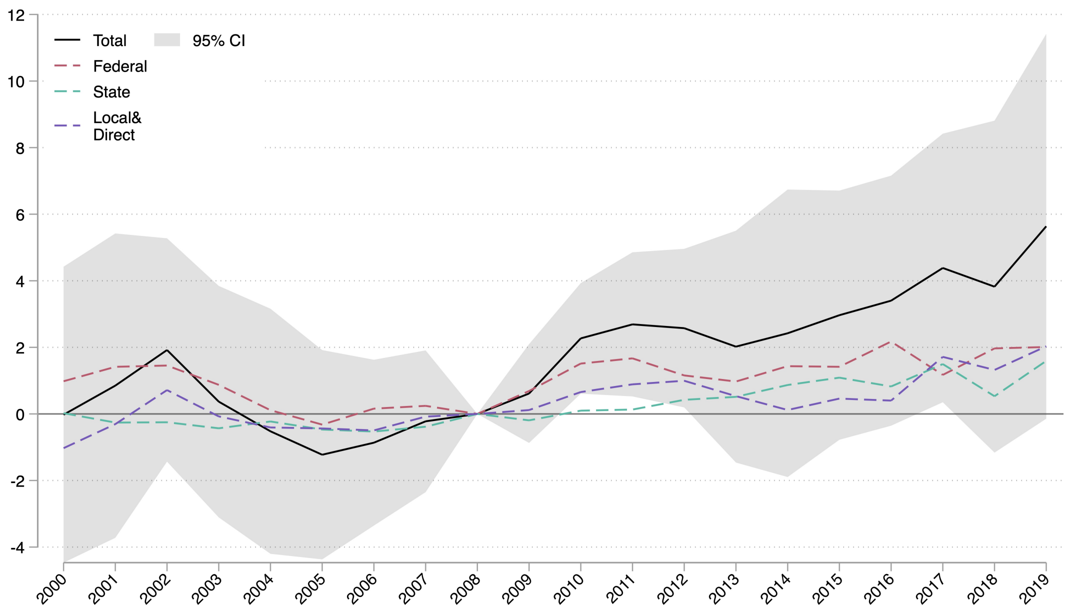
portation compared to the previous estimates. This observation supports the hypothesis that large upfront costs or cost overruns contribute to the crowding-in of additional state and local funds.

6 Conclusion

This paper provides evidence of a substantial crowding-in effect of federal funding on public transit investment. Such finding suggests that federal funds not only directly increase transit spending but also stimulate additional investment from state and local governments. The potential mechanisms include establishment of political links with the state government, large upfront costs, and cost overruns.

The unexpected nature of the ARRA funding, as opposed to predictable regular federal grants, likely played a crucial role in generating this crowding-in effect. Regular federal funding streams may incentivize state and local planners to divert funds intended for transit to other purposes, diminishing the overall impact on transit investment.

Figure 4: Annual Effect of $1 of ARRA Funding on Capital Expenditures for UZAs with Rail Transportation



This figure shows the result of an event study estimation for the effect of 2009 ARRA UAF funding on capital transit expenditures across UZAs 34 that have rail transportation in 2009, excluding NYC. Each coefficient represents how expenditures in that year depend on ARRA funding, relative to the same relation in 2008. Both funding and expenditures are expressed in per-capita 2009 dollars terms. Demographic covariates and UZA and year fixed effects are included. Standard errors are clustered at the UZA level.

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7 Appendix

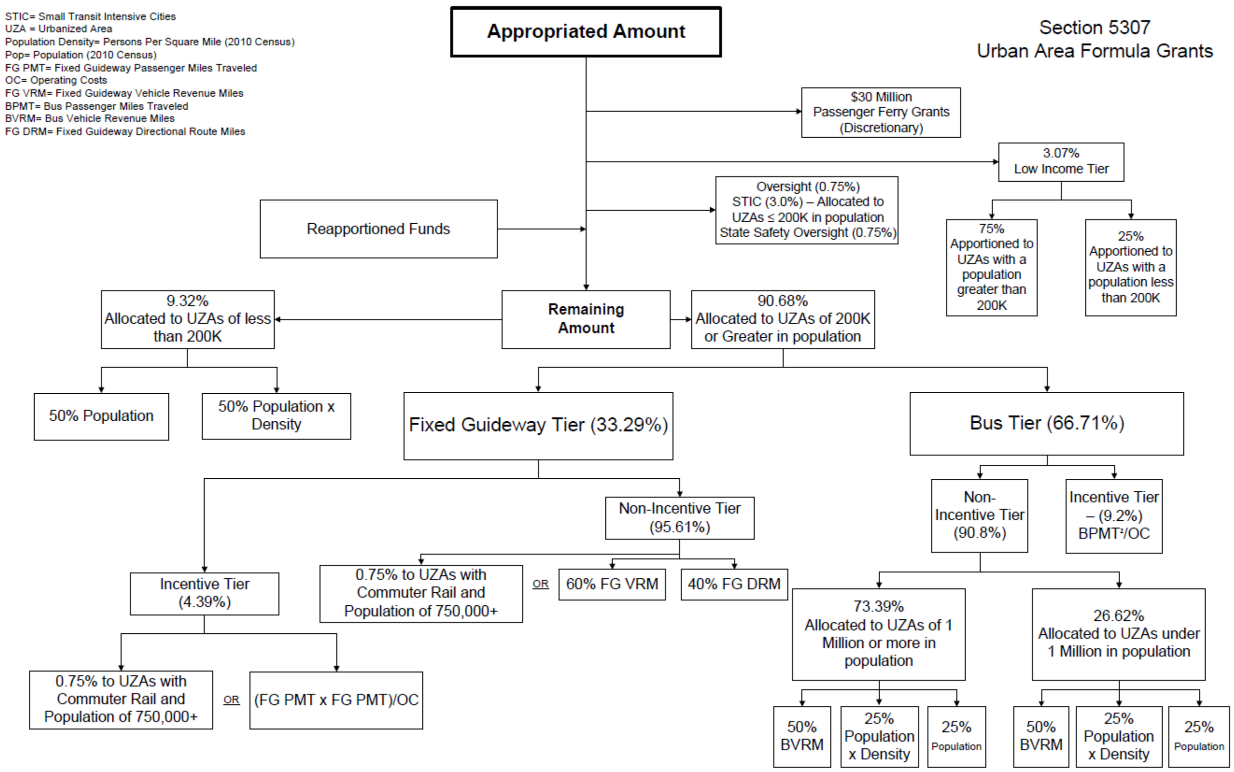

Figure 5: Formula 5307 Allocation Scheme. Source: https://www.transit.dot.gov/

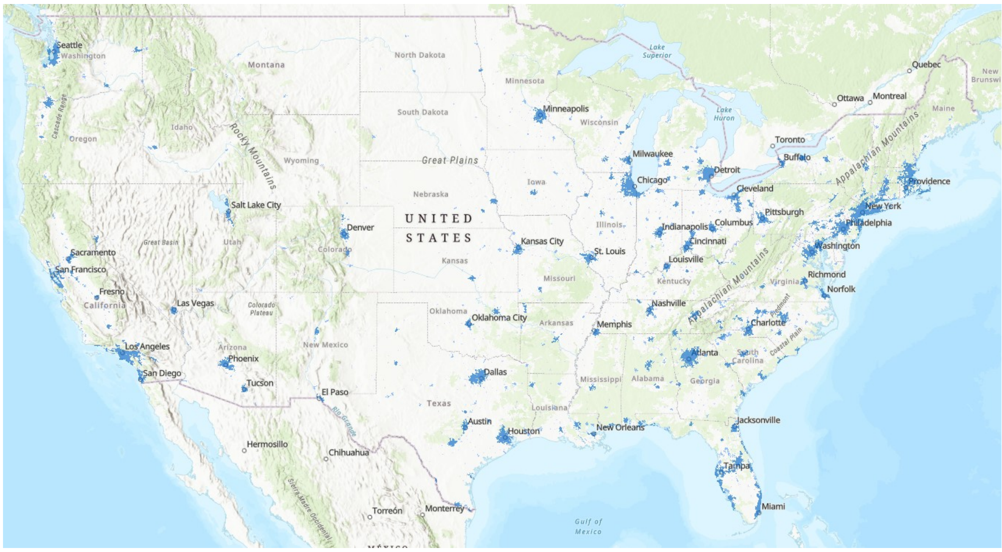

Figure 6: UZAs in the US. Source: https://www.census.gov/

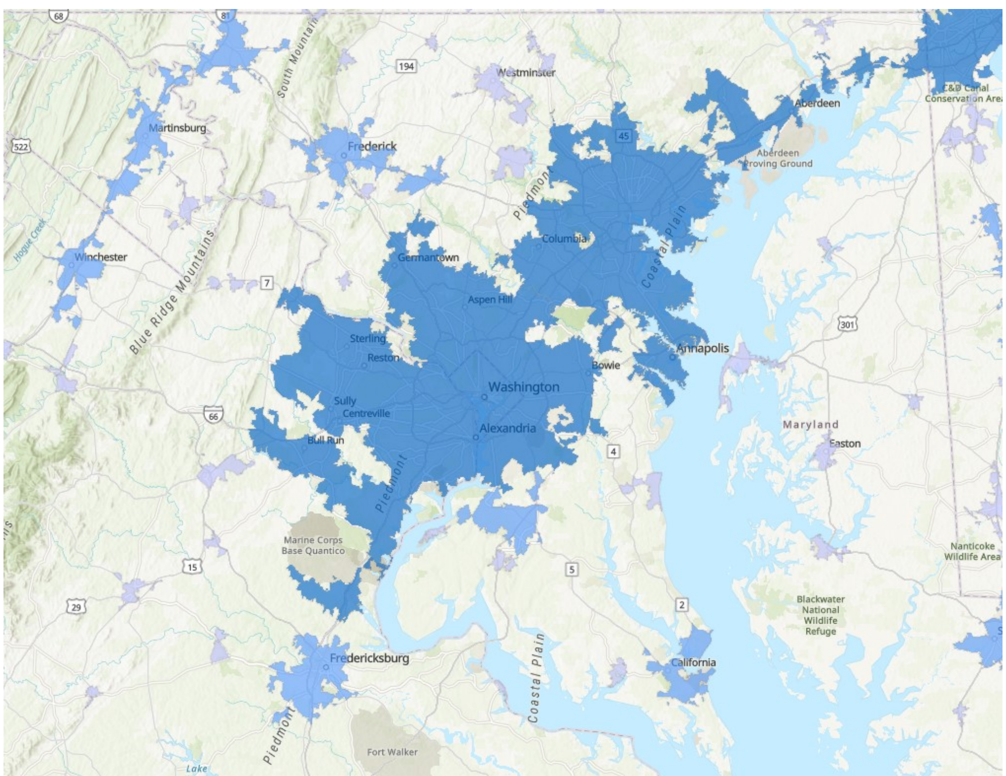

Figure 7: UZAs in the DMV area. Source: https://www.census.gov/