The Supply Elasticity of Municipal Debt: Evidence from Bank-Qualified Bonds

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Abstract

This paper provides novel estimates of the supply elasticity of municipal debt by exploiting a discrete jump in interest rates created by the Tax Reform Act (TRA) of 1986. In order to qualify for bank financing of tax-exempt debt, governments can issue no more than $10 million of nominal debt per year. Using bunching methods, I quantify both the intensive and extensive margin responses to the notch. The estimates indicate that the average marginal bunching government lowers their borrowing by approximately 5 percent in response to a 9-18 percent increase in interest costs, implying a price elasticity of -0.3 to -0.5. The results have implications for the optimal financing of public infrastructure.

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1 Introduction

In 2019, state and local governments in the United States issued \$426 billion of municipal bonds, for an outstanding total of \$3.9 trillion (SIFMA, 2021). A distinguishing feature of this market is the federal tax exemption on municipal bond yields. In place since the federal income tax was enacted in 1913, the "muni exemption" is typically justified on the grounds that it stimulates infrastructure investment by lowering the cost of borrowing for state and local governments. Lowering the cost is crucial because state and local governments are the primary stewards of public assets, owning 90 percent of non-defense public infrastructure assets and paying 75 percent of the cost of maintaining and improving them (McNichol, 2019). In fact, so central to infrastructure investment is municipal borrowing that, in addition to the muni exemption, the federal government has employed a variety of means to keep the cost low. The Build America Bonds program created by the Obama administration as part of the American Recovery and Reinvestment Act also increased the subsidy rate available to state and local governments embarking on new capital projects. Other programs that have provided income tax incentives to purchasers of municipal bonds include Qualified Zone Academy Bonds (QZAB), Clean Renewable Energy Bonds (CREBs), and Qualified School Construction Bonds (QSCB).

Whether these efforts on the part of the federal government to lower the cost of borrowing actually stimulates infrastructure investment depends crucially on the interest rate elasticity of capital spending. This paper seeks to answer this question by focusing on the supply elasticity of municipal debt. State and local capital spending and debt issuance are tightly linked for two reasons. Unlike in the private sector where investments can be financed through equity, 90 percent of state and local capital spending is financed through debt (Marlowe, 2015). Moreover, due to a combination of balanced budget laws and debt limitations, most governments are prevented from financing their operating expenditures with debt (McNichol and Mazerov, 2020; Gordon and Metcalf, 1991). This means that the overwhelming majority of municipal debt is issued for the acquisition and renovation of public infrastructures rather than for ongoing expenditures. These factors make the supply elasticity of capital spending a crucial input into infrastructure investment in the United States.

Despite the importance of this parameter, there are few existing estimates in the research literature.[1] This is due in large part to data limitations as well as a lack of plausibly exogenous variation in tax-exempt interest rates. While similar challenges have limited research on the elasticity of corporate debt, there does exist a broader literature on the sensitivity of consumer credit that exploits variation in interest rates from either direct randomization or quasi-experimental policy changes (DeFusco and Paciorek, 2017; Alessie, Hochguertel and Weber, 2005; Attanasio, Koujianou Goldberg and Kyriazidou, 2008; Karlan and Zinman, 2008).

In this paper, I estimate the supply elasticity of municipal debt by exploting a discrete jump in interest rates created by the Tax Reform Act (TRA) of 1986. Prior to 1986, commercial banks were the largest investor group in the municipal bond market, holding 39 percent of all outstanding issues (Marlin, 1994). The TRA removed the ability of banks to take advantage of tax-exempt bond interest, causing banks' demand for tax-exempt securities to plummet. The TRA did however preserve deductibility for a certain class of securities; banks could still deduct 80% of the carrying cost of securities designated as "bank-qualified." In order to meet the requirements for bank qualification, the security had to be issued by a "qualified small issuer," an issuer that does not reasonably expect to issue more than $10 million in tax-exempt obligations during the year. This in effect created a debt notch; governments issuing less than $10 million per year would be able to reap interest rate savings because of the demand from commercial banks, while those above the notch would not. The notch induces some government borrowers who would otherwise borrow in excess of $10 million to instead bunch at the limit. Figure 1 provides evidence for the behavioral response, showing how the density distribution of tax-exempt borrowing is distorted at the $10 million threshold. Governments bunch to one side of the limit, creating excess mass below the notch and a region of missing mass above it.

To estimate the supply elasticity, I combine estimates of the average behavioral response to the notch, obtained through standard bunching methods, with an estimate of the interest cost

[1] An older set of papers investigated the efficiency of the muni exemption, however these papers primarily rely on panel methods rather than quasi-experimental variation (Gordon and Metcalf, 1991; Metcalf, 1993; Holtz-Eakin, 1991; Coronado, 1999; Poterba and Ramirez Verdugo, 2011). Joulfaian and Matheson (2009) is the only paper that I am aware of that directly studies the supply elasticity. They use fixed effects models to conclude that a one percentage point drop in interest rates is associated with an increase in bond issuance of $8.7 billion (2009 dollars).

differential at the notch. To estimate the average behavioral response, I begin by quantifying the extent of bunching. By comparing the size of the excess mass on one side of the notch to the missing mass on the other, I separate the bunching into extensive margin responses (new borrowing) and intensive margin responses (governments lowering their borrowing in order to take advantage of the interest rate savings). I then use standard assumptions to translate the intensive margin response into an estimate of the "behavioral response," the amount of debt foregone by the average buncher (Chetty et al., 2011; Saez, 2010; Kleven and Waseem, 2013; Kleven, 2016). To estimate the interest cost differential at the notch, I pursue two different approaches. The first uses a difference-in-differences approach to compare governments that were and were not exposed to bank financing by exploiting a temporary increase in the small issuer limit that occurred in 2009-2010. The second approach uses a donut estimator to model the distribution of interest costs at the notch, in the spirit of a regression discontinuity (RD) design, while excluding observations in a narrow band around the threshold to account for the selection bias that would problematize the standard RD approach.

I find that the excess mass represents approximately 0.5% of all governments in the sample, with two thirds of this response representing intensive margin responses. This is equivalent to the average government operating along the intensive margin lowering their debt issuance by approximately $500,000 in response to the notch. I estimate the interest cost differential at the notch to be on the order of 9-18 log points. Combining these two estimates together yields a supply elasticity of -0.3 to -0.5, which is substantially lower than has been previously assumed (Joulfaian and Matheson, 2009). I also show that refunding constitutes an insignificant fraction of the bunching at the notch, and thus that the estimated elasticity represents the elasticity of new debt.

This paper is closely related to two strands of the public economics literature. The first is papers that exploit bunching at kinks or notches created by the tax code to estimate policy-relevant elasticities. While most of the early literature studied the individual income tax schedule (Chetty et al., 2011; Saez, 2010; Kleven and Waseem, 2013), researchers have since extended the scope of inquiry to examine the behavioral responses of private firms (Liu et al., 2019; Chen et al., 2018) and nonprofits (Marx, 2018; St. Clair, 2016). To my knowledge, this paper is the first to examine bunching among governments. In addition to focusing mainly on individuals, much of the early literature examined bunching in income or in prices; those few papers that have examined debt notches have focus mainly on the mortgage market (DeFusco and Paciorek, 2017; Best et al., 2020).

This paper is also related to the literature on municipal bonds and capital investment (Garrett et al., 2017; Liu, Denison et al., 2014; Adelino, Cunha and Ferreira, 2017; Haughwout, Hyman and Shachar, 2021). The interest on municipal bonds represents a sizable expense for most state and local governments, while at the same time the muni exemption represents an important tax expenditure for the federal government. Understanding the interplay between these two factors is essential to understanding the scale of public goods provision. More broadly, the United States faces an enormous gap between the infrastructure needed to support economic growth and its current rates of spending, a gap that the country will struggle to close without substantial municipal borrowing (American Society of Civil Engineers, 2017).

This paper proceeds as follows. Section 2 provides background on bank-qualified bonds, while section 3 provides a conceptual framework for understanding the small issuer threshold. Section 4 describes the data. Section 5 discusses the bunching methods and provides estimates of the excess mass and the behavioral response to the notch. Section 6 investigates the interest cost differential at the notch. Section 7 combines these two sets of results to provide estimates of the supply elasticity of borrowing. Section 8 concludes.

2 Background on Bank-Qualified Bonds

Since the federal income tax was enacted in 1913, the interest on state and local bonds has been excluded from taxation. Prior to 1986, commercial banks were among the largest holders of tax-exempt obligations, holding approximately 39 percent of outstanding municipal issues (Marlin, 1994). The Tax Reform Act of 1986 (TRA) significantly scaled back the deductability of the interest expense on a bank's own borrowings in an amount proportional to the interest it receives on tax-exempt bonds, effectively preventing banks from taking advantage of tax-exempt bond interest. However, the Act carved out an exception for securities designated as "bank qualified." The exception allows banks to continue to deduct 80% of the carrying costs of the tax-exempt securities; however, in order for bonds to be bank-qualified, they must 1) not be private activity bonds, 2) be issued by a qualified small issuer, 3) issued for a public purpose, and 4) designated as qualified tax-exempt obligations. Importantly, qualified small issuers were defined as issuers that reasonably expect to issue no more than $10 million of tax-exempt obligations during the calendar year. As a result of the TRA, the demand by commercial banks for tax-exempt securities declined considerably, with holdings decreasing from approximately $235 billion in 1985 to $99 billion by 1992 (National Association of Bond Lawyers, 2017).

Since 1986, the demand by commercial banks for tax-exempt securities has been almost entirely limited to bank-qualified bonds. These provisions remained in place until 2009, when the American Recovery and Reinvestment Act (ARRA) temporarily raised the qualified small issuer limit from $10 million to $30 million for obligations issued in 2009 or 2010.

The interest rate savings to issuers depends on the spread between private and tax-exempt bonds, however the Government Finance Officers Association has estimated that the interest rate differential is equivalent to 25-40 basis points (Government Finance Officers Association, 2020). The savings make it clearly beneficial for governments issuing debt around $10 million dollars, but even for governments planning on larger issues, there are potential advantages to splitting the issue, assuming that the additional costs of issuance or the risk of interest rate swings do not outweigh the savings. In 2019, two members of the House Committee on Ways and Means introduced The Municipal Bond Market Support Act of 2019, which would permantly increase the the annual limit from $10 million to $30 million and require it to be adjusted for inflation.

In the one piece of academic work on bank-qualified bonds, Dagostino (2019) exploits the temporary increase in the notch in 2009 to estimate the effect of a marginal dollar of bank-financed debt on local employment and wages. She finds that every million dollars of extra bank-financed spending generated around 14 jobs per year in the private sector and had no impact on government jobs.[2]

[2]Dagostino (2019) also provides estimates of bunching at the small issuer threshold, however her paper is focused on fiscal multipliers and uses data only from municipalities. In contast, this paper focuses on the supply elasticity of debt and consequently examines bunching among all types of governments in addition to estimating the interest rate differential attributable to bank financing.

3 Conceptual Framework

In equilibrium, governments will issue debt to finance a preferred level of investment until they are indifferent between financing the remaining costs through borrowing or through taxation (Gordon and Metcalf, 1991). Assuming a balanced budget requirement, the government's budget constraint is $g = t + d - c$, where g represents government expenditure, t is the current level of taxation, and $d - c$ represents new debt issuance net of the end of period cost. Capital investment, k, is financed by debt and a portion of current taxes: $k = d + t_k$. Operating expenditures, o, are financed by the remaining portion of taxes: $o = t - t_k$. The amount of capital investment, k, will be equal to $k = d + o - t$, or in other words, new borrowing plus any residual operating surplus that is allocated to capital investment.

Now consider the effect of introducing a notch in the interest rate schedule at the small issuer threshold. Borrowing above this amount is ineligible for bank financing and thus subject to a higher interest rate. This leads to the new interest rate schedule where interest costs for government g issuing debt d in period t will equal

$$c_g = \begin{cases} r_g * d & \text{if d} \leq \$10 \text{ mil} \\ (r_g + \Delta r_g) * d & \text{if d} > \$10 \text{ mil} \end{cases} \tag{1}$$

where Δr is the average interest rate savings from issuing bank-qualified bonds.

Consider first governments that operate along the intensive margin, i.e. those that would borrow more if all debt were bank-financed, but that adjust the amount of their borrowing in response to the discrete jump in interest rates at the notch. Figure 2a shows how the budget constraint changes at the notch. The marginal bunching government borrows $d + \Delta d$ in the counterfactual in which all debt is bank-qualified. When borrowing above the notch is not eligible for bank-financing, it is indifferent between locating at point d_1 and locating at the notch ($10 mil). The marginal buncher that moves to the notch issues less debt but also faces lower interest payments.

Thus, the amount of observed/reported debt issued, d, is equal to

$$d = \begin{cases} d^* & \text{if d} \leq \$10 \text{ mil} \\ d^* - \Delta d, \text{where } \$10 \text{ mil} \leq d^* \leq \$10mil + \Delta d & \text{if d} = \$10 \text{ mil} \\ d^* - \gamma, \quad \text{where } d^* > \$10mil + \Delta d & \text{if d} > \$10 \text{ mil} \end{cases} \tag{2}$$

where d^* is the amount of debt the government would issue in the counterfactual in which all municipal borrowing is eligible for bank-financing, Δd is the amount by which governments just above the notch lower their debt issuance in response to the introduction of the notch, and γ is the marginal amount by which governments originally located above $\$10mil + \Delta d$ reduce their borrowing. In the presence of frictions, bunching governments may not locate directly at the threshold but within some interval just below it.

Figure 2b depicts the observed and counterfactual density distribution. In a world of perfect information and homogeneous elasticities, all governments originally locating within the interval (\$10 mil, $d + \Delta d$) bunch at the notch. With heterogeneous elasticities and imperfect information, not all governments adjust their borrowing, and there are some that appear in the manipulation region just above the notch. As a result, the empirical quantity of interest is the average behavioral response, $\bar{\Delta} d$, rather than the location of the marginal buncher. Under the assumption that governments only operate along the intensive margin, then excess mass below the notch will be equal in size to the missing mass above the notch (the so-called "integration constraint") (Chetty et al., 2011).

Now consider the possibility that some governments operate along the extensive margin, i.e. they would not borrow at all in the absence of bank financing but are willing to borrow under lower interest rates available with bank financing. The marginal buncher in this case is indifferent between issuing zero debt in period t and issuing some amount of bank-financed debt. In the case that the extensive margin response is non-negligible, then the excess mass below the notch will consist of governments operating along both the intensive and extensive margins. On the other hand, the missing mass above the notch will continue to represent only the intensive margin response and will thus be strictly smaller in size than the excess mass. Thus, the size of the missing mass can be used to infer the average behavioral response, $\bar{\Delta d}$, of governments operating along the intensive margin.

4 Data and Summary Statistics

To conduct the empirical analysis, I use data from the Census of Governments and the Annual Survey of State and Local Government Finances. The Census has collected data on government revenues and debt issuance since 1967 and is "the only comprehensive source of information on the finances of local governments in the United States" (Pierson, Hand and Thompson, 2015). Every five years the Census collects a full survey of state and local governments, asking questions about the range of government financial activities (revenues, expenditures, debt, and financial assets). Census workers clean the responses and compare them to audited financial statements. In non-census years, the surveys are stratified by government type, with the probability of selection proportional to size.[3] The Census data is especially advantageous in this setting because it contains information on the total amount of debt issued by governments each year as well as the total interest expense. Because the small issuer threshold is based on the total amount of annual borrowing, data on total government borrowing is more informative than data on individual bonds.

I place two restrictions on the sample. First, because the difference-in-differences design I pursue in section 6 requires a true panel, I restrict the sample to governments that have at least seven consecutive years of observations. This removes very small governments that appear only intermittently in the data, many of whom would be unlikely to borrow on the bond market and appear in the vicinity of the notch. Second, I limit the time period to 1998-2015. Not only does this limit the number of governments with missing panel data, but it also excludes the period immediately following the TRA in which fewer governments were limited by the threshold.[4]

Table 1 provides summary statistics. Each record in the dataset represents a government's annual totals. The median government in the sample collects $6.5 million per year (2015 dollars) in own-source revenues and has 8.1 million in outstanding debt. There are five types of governments

[3]See the Census of Governments for more details: https://www.census.gov/govs/local/

[4]Because the threshold is fixed in nominal terms, its real value has declined over time. Figure A1 show the extent of bunching by census year.

in the data: counties, municipalities, townships, special districts, and school districts. Although prior work has restricted the analysis of the notch only to municipalities (Dagostino, 2019), this paper includes all forms of government borrowers, as special districts and school districts constitute the majority of government borrowers and issue 46 percent of aggregate debt.

5 Bunching at the Small Issuer Threshold

In this section, I quantify the extent of bunching at the notch and use this to estimate the average behavioral response along the intensive margin of the marginal buncher. Figure 1 presents the density distribution of governments near the $10 million debt notch for the period 1998-2015. The figure excludes private activity debt as well as debt issued during 2009-2010 when the ARRA temporarily raised the limit. The figure shows a sharp spike in the density distribution at a borrowing level of $10 million, consistent with governments borrowing up to a level that still enables them to qualify as "small issuers." There is no "hole" in the density distribution above the notch as would be expected in a notch analysis with homogenous elasticities (Kleven, 2016). However, this is consistent with a model of heterogeneous elasticities, in which not all municipalities are equally price sensitive in their debt issuance. There is also a small amount of round-number bunching, with smaller peaks visible at 5 and 15 million dollars.

In order to validate that governments have adjusted their borrowing in response to the notch and confirm that the bunching is not simply in response to a reference point, Figure 3 plots the density distribution of debt between 2009 and 2010 when the borrowing limit for small issuers was temporarily raised.[5] The figure shows no evidence of bunching at $10 million, confirming that the bunching observed in Figure 2 occurs in response to the discontinuity in debt costs at the threshold rather than simply in response to a reference point.

[5]The fiscal year for most state and local governments does not correspond to the calendar year, and subsequently there is a lot of partial overlap between government fiscal years and calendar years 2009-2010. This is further complicated by the fact that the "survey years" reported by the census do not always correspond to the fiscal year of the government. When referring to 2009-2010, I include only those fiscal years that fall entirely in the 2009-2010 calendar year window. Specifically, I include survey year 2010 for governments with fiscal years that end prior to July 1 and survey year 2011 for governments with fiscal years that end after June 30.

5.1 Size of excess mass

The graphical results presented in Figures 1 and 3 provide evidence of governments adjusting their debt issuance in response to the notch. In this section, I estimate - separately - the size of the excess mass and the size of the missing match at the notch. Further, I use information on the missing mass to infer the size of the behavioral response of governments that operate along the intensive margin.

First, I use a standard bunching design to quantify the extent of bunching. Borrowing the notation of Kleven (2016), I estimate a regression of the following form:

$$n_j = \sum_{i=0}^{p} \beta_i \cdot (d_j)^i + \alpha_i (d_j)^i \cdot 1[d_j > \$10Mil] + \sum_{i=d_L}^{d_U} \gamma_i \cdot 1[d_j = i] + \nu_j \quad (3)$$

where n_j is the number of governments in bin j, d_j is the level of borrowing in bin j, $[d_L, d_U]$ is the excluded range, and p is the order of the polynomial. Importantly, I fit flexible polynomials separately to both sides of the threshold, and I do not attempt to satisfy the "integration constraint" that is a common feature of bunching analyses. The presumption is that some governments respond along the extensive margin, and thus that the excess mass at the notch is likely to exceed the size of the missing mass. I provide estimates for both total manipulation and in-range manipulation. Total manipulation is the excess/missing mass as a percent of the total sample size. In-range manipulation is the excess/missing mass as a percent of the number of charities in the counterfactual range in the region of missing mass (bins \$10 million to d_U) (Dee et al., 2019). I estimate the standard error by block bootstrapping the entire procedure over 500 draws, sampling at the government level. The identifying assumption is that the density distribution would be smooth in the absence of the notch.

Figure 4 shows the empirical and counterfactual density distributions. The baseline specification fits second order polynomials to both sides of the threshold and uses a bin size of \$500k, and an excluded range of \$8.5-\$14 million. Table 2 presents the measurements of the extent of bunching, using a variety of specifications. In the baseline specification, the excess mass is equal to 0.54% of all governments, or alternatively 26% of the governments just above the notch under the counterfactual. The missing mass is smaller: equal to 0.32% of all governments or 15% of governments in range of the notch. The estimates are fairly robust to the choice of specification, with the estimates for the in-range manipulation ranging from 0.13 to 0.15 for the missing mass and 0.20 to 0.26 for the excess mass.

Appendix Figure A2 shows how bunching differs according to the type of government. Table A1 shows estimates of the excess mass. The estimate for municipalities is within the range of estimates reported by Dagostino (2019). While all governments show a spike in the density distribution at $10 million, the extent of bunching is smaller among general purpose governments (counties, municipalities) and larger among school districts and special districts. School districts may be more sensitive to the price of debt than general purpose governments because they do not issue debt as frequently and can more easily adjust the timing of the issues to take advantage of interest rate fluctuations.

Based on the size of the missing mass, it is possible to infer $\bar{\Delta d}$, the average behavioral response of governments that lower their debt issuance in response to the notch. While the excess mass reflects both intensive and extensive margin responses, the missing mass is due solely to governments that reduce their debt and thus operate along the intensive margin. I calculate the average amount by which governments operating along the intensive margin lower their borrowing by measuring how far the area represented by the missing mass would extend into the counterfactual distribution below the threshold.

$$\hat{\bar{\Delta d}} = \frac{\left(\sum_{i=10Mil}^{i=d_U} |\gamma_i| \cdot 1[d_j = i] \right) \cdot \rho}{f^*(10Mil)} \tag{4}$$

Specifically, I multiply the number of missing organizations (represented by the summation) by ρ, the bin width, and divide by $f^*(10Mil)$, the height of the counterfactual density distribution at the notch. This calculation follows the practice in other studies of assuming that the counterfactual density distribution is approximately flat in a narrow range around the notch (Homonoff, Spreen and StClair, 2020; Marx, 2018; Kleven, 2016). Using a bin width of $500k and the estimate of the missing mass from column 1 in Table 2, the average government operating along the intensive margin lowers their debt issuance by $484k in response to the notch, or 4.6 percent ($\frac{\$484k}{\$10Mil+\$484k}$).

5.2 Extensive Margin

To measure the extent of extensive margin responses, I follow Kopczuk and Munroe (2015) and Marx (2019) by calculating the difference between the excess and the missing mass. In the absence of extensive margin responses, the two should be equal under the "integration constraint" (Chetty et al., 2011). In the presence of extensive margin responses, governments that "newly" issue debt in response to the notch will only appear below the notch, causing the size of the excess mass to exceed the size of the missing mass.

Under the baseline specification, the difference between the excess mass and the missing mass is 0.0022 percent of governments, or 11 percent of governments in range of the notch, suggesting that extensive margin responses constitute approximately 40% of the total excess mass. Using the same bootstrap samples generated to calculate the standard errors in Table 2, I estimate a standard error of 0.0007 for the difference between the excess mass and the missing mass as measured by the total manipulation (0.035 for the in-range manipulation), confirming that the difference is significant at the 1 percent level.

6 Interest Cost Differential

In order to convert the estimate of the behavioral response to an elasticity, it is also necessary to calculate the average difference in price at the notch for the marginal buncher, i.e. the average difference in cost between issuing debt with and without bank financing. This exercise is complicated by the borrower selection that occurs around the threshold, documented in the previous section. Governments in the manipulation region may have unobserved characteristics that are correlated with interest rates, thereby biasing a comparison of interest rates on either side of the notch that conditions only on observables. To address this challenge, I pursue two approaches. First, I use a difference-in-difference (DiD) approach that leverages the temporary increase in the small issuer threshold in 2009-2010. Intuitively, I compare interest costs for governments that issued less than \$30 million (but more than \$10 million), pre- and post-reform, to the interest costs of governments that issued more than \$30 million. The latter group helps to establish a counterfactual of what would have happened to interest costs had the temporary increase in the notch not occurred. The assumption is that any difference in interest costs between the two groups can be attributed to bank-financing. In the second approach, I use a donut estimator that models the distribution of interest costs around the threshold in the same vein as a regression discontinuity design but excludes observations within the manipulated range. This approach uses information about the size of the manipulatation region from the bunching analysis and benefits from the fact that governments bunch in a relatively small band around the notch. In both cases I measure $\hat{\Delta c}$ as a difference in log interest costs, which is approximately equal to the percentage change in interest costs.

6.1 Difference-in-Differences

The intuition behind the DiD approach is to compare the evolution in interest costs for a treatment group that is eligible to issue bank-financed debt with the evolution in interest costs for a comparison group that is not. Fortunately, the temporary increase in the small issuer threshold in 2009-2010 offers a plausibly exogenous change in the eligibility for bank financing. As part of the American Recovery and Reinvestment Act, Congress raised the cutoff for the bank-qualified designation from \$10 million to \$30 million, allowing a much larger proportion of municipal issuers to capitalize on bank financing. The change went into effect in February 2009 and expired nearly two years later on December 31, 2010. Thus, governments that would not previously have been able to issue bank-qualified debt at their preferred level of borrowing were able to do so for a short window of time.

To exploit the temporary increase, I compare interest costs among governments that borrowed less than \$30 million (but more than \$10 million), both prior to as well as "post" reform (i.e. during 2009-2010), with governments that borrowed more than \$30 million during the same periods.[6] To measure the cost of debt (c), I calculate the difference between log interest paid in the year that the debt is issued and log interest paid in the subsequent year ($log\_interest_{t+1} - log\_interest_t$). Because in some cases government may pay interest on debt in the same year that it issues the debt, I also include alternative specifications in which I measure the cost instead as ($log\_interest_{t+1} - log\_interest_{t-1}$).

[6] I use survey year 2007 as the pre-reform year because it was a full-census year and thus affords more observations.

I then estimate a DiD design of the following form:

$$c_{gt} = \alpha + \beta_1 \cdot Treat_g + \beta \cdot Post_t + \gamma \cdot Treat_g \cdot Post_t + \psi_{gt} + \theta_g + \epsilon_{gt} \quad (5)$$

where c_{dt} represents the log interest cost ($log\_interest_{t+1} - log\_interest_t$) for government g issuing debt in period t, $Treat_g$ represents governments that issue less than \$30 million of debt pre- and post- reform, and $Post_t$ represents the period in which the threshold was temporary increased (2009-2010).[7] The right hand side also includes vectors of time-varying, ψ_{gy}, and fixed, θ_g, covariates. The covariates include the amount of (log) debt issued, log capital spending, log total debt outstanding, and indicator variables for the type of government (school district, etc.). Standard errors are clustered at the level of the government.

The DiD results (equation 5) are presented in Table 3. The first two columns show results when the dependent variable is measured as the difference in interest costs between year t+1 and year t. The third and fourth columns show results when the dependent variable is measured as the difference in interest costs between year t+1 and year t-1. If the first interest payment of a bond is due in the same fiscal year in which it is issued, then measuring the increase in interest costs from the bond as $log\_interest_{t+1} - log\_interest_t$ may understate the true increase. On the other hand, if a government issues debt every year, then measuring the increase in interest costs as $log\_interest_{t+1} - log\_interest_{t-1}$ may overstate the true costs. However, so long as these differences are fixed across the treatment and comparison groups, this measurement error need not bias the results.

The estimates in columns 1-2 imply that bank-financing lowers interest costs by 7-9 log points, which is approximately equal to a decrease of 7-9 percent. The estimates in columns 3-4, which use a slightly different measure of the dependent variable, imply that bank-financing lowers interest costs by 14-16 log points, or approximately 14-16 percent. To put these numbers in perspective, for a tax-exempt bond with a coupon rate of 3%, a 12% decrease in interest costs (the mid-point of the DiD estimates) is equivalent to 36 basis points. This is within the range of 25-40 basis points assumed by the Goverment Finance Officers Association (Government Finance Officers Association,

[7]As in footnote 5, I specifically use survey year 2010 for governments with fiscal years that end prior to July 1, and survey year 2011 for governments with fiscal years that end after June 30.

2020).

6.2 Donut Estimator

As an alternative approach, I also estimate the interest cost advantage of bank-financing by using a donut-RD estimator. The donut approach excludes observations in the manipulated region in order to address the selection bias that would result under the standard regression discontinuity approach (Barreca et al., 2011; Barreca, Lindo and Waddell, 2016). It has the advantage of offering some of the transparency of the standard RD design while also utilizing information on the size of the manipulation region as revealed through the bunching estimation in section 5. Moreover, in this instance, because bunching is confined to a rather narrow region (at least below the threshold), the approach has more credibility than if the excluded region were larger. In addition, the panel nature of the data affords the use of fixed effects, which is useful for addressing unobserable characteristics that are correlated with interest rates and also fixed over time. I measure interest costs as log interest in year t+ 1 (the year following a debt issue) since governments may not pay the full interest expense until the year after it issues debt.

I estimate regressions of the following form:

$$c_{gt} = \alpha + f(b) + Small_{gt} + f(b) \cdot Small_{gt} + \psi_{gt} + \eta_g + \delta_t + \epsilon_{gt} \tag{6}$$

where c_{dt} represents total log interest costs for government g in year t+1, $f(b)$ represents a polynomial function in the amount of borrowing in year t, $Small_{gt}$ represents an indicator variable for a government falling under the small issuer threshold in year t, ψ_{gt} represents a set of time-varying covariates, η_g represents government fixed effects, δ_y represents year fixed effects, and ϵ_{gt} is the error term. In the baseline specification, I use linear polynomials, estimated separately on both sides of the threshold. Importantly, observations within the manipulated region are excluded.

Figure 5 plots residuals from the baseline specification that includes linear polynomials, year and government fixed effects, but no covariates. Each circle represents the average amount of borrowing within bins of $500,000. The figure omits only one bin on either side of the threshold (representing the range $9.5-$10.5 million). The figure indicates a discontinuity in log interest costs of approximately 10 log points. Although not the focus of the analysis, the figure also indicates a change in slope at the notch, suggesting that interest costs rise at a slower rate as the amount of principal increases among bonds that are bank-financed. The results from donut estimation are presented in Table 4. The specifications in the table vary the size of the excluded region as well as the order of the polynomials.

The results using a linear functional form indicate that bank financing confers a cost advantage of 10-18 log points. When the excluded region is limited to $9-11 million in debt, the estimates range from 10-13 log points. With a wider excluded region, the estimates increase slightly to 14-18 log points. The specifications using a quadratic polynomial indicate a differential of at least twice this size (20-40 log points), but as these specifications show a poor fit to the data (and do not yield statistically significant coefficients), I do not place much weight on the estimates. Thus, the results from the donut estimator indicate a interest cost differential of 10-18 log points, in line with the DiD estimates above.

Neither the DiD or the donut approach are without flaws. In particular, the difference-in-difference approach assumes parallel trends, which cannot be tested in this context. The extremely small number of governments that issue between $10-$30 million debt every year over the period 2006-2010 precludes a proper panel analysis covering a wider range of years. The donut estimator departs from standard RD assumptions by dropping observations near the cut-off point. Nevertheless, both methods use a variety of different specification to arrive at similar estimates of the interest cost differential: approximately 9-18 log points.

7 Elasticities

7.1 Estimates

In this section, I use the results from the previous two sections to estimate the supply elasticity of municipal debt. From section 5, I use the average debt response of the marginal buncher, which I convert to a percentage change. From section 6, I use the interest cost differential at the notch, which is equivalent to the change in price facing the marginal buncher. Note that the estimates in Section 6 are not estimates of a change in interest *rates*; they are estimates of the percentage change in interest *costs*. This simplifies that analysis because, unlike DeFusco and Paciorek (2017), I do not need to differentiate between an average change in interest rates and the marginal cost facing the marginal bunching borrower. I calculate the elasticity as

$$\epsilon = \frac{\frac{\hat{\Delta d}}{\$10mil+|\hat{\Delta d}|}}{\hat{\Delta c}} \tag{7}$$

Table 5 reports the elasticities for a range of estimates of $\hat{\Delta d}$ and $\hat{\Delta c}$. Each elasticity is calculated from the estimate of $\hat{\Delta c}$ at the top of that column and the estimate of $\hat{\Delta d}$ reported at the beginning of that row. Since the estimates of the excess mass in Table 2 are so consistent, I use only one value for $\hat{\Delta d}$, but I vary the estimates of $\hat{\Delta c}$ from a low of 0.086 to a high of 0.175, based on the specificiations that yield statistically significant coefficients. The standard errors are calculated using the delta method. The elasticity stimates range from -0.26 to -0.54, implying that a one percent increase in debt costs results in a reduction of municipal debt supply of 0.3 to 0.5 percent.

7.2 Refunding

The elasticity that is most relevant to policy is the supply elasticity of new debt. This provides information to policymakers about new projects undertaken for capital purposes. If the estimated elasticity incorporates debt issued for refunding purposes, then it would not necessarily be informative about the responsiveness of new borrowing to changes in the cost of debt. This is a potential concern, as refunding obligations can be designated as bank-qualified.

To investigate the extent to which the borrowing at the notch reflects refunding obligations as opposed to new debt, Figure 6 plots the density distribution of debt when the sample is limited to government-years in which the government's total debt outstanding remained constant. The assumption is that, with total debt outstanding remaing constant, any debt that is issued will be for refunding purposes. There are two things worth noting about the figure. First, the number of debt issues is small relatively to the amount of borrowing depicted in Figure 1. There were only 11 instances of governments borrowing an amount between \$9-10 million. Second, while there is a slight uptick in the distribution around $10 million, there is no stark evidence of bunching as is visible in Figure 1. These results suggest that bunching at the small issuer threshold primarily consists of new borrowing and that the elasticity results presented in Table 5 reflect the supply elasticity of new debt.

8 Conclusion

This paper estimates the supply elasticity of municipal debt by exploiting a discrete jump in interest rates created by the Tax Reform Act of 1986. First, I documents bunching at the small issuer threshold. I calculate the size of the excess mass at the notch and use this information to infer the average reduction in borrowing for the marginal borrower, concluding that the margin buncher reduces their borrowing by $500,000, or approximately 5%. Next, I calculate the interest cost differential at the notch using two different approaches, one that exploits the temporary suspension of the notch and another that models the distribution of interest costs around the notch. These approaches yield estimates of 9 to 18 log points for the interest rate differential. Finally, I combine these two estimates to calculate the price elasticity of municipal debt supply. The results indicate that subnational governments, including municipalities, counties, school districts, and special districts, lower their debt supply by 0.3-0.5 percent in response to a 1 percent increase in borrowing costs.

This result has significant implications for the efficient financing of infrastructure investments. Numerous federal programs, including the muni tax exemption, the Build America Bonds (BAB) program, Qualified Zone Academy Bonds, Clean Renewable Energy Bonds, and Qualified School Construction bonds, aim to stimulate infrastructure investment by lowering the cost of borrowing for state and local governments, who are the primary stewards of non-defense public infrastructure assets. These programs are only effective insofar as government borrowing is responsive to the change in cost and the change in borrowing directly translates into new capital spending. The results in this paper suggest that, in fact, state and local borrowing is not as responsive to changes in interest rates as may have been previously believed. Given that the exclusion of municipal debt interest is forecast to cost the federal government more than $500 billion over the next decade

(Garrett et al., 2017), this implies that the federal government should shift its approach toward a greater emphasis on public private partnerships or direct spending.

There are several limitations to this article's approach that are worth noting. First, it is not obvious that responses to changes in the price of debt are symmetrical, i.e. whether governments respond equally to a price reduction as they do to a price increase. Findings in behavioral economics indicate that consumers are often more sensitive to price increases than they are to price decreases (Homonoff, 2018; Benzarti et al., 2020), though in this case that would suggest that governments might be even less responsive to a decrease than the results here indicate. Second, the results described here are local to the notch. Small municipal governments may not react the same way to price changes as larger governments with more sophisticated debt management strategies, who are, after all, responsible for a large portion of capital spending. Nevertheless, most governments in the United States are smaller governments; in 2015, 85% of governments collected less than $10 million in tax per year.

Given the deteriorating condition of infrastructure in the United States, it is more important than ever to understand the policy levers that are available to stimulate infrastructure investment and to do so at minimal cost to the US taxpayer. The municipal debt market remains central to the ability of subnational governments to finance infrastructure investment, but it is not the only mechanism. Discussion around U.S. infrastructure policy may benefit from further work that compares and contrasts the efficiency of various infrastructure financing mechanisms and sheds light on those matters of local context that are most important.

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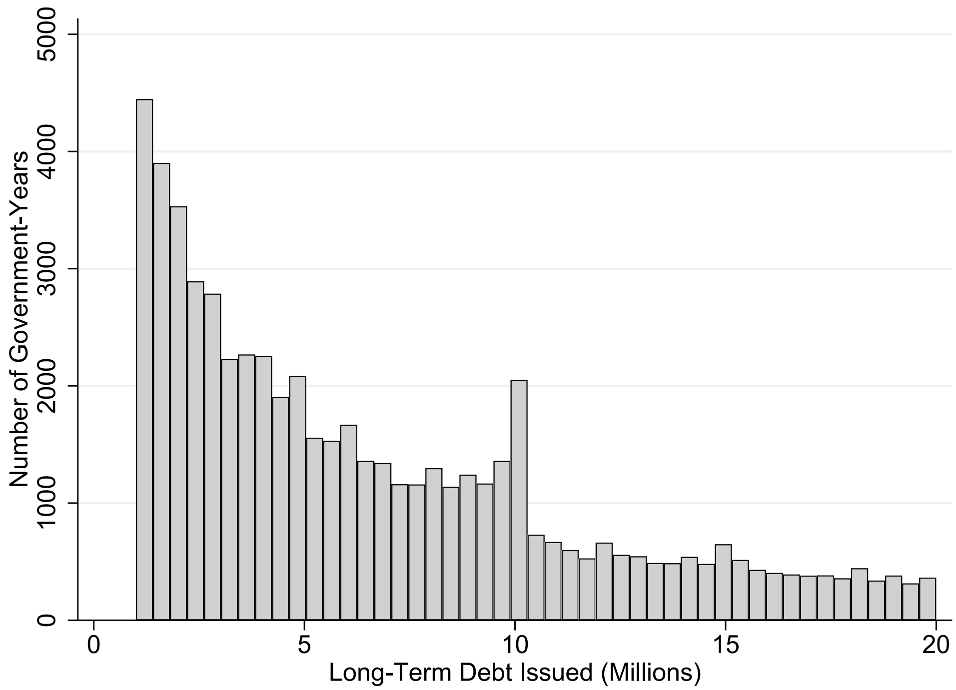
Figure 1: Bunching at the Small Issuer Threshold: 1998-2015



Note: The figure shows the density distribution of long-term debt between 1998-2015. The sample excludes private purpose debt as well as debt issued between 2009 and 2010 when the small issuer threshold was temporarily increased due to the American Recovery and Reinvestment Act.

Figure 2a: Budget set diagram

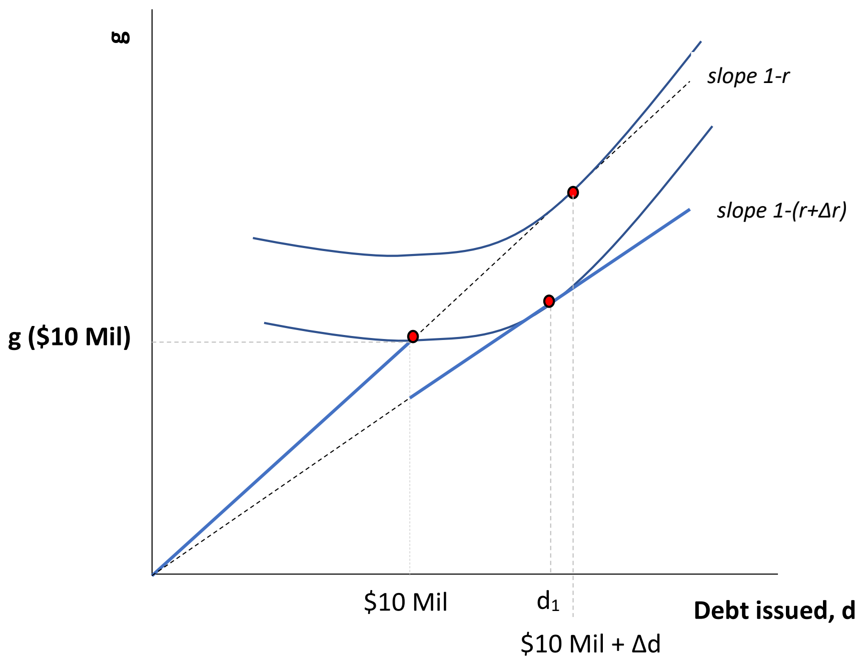


Figure 2b: Density distribution diagram

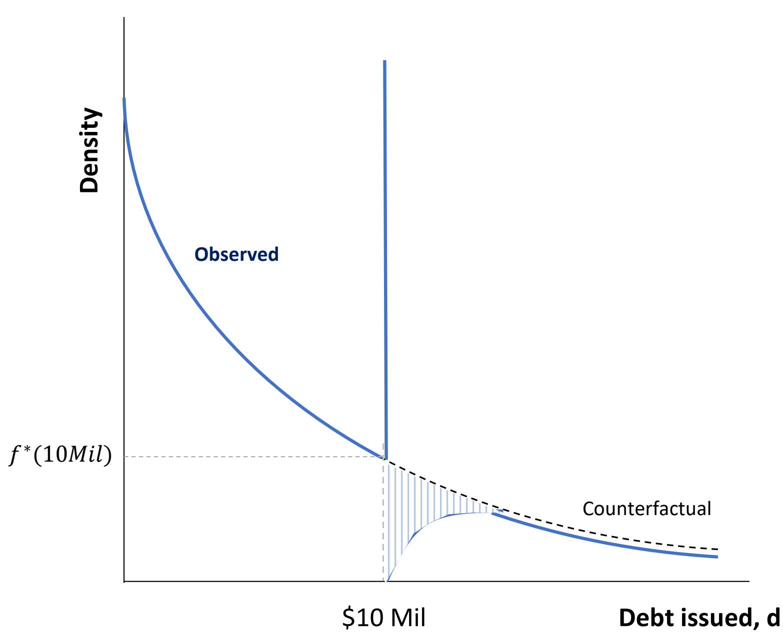
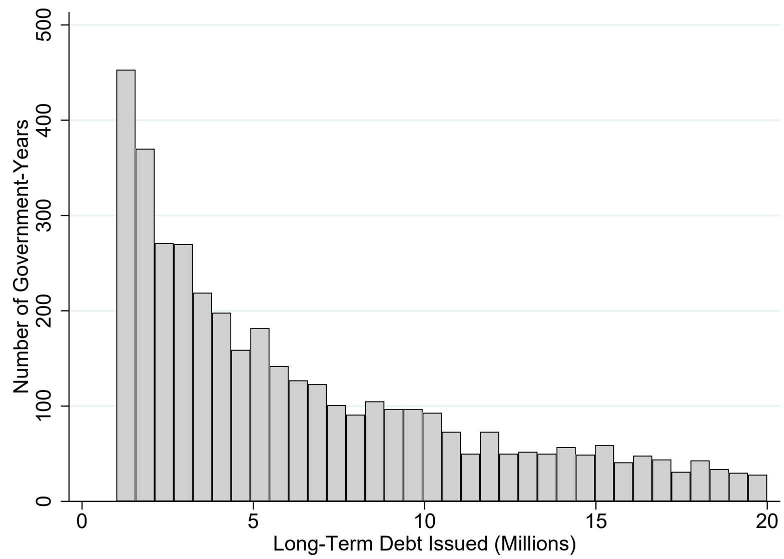
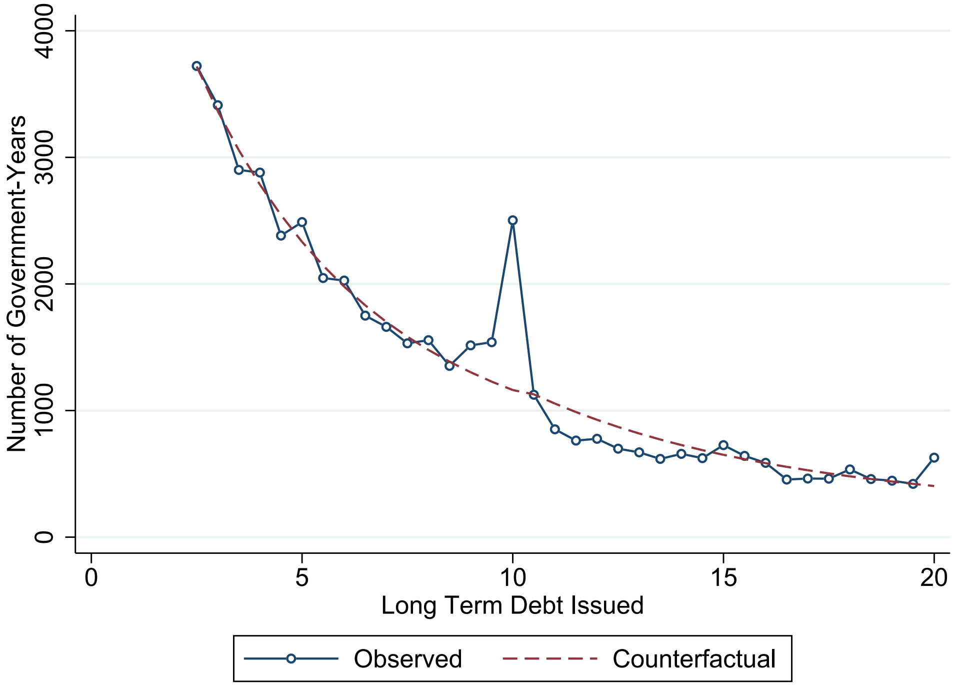


Figure 3: Long-Term Debt Issued in 2009 and 2010



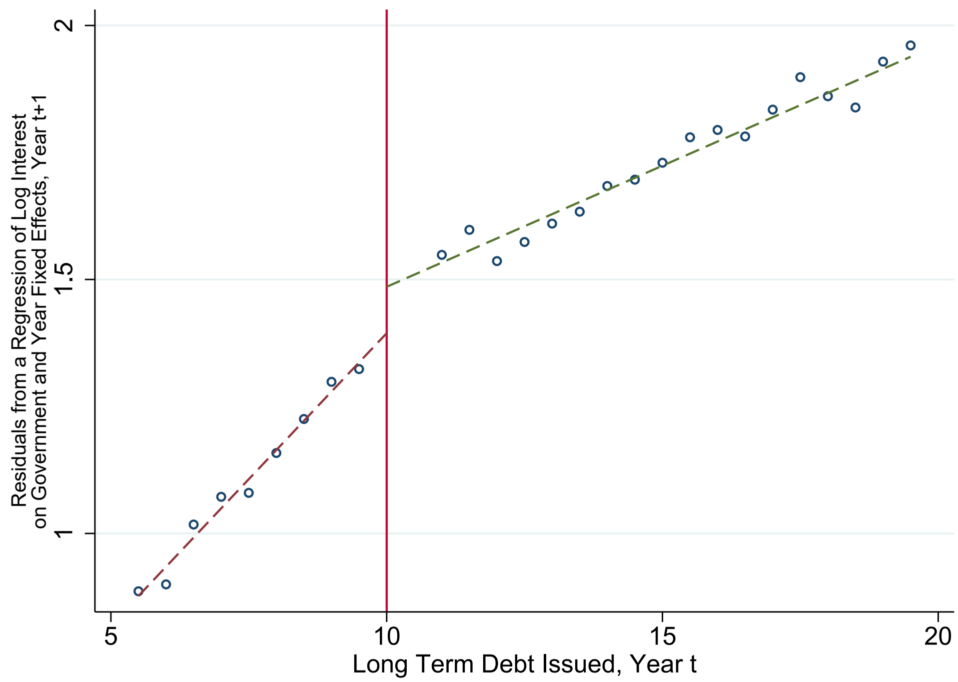
Note: The figure shows the density distribution of long-term debt in 2009 and 2010 when the ARRA temporarily raised the $10 million limit for small issuers.

Figure 4: Bunching Estimation



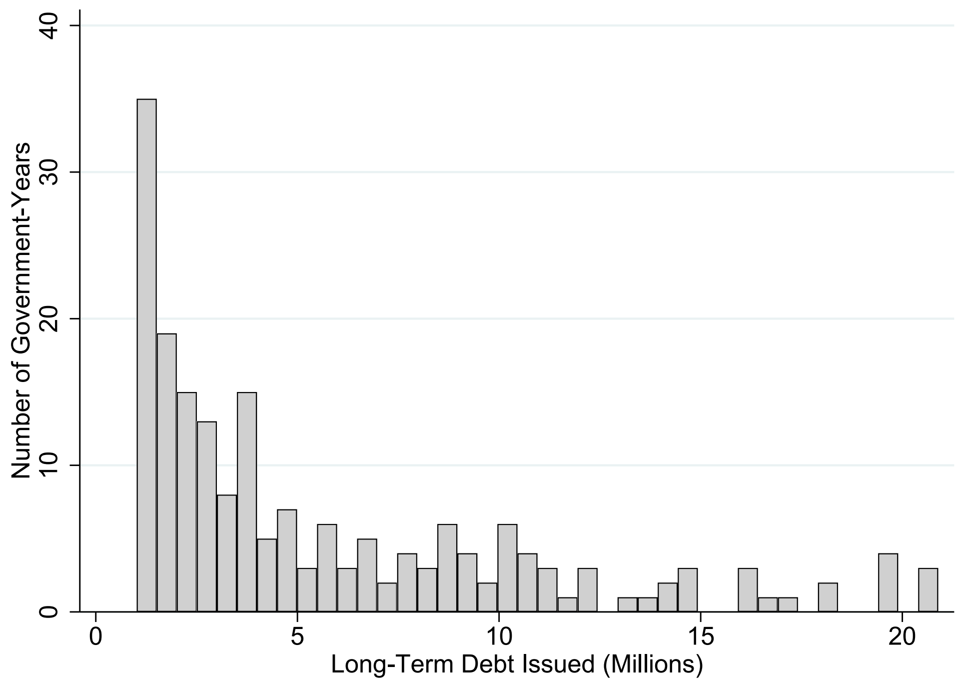
Note: The figures depicts the observed distribution of long-term debt between 1998-2015 (excluding 2009-2010), shown as the mean of bins of size \$500,000, and the modeled counterfactual, based on second order polynomials fit separately to both sides of the notch. The excluded range is \$8.5 - \$14 million.

Figure 5: Mean Interest Expense by Amount of Borrowing



Note: The figure plots residuals from a regression of log interest on government and year fixed effects as a function of the amount of annual long-term debt issued. Each circle represents the mean amount of log interest payments within bins of $500,000. The dashed lines are predicted values from a regression fit to the binned data, allowing for changes in the slope and intercept at the $10 million threshold. One bin on either side of the threshold ($10 mil-$10.5 mil) is omitted.

Figure 6: Refunding



Note: The figure shows the density distribution of long-term debt between 1998-2015 (excluding 2009-2010) for a sample of government-years in which total debt outstanding did not change from the prior year.

Table 1: Summary Statistics

VARIABLES	(1) mean	(2) sd	(3) min	(4) max
Long Term Debt Issued	13	151	0	26,679
Total Debt Outstanding	77	910	0	138,027
Total Interest	3.6	43	0	6,211
Total Taxes	26	307	0	52,398
Own-Source Revenues	45	512	0	96,343
Cash and Securities	70	1,284	0	215,601
Total Expenditures	78	764	0	119,203
County	0.08	0.26	0	1
Municipality	0.11	0.31	0	1
Township	0.04	0.19	0	1
Special District	0.13	0.33	0	1
School District	0.66	0.478	0	1

Note: Financial variables are in millions of 2015 dollars. Data come from the Census of Governments and the Annual Survey of State and Local Government Finances. Summary stats are for 1998-2015, excluding 2009-2010. The variable "Long Term Debt Issued" excludes private purpose debt. The sample is restricted to governments with at least seven consecutive years of observations.

Table 2: Size of Excess Mass

	(1) Total Manip.	(2) In-Range Manip.	(3) Total Manip.	(4) In-Range Manip.	(5) Total Manip.	(6) In-Range Manip.	(7) Total Manip.	(8) In-Range Manip.
Excess Mass	0.0054***	0.26***	0.0049***	0.24***	0.0051***	0.25***	0.0049***	0.20***
	(0.0005)	(0.024)	(0.0008)	(0.038)	(0.0005)	(0.024)	(0.0007)	(0.030)
Missing Mass	0.0032***	0.15***	0.0027***	0.13***	0.0031***	0.15***	0.0032***	0.13***
	(0.0004)	(0.019)	(0.0008)	(0.034)	(0.0004)	(0.019)	(0.0006)	(0.022)
Size of bins	500k		500k		250k		500k	
Polynomial order	2nd		3rd		2nd		2nd	
Excluded range	8.5-14 Mil		8.5 - 14 Mil		8.5 - 14 Mil		8-15 Mil	

Note: *** $p < 0.01$. The table presents estimates of the size of the excess mass and the missing mass. Total manipulation is the excess/missing mass as a percentage of all governments in the sample. In-range manipulation is the excess/missing mass relative to the counterfactual distribution in the range of the missing mass. The polynomial order reflects that order of the polynomials that are estimated separately on both sides of the notch. Block bootstrapped standard errors in parentheses.

Table 3: DiD Results - Interest Cost Differential

	(1)	(2)	(3)	(4)
	$\Delta_{t+1,t}$		$\Delta_{t+1,t-1}$	
Treat*Post	-0.073	-0.086*	-0.144*	-0.159**
	(0.049)	(0.048)	(0.079)	(0.080)
Covariates	No	Yes	No	Yes
N	1,042	1,042	1,044	1,044

Note: * p < 0.1, ** p > 0.05, *** p < 0.01. This table shows estimates of γ based on equation 5. The outcome variable is the change in log interent costs. Columns 1-2 measure the outcome variable as the change in interest costs between years $t + 1$and year t. Columns 3-4 measure the outcome variable as the change in interest costs between years $t+1$ and $t-1$. The covariates include the amount of (log) debt issued, log expenditures, log total debt outstanding, log own-source revenues, and indicator variables for the type of government (school district, etc.). Standard errors are clustered at the level of the government.

Table 4: Donut RD Results - Interest Cost Differential

	(1)	(2)	(3)	(4)	(5)	(6)
$Small_{gt}$	-0.130***	-0.097**	-0.197	-0.175***	-0.140**	-0.408
	(0.047)	(0.045)	(0.260)	(0.061)	(0.059)	(0.377)
Covariates	No	Yes	Yes	No	Yes	Yes
Functional Form	Linear	Linear	Quadratic	Linear	Linear	Quadratic
Excluded Region	$9-11 Mil	$9-11 Mil	$9-11 Mil	$8.5-14 Mil	$8.5-14 Mil	$8.5-14 Mil
N	25,090	25,083	25,083	20,386	20,379	20,379

Note: * $p < 0.1$, ** $p > 0.05$, *** $p < 0.01$. This table presents estimates of the interest rate differential at the notch based on OLS regressions on log interest in year t+1 as a function of the amount of long-term borrowing in year t, allowing for changes in slope and intercept at the $10 million borrowing threshold. The sample includes all government years between 1998-2015 (excluding 2009-2010). The regressions are estimated over the range 5-30 million in debt issued, with observations in the excluded region omitted. All specifications include government and year fixed effects. Covariates include log expenditures and log own-source revenues. Standard errors clustered by government in parentheses.

Table 5: Supply Elasticity of Municipal Debt

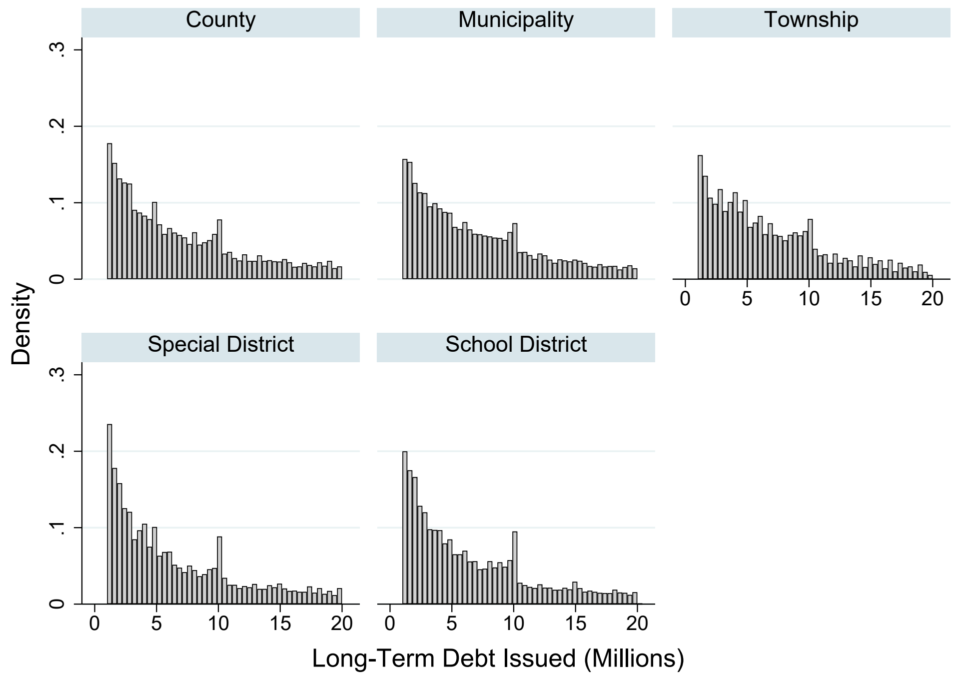
		$\Delta\hat{c}$	
	(1)	(2)	(3)
	0.086	0.130	0.175
	(0.048)	(0.047)	(0.061)
$\Delta\hat{d}$			
-0.046	-0.54	-0.36	-0.26
(0.006)	(0.09)	(0.02)	(0.01)

Note: This table reports estimates and standard errors (in parentheses) of the interest rate elasticity of municipal debt supply for a range of different estimated parameters. The three columns represent low, mid-range, and high estimates of the interest cost differential ($\Delta\hat{c}$). Each cell reports the elasticity implied by the estimated behavioral response ($\Delta\hat{d}$) and corresponding interest cost differential ($\Delta\hat{c}$). Standard errors for the elasticities were calculated using the delta method.

Figure A1: Bunching By Census Years

Note: Figure A1 shows the density distribution of long-term debt during the years of a full census. Excludes private activity debt.

Figure A2: Bunching By Type of Government



Note: Figure A2 shows the distribution of debt by type of government. The sample excludes private purpose debt as well as debt issued between 2009 and 2010 when the small issuer threshold was temporarily increased due to the American Recovery and Reinvestment Act.

Table A1: Size of Excess Mass by Type of Government

	(1) County	(2) Municipality	(3) Township	(4) Special District	(5) School District
Excess Mass	0.20***	0.17***	0.37***	0.28***	0.27***
	(0.074)	(0.051)	(0.102)	(0.064)	(0.031)

Note: * $p < 0.1$, ** $p > 0.05$, *** $p < 0.01$. Table 2 presents estimates of the excess mass by the type of government. The extent of bunching is measured in terms of the in-range manipulation, the excess mass relative to the counterfactual distribution in the range of the missing mass. All estimates use bins of $500k, 2nd order polynomials estimated separately on both sides of the threshold, and an excluded range of $8.5-14 million. Block bootstrapped standard errors in parentheses.