Municipal Capital Structure*

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Abstract

Municipalities provide infrastructure and essential services financed by taxes and debt. We develop a model of municipal capital structure, defined as the debt-to-investment ratio, that rests on two primary economic forces: the elasticity of the tax base with respect to taxes and services, and the process for resolving financial distress. We show how municipalities determine optimal financing, highlighting legal structures governing financial distress, state-by-state variation in allowance of workouts under bankruptcy law, and the pro-creditor leaning of courts. We show that municipalities that issue safe debt, for either political or behavioural reasons, decrease overall welfare.

1 Introduction

The critical importance of well-functioning public infrastructure and essential services is undeniable. In the US context, state and local governments are the primary owners and operators of these systems and are responsible for the majority of their investment requirements.[1] Municipal expenditures are expected to increase even further, since legacy investments in many jurisdictions are in need of renewal or repair, while at the same time new social, technical and ecological imperatives necessitate design, construction and operation of new projects.[2]

Infrastructure spending is ultimately funded by taxpayers, current and future, who implicitly back municipal tax and debt financing choices. Well-developed literature has examined these two financing channels separately. On the one hand, there is a large literature based on the seminal contribution of Tiebout (1956), that examines the economic efficiency of tax financed municipal spending when citizens are free to 'vote with their feet' when choosing where to live. On the other hand, there is a large literature that examines the Municipal Bond Market, a primary source of funding for municipalities.[3] There is, however, a dearth of research into how the mix of debt and taxes – the municipal capital structure – is determined. Our study brings these two strands of the literature together to explain optimal municipal capital structure.

In this paper, we theoretically model investment and financing decisions of "municipal corporations," typically cities, that are granted the authority and responsibility to own, operate, and finance infrastructure. We show how the risks associated with exogenous fluc-

[1]Tomer, Kane, and George (2021, TKG) estimate that state and local governments account for 3/4 of annual public infrastructure spending. The U.S. Bureau of Economic Analysis (2021) reports 2019 state and local fixed asset investment of \$431 B. State and local governments would have ranked second in investment only to US manufacturing (\$555 B, Table 3.7) if infrastructure was classified as an industry.

[2]The American Society of Civil Engineers (2021) forecasts 2020-2029 investment needs of \$5.9 T. Traditional infrastructure accounts for a large share, but highlighting the importance of digital infrastructure and, similar to comments in TKG on infrastructure requirements of resilient and smart cities, the report includes a special note on broadband. Municipal spending will also be impacted by calls for improved social infrastructure in the areas of education, inclusion, and social justice.

[3]For an excellent summary of the Municipal Bond Market see Cestau, Hollifield, Li, and Schürhoff (2019).

tuations in the municipality's tax base and the sensitivity of the tax base to infrastructure quality and tax rates factor into investment and financing decisions. We also study how the municipality's decisions are related to the legal structures that govern repayment and remedies available in financial distress. Our analysis in particular provides insights into the workings of Chapter 9 of the US Bankruptcy Code and demonstrates the consequences of state-by-state variation in how bankruptcy is accessed and applied.

The fiscal history of Detroit, prior to and including its 2013 bankruptcy filing, dramatically illustrates the importance and complexity of municipal debt and financial distress. On June 14, 2013 the city presented a Proposal to Creditors asking for its debt payments to be rescheduled (City of Detroit, 2013). The city argued that its debt burden along with underlying economic factors resulted in default on cash flow obligation to its creditors. Importantly, unlike public corporations, municipal corporations also face a *minimum service obligation* to citizens and Detroit argued it was also not able to meet this obligation. The proposal notes the population of the city had declined by 26% since 2000 and that property tax revenues had shrunk by 20% over the previous five years, despite imposing the highest tax burden in Michigan. Directly highlighting the impact on essential city services, the police department had seen a dramatic decline in manpower resulting in slow response times, low case clearing rates, and a high crime rate.[4] Shockingly, 40% of the street lights did not work. Deterioration of infrastructure had also contributed to out-migration and abandonment of houses. The report notes that there were 78,000 abandoned and blighted structures in addition to 66,000 blighted and vacant lots.

From a corporate finance perspective the Detroit bankruptcy illustrates a number of important questions. What explains a city's choice of debt financing levels? Since there is no tax advantage for municipalities, what is the benefit of debt relative to tax financing? What are the dead-weight costs of municipal financial distress and are they avoided through

[4]Police manpower had fallen by 40% vs. 10 years prior, response times averaged 58 minutes vs. the 11 minute national average, case clearing rates were 8.7% vs. 34% for Pittsburgh, and the violent crime rate was 5 times the national average.

reorganizations? What are the rules of municipal bankruptcy, how do they affect the efficiency of bargaining and reorganization and, recursively, how do they affect investment and debt levels? Should municipalities be required to structure their finances to avoid financial distress? Should municipalities be allowed to access bankruptcy law in addition to contract law? Our theory may be viewed as a model of municipal capital structure, defined as the ratio of debt to investment,[5] that addresses these questions.

Our paper extends the traditional capital structure literature by recognizing that the municipal corporation is fundamentally different from a public corporation. For instance, while the market value maximization objective of a public corporation is well defined, there is no clear equivalent objective for a municipal corporation. Moreover, there is a limited ability of individuals to realize the financial value of their municipal "equity:" For example, a citizen whose taxes helped pay for infrastructure is limited in their ability to monetize any fraction of the value of public assets and services they helped build if they decide to move.[6] In addition, an important contribution of our theory is to recognize that the process by which municipal debt contracts are enforced is fundamentally different from public corporations due to the quasi-sovereign nature of the municipality.

In order to capture the special nature of the municipal corporation we build on Tiebout's (1956) insight that municipal taxes and amenities factor into individuals' location decisions. There are now hundreds of studies of the hypothesis and overall support for the basic assumption that municipal citizens are tax and service elastic.[7] To the best of our knowledge, this literature has not recognized the potential role of debt financing in managing the tax base. A primary contribution of our paper, therefore, is to add debt financing to the municipality's choice set, recognizing the dynamic nature of infrastructure investment, and to

[5]Traditional measures such as debt/equity are conceptually relevant but impractical to apply for municipalities since values of non-excludable and non-rivalrous public assets are difficult to assess.

[6]We recognize that, to varying extents, municipal infrastructure values may be reflected in real estate values. See Oates (1969) for an early empirical analysis of these links.

[7]The importance of tax base elasticity is reflected in the City of Detroit (2013) proposal where "Key objectives for a financial restructuring" are listed, including: "Provide incentives (and eliminate disincentives) for businesses and residents to locate and/or remain in the City." More generally, see Saltz and Capener (2016) for a recent survey of empirical evidence.

show how this determines the municipality's capital structure.

To develop intuition for the advantage of debt in municipal capital structure, consider a municipality constructing durable infrastructure. If no debt is used, the high taxes required today to cash-finance construction might lead some individuals to select a lower tax jurisdiction, thereby increasing the tax burden on those who stay. In future years, conversely, the infrastructure will provide services that have already been paid for, allowing lower taxes and a population rebound. If instead the municipality mixes taxes and borrowing to put the infrastructure in place, fluctuations in the tax burden and migration can be managed, as debt issuance proceeds allow reduction of current taxes but give rise to repayments, and higher taxes, in the future.

In a framework that recognizes these factors and is based on an utilitarian objective function, we identify benefits of using municipal debt to efficiently share infrastructure costs over time and across states. Although we assume that citizens have linear utility, we find that the city as a whole enjoys non-linear benefits from sharing infrastructure costs with debt holders. Concavity in municipality objective functions results from the tax/service elasticity of the tax base when welfare accounts for the number of people who enjoy public infrastructure, the quality of that infrastructure, and the taxes that must be levied to pay for the infrastructure.[8] At the optimal financing structure, therefore, the city will smooth payment for infrastructure over time and across states of the world to equate the quality-adjusted marginal tax burdens.

Is the tax-smoothing benefit of debt affected by the institutional environment in which municipal financial distress is resolved? Answering this question involves more than a reinterpretation of existing models of corporate distress, both because of fundamental differences between municipal and public corporations, as discussed above, and because municipalities have limited sovereignty over their operating and taxing choices, thereby requiring a different

[8] Our municipal objective function differentiates us from Gordon, Guerrón-Quintana, et al. (2021), who maximize a representative household's utility, and Myers (2021), who maximizes a concave function of municipal services. In contrast, our citizens have linear utility but the tax and service elasticity induces concavity in the mayor's objective function.

legal apparatus to resolve financial distress.

From a legal perspective two bodies of law are involved in resolving financial distress for both municipal and public corporations; contract law and bankruptcy law. Contract law provides a process for assessing the legitimacy of a creditor's claim, determining a remedy and employing the power of the state to enforce the remedy. Bankruptcy law is a mechanism that can impose a stay of contract law in order to allow the debtor to propose a reorganization. For municipalities, both bodies of law are constrained by their quasi-sovereign nature. In terms of contract law, property owned by municipal debtors cannot be seized nor can the court dictate operating decisions since both actions could be viewed as an imposition on the ability of elected representatives to govern according to their democratic mandate.[9] US bankruptcy is governed by federal law, which explicitly treats municipalities as distinct from public corporations in Chapter 9 of the Bankruptcy Code. Allowing municipalities unencumbered access to federal law was, however, seen as an infringement on states' responsibility to govern its citizens. As a result and unlike public corporations, a municipal debtor must have the permission of the state to utilize bankruptcy law. Our model allows analysis of the impact of disallowing access to bankruptcy and therefore provides a framework for econometric and policy analysis across states that do or do not allow municipalities to access federal bankruptcy courts.

There are few theoretical studies of municipal debt financing with default. Gordon, Guerrón-Quintana, et al. (2021, GG) addresses complementary questions to ours and provides the only other model we are aware of that jointly studies municipal taxes, debt, and default with an endogenous tax base. While we focus a single municipality's capital structure, their focus is on general equilibrium cross-sections of borrowing, default, and city size. Our mayors internalizes how decisions impact migration, while theirs take equilibrium migration as given when optimizing. Governments in GG place no weight on second-period immigrant

[9] We recognize that there are work-around tactics. Detroit was not able to sell its art gallery or any of the gallery's holdings but was able to monetize it. However, even when economically feasible, seizure is difficult. See Skeel Jr (2015), who also points out limitations of court mandamus orders to satisfy creditor demands.

taxpayer utility, leading to excessive debt. Finally, our model explicitly captures features of US bankruptcy and contract law and studies the impacts of state and court discretion, while GG model default as the arrival of the city's productive assets value process at a lower bound, more along the lines of traditional models of corporate bankruptcy.

Myers (2021) considers municipal insolvency in a setting where governments maximize a concave function of the service flows they provide. This objective may value government spending more than citizens, leading to agency conflicts such as over-reliance on emergency transfers from citizens (bailouts) and excessive risk taking or under-saving in pension asset management. Several other assumptions differentiate our models. Myers focuses on service flows while we focus on long-lived infrastructure, and while in practice governments spend on both, it is important to recognize the different economic and financing consequences of these assumptions. His households do not make location choices, while migration is central to our model of optimal capital structure. Default in his model is largely exogenous while we explicitly model cash-flow and service insolvency. Finally, his focus is on public pensions while ours is on infrastructure and municipal debt.

In section 2 we review the relevant institutional details involved. Section 3 presents the analytical model that we use to capture this setting. We present basic results in Section 4 and conclude the paper in section 5.

2 Institutional Setting

In this section, we sketch out the essential features of municipalities, municipal debt, and applicable bankruptcy law, as well as assumptions we make to represent these institutions.

2.1 Municipal Corporation

A municipal corporation (municipality) is established to provide basic services to individuals who choose to live within a particular geographic area – i.e., it's citizens. A municipality is established through state incorporation which grants corporate status along with a charter that defines its rights, responsibilities, and governance. The political economy underlying municipalities is complex and interesting in many ways. To focus on finance questions, however, we simplify by assuming that decisions are made by a benevolent mayor who has the power to invest in infrastructure, is able to compel citizens to pay taxes, and is able to issue debt on behalf of the municipality.

In practice, the state is also an important player in the governance of municipalities. In addition to granting corporate status, the state monitors the municipality, can restrict debt issuance and taxes, and may intervene in the event of financial distress or mismanagement.[10] We further simplify by assuming that there is no principal-agent conflict between the mayor and the state, so that monitoring and related debt limits are not an issue. Importantly in terms of our study, the state may allow or restrict, conditionally or unconditionally, a municipality's access to bankruptcy law in resolving financial distress. To study the gate-keeping role of the state with respect to the bankruptcy code, we consider games where either the municipality is allowed to apply for bankruptcy protection or ones where they are not.

2.1.1 Municipal Debt

Municipalities defer expenditures using two broadly-defined forms of debt: municipal bonds and pension liabilities. While pension liabilities are economically important and interesting, in order to focus on the overall capital structure decision, we assume that the municipality only issues municipal bonds.

There are two main types of municipal bonds: revenue bonds and general obligation (GO) bonds. Revenue bonds may be used to finance some assets, such as toll bridges, that generate cash flows that can be pledged to bondholders. Although independently interesting, revenue bonds do not raise the novel corporate finance issues that GO bonds do; hence, we

[10] See Moringiello (2017) for a discussion of municipal bankruptcy including the role of the state.

focus on GO bonds. GO bonds are backed by the 'good faith and credit' of the citizens of the municipality, which we assume means payments sourced from tax revenues only.

2.1.2 Financial Distress and Bankruptcy Law

In common with public corporations, municipal financial distress can be the result of cash-flow insolvency. In addition, however, courts have ruled that municipalities can also be 'service insolvent.' This term has evolved through court rulings, the most famous of which may be Judge Steven Rhodes' ruling in the Detroit bankrupcty:[11]

> A large number of people in this City are suffering hardship because of what has been antiseptically called service delivery insolvency. What this means is that the City is unable to provide basic municipal services such as police, fire and emergency medical services to protect the health and safety of the people here.

We capture this aspect of the law by assuming that a municipality with infrastructure below an exogenous minimum quality level is legally consisdered service insolvent. In addition, a reorganization proposal must plan to achieve this minimum quality level in order to be confirmed by a court. The existence of a service standard is in sharp contrast to public corporations where the quality of the product provided is not a separate solvency standard.

If financial distress arises, its resolution may involve the following:[12]

1. **Informal restructuring**, where all claimants to the municipality agree to alter the nature of their claims without the aid of the courts.[13]

2. **State intervention**, where the state may provide emergency funding, technical advice and may appoint an emergency manager who has the power to make operating decisions

[11] As cited from the excellent discussion in Dick (2018).

[12] For an excellent overview of the legal environment see Frost (2014).

[13] For example, the city of Fritch Texas announced that it was unable to meet debt obligations due to what was later shown to be employee fraud. It took legal action against those responsible and subsequently made all payments on its debt (City of Fritch, Texas (2021).)

and renegotiate the municipality's obligations.[14]

3. **Contract court**, where debt holders petition to enforce a remedy when a debtor has defaulted on the debt contract. For a public corporation, this involves obtaining the right to seize the debtor's property. In contrast, for a municipality: "Instead of a property basis, municipal credit has a public purpose basis" Moringiello (2017). Moreover, the courts are limited in their ability to direct the city to implement a particular solution to the financial distress.[15]

   Despite the somewhat imperfect mechanism available to contract courts, we assume that the court is able to enforce a repayment amount that is the most that can be repaid while still meeting the minimum service requirement discussed above.

4. **Bankruptcy court**, which has the power to suspend creditor actions taken under contract law in order to allow a debtor to propose an adjustment to the debt contract. In the US this involves Chapter 9 of the bankruptcy code which, as discussed below, is fundamentally different from the more familiar Chapter 11.

2.2 Chapter 9 versus Chapter 11

As Moringiello (2017) states, "Bankruptcy law is property law," while for municipalities, "...municipal bankruptcy law is not property law. The Code explicitly prohibits the court from interfering with the municipality's property ... ." Chapter 9 therefore grants greater power to the debtor than does Chapter 11 in that it provides a barrier to property seizure and operating oversight. In addition, while both Chapter 11 and Chapter 9 allow the creditor the exclusive right to present a proposal to the court, the exclusivity period in Chapter 11 is

[14]For example, the Governor of Michigan appointed an 'emergency manager' for the City of Detroit who was in place when the city filed a Chapter 9 petition. See Gilson, Mugford, and Lobb (2020).

[15]For instance, the court is not able to direct the city to increase taxes. It is able, however, to issue a *writ of mandamus* directing an officer of the city to increase taxes. The effectiveness of this is dampened by the fact that the officer need not comply with the writ if prohibited to by state law. Moreover, the officer to whom the writ is directed may also resign from the position, making the writ ineffective and requiring the issue of a new writ.

90 days whereas in Chapter 9 it is indefinite. On the other hand, bondholder entitlement in Chapter 9 is protected by the vague requirement that the proposed adjustment is made 'in good faith' and is 'in the best interests of the creditors.' This requirement grants considerable discretion to the court, as noted by Buccola (2017):

> What substantive rights creditors have are secured by the vague 'best interest' standard, which in practice allows the bankruptcy judge to impair creditors' claims by however much he thinks reasonable ...

Given that Chapter 9 explicitly considers the public purpose, the 'best interest' requirement grants judicial discretion over what is considered an acceptable reorganization in a way that could favour the municipality. We capture this in our model by explicitly recognizing the pro-creditor leaning of the court.

The court also has two important controls over the municipal debtor: the ability to deny a municipality the right to have their petition heard (admission control) and the ability to refuse to confirm a proposed reorganization (exit control). If the court does not allow a case to be heard or if it refuses to confirm a proposal, the case is adjudicated through contract law. In terms of admission, a municipality is considered eligible for Chapter 9 if: a) It is insolvent; b) It has attempted to negotiate with its creditors but has failed to reach an agreement, and; c) The state has given the municipality permission to file for Chapter 9 protection.[16] If these conditions are not met, the court may deny the municipality the advantages of Chapter 9.[17] In terms of exit, the court will confirm a proposal if: a) It is feasible, in that the proposal is expected to meet budget and minimum service constraints, and; b) It is a 'good faith offer' that is in the 'best interests' of the creditors, as discussed above. If the proposal is not confirmed, the debt adjustment is undertaken without the protection of Chapter 9.

[16]See Gao, Lee, and Murphy (2019) and The Pew Charitable Trusts (2013) for extensive overviews of the differences in state restrictions.

[17]For example, Bridgeport Connecticut filed a Chapter 9 petition on June 6, 1991, arguing that to meet its debt obligations the city would have to raise taxes by 18% and cut services. The petition was dismissed on August 1, 1991 when the judge ruled Bridgeport was not insolvent. For a discussion of the case see Dubrow (1992).

3 Model

We assume the existence of a municipal corporation established under state law, and we study a model with three dates, denoted $t \in \{0, 1, 2\}$.

3.1 Agents

The municipal corporation interacts with four groups of agents: citizens or the tax base (N), the mayor (M), a bond holder (B), and a court (C). All agents are risk neutral and the discount rate is zero. Nature determines the only exogenous risk in our model by selecting a state contingent population shock ϵ^i, where $i \in \{+, -\}$ is the state of the world revealed to all parties at $t = 1$ and realized at $t = 2$. For convenience, assume $\epsilon^- \leq 0 \leq \epsilon^+$ and $|\epsilon^-| = |\epsilon^+|$. Let p denote the probability of $i = +$, hence, $p > .5$ implies a municipality that is expected to grow.

At $t = 0$ the municipality makes investment and financing decisions which attract an initial population to the city. At $t = 1$ information arrives about the population shock and, based on the information, renegotiation of the issued debt takes place but no other decisions are made. Finally, at $t = 2$ the court rules on any petitions presented to it, after which final investment, taxation and debt repayment decisions are made. The structure of our model is depicted in Figure 1.

3.1.1 The Municipality

The municipal governance structure empowers a mayor with taxing and investment authority.[18]. We specifically assume that the mayor assesses and collects taxes from each resident at $t = 0$ and $t = 2$ of $\tau_0 \geq 0$ and $\tau_2^i \geq 0$, respectively. These taxes represent the per capita dollar value of all taxes under the municipality's control.[19]

[18] Ahern (2021) provides an excellent overview of municipal operating and financing decisions for a sample of large US cities.

[19] For example, municipalities may be able to impose some or all of property tax, sales tax, income tax, hotel taxes, user fees, etc., sometimes with self imposed or state restrictions. We treat these as one form of

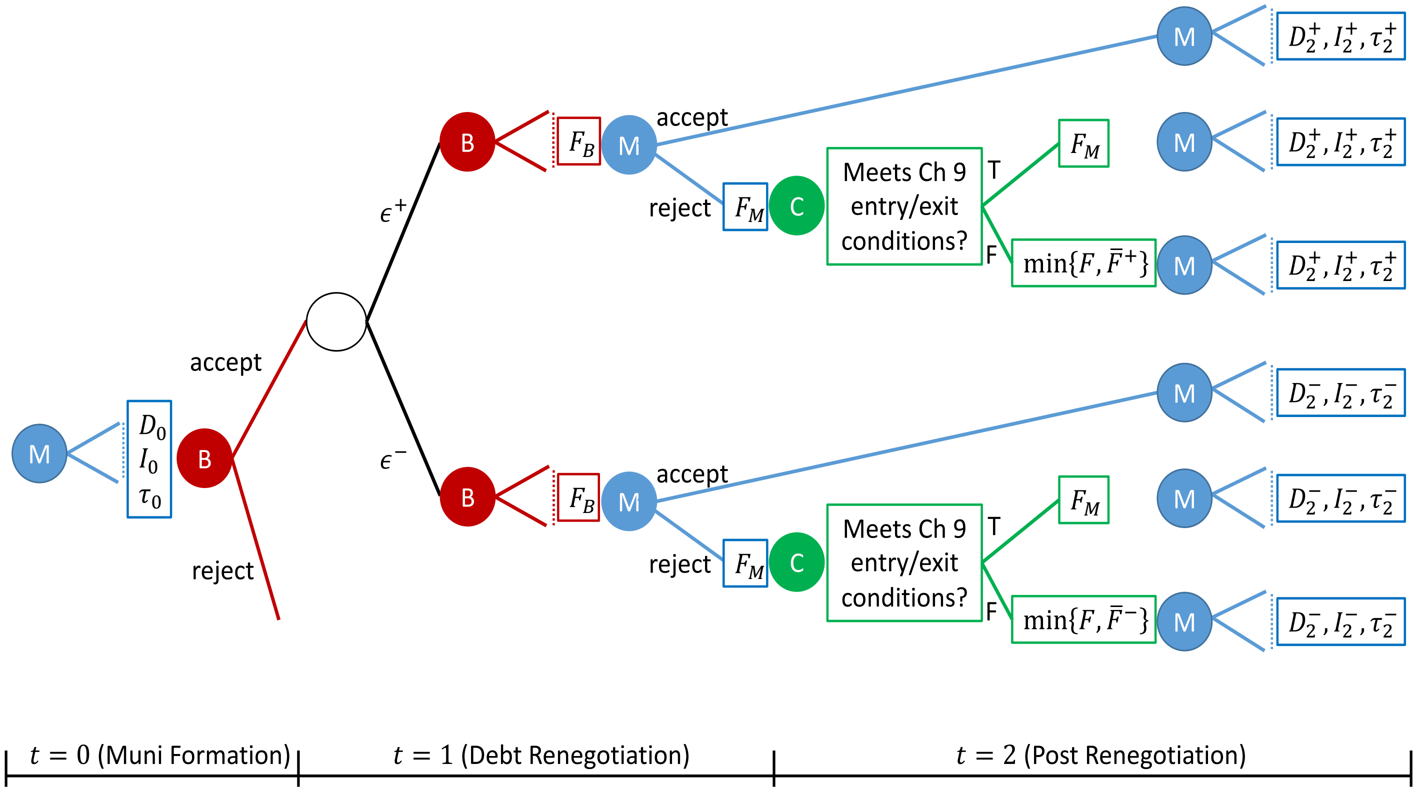

Figure 1: **Game Structure**

To model investment, we assume the mayor installs durable municipal infrastructure requiring an initial outlay of I_0. Let the replacement cost of municipal infrastructure at $t = 0$ be denoted by A_0 and assume:

$$A_1 = A_0 = I_0 \tag{1}$$

$$A_2^i = (1 - \delta)A_1 + I_2^i \tag{2}$$

where δ is exogenous depreciation and $I_2^i \geq -(1 - \delta)A_1$ is incremental investment ($I_2^i \geq 0$), or disinvestment ($I_2^i < 0$), conditional on the population shock ϵ^i. Let $A_1 = A_0$ and We further assume that disinvestment generates a positive cash flow to the municipality of $-I_2^i$ but also involves a dead-weight decommissioning cost of γI_2^i. Hence, the dead-weight cost of

taxation.

disinvestment is $(\Gamma(I_2^i) \times I_2^i)$ where

$$\Gamma(I_2^i) = \begin{cases} 0 & \text{if } I_2^i \geq 0 \\ \gamma & \text{if } I_2^i < 0. \end{cases}$$

The parameter γ captures the degree of reversibility in the city's investment technology.[20]

3.1.2 Citizens/tax base

The municipality's residents enjoy utility from unmodelled private consumption as well as the consumption of public infrastructure, modelled as a public good following Samuelson (1954). Each person's utility from consumption of infrastructure, net of the tax dis-utility, is additively separable from private consumption and is given by

$$u = q - \tau \tag{3}$$

where

$$q = \beta \times A, \quad \beta > 0 \tag{4}$$

is the service each individual enjoys from the infrastructure.[21] Each resident must either pay taxes or move to another municipality and does so based on whether or not u_0 and u_2^i meet some unmodelled heterogeneous participation constraint.

Incorporating these factors in reduced form, we model the tax base at $t = 0$ as

$$N_0 = a + bq_0 - c\tau_0 \tag{5}$$

$$N_2^i = a + \epsilon^i + bq_2^i - c\tau_2^i \tag{6}$$

where $\{a,\ b,\ c\}$ are positive, exogenous constants.

[20] We have also considered irreversible investment but to focus on our main issues we omit that analysis.

[21] This specification assumes that infrastructure is both non-excludable and non-rivalrous.

Aggregate tax revenues at $t = 0$ and $t = 2$ are therefore $N_0 \tau_0$, and $N_2^i \tau_2^i$, respectively.

General Obligation Bonds

The mayor's authority includes an ability to borrow, which we model as municipal issuance of GO bonds described above in Section 2.1.1. Debt contracts are characterized by a promised single contractual face value $\tilde{F}_t$ payable at time $t = 2$. The contractual amount begins at a value of $\tilde{F}_0 = F$ when the municipality issues the bond. Between $t = 0$ and $t = 2$ $\tilde{F}_t$ evolves as described below through renegotiation and the court process. The final value of $\tilde{F}_2$ is enforced by the court and results in a payment to the bondholders of $\tilde{D}_2 = \tilde{F}_2$. This equality reflects the assumption that, at the maturity of the bond, the potential of formal court enforcement backs full repayment of the final contractual amount.

3.1.3 Bond Holder

The bond holder is assumed to be competitive in the sense of having unlimited funds and a willingness to acquire any asset providing an expected return of at least zero. At $t = 0$ the bond holder is offered a bond with face value F and an asking price of D_0 and either accepts or rejects the offer. If the proposal is accepted, then at $t = 1$, based on information about the impending population shock ϵ^i, the debt holder rationally anticipates how the debt enforcement game will be played and proposes a new face value of F_B that maximizes $E_1(D_2^i)$. At $t = 2$, D_2^i is received from the municipality and no further action is taken by the bond holder.

3.1.4 The Mayor

Objective

The mayor evaluates welfare flow as the sum of current citizens' single period utility flows.

Welfare flows are therefore defined by

$$W_0(\tau_0, q_0) = N_0(q_0 - \tau_0) = (a + bq_0 - c\tau_0)(q_0 - \tau_0) \tag{7}$$

$$W_2(\tau_2^i, q_2^i, \epsilon^i) = N_2^i(q_2^i - \tau_2^i) = (a + \epsilon^i + bq_2^i - c\tau_2^i)(q_2^i - \tau_2^i). \tag{8}$$

At $t = 0$, anticipating time $t = 2$ welfare given any current choice, the mayor maximizes

$$V_0 = W_0(\tau_0, q_0) + E_0(W_2(\tau_2^i, q_2^i, \epsilon^i)), \tag{9}$$

while at $t = 2$ the mayor maximizes

$$V_2^i = W_2(\tau_2^i, q_2^i, \tilde{\epsilon}). \tag{10}$$

Actions

At $t = 0$ the mayor determines the size of the initial investment, I_0, and finances this with debt and taxes. To raise debt proceeds, the mayor offers a debt contract with face value F to bondholders at a price of D_0. If the offer is rejected, the game ends. If the offer is accepted it becomes the contractually owed amount $\tilde{F}_0$. In any equilibrium, the offering price satisfies $D_0 = E_0(D_2^i)$ and the contract is accepted.[22] The mayor then constructs the infrastructure and imposes a per person tax rate of τ_0 on each citizen, thereby raising aggregate tax revenue of $N_0\tau_0$.

At the $t = 1$ negotiation stage, if the proposed bond has been accepted the mayor must respond to the bondholder's proposal of F_B by either accepting the offer or filing a Chapter 9 petition requesting the court to adjust the promised debt payment to F_M.

At $t = 2$ the court rules on any petitions that have been filed and the mayor selects (τ_2^i, I_2^i, D_2^i) while honouring the court's mandated contractual payment.[23]

[22] We introduce the equation for D_0 here to aid exposition in the next section. Our justification for the equation is presented in Section 3.3.

[23] The court process that determines D_2^i is set out in Section 3.2.

Constraints

The mayor's choices at $t = 0$ and $t = 2$ must lead to infrastructure quality in excess of the minimum service requirement that we model as an exogenous constraint $q \geq q_L$. This implies a lower bound $A_L \geq q_L/\beta$ on the replacement value of infrastructure, or alternatively minimum investment amounts satisfying

$$I_0 \geq \frac{q_L}{\beta} \tag{11}$$

$$I_2^i \geq \frac{q_L}{\beta} - (1-\delta)A_0. \tag{12}$$

The mayor must also balance the city budgets:

$$N_0\tau_0 + D_0 = I_0 \tag{13}$$

$$N_2^i\tau_2^i = \big(1 - \Gamma(I_2^i)\big)I_2^i + D_2^i. \tag{14}$$

3.2 Debt Enforcement

Debt enforcement begins at $t = 1$ with the revelation of ϵ^i, the public information regarding the shock to the tax base that will occur at $t = 2$. We assume that, based on the information about ϵ^i, the bondholder moves first by proposing an adjustment of the face value from F to F_B. The mayor moves next by either accepting the adjustment, in which case a new contract replaces the existing contract, i.e., $\tilde{F}_1 = F_B$, or rejecting the proposal by filing a petition with the court to confirm a new contract with a face value of F_M.

If at $t = 2$ the mayor has accepted B's proposed adjustment then $\tilde{F}_2 = F_B$. Alternatively, the mayor has rejected the offer and filed a petition with the court to confirm that $\tilde{F} = F_M$. The judge first makes an admission decision: If admitted, the petition for an adjustment of the face value to F_M is adjudicated under Bankruptcy Law; if dismissed, the original contract with face value F is adjudicated under contract law. The judge's exit decision under bankruptcy law is either to confirm the proposed adjustment or to reject it and impose bondholder payments consistent with contract law. We now formalize these assumptions.

3.2.1 Bankruptcy Admission Conditions

The court uses bankruptcy law to consider the mayor's proposal if it finds that the municipality is *insolvent*, that is the court deems that there is no tax rate that would allow repayment of $\tilde{F}_1$ while achieving the minimum service level. Accordingly, to make a ruling the court first computes the maximum payment that could be made to an outside claimant in the current state:[24]

$$\bar{F}^i = \max_{I,\tau} \left(a + \epsilon^i + b\beta \big[A_0(1-\delta) + I \big] - c\tau \right) \tau - \big(1 - \Gamma(I) \big) I \tag{15}$$

subject to

$$I \geq A_L - (1-\delta)A_0.$$

In each state i, the court will rule that the firm is insolvent and therefore consider the proposal under bankruptcy law if the following *insolvency condition* holds:

$$\tilde{F}_1 \geq \bar{F}^i. \tag{16}$$

Given the enforcement rules we have adopted, we can, without loss of generality, require that $F, F_B, F_M \leq \bar{F}^+$.[25] Hence, bankruptcy law is only relevant for a city in decline.

If the court does not grant admission to bankruptcy law, it then applies contract law to the dispute by requiring that $\tilde{F}_2 = \bar{F}^i$.

3.2.2 Bankruptcy Exit Conditions

If the petition is considered under bankruptcy law then the proposed contract is confirmed if the court rules that the proposal, F_M, is feasible and is made in 'good faith.' It is feasible

[24]See Appendix D for closed form solutions to the following optimizations.
[25]We discuss this further in Appendix B.

if the municipality is able to pay F_M and provide a quality level of at least q_L. A contract is considered to be made in good faith if it provides a minimum acceptable payment as determined by the court.

As discussed in Section 2.2, there is considerable judicial discretion in defining an offer that is 'made in good faith' and is 'in the best interests of the creditors'. To capture this discretion, we assume the judge uses a weighted average of the mayor's best possible contract and the bondholders' best possible contract. The best outcome the mayor can hope for is that the new face value would be $\tilde{F}_2 = 0$. The best outcome the bondholder could expect is $\tilde{F}_2 = \bar{F}^i$. To satisfy the exit condition, the court will therefore confirm any F_M satisfying

$$F_M \geq \pi \bar{F}^i \tag{17}$$

where $0 \leq \pi \leq 1$ is exogenous and represents the *pro-creditor leaning* of the court.

If the court does not confirm M's proposal, it then applies contract law to the dispute by requiring that $\tilde{F}_2 = \bar{F}^i$.

3.2.3 Debt Enforcement Summary

In summary, contract enforcement will result in:

- $\tilde{F}_2 = F_B$, if B's offer is accepted by the mayor;
- $\tilde{F}_2 = F_M$, if B's offer is rejected by the mayor and the court confirms the mayor's proposal under bankruptcy law, and;
- $\tilde{F}_2 = \min\{F, \bar{F}^i\}$ if the court rejects the mayor's petition and uses contract law to resolve the dispute.

In all cases, the court ensures that the municipality pays the bondholder $D_2^i = \tilde{F}_2$.

3.3 Equilibrium

We examine sub-game perfect equilbria by solving the game recursively, and further restrict attention to pure strategies. Beginning with the final decision, the mayor honours the court's determination and accordingly makes payment $D_2^i = \tilde{F}_2$. Constrained by the repayment obligation, the mayor optimally selects I_2^i and τ_2^i.

Prior to the mayor's final choices the court acts as a strategic dummy that follows the rules set out above. It turns out that, although there are many possible equilibrium offer- and counter-offer strategies, due to the assumed behaviour of the court and the fact that all agents have full information, for a given enforcement structure (i.e. q_L and π), all strategies will lead to the same D_2^i. Consequently, for each enforcement structure we will only discuss one set of equilibrium strategies.

Prior to the court's rulings, the mayor either accepts B's offer or proposes F_M. Consider first the sub-game where the mayor rejects F_B and files a petition for an adjustment F_M. If the municipality is solvent, the court will not allow the case to be heard under bankruptcy law and will enforce $\tilde{F}_2 = F$ under contract law. Hence, if solvent, the mayor will propose $F_M = F$. If insolvent, for any $F_M < \pi\bar{F}_2^i$ the court will reject the petition and, under contract law, impose $\min\{F, \bar{F}^i\} \geq \pi\bar{F}_2^i$. Since the welfare of the municipality is decreasing in D_2^i, the mayor will offer $F_M = \pi\bar{F}_2^i$.

Next consider the consequences of the mayor accepting F_B. As we have just seen, if solvent and the bondholder offer is rejected, the payment will be $D_2^+ = F$. Hence, the mayor will only accept $F_B \leq F$. If insolvent, the mayor realizes rejection leads to $\pi\bar{F}_2^-$ and hence will only accept an offer of $F_B \leq \pi\bar{F}_2^-$.

Now consider B's offer of F_B, based on the knowledge of ϵ^i. Understanding the mayor and the court's responses, B will maximize $E_1(D_2^i)$ by offering $F_B = F$ to a solvent municipality and $\pi\bar{F}_2^-$ to an insolvent mayor as all other offers would be rejected.

At $t = 0$ B must either accept or reject the mayor's debt offer of $\tilde{F}_0 = F$ at a price of D_0. B will accept this offer if $D_0 \leq E_0(D_2^i)$. It is clear that, for any $\tilde{F}_0 = F$ the mayor will set $D_0 = E_0(D_2^i)$.

Finally, the game begins with the mayor selecting (τ_0, I_0, F) in order to maximize (9), based on rational expectation of all the above

In Appendix C we set out necessary parameter restrictions to ensure existence of an equilibrium. Our analytic analysis in Appendix D provides expressions for τ_0, τ_2^i, F and D_0/I_0 *for any investment policy.* However, we require numerical methods to solve for the optimal investment policy. We provide analytical details on the equilibrium choices of the players in Appendix D and characterize these choices numerically in the next section.

4 Model Solutions

In order to provide a benchmark, we begin analysis of our model in Section 4.1 by characterizing the municipality under the assumption that the mayor can issue securities specifying state-contingent repayments. In this setting, rather than solving the recursive game described in the previous section, the mayor selects state contingent values of investment and taxes subject to the static constraint that *total discounted expected* tax revenues and infrastructure expenditures are equal. This benchmark solution that we label 'first-best' implicitly utilizes pure securities that allow funds to be transferred between dates and states to meet budget constraints.

We then analyse solutions when the mayor issues standard debt specifying a state-independent face value repayment but possibly subject to default. In Section 4.2.1 we examine the equilibrium when mayors have access to bankruptcy law, followed in Section 4.2.2 when they do not. Finally, in Section 4.2.3 we consider the possibility that, due to political or behavioral reasons, the mayor chooses to finance infrastructure with safe debt.[26]

Our numerical solutions are based on parameter assumptions itemized in Table 1. Our model is designed to provide economic insight into optimal municipal capital structure but not to produce realistic empirical moments. We therefore utilize the numerical optimiza-

[26]See the Appendix for technical details on the solution approach, specific formulas, and proofs.

tion results to compare and contrast the economic forces at play and to give insights into comparative statics across the cases we study.

Table 1: Parameter Values

Parameter	Value	Description
p	0.9	Probability of ϵ^+
ϵ^+	25.0	Population shock
a	100.0	Population base
b	1.0	Quality sensitivity
c	100.0	Tax sensitivity
β	0.1	Public good utility (per unit q)
γ	0.7	Decomissioning cost (%)
δ	0.1	Public good depreciation
q_L	1.0	Minimum standard of public good
π	0.6	Bondholder recovery (per unit $\overline{F}$)

4.1 The Mayor's Complete Markets Solution

The mayor's formal optimization problem under state-contingent contracting is

$$\max_{\{I_0, I_2^+, I_2^-, \tau_0, \tau_2^+, \tau_2^-\}} V_0 = W_0(\tau_0, q_0) + pW_2(\tau_2^+, q_2^+, \epsilon^+) + (1-p)W_2(\tau_2^-, q_2^-, \epsilon^-) \tag{18}$$

subject to the public asset replacement value initial condition (1) and dynamic equations (2); the mapping from replacement value to quality (4); the per-period welfare flow definitions (7) and (8); the population equations (5) and (6); the minimum service constraints (11) and (12), and; the time $t = 0$ budget constraint

$$N_0\tau_0 + pN_2^+\tau_2^+ + (1-p)N_2^-\tau_2^- = I_0 + pI_2^+ + (1-p)I_2^-. \tag{19}$$

Given a solution, pure security repayments D_2^+ and D_2^- can be recovered from the time $t = 2$ budget constraints (14), and issuance proceeds can be calculated using the pricing relationship $D_0 = E_0(D_2^i) = pD_2^+ + (1-p)D_2^-$. We are not able to analytically solve for all six choice variables but given any investment policy $\{I_0, I_2^+, I_2^-\}$ (equivalently $\{q_0, q_2^+, q_2^-\}$) there exist explicit formulas for optimal tax levels $\{\tau_0, \tau_2^+, \tau_2^-\}$.[27] The municipal debt Euler equations are central to our solution strategy:

$$\frac{\mathrm{MTR}_0}{q_0} = \frac{MTR_2^+}{q_2^+} = \frac{\mathrm{MTR}_2^-}{q_2^-} \tag{20}$$

where $MTR_t^i = \frac{d}{d\tau_t^i} N_t^i \tau_t^i = a + \epsilon^i + bq_t^i - 2c\tau_t^i$. These Euler equations provide insight into the economic determinants of optimal municipal capital structure and illustrate the fundamental differences between the capital structure decisions of public and municipal corporations. Capital structure theory for public corporations shows that, for any level of real investment, optimal financing equates the marginal tax advantage of debt with marginal direct or indirect bankruptcy costs. For a municipality, also taking investment as fixed, we see a fundamentally different trade off where debt balances quality-adjusted marginal tax revenues over time and across states. That is, municipalities have an interior optimal capital structure in our model, despite the fact that there are no tax benefits or bankruptcy costs associated with debt, that optimally shares tax burdens across generations.

Table 2 presents the optimal choice variables and endogenous outcomes at the complete markets solution. At $t = 0$ the mayor puts in place infrastructure with a replacement value of $A_0 = 61.26$, a quality level of $q_0 = 6.13$, and sets per capita taxes at $\tau_0 = 0.34$. With this tax burden and infrastructure quality, $N_0 = 72.51$ individuals reside in the municipality and total time $t = 0$ tax revenue is $N_0 \times \tau_0 = 24.38$.[28] The remainder of the infrastructure investment ($D_0 = 36.88$) is financed by state-contingent security proceeds: The mayor sells pure security claims repaying $D_2^+ = 39.52$ in the growth state and $D_2^- = 13.14$ in the decline state.

Following common practice in complete market settings, we assume that if the mayor does not voluntarily honour the pre-specified payments D_2^+ and D_2^- then contract courts

[27] See, e.g., equations (40) and (41) that provide a closed-form solution for τ_2^-.

[28] We report output to two decimals, leading to rounding errors when multiplying values.

Table 2: Model Summary: Complete Contracts

Variable	t = 0	t = 2	
Population shock (ϵ^+)	0.00	25.00	-25.00
Population (N)	72.51	82.76	57.76
Endogenous Migration	0.00	-14.75	10.25
Quality (q)	6.13	5.51	5.51
Taxes (τ)	0.34	0.48	0.23
Investment (I)	61.26	-0.00	0.00
Debt payments (D)	36.88	39.52	13.14
Capital structure ($\frac{D_0}{I_0}$)	60.21		
Debt per capita ($\frac{D_0}{N_0}$)	0.51		
Maximum recovery ($\bar{F}$)		53.23	27.98
MTR/quality ratio ($\frac{dW_t^i/d\tau_t^i}{q_t^i}$)	6.35	6.35	6.35
Welfare flow (W)	419.80	416.75	305.29
Welfare (V)	825.41		

will enforce full repayment. There are, consequently, no actions of interest at date $t = 1$.

At $t = 2$ the decisions of the mayor are contingent on the exogenous population shock. Consider the growth state first. In the absence of any change in tax or investment policy, $\epsilon^+ = 25$ additional people would move to the city which, without 'endogenous migration' due to marginal tax and investment decisions, would leave the municipality with a population of 97.51. The mayor must repay $D_2^+ = 39.52$ to the city's lenders, decide on any additional infrastructure investment, and set a tax rate to balance the budget. To maximize welfare, the mayor finds it best to make no additions to infrastructure, $I_2^+ = 0$, leaving the replacement value at its depreciated level $A_2^+ = 55.1$, thereby providing quality of $q_2^+ = 5.51$. Taxes are required to cover only security repayments, necessitating an increase in taxes to $\tau_2^+ = 0.48$. Factoring in the positive exogenous population shock ($\epsilon^+ = 25$) and the negative endogenous migration due to reduced service quality and higher taxes (-14.75 citizens), the time $t = 2$ population grows to $N_2^+ = N_0 + 25 - 14.75 = 82.76$.

Next consider the population decline state where the required pure security payment is $D_2^- = 13.14$. Again, no new investment is optimal $I_2^- = 0$, and the mayor selects taxes of $\tau_2^- = 0.23$, less than half the tax level in the growth state. Lower taxes lead to endogenous migration of 10.25 citizens, offesting the exogenous population shock and leading to a population of $N_2^- = N_0 - 25 + 10.25 = 57.56$.

Summarizing qualitatively, with pure securities the mayor invests in initial infrastructure that will provide benefits to both current and future citizens. Interestingly, the city builds at time $t = 0$ for the growth state such that no new infrastructure is built conditional on a positive population shock.[29] Financial markets allow sharing of the costs between generations and across states. Included in the optimal plan are dramatically lower lender repayments in the event of a negative population shock ($D_2^- \approx 0.33 D_2^+$), e.g., such as a major employer shutting down or moving out of the city.

The numerical example illustrates that at the optimum, pure securities provide sufficient financing flexibility to optimally share the tax burden of investment according to the Euler equations

$$\frac{MTR_0}{q_0} = \frac{\mathrm{MTR}_2^+}{q_2^+} = \frac{MTR_2^-}{q_2^-} = 6.35. \tag{21}$$

The municipality's optimal 'capital structure' sets $D_0/I_0 = 60.21\%$, indicating that the majority of the initial infrastructure investment is financed by deferred payments. In fact, the per capita value of state-contingent claims, $D_0/N_0 = 0.51$, exceeds taxes.

4.2 The Mayor's Solution with Traditional Debt

We now consider the Mayor's optimal choice of investment and financing when pure securities are not available. We solve the mayor's problem in three special cases where: 1) Chapter 9 is available to municipalities; 2) Chapter 9 is not available to municipalities, and; 3) Mayors avoid financial distress by issuing safe debt.

[29]This is a consequence of our assumption that the financial rate of return is zero but, except when depreciation is complete, the real rate of return from infrastructure is positive. Under any circumstance where a time $t = 2$ investment ΔI would increase the welfare flow W_2^+, the mayor could instead put additional assets $\Delta I/(1-\delta)$ in place at time $t = 0$ and thereby benefit both generations, effectively a strictly positive NPV investment.

4.2.1 Chapter 9 – Equilibrium with Access to Bankruptcy Law

Recall from our equilibrium description in Section 3.3 that Chapter 9 is relevant to municipalities only in the decline state since cities will be legally solvent in the growth state. Furthermore, following from the admissibility criterion for bankruptcy whereby if mayors petition the court they must offer $F_M \geq \pi \bar{F}^-$, we compute investment, taxes, and financing decisions subject to $t = 1$ bondholders offering, and the mayor accepting, the following equilibrium final contractual amounts:

$$F_B = \begin{cases} F & \text{if } \tilde{\epsilon} = \epsilon^+; \\ \pi \bar{F}^- & \text{if } \tilde{\epsilon} = -\epsilon. \end{cases} \tag{22}$$

Date $t = 2$ state-contingent bondholder payments are therefore $D_2^+ = F$ and $D_2^- = \pi \bar{F}^-$.[30] Given this specification of final debt payments, we show in the appendix that the mayor's equilibrium choices at $t = 0$ and $t = 2$ can be obtained by selecting only three endogenous variables, $\{q_0, q_2^+, q_2^-\}$, to maximize a single non-linear, tri-variate objective subject to non-linear constrains.

Unlike in the first-best case, the Euler equations no longer hold across all states. The mayor's flexibility to choose the face value of debt, which is the repayment to bondholders conditional on growth ($D_2^+ = F$), but their inability to directly choose the debt payment in the decline state ($D_2^- = \pi \bar{F}^-$), leads to:

$$\frac{MTR_0}{q_0} = \frac{MTR_2^+}{q_2^+} = 6.36 > \frac{MTR_2^-}{q_2^-} = 5.07. \tag{23}$$

The impact of Chapter 9 is perhaps most apparent when we consider the fate of a municipality in decline relative to outcomes in the complete contracts case (see the third columns of Tables 2 and 3). The most important differences are that the mayor repays more to bondholders ($D_2^- = 16.84 > 13.14$), increases taxes ($\tau_2^- = 0.28 > 0.23$), and must sell infrastructure,

[30] The formula for $\bar{F}^-$ is dependent on only one choice variable, q_0, and thus fully specified given I_0.

allowing a balanced budget ($I_2^- = -7.96 < 0$) but reducing quality ($q_2^- = 4.74 < 5.51$).[31] The net impact of the negative population shock, $\epsilon^- = -25$, is therefore, more severe than in the first best case, resulting in a less populated city ($N_2^- = 51.91$ vs. 57.76).

The differences can also be illustrated in terms of welfare comparisons. Overall welfare in the Chapter 9 regime is below first best ($V = 824.07 < 825.41$). This seemingly small difference masks the fact that the welfare costs of financial distress are not shared equally by all generations of citizens. In fact, the $t = 0$ initial and $t = 2$ growth state welfare are slightly larger than in first best ($W_0 = 423.03 > 419.8$, $W_2^+ = 419.84 > 416.75$). This follows because higher recovery in default leads the mayor to optimally raise greater debt proceeds ($D_0 = 37.23 > 36.88$) , while (weakly) reducing taxes ($\tau_0 = 0.33 < 0.34$, $\tau_2^+ = 0.48$) and delivering higher quality ($q_0 = 6.16 > 6.13$, $q_2^+ = 5.54 > 5.51$). The decline state citizens, however, through higher taxes and infrastructure sales, bear the costs of higher bondholder recovery in distress and suffer significant welfare loss relative to first-best ($W_2^- = 231.85 < 305.29$).

A critical determinant of the impact of bankruptcy law is the pro-creditor leaning of the court, π. Recall that this parameter is used to represent what a judge would require for a proposal to be a good-faith offer that addresses the best interests of the creditors. Figure 2 graphically depicts welfare differences as we vary the pro-creditor leaning of the court. The figure clearly shows that decline state citizens carry the burden of accomodating higher bondholder recovery in distress. In fact, as π increases, the figure depicts a knock-on effect further reducing W_2^-, namely a welfare transfer that (slightly) increases W_0 and W_2^+.

The figure also shows that bankruptcy courts can achieve first-best outcomes. Overall welfare, V, is maximized and equal to its first-best level when $\pi = \pi^* \approx 0.47$. An ability to achieve first-best welfare through policies altering the pro–creditor leaning of bankruptcy courts is an artifact of our two-state model, since this allows the first-best state-contingent

[31]It is notable that the minimum quality constraint does not bind in bankruptcy, reminiscent of the fact that Judge Steven Rhodes provided room in Detroit's post-bankruptcy budget to improve city quality while restricting bondholders repayments.

Table 3: Model Summary: Ch. 9 Enforcement Regime

Variable	t = 0	t = 2	
Population shock (ϵ^+)	0.00	25.00	-25.00
Population (N)	72.66	82.90	51.91
Endogenous Migration	0.00	-14.77	4.25
Quality (q)	6.16	5.54	4.74
Taxes (τ)	0.33	0.48	0.28
Investment (I)	61.57	-0.00	-7.96
Debt payments (D)	37.23	39.50	16.84
Capital structure ($\frac{D_0}{I_0}$, %)	60.47		
Debt per capita ($\frac{D_0}{N_0}$)	0.51		
At-issue yield (($\frac{F}{D_0} - 1$), %)	6.09		
Maximum recovery ($\bar{F}$)		53.31	28.06
MTR/quality ratio ($\frac{dW_t^i/d\tau_t^i}{q_t^i}$)	6.36	6.36	5.07
Welfare flow (W)	423.03	419.84	231.85
Welfare (V)	824.07		

payments of $D_2^+ = F = 39.52$ and $D_2^- = \pi^* \bar{F}^- = 13.14$. The general economic intuition that redistributions in bankruptcy can have important welfare implications is clear, however, as is the result that welfare consequences are greater when decline is more likely (e.g., as in our model when p is small).

Our model parameterization leads to optimal capital structure and per capita debt that are similar to first-best levels ($D_0/I_0 = 60.47 \approx 60.21\%$, $D_0/N_0 = 0.51$). Figure 3 more generally addresses the question of determinants of optimal capital structure, where we demonstrate the univariate impact of the probability of growth p on debt-to-investment D_0/I_0. The top panel shows the monotonic dependence on growth, where low-growth cities finance investment only 40% with debt while high-growth cities utilize in excess of 60% debt. The intuition for this result follows from the role of debt in sharing the cost of infrastructure benefits; the larger the average future population, the greater the ability of the next generation to repay debt. Note that in our model the cost-sharing motive is strong, with deviations in capital structure of only 10% or less around the 50/50 inter-generational

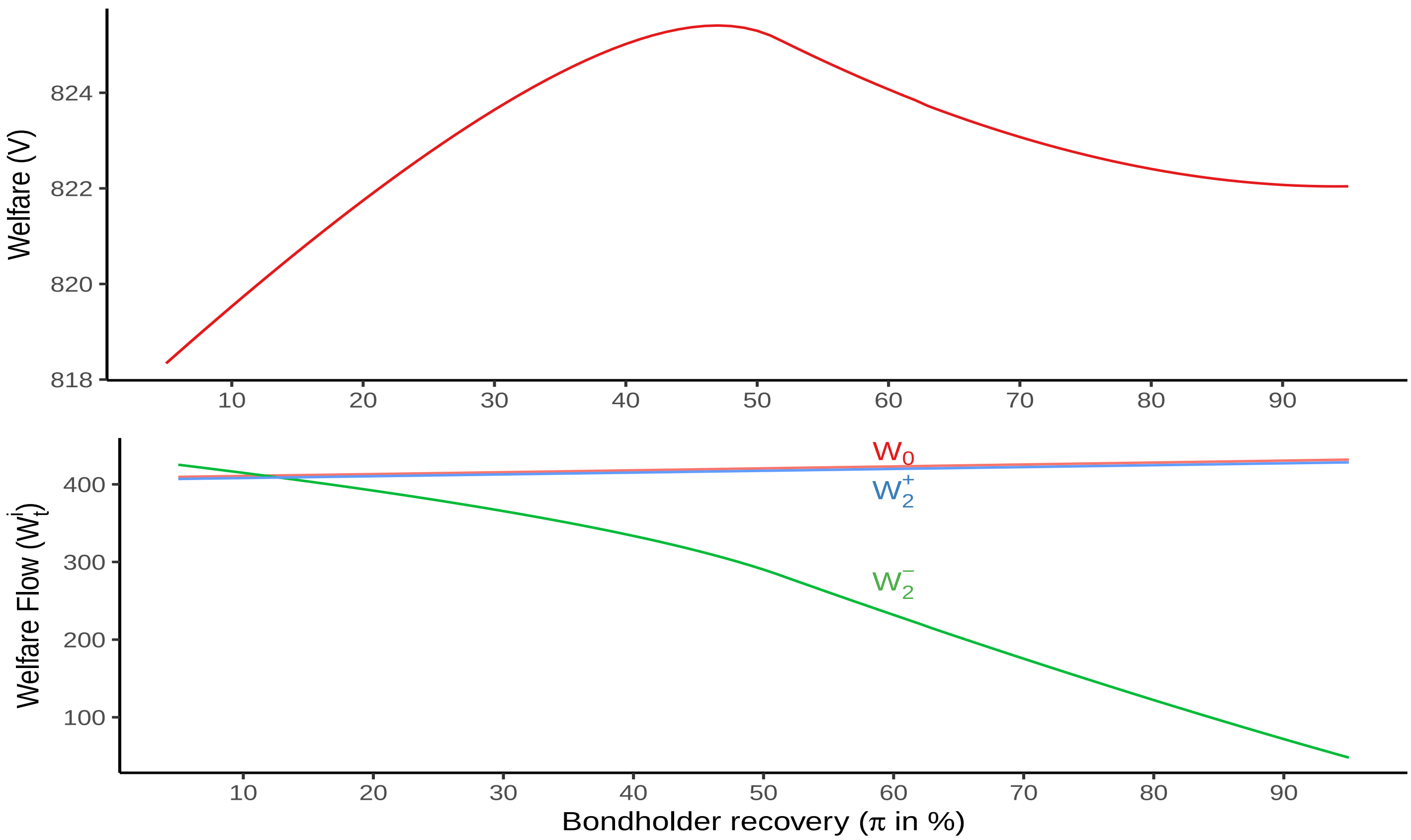

Figure 2: **Welfare vs. Bondholder Recovery**

sharing rule.

The bottom panel of the figure shows the impact of growth on municipal bond yields, where higher expected growth leads to lower yields. Viewed together, the top and bottom panels illustrate that a naiive regression controlling for the effect of debt levels on municipal yields would produce a counter-intuitive negative coefficient. More generally, our model provides structure in which to discover novel sources of endogeneity that empiricists studying municipal bonds may wish to consider.

4.2.2 Contract Court – Equilibrium with no Access to Bankruptcy Law

As pointed out by Gao, Lee, and Murphy (2019), not all states allow municipalities to restructure under Chapter 9. We model rulings in this case, under contract law as previously motivated in Section 2.1.2, by imposing the condition $\pi = 1$. In our framework, therefore,

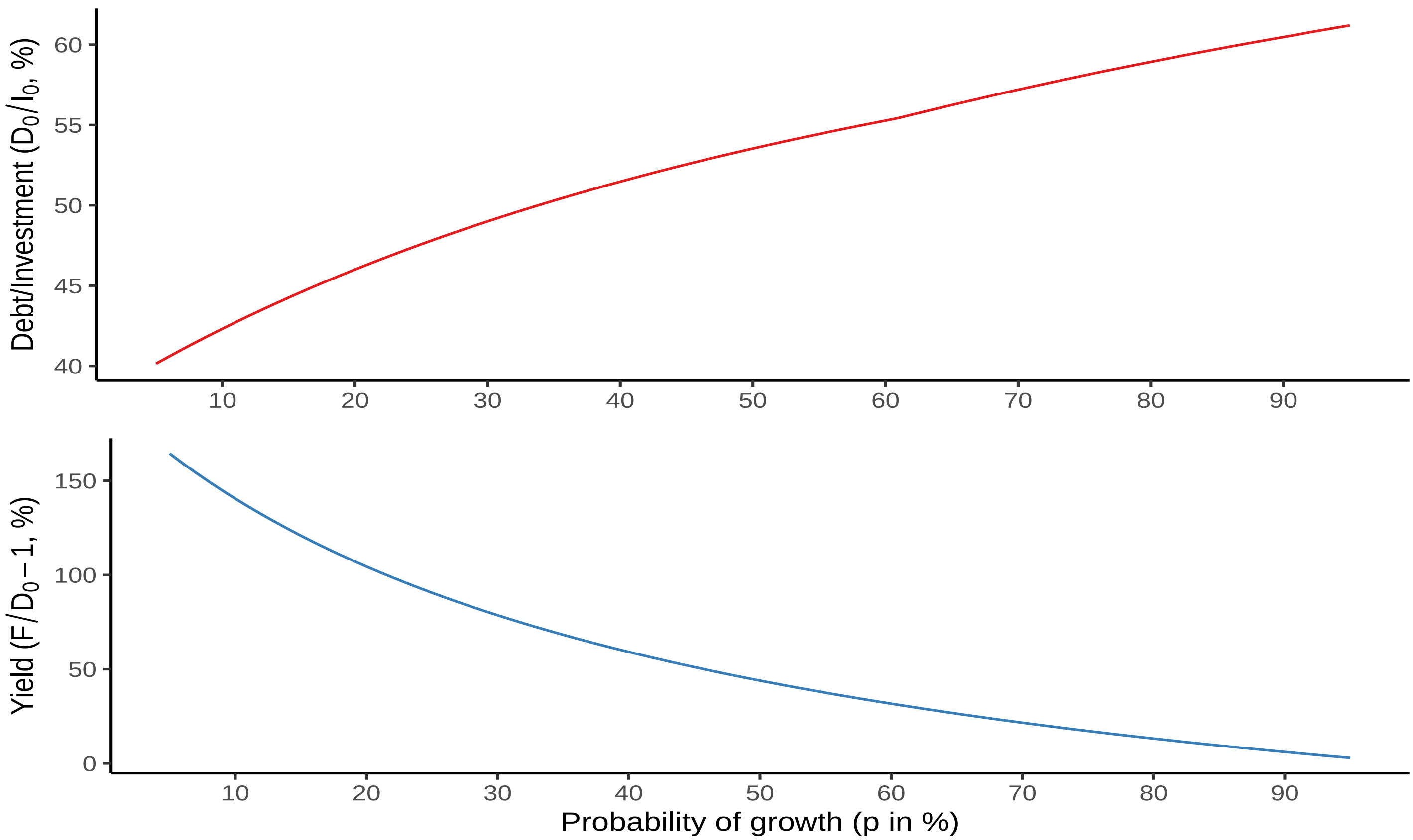

Figure 3: **Debt-to-investment vs. Growth**

states that disallow access to Chapter 9 effectively sidestep the necessity of courts to balance creditor and taxpayer interests, instead insisting on maximally creditor-friendly repayments to bondholders. In this case, the equilibrium offer by the bond holder, which is accepted by the mayor and enforced by the court, is:

$$F_B = \begin{cases} F & \text{if } \tilde{\epsilon} = +\epsilon; \\ \bar{F}^- & \text{if } \tilde{\epsilon} = -\epsilon. \end{cases} \tag{24}$$

As seen in Table 4, debt enforced by contract law leads to more reliance on debt financing ($D_0/I_0 = 61.23\% > 60.47\%$). Outcomes at date $t = 0$ and in the growth state are again, as under Chapter 9, marginally better than in the first-best case. In the distress state: Repayments to debtholders are higher ($D_2^- = 28.05$), all possible infrastructure is sold leading a nearly minimum quality level ($q_2^- = 1.05 \approx q_L = 1$), and taxes are high ($\tau_2^- = 0.34$). Overall welfare decreases even further ($V = 822.10$), and in the decline state welfare flow is very low ($W_2^- = 29.73$).

Table 4: Model Summary: Ch. 9 Not Available

Variable	t = 0	t = 2	
Population shock (ϵ^+)	0.00	25.00	-25.00
Population (N)	73.04	83.24	41.84
Endogenous Migration	0.00	-14.80	-6.20
Quality (q)	6.26	5.63	1.05
Taxes (τ)	0.33	0.47	0.34
Investment (I)	62.57	0.00	-45.79
Debt payments (D)	38.31	39.45	28.05
Capital structure ($\frac{D_0}{I_0}$, %)	61.23		
Debt per capita ($\frac{D_0}{N_0}$)	0.52		
At-issue yield (($\frac{F}{D_0} - 1$), %)	2.98		
Maximum recovery ($\bar{F}$)		53.58	28.33
MTR/quality ratio ($\frac{dW_t^i/d\tau_t^i}{q_t^i}$)	6.36	6.36	7.25
Welfare flow (W)	432.76	429.29	29.73
Welfare (V)	822.10		

The difference between contract court and Chapter 9 is also evident when comparing bond yields. Under Chapter 9, the municipal debt at-issue yield is $y = 6.09\%$ while under contract court the yield is $y = 2.98\%$. This prediction generalizes across parameterizations of our model, hence our theory predicts that states that ban Chapter 9 will have municipalities issue more debt with lower yields than in states that allow Chapter 9 bankruptcy proceedings.

4.2.3 Equilibrium with Safe Debt

It may be that for political or behavioural reasons the mayor simply does not want to issue so much debt that municipal default is a possiblity. This may reflect a directive issued to the mayor by the state legislature, formally or informally, or it may reflect career concerns of an elected official who, correctly or incorrectly, percieves that a default would interfere with political ambitions.

In the context of our model, issuing safe debt is equivalent to imposing the additional constraint that the face value of debt not exceed the maximum amount repayable in the decline state:

$$F \leq \bar{F}^{-}. \tag{25}$$

With this restriction, full repayment of the face vaue is feasible and the firm is unconditionally solvent. Moreover, even if Chapter 9 is available to the municipality and it files a petition for a reorganization, the solvent municipality would be denied access to Chapter 9 and full repayment of the face value F enforced by contract courts (see Section 3.2).

Table 5 provides the mayor's optimal decisions subject to safe debt issuance. Safe debt leads to significant welfare costs relative to the complete contracts case ($V = 748.14 < 825.41$). The population is much more sensitive to population shocks ($N_2^- = 38.77 < 57.56$, $N_2^+ = 94.42 > 82.76$) and the initial population is lower ($N_0 = 66.82 < 72.51$). Taxes remain relatively constant regardless of the population shocks. Perhaps most importantly, the infrastructure quality is lower initially, the municipality undertakes investment in the expansion state, but infrastructure is sold to finance safe debt repayments in the decline state, causing the minimum service constraint to bind.[32]

Comparing safe and risky debt outcomes shows that welfare is lowest for safe debt ($V^{SD} = 748.14 < V^{CC} = 822.10 < V^{BC} = 824.07 < V^{FB} = 825.41$). In fact in our model, as we prove in the appendix, safe debt is guaranteed to produce *strictly lower welfare* than risky debt when issued in any legal regime, i.e., irrespective of the value of π. The intuition for the result follows from what is effectively a second-order stochastic dominance argument applied to net-of-tax consumption: Given any investment policy financed by safe debt, a marginal transition to risky debt will leave expected taxes and consumption unchanged but allow a reduction in net-of-tax consumption variance, which is strictly preferred given our concave

[32] Unlike in prior cases where time $t = 0$ investment leads to no further investment at $t = 2$, that is where the city builds for growth, safe debt leads to a financial constraint at $t = 0$. This accounts for the investment at time $t = 2$ in the growth state, where the financial constraint is no longer a consideration and funds can be raised to meet demand for previously unaffordable quality.

Table 5: Model Summary: Safe Debt

Variable	t = 0	t = 2	
Population shock (ϵ^+)	0.00	25.00	-25.00
Population (N)	66.82	94.42	38.77
Endogenous Migration	0.00	2.59	-3.06
Quality (q)	5.07	5.45	1.00
Taxes (τ)	0.38	0.36	0.37
Investment (I)	50.68	8.90	-35.61
Debt payments (D)	25.12	25.12	25.12
Capital structure ($\frac{D_0}{I_0}$, %)	49.57		
Maximum recovery ($\bar{F}$)		50.37	25.12
Welfare flow (W)	313.11	480.66	24.33
Welfare (V)	748.14		

welfare flows. As a result, all equilibria in our model feature risky debt that will default in the decline state. This finding provides further insight into the welfare benefits owing to an ability to access courts to settle contractual disputes during times of economic distress.

5 Conclusion

Investment in infrastructure is of critical importance to the economy and largely the responsibility of municipalities. In this study we examine the municipal corporation's decision to finance infrastructure with debt relative to current taxes. We refer to the debt-to-investment level as the municipality's capital structure and characterize the municipality's optimal choice. We build on Tiebout (1956) in recognizing that citizens 'vote with their feet' by deciding where to live based, in part, on the public infrastructure provided and the taxes paid. The resulting 'elasticity of the tax base' is the driving force in the municipal capital structure decision in our model. Hence, we show that the determinants of a municipality's capital structure are very different from those of a public corporation. Whereas the driving forces for a public corporation are the tax advantage of debt relative to dead-weight bankruptcy costs, for a municipality the critical factor is service/tax elasticity of the tax base. Moreover, while we do not assume the existence of exogenous dead-weight financial distress costs, municipalities do select debt levels knowing the disruption to population and infrastructure that can result from financial distress.

In addition, our model also incorporates the differences in municipal bankruptcy relative to public corporation bankruptcy (e.g., Chapter 9 versus Chapter 11). We use this characterization to show how contract law and bankruptcy law combine to constrain the municipality's ability to smooth the tax burden across time and states.

Our model allows us to address a number of important questions. First we show that, despite the fact that municipalities do not benefit from the tax deductibility of interest, they do benefit from the ability of debt to manage the tax burden across time and states of nature. We also examine in detail the legal mechanisms of resolving financial distress and show: a) That the availability of bankruptcy law moderates the severity of population shocks on infrastructure consumption, and; b) The degree of moderation is dependent on the pro-creditor leaning of the court. Finally, we examine the consequences of municipalities issuing only safe debt, for behavioural or political reasons, and show the significant welfare losses that such a restriction produces.

A Technical Appendix

This appendix provides further detail on our solution methods and, where possible, analytic results.

A.1 An Equivalent Optimization for Equilibrium Outcomes

We define an equivalent optimization program that solves for the mayor's optimal choices yet provides a more tractable solution approach. This leads to closed-form solutions for optimal taxes and municipal debt face value given any choice of optimal quality.

We begin by formalizing the recursively optimal choices made by the mayor conditional on the equilibrium enforcement by the courts. Begin by assuming an arbitrary but feasible date $t = 0$ choices of taxes, investment, and debt terms (τ_0, I_0, F). At date $t = 2$, conditional on the additional knowledge of the population shock $\epsilon^i = \epsilon^+$, the mayor chooses taxes τ_2^+ and investment I_2^+ to solve

$$\max_{\tau,I}(a + \epsilon^+ + bq - c\tau)(q - \tau) \tag{26}$$

subject to

$$\begin{aligned}
(a + \epsilon^+ + bq - c\tau)\tau &= F + \big(1 - \Gamma(I)\big)I \\
q &= \beta\big((1 - \delta)A_0 + I\big) \\
q &\geq q_L \\
A_0 &= I_0.
\end{aligned}$$

Similarly, conditional on $\epsilon^i = \epsilon^-$ and insolvency, the optimization is

$$\max_{\tau,I}(a + \epsilon^- + bq - c\tau)(q - \tau) \tag{27}$$

subject to

$$
\begin{aligned}
(a+\epsilon^- + bq - c\tau)\tau &= \pi \bar{F}_2^- + \big(1-\Gamma(I)\big)I \\
q &= \beta\big((1-\delta)A_0 + I\big) \\
q &\geq q_L \\
A_0 &= I_0.
\end{aligned}
$$

where $\bar{F}_2^-$ is defined in equation (15).[33] Denote the solutions and optimal choices for programs (26) and (27) by $V_2^i(\tau_0, I_0, F)$, $\tau_2^i(\tau_0, I_0, F)$, and $I_2^i(\tau_0, I_0, F))$ for $i \in \{+,-\}$. Unfortunately in our setting, these functions do not have a convenient form.

At the initial date $t = 0$ the Mayor maximizes

$$
\max_{\tau_0, I_0, F} (a + bq_0 - c\tau_0)(q_0 - \tau_0) + pV_2^+(\tau_0, I_0, F) + (1-p)V_2^-(\tau_0, I_0, F) \tag{28}
$$

subject to

$$
\begin{aligned}
(a + bq_0 - c\tau_0)\tau_0 + pF + (1-p)\pi\bar{F}_2^- &= I_0 \\
q_0 &= \beta I_0 \\
q_0 &\geq q_L.
\end{aligned}
$$

The lack of convenient functional forms for V_2^i means that we cannot formalize the solution to this optimization problem.

We define an alternative and equivalent optimization that gives rise to analytic results and is more amenable to numeric solution. Our strategy, similar to the "Martingale Solution" strategy in asset pricing (e.g., Duffie (2010), replaces a recursive optimization with a static,

[33] If the municipality is insolvent, substitute F for $\pi\bar{F}_2^-$.

constrained optimization

$$\max_{\{I_0, I_2^+, I_2^-, \tau_0, \tau_2^+, \tau_2^- F\}} (a+bq_0-c\tau_0)(q_0-\tau_0)+p(a+\epsilon^+bq_2^+-c\tau_2^+)(q_2^+-\tau_2^+)+(1-p)(a+\epsilon^-bq_2^--c\tau_2^-)(q_2^--\tau_2^-) \tag{29}$$

subject to

$$\begin{aligned}
(a+bq_0-c\tau_0)\tau_0 + pF + (1-p)\pi\bar{F}_2^- &= I_0 \\
(a+\epsilon^+bq_2^+ - c\tau_2^+)\tau_2^+ &= \big(1-\Gamma(I_2^+)\big)I_2^+ + F \\
(a+\epsilon^-bq_2^- - c\tau_2^-)\tau_2^- &= \big(1-\Gamma(I_2^-)\big)I_2^- + \pi\bar{F}_2^- \\
q_t^i &\geq q_L,
\end{aligned}$$

for $t \in \{0, 2\}$ and $i \in \{+, -\}$. It is straightforward, using the form of the constraints and the fact that all of the time $t = 2$ choices are additively separable in the objective of (29), to show that the solutions to programs (26) - (28) are identical to those of program (29), and the remainder of the appendix utilizes program (29) to characterize the analytic and numeric properties of our game.

B Proof that $F, F_B, F_M \leq \bar{F}^+$ is not binding

Contrary to our assumption, suppose that the bondholder proposed an offer of $F_B > \bar{F}^+$ to the mayor. If the mayor rejects the offer by proposing any offer $F_M > \bar{F}^+$, by condition (16), this will result in the court ruling that the municipality was insolvent. Moreover, since the offer is greater than $\bar{F}^i$ $\forall i$ the court would rule that such a proposal would result in service insolvency and would not confirm the proposal. As a result, contract law would be involved and would result in the confirmation and enforcement of $\bar{F}^i$. Since this is lower than F_B, the mayor would reject the offer and the result will be $\bar{F}^i$. Hence, if we allowed reorganization offers greater than $\bar{F}^+$, they would result in exactly the same outcomes as would result from a contracts restricted to $F \leq \bar{F}^i$. By the same argument, restricting $F_M \leq \bar{F}^+$ would result in the same outcome as a game that allowed $F^M > \bar{F}^+$ since this proposal will be rejected.

Finally, consider the possibility that the mayor's initial proposed has $F > \bar{F}^+$. If the bondholder proposes any $F_B > \bar{F}^+$, the argument just presented shows that the result will be $\bar{F}^i$ which is the same outcome as would obtain with $F \leq \bar{F}^+$. On the other hand, if $F > \bar{F}^+$ there are values of F_B and or F_M that are less than $\bar{F}^+$ that might be confirmed by either bankruptcy or contract law. However, such outcomes could also be achieved with $F \leq \bar{F}^+$.

C Parameter Restrictions

We require that the initial quality be chosen from the interval $[q_L, q_{UB}]$ where q_{UB} is the largest of the smallest roots of the quadratics in q

$$\big(a + bq\big)^2 + p\big(a + \epsilon + bq_L\big)^2 + (1-p)\big(a - \epsilon + bq_L\big)^2 - \frac{4c}{\beta}\Big(\big(\delta + \gamma(1-\delta)\big)q + (1-\gamma)q_L\Big) \quad (30)$$

or

$$\big(a + bq\big)^2 + p\big(a + \epsilon + bq_L\big)^2 + (1-p)\big(a - \epsilon + bq_L\big)^2 - \frac{4c}{\beta}\big(\delta q + q_L\big). \quad (31)$$

To ensures existence of q_{UB} we further require that the parameters satisfy

$$(a - \epsilon)^2 + (c - ab\beta)^2 - a^2(1 + 2b^2\beta^2) \geq 0. \quad (32)$$

D Solution Details

Analytic Solution for $\bar{F}$

In order to solve for the maximal payment available to bondholders in a default state, we begin by establishing the maximal payment for an arbitrary quality level at $t = 2$ and in the state $\tilde{\epsilon} = -\epsilon$:

$$\max_{\tau} N_2^{-}\tau = (a - \epsilon + bq - c\tau)\tau. \tag{33}$$

It is straightforward to show that the conditionally optimal tax rate is $\tau^*(q) = \frac{a-\epsilon+bq}{2c}$, yielding maximal tax revenues of

$$R_2^{-}(q) = \frac{(a-\epsilon+bq)^2}{4c}. \tag{34}$$

To determine $\overline{F}$ we must additionally determine the optimal level of q by solving for the maximal net-of-investment tax revenues

$$\max_{q} \frac{(a-\epsilon+bq)^2}{4c} - \frac{q}{\beta}. \tag{35}$$

Within the relevant range $q \in [q_L, q_{UB}]$ this objective is decreasing in q, hence the solution to bondholders' maximal request for payment, optimization problems (15), is given by

$$\bar{F} = \frac{(a-\epsilon+bq_B)^2}{4c} + (1-\gamma)\frac{(1-\delta)q_0 - q_B}{\beta} \tag{36}$$

where

$$q_B = \max\{q_L, (1-\delta)q_0\} \tag{37}$$

when investment is irreversible and $q_B = q_L$ when investment is reversible.

Solution to the Base Case Optimization

To illustrate our solution method in all cases we begin with a detailed description of our solution methodology in the case where investment is irreversible. We restate the Mayor's optimization (9) in this special case

$$\max_{\{I_0, I_2^+, I_2^-, \tau_0, \tau_2^+, \tau_2^- F\}} V_0 = W_0(q_0, \tau_0) + pW_2(I_2^+, \tau_2^+, +\epsilon) + (1-p)W_2(I_2^-, \tau_2^-, -\epsilon) \tag{38}$$

s.t.

$$
\begin{aligned}
pF + (1-p)F^* + N_0\tau_0 = I_0 \\
N_2^+\tau_2^+ = (1-\gamma \mathbb{1}_{I_2^+<0})I_2^+ + F \\
N_2^-\tau_2^- = (1-\gamma \mathbb{1}_{I_2^-<0})I_2^- + F^*,
\end{aligned}
$$

where $\mathbb{1}_{I<0}$ is an indicator for negative investment. Equation (36) shows that F^* is a function of q_0 and, therefore, not a distinct choice variable in the problem.

Substituting for the appropriate functions and conditional on $\tilde{\epsilon} = -\epsilon$, the Mayor's $t = 2$ sub-problem is

$$
\max_{\{I,\tau\}} \big(a - \epsilon + bq - c\tau\big)\big(q - \tau\big) \tag{39}
$$

s.t.

$$
\begin{aligned}
\big(a - \epsilon + bq - c\tau\big)\tau - (1-\gamma \mathbb{1}_{I<0})I - \pi\frac{\big(a-\epsilon+bq_B\big)^2}{4c} = 0 \\
q - \big((1-\delta)q_0 + \beta I\big) = 0.
\end{aligned}
$$

Substituting for the tax rate that satisfies the budget constraint yields

$$
\tau = \frac{1}{c}\Big(\frac{a-\epsilon+bq}{2} - \phi_2\Big) \tag{40}
$$

where

$$
\phi_2^2 = \frac{\big(a-\epsilon+bq\big)^2}{4} - c\Bigg[\frac{(1-\Gamma(I_2^-))(q-(1-\delta)q_0)}{\beta} + \pi\Bigg(\frac{\big(a-\epsilon+bq_B\big)^2}{4c} + (1-\gamma)\frac{(1-\delta)q_0 - q_B}{\beta}\Bigg)\Bigg]. \tag{41}
$$

A similar strategy allows elimination of τ_0 and τ_2^+ from the optimization. The first-order conditions of the Lagrangian of problem (38) produce the following equations for the tax rates:

$$\tau_0 = \frac{1}{c}\Big(\frac{a + bq_0}{2} - \phi q_0\Big)$$
$$\tau_2^+ = \frac{1}{c}\Big(\frac{a + \epsilon + bq_2^+}{2} - \phi q_2^+\Big)$$

where

$$\phi^2 = \Bigg(\frac{\big(a + bq_0\big)^2 + p\big(a + \epsilon + bq_2^+\big)^2 + (1-p)\pi\big(a - \epsilon + bq_B\big)^2}{4}$$
$$- c\frac{q_0 + p\big(1 - \Gamma(I_2^+)\big)\big(q_2^+ - (1-\delta)q_0\big) + (1-p)\pi(1-\gamma)\big(q_L - (1-\delta)q_0\big)}{\beta}\Bigg)\Big/\Big(q_0^2 + pq_2^{+2}\Big). \tag{42}$$

A final substitution produces the "concentrated" objective that we solve numerically

$$\max_{q_0, q_2^+, q_2^-} \frac{(a + bq_0)q_0 + p(a + \epsilon + bq_2^+)q_2^+ + (1-p)(a - \epsilon + bq_2^-)q_2^-}{2}$$
$$- \frac{q_0 + p\big(1 - \Gamma\big)\big(q_2^+ - (1-\delta)q_0\big) + (1-p)\big(1 - \Gamma\big)\big(q_2^- - (1-\delta)q_0\big)}{\beta}$$
$$+ \phi\sqrt{q_0^2 + pq_2^{+2}} + (1-p)\phi_2 q_2^-. \tag{43}$$

Analogous arguments yield the following form of the objective for the first-best case:

$$\max_{q_0, q_2^+, q_2^-} \frac{(a + bq_0)q_0 + p(a + \epsilon + bq_2^+)q_2^+ + (1-p)(a - \epsilon + bq_2^-)q_2^-}{2}$$
$$- \frac{q_0 + p\big(1 - \Gamma(I_2^+)\big)\big(q_2^+ - (1-\delta)q_0\big) + (1-p)\big(1 - \Gamma(I_2^-)\big)\big(q_2^- - (1-\delta)q_0\big)}{\beta}$$
$$+ \phi_{fb}\sqrt{q_0^2 + pq_2^{+2} + (1-p)q_2^{-2}}, \tag{44}$$

where

$$\phi_{fb}^2 = \Bigg(\frac{\big(a+bq_0\big)^2 + p\big(a+\epsilon+bq_2^+\big)^2 + (1-p)\big(a-\epsilon+bq_2^-\big)^2}{4} \\ - \frac{c}{\beta}\Big[q_0 + p\big(1-\Gamma(I_2^+)\big)\big(q_2^+ - (1-\delta)q_0\big) \\ + (1-p)\big(1-\Gamma(I_2^-)\big)\big(q_2^- - (1-\delta)q_0\big)\Big]\Bigg) \Big/ \Big(q_0^2 + pq_2^{+2} + (1-p)q_2^{-2}\Big). \quad (45)$$

Debt-to-Investment

For any levels of investment, the debt-to-investment ratio is given by the equation

$$\frac{D_0}{I_0} = 1 - \frac{\beta}{cq_0}\bigg(\frac{(a+bq_0)^2}{4} - \phi^2 q_0^2\bigg). \quad (46)$$

Expanding terms, this formula becomes

$$\frac{D_0}{I_0} = \Bigg[p\bigg\{(1-\delta) + (1-\alpha)\Big[\frac{\beta a}{2c}\Big(\alpha b + \frac{(1+\alpha)a}{2q_0}\Big) - \alpha\Big] + \frac{\beta\epsilon}{2c}\Big(\alpha b + \frac{a+\epsilon/2}{q_0}\Big)\bigg\} \\ + (1-p)\frac{\beta\pi\big(a-\epsilon+bq_B\big)^2}{4cq_0}\Bigg] \Big/ (1+p\alpha^2) \quad (47)$$

where $\alpha = q_2^+/q_0$ and q_B is defined in equation (37)

In the further special case with no uncertainty ($p = 1$), no depreciation, and no investment at date $t = 2$, this equation becomes

$$\frac{D_0}{I_0} = \frac{1}{2} + \frac{\beta\epsilon}{4c}\Big(b + \frac{a+\epsilon/2}{q_0}\Big). \quad (48)$$

Optimality of Safe Debt

We begin by eliminating τ_2^i from the time $t = 2$ welfare function $W_2(\tau_2^i, q_2^i, \tilde{\epsilon})$, given any q_2^i and D_2^i, using the budget constraint

$$\big(a + \tilde{\epsilon} + bq_2^i - c\tau_2^i\big)\tau_2^i - \frac{q_2^i - (1-\delta)q_0}{\beta} - D_2^i = 0. \tag{49}$$

The leftmost zero of this conditional quadratic equation in τ_2^i is given by

$$\tau_2^i = \frac{1}{c}\Big[\frac{a + \tilde{\epsilon} + bq_2^i}{2} - \phi\Big] \tag{50}$$

where

$$\phi_2^i = \sqrt{\rho_2^i - cD_2^i} \tag{51}$$

and

$$\rho_2^i \equiv \frac{\big(a + \tilde{\epsilon} + bq_2^i\big)^2}{4} - c\frac{q_2^i - (1-\delta)q_0}{\beta} \tag{52}$$

This substitution produces the following formula for $t = 2$ expected welfare

$$\begin{aligned} E_0(W_2(\tau_2, q_2, \tilde{\epsilon})) = p\Big(&\frac{a + \epsilon + bq_2^+}{2}q_2^+ - \frac{q_2^+ - (1-\delta)q_0}{\beta} - D_2^+ - \phi_2^+ q_2^+\Big) \\ + (1-p)\Big(&\frac{a - \epsilon + bq_2^-}{2}q_2^- - \frac{q_2^- - (1-\delta)q_0}{\beta} - D_2^- - \phi_2^- q_2^-\Big) \end{aligned} \tag{53}$$

We now consider the choice of debt repayments at $t = 2$ given any values of the choice variables (q_0, q_2^+, q_2^-) and subject to $D_0 = pD_2^+ + (1-p)D_2^-$. The solution to optimization equation (53) is identical to that of

$$\min_{D_2^+, D_2^-} \omega\phi_2^+ + (1-\omega)\phi_2^- \tag{54}$$

where $\omega = \frac{pq_2^+}{pq_2^+ + (1-p)q_2^-}$. Equation (51 defining ϕ_2^i is convex in D_2^i, hence if

$$\rho_2^+ - cD_0 > \rho_2^+ - cD_2^+ > \rho_2^- - cD_2^- > \rho_2^- - cD_0 \tag{55}$$

then

$$\left(p\sqrt{\rho_2^+ - cD_0} + (1-p)\sqrt{\rho_2^+ - cD_0}\right) > \left(p\sqrt{\rho_2^+ - cD_2^+} + (1-p)\sqrt{\rho_2^+ - cD_2^+}\right) \tag{56}$$

This equation shows that when raising debt proceeds of D_0, safe debt results in higher welfare costs, hence lower welfare, than risky debt.

The inequalities (55) are typically satisfied under the parameterizations we consider. In words, the condition requires that conditional on a positive economic shock $\tilde{\epsilon} = +\epsilon$: 1) Tax revenues net of investment is higher, and; 2) Debt repayments are higher. Drawing parallels to the fundamentals of choice under uncertainty, when risky debt repayments give rise to mean-preserving variance reductions in welfare, increasing welfare in the $\tilde{\epsilon} = -\epsilon$ state and decreasing welfare in the $\tilde{\epsilon} = +\epsilon$ state, our concave $t = 2$ expected welfare function increases relative to the higher variance safe debt repayments.

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