Municipal Capital Structure*

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Abstract

Municipalities provide critical infrastructure and essential services financed largely by debt and taxes. There has been, however, very little theoretical study of a municipality's debt vs tax financing decision. We define municipal capital structure as the debt-to-investment ratio and develop a model of municipal capital structure that rests on two primary economic forces; the elasticity of the tax base with respect to taxes and service levels, and municipal financial distress. We show how debt improves the welfare of the municipality in a way that depends on the legal structure governing municipal financial distress, the reversibility of the infrastructure put in place, and the pro—creditor leaning of the courts. We also show that municipalities that ensure repayment may decrease overall welfare.

1 Introduction

The critical importance of well-functioning public infrastructure and the provision of 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] These expenditures are expected to increase even further, since legacy investments in many jurisdictions are in need of renewal or repair, while social, technical and ecological considerations necessitate design, construction and operation of new projects.[2]

Funding infrastructure spending is ultimately the responsibility of taxpayers, current and future. In this paper, we theoretically model optimal spending and financing decisions of "municipal corporations," typically cities, that are granted the authority to own and operate infrastructure as well as the responsibility to pay for it. We show how the risks associated with exogenous fluctuations 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 municipalities 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, dramatically illustrates possible negative outcomes that should be recognized and factored into municipal investment planning and financing. Infrastructure assets are restricted to particular geographies and are therefore exposed to local economic fluctuations. Shocks to large employers or

[1] Tomer, Kane, and George (2021) estimate that state and local governments account for three quarters of annual spending on public infrastructure. The US BEA reports 2019 state and local fixed asset investment of \$431 B (U.S. Bureau of Economic Analysis (2021)). If state and local government public infrastructure was considered an industry, it would have ranked second in 2019 investment only to US manufacturing (\$555 B, Table 3.7).

[2] The American Society of Civil Engineers 2021 Report Card for American Infrastructure forecasts 2020-2029 investment needs of \$5.9 T. Traditional infrastructure, such as transportation, is responsible for a large share of spending but highlighting its future importance, a special note on broadband is included in the report card. Tomer, Kane, and George (2021) also comment extensively on the need for infrastructure that enables resilient, smart cities.

correlated shocks affecting many can give rise to a cycle of depopulation, failure of infrastructure, inadequate city services, and an inability to raise sufficient funds through taxation. Financial distress among the "big three" automakers, precipitated by the Great Recession of 2007-2009, ultimately led to a financial crisis for the city of Detroit, and on June 14, 2013 the city presented a Proposal to Creditors asking to reschedule debt payments.[3] The city argued that its debt burden along with underlying economic factors placed Detroit in default of its service obligation to its citizens. 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] A shocking number of streetlights did not work (40%). In terms of the city's responsibilities for education, only 9% of 8th graders were at minimal reading levels compared to a national average of 35%. Deterioration of infrastructure had also contributed to out-migration and abandonment of houses; between 2009-2013, there were 75,000 house mortgage foreclosures, and the report notes 78,000 vacant and blighted structures.[5]

From a corporate finance perspective the Detroit bankruptcy illustrates a number of important questions that we address. What explains the 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 rules of municipal bankruptcy, how do they recursively impact on investment and debt levels, and how do they affect economic efficiency? Should municipalities 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,[6] that

[3] City of Detroit Proposal for Creditors, June 14, 2013.

[4] The report notes police manpower had fallen by 40% over the previous 10 years, response times averaged 58 minutes vs. a national average of 11 minutes, case clearing rates were 8.7% vs. 35% for Pittsburgh, and the crime rate was 5 times the national average. 40% of streetlights did not work.

[5] For further details on the Detroit and its bankruptcy see also Gilson, Mugford, and Lobb (2020).

[6] The traditional debt/equity or debt/value measure is conceptually possible but practically of little value

addresses these questions.

In doing so, we add to the traditional capital structure literature by recognizing that the municipal corporation is fundamentally different from a non-municipal (NM) corporation. For instance, while the objective of market value maximization of a NM corporation is well defined, there is no clear equivalent objective for a municipal corporation. Moreover, there is essentially no liquidity for a share of municipal ownership: A citizen who has helped pay for the construction of infrastructure is not able to monetize the value of the asset they helped build if the value they see in the asset drops.[7] Similarly, the only way to "liquidate" a share of municipal ownership is to move and stop paying taxes. In addition, our theory of municipal capital structure recognizes that the process by which municipal debt contracts are enforced is fundamentally different from NM corporations due to the sovereign nature of the municipality.

Based on an objective function that recognizes these factors, we identify non-tax benefits of municipal debt that derive from efficiently sharing tax burdens over time and across states. Our key assumption is the "tax and service" elasticity of the tax base: The propensity of citizens to leave a municipality rises if taxes are increased or infrastructure deteriorates.[8]

To build intuition for why tax base elasticity matters, consider a municipality constructing irreversible infrastructure today that will benefit its citizens today and in some distant tomorrow. If the infrastructure is paid exclusively by levying high taxes today many citizens will leave (i.e., the tax base will decrease) thus necessitating higher taxes or lower service quality, both of which will induce even further emigration. In future years, conversely, the infrastructure will provides services that have already been paid for, allowing lower taxes

for a municipality since the value of the underlying public assets, providing non market externalities, is difficult to measure.

[7]For instance, the value of high quality schools may be high while a taxpayer's children attend but may drop when they become empty-nesters.

[8]The importance of "tax base elasticity" is reflected in the proposal presented by the City of Detroit to its creditors, where the central objective is to provide incentives, and eliminate disincentives, for businesses and residents to remain in the city by normalizing services and taxes. More generally Tiebout (1956) argued that municipalities compete for citizens who 'vote with their feet' for the municipal service bundle they wish to acquire through their taxes. See Saltz and Capener (2016) for a survey.

and a population rebound. If instead the municipality mixes taxes and borrowing to put the infrastructure in place, the fluctuations in the tax burden and migration will be dampened as debt issuance today will reduce current taxes but debt repayment tomorrow will require higher taxes.

Although we assume all agents are risk neutral, we find that the city enjoys non-linear benefits from sharing tax revenue risk 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. At the optimal financing structure, therefore, the city will smooth payment for infrastructure over time and across states of the world to equate marginal tax burdens.

Is the tax smoothing benefit of debt modified by the institutional environment in which municipal financial distress is resolved? Understanding municipal financial distress involves more than a reinterpretation of existing models, both because a municipality is fundamentally different from a NM corporation, as discussed above, and because a municipality legally has a degree of sovereignty requiring a different legal apparatus to resolve financial distress. From a legal perspective two bodies of law are involved in resolving financial distress for both municipal and NM corporate debt; 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 the sovereign nature of a municipality. In terms of contract law, the sovereign nature of municipalities means that property owned by the debtor cannot generally be seized nor can the court dictate operating decisions as it can for a NM corporation.[9] Allowing either seizure or operating interference could be viewed as an imposition on the ability of elected representatives to govern as they see

[9]We realize that there are work around tactics; Detroit was not able to sell its art gallery but was able to monetize it. However, even when possible, seizure is difficult. See Skeel Jr (2015).

fit. As a result, the actions available to the creditor of a municipality under contract law are constrained. In terms of bankrupcty law, in the US this is governed by a federal law. However, allowing municipalities to have unencumbered access to federal law can be seen as an infringement on a state's responsibility to govern the citizens of the state. An example of the consequence of this tension is that, unlike public corporate debtors, a municipal debtor must have the permission of the state to utilize bankruptcy law.

Our work adds to the general literature on capital structure by recognizing the special nature of municipalities and the special rules around debt enforcement for municipalities. At the core of our model is the importance of net tax base migration to the riskiness of municipal debt combined with the specifics of bankruptcy law. Tiebout (1956) first introduced the idea of intercity competition for the tax base and the affect of this competition on intercity migration. This was followed by a large literature examining this force in detail (see the survey of Saltz and Capener (2016).). This literature does not consider the use and riskiness of municipal debt or the debt enforcement mechanism.

There are relatively few theoretical studies of municipal debt financing with default. Gordon, Guerrón-Quintana, et al. (2021) is the only work we are aware of that relates municipal financing and default to a somewhat endogenous tax base. While Gordon and Guerron provide greater detail on the migration decision, they employ a very simple default mechanism, similar to that employed in the soveriegn debt literature; municipalities can decide to repudiate their debt without making any payments and then reissuing debt after a delay. While intersting, this is not consistent with actual municipal bankruptcy and contract law since municipalities are not allowed to repudiate debt nor do creditors recieve zero in default. We explicitly identify the value of debt to municipalities and show how contract law and bankruptcy law allow courts to determine state contingent debt reorganizations and hence marginal economic efficiency.

Myers (2021) considers a model of municipal default that is the result of risky exogenous risky revenues. In his model there is no tax base migration, and the focus is on a game between government and taxpayers where governments realize overspending may generate a future tax payer bailout. In contrast the risk in our model is due to shocks in the tax base of the municipality an our focus is on bankruptcy laws as opposed to emergency bailouts.

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 sections 4 and 5 and conclude the paper in section 6.

2 Institutional Setting

There are two important institutions represented in our model, the municipality and the court. In this section we sketch out some of the elements of these institutions. We also identify simplifications made in our model.

2.1 Municipal Corporation or Municipality

A municipal corporation is a corporation established to provide basic services to those who live within a particular geographic area. A municipal corporation is established through state or provincial incorporation that grants corporate status along with a municipal charter that defines the rights, responsibilities, and governance of the municipality. Clearly the political economy underlying municipalities is complex and interesting for many reasons. To focus on the finance components, however, we greatly simplify by assuming that decisions are made by a benevolent *mayor* who has the power to invest in infrastructure and incur debt liabilities in order to finance municipal investment.

In reality, an active player in the governance of the municipality is the state that, in addition to granting corporate status to a group of people, also monitors the municipality and has considerable power to intervene in the event of municipal fraud or mismanagement.[10]. Indeed, an important decision of the state is whether or not it will allow a municipality to

[10] See Moringiello (2017) for a detailed discussion of the states role in municipal bankruptcy

access the relevant part of the bankruptcy code to resolve financial distress. We further simplify our model by assuming there is no principal agent conflict between the mayor and the state who are assumed to have the same objective, so that monitoring is not an issue. To study the gate keeping role of the state, we consider games where the municipality can choose to apply for bankruptcy protection and games where they are prohibited from doing so.

2.1.1 Municipal Debt

Municipalities generally have the ability to issue municipal bonds. There are two main types of municipal debt, general obligation or GO bonds and revenue bonds. GO bonds are not backed by a particular revenue stream or asset and are often said to be backed by the 'good faith and credit' of the citizens of the municipality.[11]

2.2 Financial Distress and the Courts

In common with NM corporations, municipal financial distress can be evidenced by the inability of the debtor corporation to make required debt payments as they come due. In addition, however, municipalities may be in service delivery insolvency defined as ' a significant reduction in the availability of city services' (Gillette (2019)). This is in sharp contrast to public corporation financial distress where the quality of the product provided is not a consideration apart from its affect on cash flows.

The environment under which municipal restructuring takes place varies widely and includes the following[12]:

1. **Informal restructuring**, where all claimants to the municipality agree to alter the nature of their claims. For example, the city of Fitch Texas announced that it was un-

[11] We note that other municipal assets, such as a toll bridge, do generate cash flows that could be pledged in a debt contract. These are referred to as Revenue Bonds and, although interesting, do not raise the novel issues that GO bonds do.We only consider GO bonds as they are more distinct from the standard debt of NM corporations.

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

able to meet debt obligations due to what was later shown to be fraud. It subsequently announced an mutually agreed upon extension of its debt .

2. **Contract court** where debt holders petition the court to help them collect as much as possible from the creditor.[13]. In sharp contrast to NM corporations, the court is not able to interfere with the operations of the municipality. An aspect of debt collection law that is very distinct for municipalities is the limited ability to require the municipality to increase taxes. In a chapter 11 filing, although a judge is not able to require that the company increase prices for its products, it can appoint a trustee to do so. For municipalities, such interference in the operations of the municipality is considered a breach of the municipality's and the state's sovereignty for a non elected official to mandate a tax increase. The court is able, however, to issue a *writ of mandamus* directing an officer of the city to increase taxes. The effectiveness of this is, however, dampened by the fact that the officer need not comply with the writ if prohibited to by state law. The officer to whom the writ is directed may also resign from the position, making the writ ineffective.

   Despite the somewhat imperfect mechanism available to contract courts, we assume that the court has limited ability to set terms of the restructuring. Specifically, in our model, we will 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.

3. **Bankruptcy court** In the US this involves Chapter 9 of the bankruptcy code. Below we will discuss the differences between chapter 9 and chapter 11.

4. **State intervention**, where the state may provide emergency funding, technical advice and appoint an emergency manager who has the power to make operating decisions and renegotiate the municipality's obligations.

[13] For NM corporations this involves seizing and liquidating corporate assets. For municipalities, seizure is not generally available and only applies to assets that can be legally pledged. See Skeel Jr (2015).

Although all of these responses are in principle possible, what municipalities can actually do is governed by State law. For instance, while the federal bankruptcy code allows municipalities to petition the court under Chapter 9, it also states that this requires that the state first give its permission to do so. According to the Pew Charities Study, only 21 states provide blanket authorization to apply for bankruptcy protection, another 12 allow conditional or limited filing and 10 have an outright prohibition on filing for bankruptcy.

Similarly, there is considerable variation in state intervention and, in the event of intervention, in what the intervenor is allowed to alter. Table 1, based on Gao, Lee, and Murphy (2019) and Pew Charitable Trusts (2013) illustrates the differences across states.

2.3 Chapter 9 versus Chapter 11

For private corporations, one of the primary purposes of Chapter 11 is to solve the so called "common pool" problem due to economies of scope, where the value of assets are worth more together than they are separately. The common pool problem arises when various creditors seize specific collateral without consideration of the impact firm productivity and, therefore, the value of other claims. Bankruptcy law is a solution to the problem in that it provides a stay of legal actions against a debtor, so that no assets can be seized, while a reorganization (chapter 11) or liquidation (chapter 7) is contemplated. For municipalities, however, the common pool problem is not an issue. Instead, chapter 9 is intended to facilitate an adjustment to the debt outstanding while allowing the municipal government to continue providing services to its citizens.

Municipal bankruptcy law does provide the municipality with more bargaining power that does Chapter 11. To start, only the municipality is allowed to present a proposal whereas in Chapter 11 this monopoly power is granted only for 90 days. In addition, unlike chapter 11, the court is not able to direct the activity of the debtor during the bankruptcy process and, hence, has less direct impact on the reorganization. The court does, however, have two important controls in the case of Chapter 9; the ability to allow a petition to be heard by the court (admission control) and the ability to confirm a proposed reorganization (exit control).

In terms of admission to the bankruptcy process, a municipality is considered eligible for chapter 9 if: a) it is insolvent, either because it is not able to make debt payments as they come due or it is not able to provide a minimum level of service to its citizens;[14] b) it has attempted to negotiate with its creditors but has failed to reach an agreement; c) the state has given the municipality permission to file for chapter 9 protection. 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. The terms good faith and best interests are not given a precise meaning in law.[15]

3 Model

We assume the formation of a municipal corporation, which we will refer to simply as the municipality, created by state law and governed by a mayor.

3.1 Agents

The municipality in our model interacts with four groups of agents; a bond holder (B),[16] taxpayers or the tax base (N), the mayor (M), and a court (C). All agents are risk neutral and the discount rate is zero. We examine decisions taken at three points in time, $t \in \{0, 1, 2\}$, spanning two periods: at $t = 0$, operating, investment and financing decisions are made; at $t = 1$ information arrives and, based on the information, renegotiation of the issued debt takes place but no operating decisions are made, and; at $t = 2$ the court rules on any petitions

[14] We provide precise model based definitions of these condition in section 3.

[15] We provide a model specific definition of these terms in section 3.

[16] We recognize that municipal debt is often widely held. We assume the existence of a distressed debt investor who acquires a sufficient toehold to justify representing all debt holders. Our bondholder can be thought of as the default insurer or some other large investor who internalizes the bargaining externalities available in financial distress.

presented to it and then final operating decisions are made. The structure of our model is depicted in Figure 1.

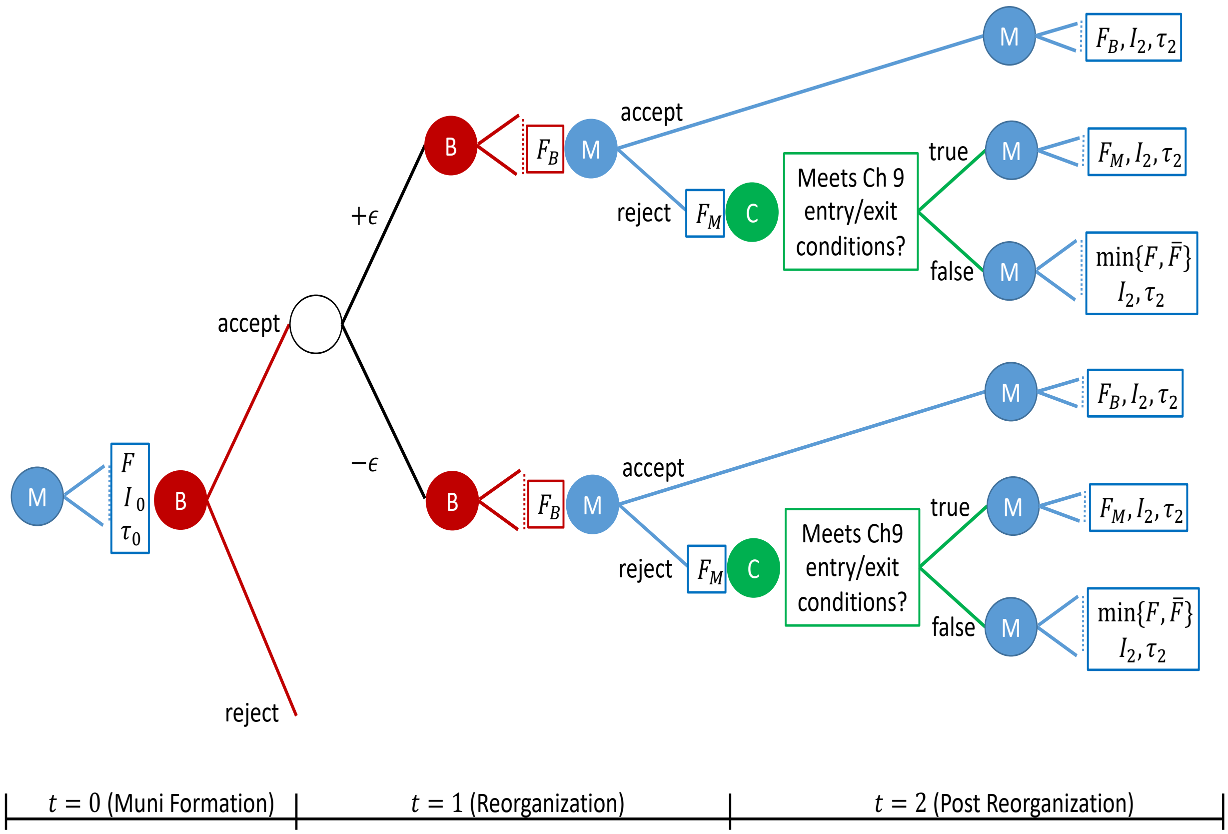

Figure 1: **Game Structure**

3.1.1 The Municipality

At $t = 0$ the municipality has the opportunity to construct infrastructure for a cost of I_0, which produces a flow of benefits to all municipal residents. Define $A_0 = I_0$ as the replacement cost of the asset. We further assume that the benefits cannot be monetized, so that financing involves General Obligation or GO bonds. Let $A_1 = A_0$ and

$$A_2 = (1 - \delta)A_0 + I_2$$

where δ is exogenous depreciation[17] and $I_2 \geq -(1-\delta)A_1$ is incremental investment ($I_2 \geq 0$), or disinvestment ($I_2 < 0$). We further assume that disinvestment generates a positive cash flow of $-I_2$ but also involves a deadweight decomissioning cost of γI_2. Hence, the net cash flow to the municipality from an asset sale is $-(1-\gamma)I_2$ The parameter γ can be thought of as the degree of partial irreversibility of the infrastructure. To illustrate, the subterranean pipes installed to deliver water are essentially irreversible and would be captured by assuming $\gamma \to 1$. At the other extreme, a small automobile used by municipal staff can be easily sold in the secondary market, represented by $0 \leftarrow \gamma$.

The municipal charter bestows upon the mayor authority to impose a tax on each resident[18] at $t = 0$ and $t = 2$ of $\tau_0 \geq 0$ and $\tau_2 \geq 0$, respectively. The mayor's authority also allows her to determine investment amounts and the extent to which the investment is financed by GO bonds relative to taxation.

In practice GO bonds are approved by citizens who confirm, often through a vote, that the bond is supported by the 'full faith and credit' of the citizens. In our model we simplify by assuming the mayor has the authority to offer debt with a promised $t = 2$ payment of F at a price of D_0. The debt is backed only by the ability to tax.

3.1.2 Bond Holder

The bond holder is assumed to be competitive in the sense of having unlimited funds and being willing to acquire any asset that provides at least an expected return of zero.

At $t = 0$, as stated in the previous section, 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. The contract will be accepted if

$$D_0 \leq E_0(\tilde{D}_2).$$

[17]We do not restrict the value of δ and indeed the case $\delta < 0$, where a public asset, such as the land on which a park is built, goes up in value, is interesting.

[18]This includes all taxes under the municipality's control. For example, municipalities are able to impose some or all of property tax, sales tax, income tax, hotel taxes, etc., sometimes with self imposed restrictions. We treat these as one form of taxation.

At $t = 1$ the debt holder rationally anticipates how the debt enforcement game will be played and proposes a new face value of F_B[19] that maximizes D_2, based on rational anticipation of the debt enforcement game.

At $t = 2$ D_2 is received from the municipality and no further actions are taken by the bond holder.

3.1.3 Tax base/citizens

The municipality's residents enjoy utility from unmodelled private consumption as well as the consumption of the modeled public infrastructure.We assume each person's utility from consumption of infrastructure, net of the tax disutility, is additively separable from private consumption and is given by,

$$u_t = q_t - \tau_t$$

where

$$q_t = \beta \times A_t, \quad \beta > 0$$

is the service each individual enjoys from the infrastructure. Each resident of the municipality must either pay taxes or move to another municipality and does so based on whether or not u_t meets some unmodelled heterogeneous participation constraint.

The only exogenous uncertainty in our model is a population shock $\tilde{\epsilon} \in \{\epsilon-, +\epsilon\}$, which is revealed to all parties at $t = 1$ and realized at $t = 2$. Let p denote the probability of $\epsilon+$, hence, $p > .5$ implies a municipality that is expected to grow.

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

$$N_0 = a + bq_0 - c\tau_0. \tag{1}$$

[19] We allow $F_B = F$.

Similarly, the tax base at $t = 2$ is

$$N_2 = a + bq_2 - c\tau_2 + \tilde{\epsilon}. \tag{2}$$

Therefore, the aggregate tax revenue collected at $t = 0$ and $t = 2$ is $\tau_0 N_0$, and $\tau_2 N_2$, respectively.

3.1.4 The Mayor

We assume that the mayor's objective at each point in time is to maximize the sum of the remaining citizen single period utility flows. This adding of individual utility implies that the first period welfare flow is defined by

$$W_0(\tau_0, q_0) = N_0(q_0 - \tau_0) = (a + bq_0 - c\tau_0)(q_0 - \tau_0), \tag{3}$$

while the state-contingent welfare at time $t = 2$ is given by

$$W_2(\tau_2, q_2, \tilde{\epsilon}) = N_2(q_2 - \tau_2) = (a + \tilde{\epsilon} + bq_2 - c\tau_2)(q_2 - \tau_2). \tag{4}$$

At $t = 0$ the mayor maximizies

$$V_0 = W_0(\tau_0, q_0) + E_0(W_2(\tau_2, q_2, \tilde{\epsilon})) \tag{5}$$

while at $t = 2$ the mayor maximizes

$$V_2 = W_2(\tau_2, q_2, \tilde{\epsilon}). \tag{6}$$

At $t = 1$ the mayor plays the debt enforcement game and chooses a strategy that maximzes the expected value of V_2 , rationally anticipating the rulings of the court, as described in 3.2.

The mayor's choices at $t = 0$ and $t = 2$ are constrained by an exogenously imposed *minimum service* requirement, effectively a lower bound on q, denoted by q_L, with an implied lower bound $A_t \geq q_L/\beta$. This model feature captures the fact that municipalities are required to maintain a minimum level of service to their citizens.

The actions available to the mayor are as follows. At $t = 0$ the mayor determines the size of the initial investment, I_0, and finances this investment using debt and taxes. To debt finance, the mayor offers a debt contract with face value F to bondholders at a price of D_0. If the bond is accepted, the mayor constructs the infrastructure and imposes a per person tax rate of τ_0 on all citizens, thereby raising aggregate tax revenue of $N_0\tau_0$. The mayor must satisfy the $t = 0$ budget constraint

$$D_0 + N_0\tau_0 = I_0, \tag{7}$$

as well as the $t = 0$ minimum service constraint of

$$I_0 \geq \frac{q_L}{\beta}. \tag{8}$$

If B rejects the offered contract, the game ends.

There is no utility flow at the renegotiation stage, $t = 1$, when the mayor must respond to the bondholder's proposal of F_B, discussed above. We assume the mayor must either accept the offer or file a Chapter 9 petition asking 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 makes the debt payment D_2 that the court mandates.[20] The mayor then selects I_2 and τ_2 honoring the mandated payment and the budget constraint

$$N_2\tau_2 = I_2 + D_2, \tag{9}$$

[20]The court process that determines D_2 is set out in section 3.2

while investing to provide at least the minimum service requirement q_L:

$$I_2 \geq \frac{q_l}{\beta} - (1-\delta)A_0. \tag{10}$$

3.2 Debt Enforcement

Debt enforcement begins at $t = 1$ with the revelation of $\tilde{\epsilon}$, which is a shock to the tax base. Based on the realized value of $\tilde{\epsilon}$, the bond holder is required to make the first move by informally 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, or rejecting the proposal by filing a petition with the court to confirm a new contract with a face value of F_M.

At $t = 2$, if the mayor has accepted B's proposed adjustment to F_B, then debt enforcement does not involve the court: The mayor pays F_B and optimally selects I_2 and τ_2. If, however, the mayor filed a petition at $t = 1$, then date $t = 2$ begins with the court ruling on the petition. The court's decision on whether or not to confirm the mayor's proposal is based on rational expectations of the investment and taxation decisions that the mayor will make following confirmation as well as on "admission" and "exit" conditions. Specifically, the court will confirm the mayor's petition if the following criteria are met:

1. Admission condition. The debtor is *insolvent* in that there is no tax rate τ_2 that would allow repayment of F as well as achievement of the minimum service level.

2. Exit condition. The proposed contract, F_M is feasible and is made in "good faith." It is feasible 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 the bondholder with a payment of at least F^*, a minimum acceptable payment as determined by the court.

While we are not aware of a theoretical basis for what would be considered a 'good faith' offer, 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 0. The best outcome the bondholder could expect is the solution to

$$\max_{D_2, I_2, \tau_2} D_2, \tag{11}$$

subject to

$$\begin{aligned} D_2 &\leq F \\ A_2 &\geq A_L \\ A_2 &= (1-\delta)A_0 + I_0 \\ \tau_2 N_2 &= (1 - \gamma \mathbb{1}_{I_2<0})I_2 + D_2. \end{aligned}$$

Let $\bar{F}$ denote the solution to (11).

To satisfy the exit condition, the court will therefore consider any F_M satisfying

$$F_M \geq F^* \equiv \pi \bar{F} \tag{12}$$

where $\pi \leq 1$ determines the degree to which debtor interests are factored into the court's good faith requirement.

If the court rejects M's petition, it then applies contract law to the dispute by requiring that B be paid $\min\{F, \bar{F}\}$.

In summary, contract enforcement will result in a payment from the municpality to the bondholder, D_2, of :

- F_B, if B's offer is accepted by the mayor
- F_M, if B's offer is rejected by the mayor and the court approves the chapter 9 petition, or

- $\min\{F, \bar{F}\}$ if the court rejects the mayor's petition and uses contract law to resolve the dispute.

4 Model Solutions

Our research objective is to characterize a municipality's bond/tax financing choice for infrastructure and the consequences of this choice on the size and service quality of cities. To provide a backdrop to our analysis, we present two benchmarks.

In the first 'complete markets' case we assume that at $t = 0$ the mayor is able to select state contingent value of I_t and τ_t subject to the constraint that total *expected* tax revenue is equal to total expected infrastructure expenditures. Note that in this representation of the model the budget constraint holds in expectations rather than state by state. As a result, our benchmark is essentially a complete Arrow/Debreu market solution to the mayor's problem as it implicitly involves pure securities that allow funds to be transferred from one state to the other in satisfying the budget constraint.

The other benchmark is the "no financing" benchmark. Here the mayor selects investment and tax rates in each state but must satisfy the budget constraint in each state. It assumes there are no capital markets.

Our two extreme benchmarks allow us to examine the allocative "costs" of debt financed infrastructure subject to contract law and bankruptcy law. In addition, the complete markets solution starkly illustrate the main forces that determine municipal capital structure.

4.1 Complete Markets

The mayor's problem in the complete markets case is given by equation 13 subject to the budget constraint 14 and the minimum service constraints 8 and 10.

$$\max_{\{I_0, I_2^+, I_2^-, \tau_0, \tau_2^+, \tau_2^-\}} V_0 = W_0(q_0, \tau_0) + pW_2(I_2^+, \tau_2^+, +\epsilon) + (1-p)W_2(I_2^-, \tau_2^-, -\epsilon) \qquad (13)$$

s.t.

$$N_0\tau_0 + pN_1^+\tau_2^+ + (1-p)N_1^-\tau_2^- = I_0 + pI_2^+ + (1-p)I_2^-, \tag{14}$$

where $N_2^+ = a + \epsilon + bq_2^+ - c\tau_t^+$ and $N_2^- = a + \epsilon + bq_2^- - c\tau_t^-$. The solution to this problem requires the solution to a system of six non-linear first order conditions and the budget constraint. As analytical solutions to this system are not available, we solved the system numerically and report a specific numerical example in Table 3.[21]

4.1.1 Municipal Capital Structure

Although we are not able to analytically solve for all six choice variables, we are able to obtain insight into the general municipal capital structure decision by fixing I_0, I_2^+ and I_2^-, which effectively also fixes q_0, q_2^+, and q_2^-, and optimally picking τ_0, τ_2^+ and τ_2^-. This delivers what might be thought of as the municipal debt Euler equations.

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

where $MTR_i = \frac{d}{d\tau_i}N_i\tau_i$.

These Euler equations illustrate the trade off inherent in a municipalities capital structure and illustrates how different the capital structure decision of a NM corporation is from a municipal corporation. The traditional NM corporation capital structure theory shows that a given level of real investment is financed in a way that balances the marginal tax advantage of debt against the marginal bankruptcy costs. In the Euler equations we see a fundamentally different trade off where debt and the tax rates are used to balance the marginal tax revenues over time and across states.

[21]See the Appendix for details on our numerical solutions.

The insight provided by the complete market's solution carries to the more realistic cases of risky debt subject to bankruptcy law. Risky debt will partially adjust state contingent payments towards the complete market's solution while bankruptcy law, by determining state contingent bargaining outcomes, may move the solution closer to or further away from the complete market's solution.

4.1.2 No Financing

In the absence of financing and without complete capital markets, the mayor will also solve (13) but subject to the following budget constraints.

$$N_0 \tau_0 = I_0$$
$$N_2^+ \tau_2^+ = I_2^+$$
$$N_2^- \tau_2^- = I_2^-$$

As with the complete markets benchmark, the solution to this problem involves six non linear first order conditions and three budget constraints. The same numerical example as in the complete contract case but for the No financing case is summarized in Table 3.

4.1.3 Gains from financial markets

A comparison of the Complete Market and No Financing constraints shows the value of employing financial markets. See Table 3 for a numerical comparison where it is clear that, not surprisingly, capital markets add significantly to welfare.

4.2 Risky Debt

We now consider the Mayor's optimal choice of investment and financing when pure securities are not available and only risky debt is issued. We begin with a formal statement of the problem.

$$\max_{\{I_0, I_2^+, I_2^-, \tau_0, \tau_2^+, \tau_2^- F\}} V_0 = W_0(q_0, \tau_0) + pW_2(I_2^+, \tau_2^+, +\epsilon) + (1-p)W_2(I_2^-, \tau_2^-, -\epsilon) \tag{15}$$

s.t.

$$\begin{aligned} D_0 + N_0\tau_0 &= I_0 \\ N_2^+\tau_2^+ &= I_2^+ + D_2^+ \\ N_2^-\tau_2^- &= I_2^- + D_2^-. \end{aligned}$$

In equilibrium at $t = 1$, bondholders make the following repayment proposals

$$F_B = \begin{cases} F & \text{if } \tilde{\epsilon} = +\epsilon; \\ F^* & \text{if } \tilde{\epsilon} = -\epsilon. \end{cases} \tag{16}$$

The Mayor accepts (conditionally) the bondholder proposal, thereby determining the date $t = 2$ state-contingent bondholder payments $D_2^+ = F$ and $D_2^- = F^*$. The Mayor's optimization then becomes a standard nonlinear, constrained optimization that we solve using standard numerical techniques.[22]

5 A Numerical Example

5.1 The Base Case with Debt Financing

Table 3 contains the parameters for a numerical example of the equilibrium decisions and is the base for some interesting comparative statics.

After describing the base case equilibrium, we will compare this case to two special cases: (i) the "first-best" solution and then (ii) the "no capital markets" solution. The first-best

[22] See the Appendix for further details.

solution replaces the two budget constraints at $t = 0$ and $t = 2$ with one combined budget constraint that requires the expected budget to balance *overall*, i.e., summed over $t = 0$ and $t = 2$, rather than balancing period-by-period. This is equivalent to assuming the existence of perfect capital markets that allows participants to move dollars over time and states with no imperfections. It could also be labeled an "Arrow-Debreu" market. The second case requires tax revenues to cover all expenditures in each separate period, allowing no issuance of debt or Arrow-Debreu securities. These two extreme cases should provide polar cases within which the base case will lie.

The key base case assumptions are:

- $I_t \geq 0$: We refer to this case as "irreversible investment." Assets acquired by the city at t=0 cannot be liquidated at t=2. This could be city infrastructure, such as sewer systems or power lines, which are immobile and have little practical use outside of their current function. These can also be thought of a critical services (fire services, EMS, etc.).

- $p = .90$: The probability of $\epsilon_2 = +25$ is high, so that the city is (ex-ante) expected to grow. The chance of a large population decline ($\epsilon_2 = -25$) is small ($1 - p = 0.1$).

- $\pi = 0.5$: This parameter is an index of the "creditor-friendliness" of the court in judicial debt-restructuring decisions. The initial $\pi = .5$ is quite generous to the city; we believe that Chapter 9 exhibits some of this debtor-friendliness.

As shown in Table 3, the optimal t=0 decisions are: $I_0 = A_0 = 60.83$ and $F = 39.54$, which creates $t = 0$ debt sale proceeds of $D_0 = 36.40$. As we will see, the debt is risky, requiring a yield of $\frac{39.54}{36.40} - 1 = .0863$, representing the credit spread on the muni debt at issue. So, the base case uses debt financing for $\frac{36.40}{60.83} = .598$ or about 60% of its investment needs.

Suppose first that at $t = 1$, all parties learn that there is a large population INFLOW ($\epsilon_2 = +25$). Then, at $t = 2$, the mayor optimally decides to repay the debt face value

($D_2^+ = F = 39.54$), while making NO new investment in muni assets ($I_2^+ = 0$). The original asset base of $A_0 = 60.83$ depreciates at the $\delta = 0.10$ rate to $A_2 = 54.75$, leading to a quality of $q_2 = 5.48$. The budget constraint requires a per-capita tax of $\tau_2 = 0.48$, leading to a $t = 2$ population of $N_2^+ = 82.61$. Thus, the city raises tax revenue of $82.61 * .48 = 39.6$, all used to repay the debt face value of 39.54.

Suppose now that, at $t = 1$, all parties learn that there is a large population OUTFLOW ($\epsilon_2 = -25$). The bondholders and the mayor will anticipate the result of going to court at $t = 2$ when choosing their actions at $t = 1$. It will be common knowledge that the city has a debt repayment problem: given that the mayor chooses investment I_2^- optimally, there is no solution to the quadratic (in τ_2^-) budget constraint $N_2^- * \tau_2^- - (I_2 + F) = 0$, where the full face value repayment, F, is made and municipal quality, q, stays above the minimum acceptable level, q_L.

Given the mayor's debt repayment problem, we model the court process as follows.

First, the court determines the most favourable outcome for the city (the worst for the bondholder) as the debt repayment amount, D_2^-, that maximizes the city objective of $N_2^- * (q_2 - \tau_2)$ subject to $q_2 \geq q_L$, $\tau_2 \geq 0$ and $N_2^- * \tau_2 - (I_2 + D_2^-) = 0$ and I_2^- chosen optimally by the mayor. In this example, the solution is $D_2^- = 0$ and we label this case as $\underline{F} = 0$.

Second, the court determines the most favorable outcome for the bondholders by finding the largest value of debt repayment, $D_2^- \leq F$, that also satisfies the budget constraint (using the mayor's optimal choice of $I_2^- = 0$). We call this value of debt repayment $\bar{F}$. In this example, $\bar{F} = 16.19$.

Finally, the court weights the two outcomes, $\underline{F}$ and $\bar{F}$ with an "index of creditor-friendliness," in the base case we use a small $\pi = 0.5$, to determine the court's choice for a debt repayment, $F^* = \pi * \bar{F} + (1 - \pi) * \underline{F} = (.5) * (16.19) + (1 - .5) * 0 = 8.10 = F^*$.

Thus, the final period begins with a judge ruling on any petitions asking for Chapter 9 protection. If one is presented, the judge grants the petition (entry to bankruptcy) if the state allows chapter 9 to be used, and there is no feasible tax rate that would generate the funds to pay back F (cash flow insolvency) while allowing the city to meet the minimum service constraint (service insolvency). Once the petition is granted, courts do not interfere with the running of the city. The next move by the court is to either approve the mayor's proposed reorganization or reject it. The reorganization will be accepted and enforced if a) it meets the minimum service requirement and "is in the best interests of the bondholders" which, as we discussed in section 3.2 means offering at least F^*. If either the initial petition or the proposed reorganization is rejected, then the judge applies contract law and requires that $\bar{F}$ be repaid.

In our example, the court process is anticipated by the mayor and bondholders and the bond holder offers to pay $F^* = 8.10$, which will be accepted by the mayor. To make the payment, the mayor sets a tax per capita of $\tau_2^- = .12$; combined with a city quality of $q_2^- = 5.47 > q_L$, the population after the negative shock ends up being $N_2^- = 68.69$. This population results in just enough tax revenue to repay the bondholders the court-ordered $F^* = 8.10$.

The t=2 outcomes for the mayor's objective are: $W_2^+ = 412.73$ and $W_2^- = 367.98$, for an expected (as of $t = 0$) payoff of $p * W_2^+ + (1-p) * W_2^- = .9 * (412.73) + .1 * (367.98) = 408.26 = E_0(W_2)$. Given the mayor's optimal $t = 0$ choices of I_0 and F, this provides $W_0 = 415.24$ and the total two-period objective of $W_0 + E_0(W_2) = 823.49$. This $t = 0$ objective value is the maximum over the choice variables at $t = 0$ of $I_0 = 60.83$ and $F = 39.54$.

5.2 The Base Case Drivers

Several facts arise in the base case example that are worth pointing out since they will arise in the comparisons to other cases.

- All investment is made at $t = 0$; $I_2^+ = I_2^- = 0$. Assets put in place at $t = 0$ will benefit both generations of taxpayers (although depreciation lowers the quality of the asset base slightly at $t = 2$). Since both generations of taxpayers benefit from the

$t = 0$ investment, the question is how to spread the cost of the investment over both generations in the form of taxes paid to the city. Debt turns out to be a quite efficient vehicle.

- The $t = 0$ investment is paid for in debt sale proceeds, $D_0 = 36.40$, and in tax revenue, $N_0 * \tau_0 = 24.60$ so that debt financing is $\frac{D_0}{I_0} = 0.60$, or 60% of the investment cost.

- The mayor fully repays debt face value if the ϵ_2^+ state occurs, but the mayor and the bondholders anticipate a bond repayment of only $D_2^- = 8.10$ in the ϵ_2^- state. The optimality of the $t = 0$ investment and financing decisions can be seen by viewing the demands made on the taxpayers in each date-state in the model.

  - Tax revenue generated in the ϵ_2^+ state is $TR_2^+ = 39.65$ and the corresponding marginal tax revenue is $MR_2^+ = 34.61$.

  - Tax revenue raised at $t = 0$ is $TR_0 = 24.58$, which corresponds to marginal tax revenue of $MR_0 = 38.28$. To compare these marginal revenues, we "discount" the $t = 0$ marginal revenue forward to make it comparable to the $t = 2$ marginal revenue. We see that $(1 - \delta) * MR_0 = 0.35 = MR_2^+$, approximately. The amount of debt face value issued and the initial investment are set to equate marginal tax revenues in the $t = 0$ and ϵ_2^+ time-states.

  - With the given debt face value and the anticipated outcome of the bankruptcy process, $t = 2$ required tax revenue is $D_2^- = 8.1$; this tax revenue implies a marginal tax revenue of $MR_2^- = 56.69$, which is much higher than in the other two time-states. This reflects the inefficiency of debt financing.

5.2.1 The Base Case Dynamics

The city evolves quite differently conditional upon having an exogenous population inflow or outflow. When the exogenous shock is positive, the mayor takes advantage of the larger population base to raise taxes over the $t = 0$ tax rate by 41.2% ($\frac{.48}{.34} - 1$). Since the optimal investment decision is to make no new investment, assets and quality decline by 10%. The exogenous shock, tax and quality effects net to population rising over the $t = 0$ level by 14.3%.

When the exogenous population shock is negative, the mayor optimally makes no new investment, renegotiates the debt repayment and slashes the per capita tax rate by -64.7% $(\frac{.12}{.34} - 1)$. Asset irreversibility means that quality only declines by 10% due to depreciation.

5.2.2 The Base Case with Perfect Capital Markets

In this solution we only require that the city's budget balance over two periods ($t = 0$ and $t = 2$), but need not balance period-by-period. This would be the case, for example, if Arrow-Debreu securities existed that had state definitions based on population shocks; this is obviously highly unlikely, but it provides an example of the very best the city could do. We'll refer to the "first-best" case and the "debt-financing case" in comparing these capital market structures.

Table 3 shows the results for the first-best case. This equilibrium does improve total welfare: first-best $W_0 + E_0(W_2) = 825.41$, compared to the debt-financing case of $W_0 + E_0(W_2) = 823.49$.

The first-best case allows sufficient financing flexibility to equalize marginal revenues, both across $t = 2$ states and over time:

$$(1 - \delta)MR_0 = MR_2^+ = MR_2^- = 34.7$$

When equating all three marginal tax revenues, the actions of the mayor and bondholders are VERY similar at $t = 0$ and in the *positive* population shock case, as seen by comparing the debt-financing case and the first-best case.

The behavior in the first-best case differs significantly from the debt-financing case when the *negative* population shock occurs. Repayment of Arrow-Debreu securities by the city is much higher (13.14 versus 8.10) than the debt workout repayment in the debt-financing case, requiring a higher tax rate in first-best than in the debt-financing case; this equates marginal tax revenues across dates-states.

The improvement of moving to perfect capital markets is not Pareto comparable: $t = 0$ citizens gain more than $t = 2$ citizens give up, but the net gain comes at the $t = 2$ citizens' expense. This is partly due to the larger $t = 0$ investment under first-best leading to higher quality at $t = 0$ under first-best than under debt-financing.

5.2.3 The Base Case with NO Capital Markets

In this solution we eliminate the use of debt financing, requiring that the city's budget balance at EACH period, $t = 0$ and $t = 2$. Here we refer to the base case as the "debt case" and the no capital markets case as the "no-debt case." Panel C in Table 3 shows the no-debt case.

Removing the ability to share the cost of $t = 0$ over two generations of taxpayers dramatically alters the investment pattern: $t = 0$ investment is dramatically cut and investment in the ϵ_2^+ state is bigger than I_0 to accommodate the population inflow in the ϵ_2^+ state. Additional investment in the ϵ_2^- state is also positive, but small.

Marginal tax revenues are different in each date-state. While investment can push $MR_2^+ = 60.36$ close to $MR_2^- = 51.45$, $t = 0$ marginal revenue is quite different ($MR_0 = 16.83$). These differences in marginal tax revenues show up in welfare results:

Total welfare drops dramatically in the no-debt case, from 823.49 to 603.16. Capital markets are welfare-enhancing! But, the inflexibility due to irreversible investment means $t = 0$ welfare is much lower, and $t = 2$ expected welfare higher, in the no-debt case compared to the debt case.

5.2.4 The Base Case Summary

A city purchasing long-lived assets to provide multi-period services to its citizens cannot efficiently finance these asset purchases from tax revenues alone. The "No Capital Markets" example above, compared to the "debt financing" example, clearly shows the importance of debt markets to municipalities. To provide multi-period services, it is efficient to put assets in place early (at $t = 0$) to benefit both $t = 0$ and $t = 2$ citizens; the only "cost" of this strategy is the depreciation of the assets over time ($\delta = 0.1$ in our example).

Financing the large $t = 0$ asset purchases is efficiently accomplished with debt. Using the appropriate mix of debt proceeds and tax revenue allows the city to spread both the benefits and costs of acquiring the assets over both cohorts of citizens, $t = 0$ and $t = 2$. In the base case using debt financing, $t = 0$ tax revenues are $N_0 * \tau_0 = 72.28 * 0.34 = 24.58$ and debt sale proceeds are $D_0 = 36.40$, for a total of $60.8 = I_0$, which is used for asset purchases. Thus, debt makes up $\frac{36.4}{60.8} = 0.60$ or 60 percent of the funds needed at $t = 0$.

The above has demonstrated the efficacy of using debt to finance long-lived assets. Next we show that issuing risky debt may actually be superior to riskless debt.

5.3 Comparative Static: Safe Debt

The mayor, or state governments responsible for municipalities and their citizens, might view the bankruptcy process underlying the issuance of risky debt as unacceptable. The bankruptcy process can be avoided by restricting the mayor to only issue riskless debt, insuring no court oversight will be required. Table 3 shows the base case except that a constraint has been added to insure that debt can be repaid fully in both the ϵ_2^+ and ϵ_2^- states.

Table 3 dispels the idea that safe debt would always be an improvement. In our model welfare, compared to the base case, falls with riskless debt to 694.06 from 823.49. Requiring a much higher ϵ_2^- state debt repayment with riskless debt imposes a very high tax rate on those taxpayers, as seen in a very low marginal tax, $MR_2^- = 4.90$.

In addition, the smaller amount of debt financing available, $D_0 = F = 15.41$, causes the mayor to drastically reduce I_0, so reducing q_0 and damaging $t = 0$ welfare. However, the lower $D_2^+ = 15.41$ with riskless debt significantly lowers τ_2^+, so raising $MR_2^+ = 58.74$. Thus, riskless debt greatly inhibits equating marginal tax revenues across dates-states, so greatly reducing welfare.

This case also shows that, moving from the risky debt to riskless debt case cuts debt sale proceeds by 58%, but the mayor only cuts $t = 0$ investment by 33%. So, in the safe debt case, only $D_0/I_0 = \frac{15.41}{40.77} = .38 = 38\%$ of chosen investment is financed with debt, compared to 60% debt financing in the risky debt case.

5.4 Comparative Static: Court Creditor-Friendly Index

U.S. municipalities are covered by a special part of the U.S. bankruptcy code: Chapter 9. We greatly simplify the impact of Chapter 9 by saying it favors the debtor (the muni) in court decisions made under Chapter 9, compared to settlements coming from courts not governed by Chapter 9. We consider two court environments:

- The base case: if the muni and bondholders go to court under Chapter 9, the court has a low creditor-friendly index of: $\pi = 0.5$.
- Comparative static: In a non-Chapter 9 court setting, the court is much more favorable to bondholders, with a high creditor-friendly index of $\pi = 1.0$.

Recall that the court's judgement has been characterized by:

$$F^* = \pi(\bar{F}) + (1 - \pi)(\underline{F})$$

where $\underline{F}$ is typically 0 and $\bar{F}$ is the largest debt payment, up to F, that the muni budget constraint will support, assuming the mayor chooses investment optimally, subject to the resulting quality meeting or exceeding q_L. The court then directs the muni to pay the bondholders the amount F^*.

Table 3 shows the result (comparable to the base case), where, instead of a court that is lenient to munis, the court favors the bondholders by awarding a larger F^*. We call this alternative to Chapter 9 the "contract court."

The driving difference between contract court and the base case (chapter 9) is that bondholders will get a more generous payment in the ϵ_2^- state: In the example, $D_2^- = 8.10$ in the base case, but in contract court the bondholder payment nearly doubles to $D_2^- = 16.05$; the contract court case has a bond recovery rate of $\frac{16.05}{39.48} = .41$ compared to the Chapter 9 bond recovery rate of only 0.20.

Since the optimal face value of the debt chosen by the mayor at $t = 0$ is approximately the same in both the base case and contract court ($F = D_2^+ = 39.5$), and the higher recovery rate in the contract court case, bondholders will pay more at $t = 0$ for the same debt promise $F = 39.5$. We can compare debt yields under the two court regimes:

Chapter 9 bond yield: $\frac{39.54}{36.40} - 1 = .0863$ Contract court bond yield: $\frac{39.48}{37.13} - 1 = .0633$.

The court being more lenient to bondholders reduces the city's cost of capital from 8.6% to 6.3%.

The court's bias is reflected in all the parties' actions, but the real impact occurs in the ϵ_2^- case. While $t = 0$ investment, total debt issued, per capita tax, population and total tax revenue are all quite similar under Chapter 9 and contract court, the ϵ_2^- case exhibits stark differences based on creditor-friendliness.

Under contract court (compared to Chapter 9) in the ϵ_2^- state:

- Bondholders receive almost twice as big a partial repayment ($D_2^- = 16.05$ versus 8.10)
- Since muni investment is irreversible, the only way the mayor can repay more to the bondholders is by raising per capita tax by 200% (from $\tau_2^- = 0.12$ to 0.36) and causing population to fall by 35.5%. The high tax rate shows up as a very low $MR_2^- = 8.29$, which is much less than the other two date-state marginal tax revenues. The ϵ_2^- taxpayers are carrying a very heavy burden.
- The creditor-friendly contract court reduces $t = 2$ citizen welfare by 8.13 (to $E_0(W_2) =$

400.13 from 408.26), but, given the same face value of debt issued under both Chapter 9 and contract court, the bondholders pay more at $t = 0$ for the debt, raising $t = 0$ citizens' welfare by 7.16.

So, a court favouring bondholders allows the mayor more debt sale proceeds, but keeps the fraction of total investment that is debt financed roughly the same as before (at 0.60), so that the mayor invests more when the court is more creditor-friendly. Still, overall city welfare is harmed by the court favoring bondholders, as total welfare drops. This welfare loss shows up in the ϵ_2^- state.

Thus, we can see that the court's attitude toward the city versus the bondholders is important, and can have dramatic effects on a city involved in a court-managed workout. While welfare effects in our example are small, population can be significantly affected, along with per capita taxes.

5.4.1 An Optimal Creditor-Friendly Index

The above analysis shows that the payment bondholders will receive in the negative epsilon case is monotonically related to the creditor-friendly index value. But a crucial feature of the creditor-friendly index value is its impact on citizen welfare: as the payment received by bondholders increases, so does the amount of $t = 0$ debt proceeds, for a given face value, increase. Thus, both utility functions W_0 and $E_0(W_2)$ are affected as π is changed.

In fact, we find an *optimal* welfare-maximizing value of π in our numerical example. In the base case, the welfare-maximizing value for π is $\pi^* = 0.83$. This value lies between the base case $\pi = 0.5$ and the comparative static "contract court" $\pi = 1.0$. Starting from our base case of $\pi = 0.5$, a court leaning more towards the municipality allows more $t = 0$ investment and a slightly lower tax rate, raising W_0. This rise in W_0 is more than the decrease in $E_0(W_2)$ that results from the higher bond repayment in default in the negative epsilon state at $t = 2$.

Thus, concavity of the welfare function in π means there is an *optimal* court attitude. Another interesting feature of our 2-epsilon-state model is that this optimal π value also matches the welfare of the first-best outcome. We view this as a special case generated by the use of a 2-epsilon-state example wherein the first-best allocation of cash flow (and so tax burden) across two states and two dates can replicate the best Arrow-Debreu solution. Adding more $t = 2$ states would render a debt contract incapable of spanning the state space. However, even in this case, there would be an optimal π^*.

5.5 Comparative Static: A Declining City

Here we alter the base case parameter p, which is the $t = 0$ probability of the of the positive epsilon state occurring at $t = 2$. The base case has $p = 0.9$ so that the city is expected to grow (the expected population shock, before adjustments from quality and taxes, is $p\epsilon_2^+ + (1-p)\epsilon_2^- = (.9)(25) + (.1)(-25) = +20$). In this comparative static, we adjust p to $p = .3$ so that the expected population shock is now $p\epsilon_2^+ + (1-p)\epsilon_2^- = (.3)(25) + (.7)(-25) = -10.0$. We characterize this as a "declining city."

Table 3 shows the results of this comparative static. Becoming a declining city (compared to the base case) shows:

- the ϵ_2^- contingent payment in the declining city case can be kept the same as the base case, resulting in similar marginal tax revenues MR_2^- in both cases.

- But, the very high probability of default ($1 - p = 0.7$) drastically reduces what the bondholders pay at $t = 0$ for the same face value issued in the base case; in the declining city, bondholders only pay $D_0 = 17.30$. Compared to the base case, debt proceeds have dropped by -52%, but the mayor reduces investment by less (31%), so the fraction of investment coming from debt in the declining city is 0.41 compared to the base case of 0.60.

- The mayor spreads the additional amount of investment that must be paid by taxpayers across both the $t = 0$ taxpayers and the tax rate paid in the ϵ_2^+ state; the resulting marginal tax revenues are very similar: $(1 - \delta) * MR_0 = 27.43$ versus $MR_2^+ = 27.23$.

- The declining city has only marginally lower $t = 0$ population despite its more gloomy outlook. However, the lower quality and higher taxes do drain the population to a degree; for example, N_0 drops by $\frac{67.48}{72.28} - 1 =$ -6.6% compared to the base case.

5.6 A Different Model: Investment Reversibility

The base case assumes that city assets cannot be liquidated at $t = 2$ to be used to repay debt or reduce per capita taxes. In this example, we drop the $I_2 \geq 0$ restriction but recognize that if the mayor sells \$1 of assets at $t = 2$, quality will drop by $\beta * 1$, but the proceeds of the sale of the \$1 of assets to the mayor is only $(1-\gamma)*1$ where we will assume that $\gamma = 0.5$. This recognizes that asset liquidation is possible, but at a steep cost.

Table 3 shows the results with reversible investment ($\gamma = 0.50$), and the Chapter 9 ($\pi = 0.50$) base case. $t = 0$ investment with reversible investment is essentially the same as the base case. And, as in the base case, no investment is made or liquidated in the ϵ_2^+ state. However, in the ϵ_2^- state, the mayor liquidates assets with a book cost of \$8.18, for net sale proceeds of \$4.09; when added to the tax revenue of 12.18, this sums to the amount repaid to bondholders, $D_2^- = 16.27$. Compared to the base case (with investment irreversibility), investment reversibility leads to:

- The mayor equates initial marginal tax revenue with the ϵ_2^+ state: $(1-\delta)*MR_0 = 34.67$ and $MR^+ = 34.77$. However, the cost of liquidating assets causes quality to drop more than the asset sale proceeds, causing a higher tax rate $\tau_2^- = .21$ (compared to 0.12 in the base case) and $MR_2^- = 38.11$.

- Total welfare in the reversible investment case actually exceeds total welfare in the first best case with irreversible investment. Investment flexibility is very welfare-enhancing.

Thus, allowing reversibility of investment is extremely important, so that it is considered as a different model from the model used in the base case and its comparative statics. This importance shows in the reverisible investment welfare value exceeding that of both the base case welfare and the "first best" welfare in the base case.

Investment reversibility provides significant flexibility to the city, and, in financial distress, the mayor uses this reversibility, despite its great cost (investment sale proceeds assume to equal 50% of the asset value (and quality) given up). The ability to sell assets leads the mayor to install more assets at $t = 0$, raising city quality at $t = 0$ and in the ϵ_2^+ state, while leading to a significant drop in city quality in the ϵ_2^- state.

Reversible investment, compared to irreversible investment, is not Pareto-comparable: $t = 2$ taxpayers' expected welfare drops (by 4.05) due to selling assets in the ϵ_2^- state, but, greater investment at $t = 0$ improves $t = 0$ welfare (by 7.20) due to higher initial city quality.

5.7 Municipal Capital Structure in the Base Case

The numerical example and comparative statics around the base case show the drivers of the use of debt by municipalities. The first-order conditions from the first-best ("perfect capital markets") case shows that Arrow-Debreu securities could be used to equate the marginal tax revenues across dates and states. We found that Arrow-Debreu securities allowed the necessary condition:

$$(1 - \delta)MR_0 = MR_2^+ = MR_2^-$$

At the optimal first-best solution, the depreciation-adjusted marginal tax revenue at $t = 0$ is set equal to the $t = 2$ state-conditional marginal revenues. This condition reflects the optimal use of taxpayer dollars for investment.

In a world without Arrow-Debreu securities, such as our Base Case example, $t = 0$ investment, I_0, is paid for by borrowing D_0 and taxpayer funds, $N_0\tau_0$:

$$D_0 + N_0\tau_0 = I_0$$

By manipulating the Base Case first-order conditions, we can show:

$$I_0 - D_0 = TR_0^* - \frac{MR_0^2}{4c}$$

where $TR^* = \frac{(a+b*q_0)^2}{4c}$ is the maximum total tax revenue possible for any given $q_0 = \beta I_0$.

This equation shows that the amount of taxpayer funding used to put I_0 in place is a function of the optimal amount of investment (and so q_0) and the optimal marginal revenue from $t = 0$.

Thus, a municipality's debt ratio is determined by the process of trying to equate marginal tax revenues across dates and states.

In our Base Case numerical example: $I_0 = 60.83$, $D_0 = 36.40$ and total taxpayer funds are $N_0\tau_0 = 24.43$. Using the above necessary condition of optimality:

$$I_0 - D_0 = TR_0^* - \frac{MR_0^2}{4c} = 28.13 - 3.66 = 24.47 = N_0\tau_0$$

In the Base Case, this optimal split of financing between debt and taxes results in a "debt ratio" of $\frac{D_0}{I_0} = 0.60$.

Interestingly, many of the other cases we examined also result in a debt ratio of $\frac{D_0}{I_0} = 0.60$: the first-best perfect capital markets case and the contract court case both have $\frac{D_0}{I_0} = 0.60$.

However, two of our comparative statics cases result in different city debt ratios: (i) the Safe Debt case and (ii) the Declining City case, which have, respectively, $\frac{D_0}{I_0} = 0.38$ and $\frac{D_0}{I_0} = 0.41$.

The constraints on equating marginal tax revenues across all dates and states imposed in these two cases are severe.

(i) Requiring riskless debt limits F to what can be repaid in the ϵ_2^- state, and so results in very little debt sales proceeds: $D_0 = F = 15.41$. In this case, marginal revenue is quite low relative to first-best: $MR_0 = 26.13$ (versus first-best $MR_0 = 38.51$). This indicates taxpayer revenue is being pushed near its limit, to offset the loss of debt-supplied funding.

(ii) In the declining city, there is a very high probability $(1 - p = 0.70)$ of default and bondholders will pay very little at $t = 0$ for such a risky bond: $D_0 = 17.30$. As above, in a declining city, marginal revenue is quite low relative to first-best: $MR_0 = 30.48$ (versus first-best $MR_0 = 38.51$). This indicates once again that taxpayer revenue is being pushed near its limit.

In both these cases, debt sales proceeds are about half of the debt sale proceeds in the base case. The mayor's optimal reaction to this is to cut optimal investment. But, doing so drops quality, q_0, and so population falls, and tax revenues decline. So, the mayor cuts optimal investment *by less than* the cut in debt financing. In both these cases, compared to the base case, D_0 falls by about half, while I_0 only falls by about a third. The result is that the optimal debt ratio, D_0/I_0 falls from about 0.60 to about 0.40

This demonstrates that municipalities use debt financing to adjust the optimal marginal tax revenues across dates and states.

6 Conclusion

In this study we examine the use of debt financing by a municipality, focusing on the amount of new investment financed by debt relative to taxes. We define the debt/tax choice as the municipal corporation's capital structure and show the forces that determine a municipality's capital structure. The determinants of a municipal's capital structure are very different from those of a non-municipal (NM) corporation. The long established tradeoff between interest deductibility and bankruptcy costs that characterize NM optimality are replaced by the tradeoff of marginal tax revenues that are dependent on net migration to the city. Our model also captures the very different and complex bankruptcy process faced by municipal bond holders and we use this characterization to show how contract law and bankruptcy law combine to modify the marginal tax revenues across time and states in a way that alters welfare.

We also numerically examine our model and show that requiring municipalities to issue safe debt is suboptimal, that the debtor/creditor leaning of bankruptcy court's affect welfare, as does the reversibility of municipal infrastructure.

Appendix

This appendix provides details of our solution methods and, where possible, analytic results.

Parameter Restrictions

We require that the initial quality be chosen from the interval $[q_L, q_{UB}]$ where q_{UB} is the smallest root to the quadratic in q

$$\big(a + bq\big)^2 + p\big(a + \epsilon + b(1 - \delta)q\big)^2 + p\big(a - \epsilon + b(1 - \delta)q\big)^2 - 4c/\beta. \tag{17}$$

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

$$(a - \epsilon)^2 + (c - ab\beta)^2 - a^2(1 + 2b^2\beta^2) \geq 0. \tag{18}$$

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 $\tilde{\epsilon} = -\epsilon$:

$$\max_{\tau} N_2^- \tau = (a - \epsilon + bq - c\tau)\tau. \tag{19}$$

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

$$R_2^-(q) = \frac{(a - \epsilon + bq)^2}{4c}. \tag{20}$$

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

$$\max_{q} \frac{(a-\epsilon+bq)^2}{4c} - \frac{q}{\beta}. \tag{21}$$

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 problem (11) is given by

$$\bar{F} = \frac{(a-\epsilon+bq_B)^2}{4c} + (1-\gamma)\frac{(1-\delta)q_0 - q_B}{\beta} \tag{22}$$

where $q_B = q_L$ when investment is reversible and $q_B = (1-\delta)q_0$ when investment is irreversible.

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 (5) in this special case

$$\max_{\{I_0, I_2^+, I_2^-, \tau_0, \tau_2^+, \tau_2^-\ F\}} V_0 = W_0(q_0, \tau_0) + pW_2(I_2^+, \tau_2^+, +\epsilon) + (1-p)W_2(I_2^-, \tau_2^-, -\epsilon) \tag{23}$$

s.t.

$$\begin{aligned} pF + (1-p)F^* + N_0\tau_0 &= I_0 \\ N_2^+\tau_2^+ &= I_2^+ + F \\ N_2^-\tau_2^- &= I_2^- + F^*. \end{aligned}$$

Equation (22) shows that F^* is a function of q_0 and, therefore, not a choice variable in the problem.

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

subproblem is

$$\max_{\{I,\tau\}} \big(a - \epsilon + bq - c\tau\big)\big(\beta I - \tau\big) \tag{24}$$

s.t.

$$\begin{aligned} \big(a - \epsilon + bq - c\tau\big)\tau - I_2 - \pi \frac{\big(a - \epsilon + b(1-\delta)q_0\big)^2}{4c} &= 0 \\ q - \big((1-\delta)q_0 + \beta I\big) &= 0. \end{aligned}$$

Substituting for the tax rate that satisfies the budget constraint yields

$$\tau = \frac{1}{c}\Big(\frac{a - \epsilon + bq}{2} - \phi_2\Big) \tag{25}$$

where

$$\phi_2^2 = \frac{\big(a - \epsilon + bq\big)^2}{4} - c\Big[\frac{q - (1-\delta)q_0}{\beta} + \pi \frac{\big(a - \epsilon + b(1-\delta)q_0\big)^2}{4c}\Big] \tag{26}$$

Substituting equation (25) into (24) gives rise to the following univariate optimization that characterizes the optimal choice of I_2

$$\max_{q} \Big(\frac{a - \epsilon + bq}{2} + \phi_2 - \frac{1}{\beta}\Big) q \tag{27}$$

A similar strategy allows elimination of τ_0 and τ_2^+ from the optimization. The first-order conditions of the Lagrangian of problem (24) produce the following equations for the tax rates:

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

where

$$\phi^2 = \left(\frac{\big(a+bq_0\big)^2 + p\big(a+\epsilon+bq_2^+\big)^2 + (1-p)\pi\big(a-\epsilon+b(1-\delta)q_0\big)^2}{4} \right.$$
$$\left. - c\frac{\big(1-p(1-\delta)\big)q_0 + q_1}{\beta} \right) \Big/ \Big(q_0^2 + pq_2^{+2}\Big). \quad (28)$$

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

$$\max_{q_0, q_2^+, q_2^-} \frac{(a-\epsilon+bq_0)q_0 + p(a+\epsilon+bq_2^+)q_2^+ + (1-p)(a-\epsilon+bq_2^-)q_2^-}{2}$$
$$- \frac{\delta q_0 + pq_2^+ + (1-p)q_2^-}{\beta}$$
$$+ \phi\sqrt{q_0^2 + pq_2^{+2}} + (1-p)\phi_2 q_2^-. \quad (29)$$

Debt-to-Investment

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

$$\frac{D_0}{I_0} = 1 - \frac{\beta\big((a+bq_0)^2/4 - \phi^2 q_0^2\big)}{cq_o\big(q_0^2 + pq_2^{+2}\big)}. \quad (30)$$

In the special case where $p = 1$, this formula becomes

$$\frac{D_0}{I_0} = \left\{ (1-\delta) + (1-\alpha)\Big[\alpha + \frac{\beta a}{2c}\Big(\alpha b + \frac{(1+\alpha)a}{2q_0}\Big)\Big] \right.$$
$$\left. + \frac{\beta\epsilon}{2c}\Big(\alpha b + \frac{a+\epsilon/2}{q_0}\Big) \right\} \Big/ (1+\alpha^2), \quad (31)$$

where $\alpha = q_2/q_0$. In the further special case of no investment and no depreciation at $t = 2$, this equation becomes

$$\frac{D_0}{I_0} = \frac{1}{2} + \frac{\beta\epsilon}{4c}\Big(b + \frac{a+\epsilon/2}{q_0}\Big). \quad (32)$$

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Table 1: State Financial Distress Environments

This table summarizes the nature of bankrupcty laws in various U.S. states

		State Can Restructure		
State	Bankruptcy Authorization	Debt Contracts	Labor Contracts	Taxes
Alabama	Yes (bonds only)			
Alaska	No			
Arizona	Yes			
Arkansas	Yes			
California	Conditional			
Colorado	Limited			
Connecticut	Conditional	Yes	Yes	Yes
District of Columbia	?	No	No	No
Deleware	No			
Florida	Conditional	No	No	No
Georgia	No			
Hawaii	No			
Idaho	Yes	No	No	No
Iowa	No (with exception)			
Illinois	?	Yes	Yes	Yes
Kansas	No			
Kentucky	Conditional	Yes	No	No
Louisiana	Conditional			
Main	No	Yes	No	Yes
Maryland	No			
Massachusetts	No	Yes	No	Yes
Michigan	Conditional			
Minnesota	Yes	Yes	Yes	No
Mississippi	No			
Missouri	Yes			
Montana	Yes			
Nebraska	Yes			
Nevada	No	Yes	Yes	Yes
New Hampshire	No			
New Jersey	Conditional	Yes	No	Yes
New Mexico	No			
New York	Conditional	Yes	Yes	No
North Carolina	Conditional	Yes	No	Yes
North Dakota	No			
Ohio	Conditional	Yes	No	No
Oklahoma	No			
Oregon	Limited	Yes	No	No
Pennsylania	Conditional	Yes	Yes	Yes
Rhode Island	Conditional	Yes	No	Yes
South Carolina	Yes			
South Dakota	No			
Tennessee	No	Yes	No	Yes
Texas	Yes			
Utah	No			
Vermont	No			
Virginia	No			
Washington	Yes			
West Virginia	No			
Wisconsin	No			
Wyoming	No			

Table 2: Baseline Parameters

Parameter	Value	Description
ϵ	25.0	Economic shock
p	0.9	Probability of $+\epsilon$
a	100.0	Population base
b	1.0	Quality sensitivity
c	100.0	Tax sensitivity
β	0.1	Public good utility (per unit q)
δ	0.1	Public good depreciation
γ	0.5	Decomissioning cost (%)
q_L	2.0	Minimum standard of public good
π	0.5	Bondholder recovery (% of $\overline{F}$)

Table 3: Numerical Solutions for Baseline Parameters

				Ch 9				
	Values			Change vs. t = 0 (%)		Ratio vs. Base Case		
Variable	t = 0	t = 2		t = 2		t = 0	t = 2	
Economic shock (ϵ)	0.00	25.00	-25.00	25.00	-25.00	0.00	25.00	-25.00
Population (N)	72.28	82.61	68.69	14.29	-4.96	1.00	1.00	1.00
Endog Pop'n	72.28	-14.67	21.41	-120.30	-70.37	1.00	1.00	1.00
Quality (q)	6.08	5.48	5.47	-10.00	-10.00	1.00	1.00	1.00
Taxes (τ)	0.34	0.48	0.12	41.59	-65.14	1.00	1.00	1.00
Investment (I)	60.83	0.00	-0.00	-100.00	-100.00			
Debt payments (D)	36.40	-39.54	-8.10	-208.64	-122.24	1.00	1.00	1.00
Capital structure ($\frac{D_0}{I_0}$)	0.60					1.00		
Maximum recovery ($\bar{F}$)		42.56	16.19				1.00	1.00
Welfare flow (W)	415.24	412.73	367.98	-0.61	-11.38	1.00	1.00	1.00
Welfare (V)	823.49					1.00		
				First Best				
	Values			Change vs. t = 0 (%)		Ratio vs. Base Case		
Variable	t = 0	t = 2		t = 2		t = 0	t = 2	
Economic shock (ϵ)	0.00	25.00	-25.00	25.00	-25.00	0.00	25.00	-25.00
Population (N)	72.51	82.76	57.76	14.14	-20.34	1.00	1.00	0.84
Endog Pop'n	72.51	-14.75	10.25	-120.34	-85.86	1.00	1.01	0.48
Quality (q)	6.13	5.51	5.51	-10.00	-10.00	1.01	1.01	1.01
Taxes (τ)	0.34	0.48	0.23	42.05	-32.31	0.99	1.00	1.93
Investment (I)	61.26	-0.00	0.00	-100.00	-100.00			
Debt payments (D)	36.88	-39.52	-13.14	-207.15	-135.63	1.01	1.00	1.62
Capital structure ($\frac{D_0}{I_0}$)	0.60					1.01		
Maximum recovery ($\bar{F}$)		42.58	16.21				1.00	1.00
Welfare flow (W)	419.80	416.75	305.30	-0.73	-27.28	1.01	1.01	0.83
Welfare (V)	825.41					1.00		
				No Financing				
	Values			Change vs. t = 0 (%)		Ratio vs. Base Case		
Variable	t = 0	t = 2		t = 2		t = 0	t = 2	
Economic shock (ϵ)	0.00	25.00	-25.00	25.00	-25.00	0.00	25.00	-25.00
Population (N)	59.83	95.36	65.45	59.40	9.40	0.83	1.15	0.95
Endog Pop'n	59.83	10.54	30.62	-82.38	-48.81	0.83	-0.72	1.43
Quality (q)	2.56	5.67	3.13	121.70	22.47	0.42	1.04	0.57
Taxes (τ)	0.43	0.35	0.13	-17.38	-70.32	1.26	0.74	1.08
Investment (I)	25.56	33.67	8.30	31.70	-67.53			
Debt payments (D)	0.00	-0.00	-0.00	-702.49	-784.26	0.00	0.00	0.00
Capital structure ($\frac{D_0}{I_0}$)	0.00					0.00		
Maximum recovery ($\bar{F}$)		40.51	14.94				0.95	0.92
Welfare flow (W)	127.37	506.80	196.61	297.89	54.35	0.31	1.23	0.53
Welfare (V)	603.16					0.73		

Table 3: Numerical Solutions for Baseline Parameters (cont'd)

	Contract Court							
	Values			Change vs. t = 0 (%)		Ratio vs. Base Case		
Variable	t = 0	t = 2		t = 2		t = 0	t = 2	
Economic shock (ϵ)	0.00	25.00	-25.00	25.00	-25.00	0.00	25.00	-25.00
Population (N)	72.69	82.93	44.29	14.07	-39.07	1.01	1.00	0.64
Endog Pop'n	72.69	-14.77	-3.40	-120.32	-104.68	1.01	1.01	-0.16
Quality (q)	6.15	5.53	5.53	-10.00	-10.00	1.01	1.01	1.01
Taxes (τ)	0.33	0.48	0.36	42.31	8.33	0.99	0.99	3.07
Investment (I)	61.45	0.00	-0.00	-100.00	-100.00			
Debt payments (D)	37.13	-39.48	-16.05	-206.31	-143.22	1.02	1.00	1.98
Capital structure ($\frac{D_0}{I_0}$)	0.60					1.01		
Maximum recovery ($\bar{F}$)		42.60	16.21				1.00	1.00
Welfare flow (W)	422.40	419.15	228.91	-0.77	-45.81	1.02	1.02	0.62
Welfare (V)	822.52					1.00		

	Safe Debt							
	Values			Change vs. t = 0 (%)		Ratio vs. Base Case		
Variable	t = 0	t = 2		t = 2		t = 0	t = 2	
Economic shock (ϵ)	0.00	25.00	-25.00	25.00	-25.00	0.00	25.00	-25.00
Population (N)	65.13	94.74	41.90	45.45	-35.67	0.90	1.15	0.61
Endog Pop'n	65.13	4.60	1.77	-92.93	-97.28	0.90	-0.31	0.08
Quality (q)	4.08	5.52	3.67	35.36	-10.00	0.67	1.01	0.67
Taxes (τ)	0.39	0.36	0.37	-8.12	-5.59	1.15	0.75	3.12
Investment (I)	40.77	18.49	-0.00	-54.64	-100.00			
Debt payments (D)	15.41	-15.41	-15.41	-200.00	-200.00	0.42	0.39	1.90
Capital structure ($\frac{D_0}{I_0}$)	0.38					0.63		
Maximum recovery ($\bar{F}$)		41.39	15.47				0.97	0.96
Welfare flow (W)	240.20	488.92	138.36	103.55	-42.40	0.58	1.18	0.38
Welfare (V)	694.06					0.84		