

On Regional Borrowing, Default, and Migration*

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Abstract

Migration plays a key roll in city finances with every new entrant reducing debt per person and every exit increasing it. We study the interactions between regional borrowing, migration, and default from empirical, theoretical, and quantitative perspectives. Empirically, we document that intercity migration rates are high in the U.S. (exceeding 6%), in-migration rates are negatively correlated with deficits, and many cities appear to be at or near state-imposed borrowing limits. Additionally, we show defaults can occur after booms or busts in labor productivity and population. Our quantitative model is able to rationalize these features of the data in large part because of a key externality that induces over-borrowing. Counterfactuals in the model reveal (1) Detroit should have slashed spending and raised taxes in 2008 to avoid default; (2) migration is overwhelmingly positive for the economy, boosting GDP by 18% or more and reducing income inequality; (3) a return to the high-interest rate environment prevailing in the 1990s could double default rates; and (4) halving the dispersion of geographic-specific productivity—which we document occurred from 1986 to 2000—can potentially account for all of the secular decline in migration rates from 1991 to 2011. This last finding provides additional support for the mechanism proposed in [Kaplan and Schulhofer-Wohl \(2017\)](#).

Keywords: Migration, municipal borrowing, default, bankruptcy, Detroit

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1 Introduction

The local government finances of Detroit and Flint, Michigan, have received significant attention in the media, and for good reason. The two cities have both experienced shrinking populations (with declines exceeding 30% since 1986) and wages (decreasing 10% and 30%, respectively) that have placed significant strain on city finances. Detroit responded to these challenges with burgeoning debt—which grew from \$2,000 per person to \$12,500 in 2010—while Flint kept debt low but was forced to raise taxes from \$3,000 to \$4,500 per person. Which of these paths was best? Could anything else have been done? Are these debt levels too high? Currently, there is scant empirical evidence and no model linking city finances, migration, and default. This paper fills these gaps in the literature in two ways: first, by merging panel data sets on local government finances, labor productivity, and migration to document patterns of cities in general and defaulting cities in particular; second, by proposing and analyzing a rich and novel general equilibrium model that successfully captures these patterns.

To guide our investigation of the data, we first consider a comparatively simple islands model (following [Lucas, 1972](#)) having two periods. Each island represents a local economy and has a continuum of households who make migration decisions and differ only in ex post moving costs, an exogenously given per person endowment that is location-specific, and a planner who issues debt in the first period (transferring the proceeds to households) and repays it in the second (using lump sum taxes). The key assumption is that the local planner maximizes the welfare of *current* residents (and consequently current residents unanimously approve of the local planner’s policies). The model reveals that, relative to an economy-wide planner, local planners have an incentive to over-borrow. The reason is simple: New entrants to the city in the second period will help repay debt issued in the first period, specifically they will repay $i/(1 - o + i)$ fraction of the debt where i and o are in- and out-migration rates, respectively. Consequently, the strength of this externality, while increasing in out-migration, is most affected by in-migration rates. There is a potentially offsetting effect, namely, that as borrowing increases, the island’s attractiveness to newcomers declines and this increases debt per person. However, we show that in general equilibrium with two heterogeneous islands, the equilibrium is not constrained efficient—i.e., not efficient taking migration decisions as given—and is therefore not Pareto efficient, either.¹ This last result suggests that a *supralocal* government should restrict local borrowing.

The theory suggests that cities should accumulate large amounts of debt, that cities with larger in- or out-migration rates else equal should accumulate more debt, that this effect should be stronger for in-migration rates, and that states or federal governments should have policies in place that restrict local borrowing. (For our purposes, we will refer to cities and municipalities interchangeably.)² Using comprehensive data sets on city finances, population, migration, and labor productivity as well as institutional details, we find support for all of these predictions. Results from fixed effects regressions reveal a statistically-significant negative correlation between deficits and in-

¹We discuss the relation of this result to [Tiebout \(1956\)](#) in Section 2.

²A municipality is a city, town, or village that is incorporated into a local government.

migration rates but an insignificant positive correlation between deficits and out-migration rates. Moreover, at least 30 states have restrictions on municipal borrowing (often with certain exemptions) and most cities seem to be close to, at, or above these limits.

A case study of municipal defaults—which are rare overall but have doubled in number since the early 2000s—show that defaulters have larger debt, expenditures, and deficits than typical cities. However, heterogeneous paths lead to default. That is, defaults have happened during challenging times characterized by population declines and low productivity (as in Detroit and Flint) but also during productivity or population booms (as in San Bernardino, Stockton, and Vallejo, CA).³ Theoretically, the *bust defaults* are unsurprising: Negative shocks should result in borrowing (provided the shocks are mean reverting) for consumption smoothing purposes and persistently negative ones lead to default (see, e.g., [Chatterjee, Corbae, Nakajima, and Ríos-Rull, 2007](#)). However, based on that intuition the *boom defaults* are very surprising. Yet, our model offers an explanation: In response to rapid population growth, cities over-borrow expecting future entrants to help repay the debt. Then, with a high amount of leverage, default looks attractive when a negative shock eventually occurs.

We extend the two-period model to allow for a decentralized economy with an infinite horizon, production, government services, housing, borrowing limits, and default. After showing the economy can be centralized, we demonstrate the calibrated model is capable of matching a host of statistics including the mean and standard deviation of in- and out-migration rates, mean default rates, interest rates on municipal debt, mean debt/income ratios, the standard deviation of log population, correlations between productivity and migration rates, and population autocorrelations. The calibrated model also generates both boom and bust defaults, consistent with the data.

Having established the model's success in matching relevant features of municipal borrowing, migration, and default, we turn to its counterfactual predictions. Feeding in the estimated productivity process for Detroit—which reveals a rapid decline beginning in 2006 and continuing through 2012—gives an alternative, and optimal, path for its economy. It reveals Detroit should have drastically cut expenditures, raised taxes, and deleveraged in 2008 to avoid default. While Detroit did raise taxes in 2009 and 2010, expenditures and debt rose almost continually from 2006 to 2011.

Next we investigate the consequences of a high return to a high-interest rate environment. In the data, we show municipal bond interest rates have declined secularly from 6.5% in the early 1990s to around 4% in 2010. (We calibrate to the latter rate.) Raising rates by 2.5% leads to a long-run doubling of municipal default rates and a halving of debt issuance. Nevertheless, the overall default rate remains small in absolute terms at only 0.07%.

A counterfactual analysis also helps interpret some surprising correlations in the data. In particular, there is a negative correlation between log productivity and out-migration rates, even after controlling for population. At face value this statistic suggests migration is unimportant as a de-

³Flint did not default, but in 2002 the state appointed an emergency financial manager, Ed Kurtz, who took over the city finances.

terminant in production. However, a counterfactual where we randomly assign movers to islands reduces steady state GDP and consumption per person by 15%. This is true despite the model matching the negative correlation (which is targeted using a moving cost parameter).

We also document a novel pattern in the data, namely, that the dispersion of residual geographic-specific log productivity (log productivity after controlling for time and city fixed effects) has followed a U-shaped pattern from 1986 to 2014. In particular, the standard deviation fell from 0.125 in 1986 to around 0.075 in 1999 and subsequently recovered to 0.125 by 2014. In a counterfactual where we feed in a 2/3 increase in dispersion, migration rates increase by around 0.5 - 0.7 percentage points. Assuming the larger dispersion corresponds to a pre-1990s steady state, its decline can potentially account for 100% (40%) of the secular decline in interstate migration that [Kaplan and Schulhofer-Wohl \(2017\)](#) document in the Current Population Survey (Internal Revenue Service) data.⁴

Finally, we investigate the consequences of bailouts in our model. Considering ε -bailouts—defined as the smallest transfer sufficient to avoid default—we find bailouts have almost no impact on the economy. The reason is that the overall low default rates observed in the data imply large default costs. Because of this, the moral hazard of cities borrowing large amounts knowing they will be bailed out is small: The utility associated with an ε -bailout is very low, and so the temporary benefit of excess borrowing is not worth the incurred cost next period.⁵

Our work touches several branches of economics. Because we study intranational migration and municipalities, we are close to the literature on regional economics. The classical work by [Roback \(1982\)](#) has equilibrium wages and rents determined by an indifference condition. The indifference condition says that each island must deliver the same amount of utility since there are no moving costs and households can go to whatever island they want. However, that each island delivers the same utility means that there are absolutely no dynamics and no reason to issue debt, tax, or not tax (endogenously, one could have exogenous taxes however).

More recently, [Armenter and Ortega \(2010\)](#) and [Coen-Pirani \(2010\)](#) provide a discussion of migration in the U.S. [Alvarez and Veracierto \(2000\)](#) use Lucas’ island framework to study the impact of labor-market policies on the economy. [Farhi and Werning \(2014\)](#) analyze the role of migration in mitigating adverse demand shocks within a currency union. They find that migrating out of regions suffering from “external demand shortfalls” may be welfare improving the regions’ macroeconomic conditions. All these papers abstract from default and making a quantitative analysis of policies like bailouts.

Because we explicitly model the decision to default by municipalities, our paper is closely related to the large literature on sovereign default, which includes [Arellano \(2008\)](#), [Hatchondo and Martinez \(2009\)](#), [Chatterjee and Eyigungor \(2012\)](#), and [Mendoza and Yue \(2012\)](#), among others

⁴We lack data to compute the intercity migration rates over a long time horizon.

⁵We do not expect this is the case for all parameterizations of the model. E.g., if utility was unbounded above and the model had no borrowing limit, in principal an infinite amount of utility could be obtained by borrowing arbitrarily large amounts. For our calibration, however, utility is bounded above and the borrowing limit is binding for many cities. Additionally, the computation requires debt choices be bounded, so we rule out this strategy a priori. This restriction may be thought of as a contingency where bailouts do not occur at excessive debt levels.

(see also the handbook chapter [Aguiar, Chatterjee, Cole, and Stangebye, 2016](#)). We contribute to this literature by studying the interaction between immigration and taxation and the decision to default. Finally, since we assume the government cannot commit to future policies (like the decision to default and tax rates), our work is also tied to the literature on time-consistent policies, which includes [Krusell and Ríos-Rull \(1999\)](#) and [Klein, Krusell, and Ríos-Rull \(2008\)](#).

Our approach is general enough that can be applied to important economic questions beyond those posed in this paper. For instance, a natural application of our framework is the recent European debt crisis. It is not difficult to appreciate the many commonalities that cities/regions in the U.S. share with the peripheral countries in Europe (such as a common currency and relatively fluid migration). Similarly, our framework could be applied to analyze the impact of population decline in Japan on its cities and provinces. Finally, tax competition is implicit in our results though we do not investigate it. Although this has been extensively studied elsewhere, we bring to the table the dynamics brought about by debt and migration. As will become clear, there is a nontrivial connection between taxes and migration, which makes the transition from one set of taxes to another one a crucial element of fiscal policy.

The rest of the paper is organized as follows. Section 2 presents a simple model that highlights the relation between borrowing and migration, which is at the core of our paper and guide our empirical investigation. Section 3 contains some relevant features about cities and municipalities in the U.S. These salient features guide us in building our model and some theoretical results are in Section 4. Section 5 gives the calibration and Section 6 the quantitative results. Section 7 concludes.

2 On borrowing and migration

Before turning to the data, we highlight how migration influences borrowing decisions using a simplified, two-period version of the model. As in the full quantitative model, we analyze (1) the impact of cities internalizing the effect of finances on household migration decisions and (2) the role of planners maximizing welfare of only those currently in a city. To focus purely on the role of borrowing, we assume the planner has full-commitment to repay their debt.

The economy is comprised of a unit measure of islands and a unit measure of households. Consider an island. Initially, there are n_1 households on the island. The island has a per person endowment of y_1 (y_2) in the first (second) period. In the first period, the local planner / government issues $-b_2$ debt per person ($b_2 > 0$ means assets) at price $\bar{q}$. Households value consumption according to $u(c_1) + \beta u(c_2)$ where c_1 (c_2) is consumption in the first (second) period. At the beginning of the second period, households make migration decisions and a proportional inflow $i_2 = \bar{i}I(u(c_2))$ where I is a differentiable, increasing function and $\bar{i}$ is an equilibrium object that ensures aggregate inflows equal aggregate outflows. Before making migration decisions, households draw an idiosyncratic utility cost of moving $\phi \sim F(\phi)$ with density f . If they decide to migrate, they pay ϕ and obtain expected utility J , which is an equilibrium object. Consequently, migration decisions follow a cutoff rule with indifference at $J - u(c_2)$ so that the outflow rate is $o_2 = F(J - u(c_2))$.

The mass of new entrants arrive giving $n_2 = (1 + i_2 - o_2)n_1$ individuals in the second period. Then the government pays back its total obligation, $-b_2n_1$, by taxing the n_2 households lump sum. Consequently, consumption in the second period is $c_2 = y_2 + b_2n_1/n_2$. The government's problem is

$$\begin{aligned} & \max_{b_2} u(c_1) + \beta \int \max \{u(c_2), J - \phi\} dF(\phi) \\ \text{s.t. } & c_1 + \bar{q}b_2 = y_1, \quad c_2 = y_2 + b_2 \frac{n_1}{n_2}, \quad n_2 = n_1(1 - o_2 + i_2) \end{aligned} \quad (1)$$

(with b_2 such that $c_1, c_2 \geq 0$).

Proposition 1 establishes the Euler equation for government bonds.

Proposition 1. *The government's Euler equation is given by*

$$u'(c_1)\bar{q} = \beta \frac{1 - o_2}{1 - o_2 + i_2} u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right). \quad (2)$$

The Euler equation reflects two competing forces. One is an externality seen in the term $\frac{1-o_2}{1-o_2+i_2}$. The term is present because if the planner borrows $\bar{q}$ units of consumption good (total) in the first period, then next period 1 unit of consumption good will need to be repaid (total). This cost will be born equally by all on the island. The fraction of this burden paid by existing residents is precisely $\frac{1-o_2}{1-o_2+i_2}$. The rest of the burden is born by new entrants to the island whom the planner does not care about. Note that this should be the political outcome as households, if they could choose the planner's policy, would seek to do this and all agree on the best policy (since there is no heterogeneity among individuals except for the i.i.d. moving cost).

The other force is seen in the term $1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2}$ is, essentially, one minus the elasticity of next period's population with respect to debt issuance. It reflects that for each person attracted to the island through less borrowing, the overall debt burden per person falls. (Conversely, if $b_2 > 0$, each additional entrant reduces assets per person.) Hence, a rational government, internalizing the effects of city finances on migration decisions, should exercise more financial discipline else equal to attract individuals to the islands to reduce debt per person.

For equilibrium, we consider two types. A closed-economy equilibrium is a $\bar{i}, J, \bar{q}$ with optimal migration, consumption, and borrowing decisions such that

1. total inflows equal total outflows, $\bar{i} \int I(u(c_{2,j}))n_{1,j}dj = \int F(J - u(c_{2,j}))n_{1,j}dj$;
2. the expected utility of moving is consistent, $J = \int u(c_{2,j}) \frac{\bar{i}I(u(c_{2,j}))n_{1,j}}{\int \bar{i}I(u(c_{2,i}))n_{1,i}di} dj$; and
3. the bond is in zero net supply, $\int b_{2,j}n_{1,j}dj = 0$.

An open-economy equilibrium differs in taking $\bar{q}$ parametrically and not requiring bond market clearing.

Is the equilibrium optimal from a societal perspective? To answer this, we need a social planner problem. To this end, let $\hat{c}_{1,i}, \hat{c}_{2,i}$ denote the optimal consumption (in periods 1 and 2, respectively) of household $i \in [0, 1]$, and let ϕ_i denote the moving cost shock realization the household receives.

Let $y_{1,i}$ denote the endowment agent i will receive in the first period (which depends on their initial island placement). Similarly, let $y_{2,i}^s$ denote the output the household will receive if they decide to stay on their island and $\bar{y}_{2,i}^m$ the output in expectation associated with their moving. Taking migration decisions as given, the planner's objective function is

$$\max_{\hat{c}_{1,i} \geq 0, \hat{c}_{2,i} \geq 0} \int \alpha_i (u(\hat{c}_{1,i}) + \beta(u(\hat{c}_{2,i}) - m_i \phi_i)) di \quad (3)$$

where α_i is the Pareto weight on household i . We will consider two formulations of the resource constraint, an open economy resource constraint given by

$$\int \hat{c}_{1,i} di + \bar{q} \int \hat{c}_{2,i} di = \int y_{1,i} di + \bar{q} \int ((1 - m_i) y_{2,i}^s + m_i \bar{y}_{2,i}^m) di \quad (4)$$

and a closed economy resource constraint given by

$$\int \hat{c}_{1,i} di = \int y_{1,i} di, \text{ and } \int \hat{c}_{2,i} di = \int ((1 - m_i) y_{2,i}^s + m_i \bar{y}_{2,i}^m) di. \quad (5)$$

If the planner can choose migration decisions, then $m_i \in [0, 1]$ should be added as a choice variable and $\bar{y}_{2,i}^m$ will be identically equal to the maximum second-period endowment value.⁶

Definition 1. *An allocation is constrained efficient if it solves the planner problem with migration decisions given for some Pareto weights.*

For either resource constraint, optimality requires marginal rates of substitution must be equated across individuals, i.e., $\beta u'(\hat{c}_{2,i})/u'(\hat{c}_{1,i}) = \beta u'(\hat{c}_{2,j})/u'(\hat{c}_{1,j})$ for almost all i, j . With the open economy constraint, it is easy to show one these must also equal $\bar{q}$, i.e.,

$$u'(\hat{c}_{1,i}) \bar{q} = \beta u'(\hat{c}_{2,i}) \quad (6)$$

for all i . In comparing (6) with the local government's Euler equation (2), it is clear that overborrowing will occur if the optimal bond choice b_2 is close to zero. In that case, the incentive to attract people—reflected in the term $1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2}$ —is close to zero while the externality of new entrants shouldering the burden—reflected in $\frac{(1-o_2)}{1-o_2+i_2}$ —is not. On the other hand, if debt issuance is large, $b_2 \ll 0$, then attracting new entrants is of primary importance and there can be under-borrowing. With $\beta u'(y_1) = \bar{q} u'(y_2)$, implementing the constrained efficient allocation requires $b_2 = 0$. But in this case, the externality dominates and so the allocation cannot be implemented. This result is formalized in Proposition 2:

Proposition 2. *Suppose there is no endowment heterogeneity across islands. Then if $\bar{q} = u'(y_2)/u'(y_1)\beta$, the open economy equilibrium is not constrained efficient. Moreover, at the constrained efficient allocation, the government would strictly prefer to borrow.*

⁶There are alternative ways to think of allowing migration here, such as a constrained efficient notion where migration decisions depend on J which would reflect aggregate consumption, but these are beside the point for our purposes.

Tiebout (1956) showed that, under certain assumptions, equilibria are efficient when local governments compete for workers. One of his key assumptions that is not met here is that of costless and fully directed mobility. In fact, the equilibrium can be Pareto efficient if search is fully *directed*. To see this, consider the case where (1) output is homogenous across islands and across time and equal to y , (2) Pareto weights are equal for each individual, and (3) $\beta = \bar{q}$. The Pareto optimal allocation in this case requires consumption be equated across individuals and across time, which requires $b_2 = 0$, and the Euler equation (2) gives a contradiction in requiring $1 = (1 - o_2)/(1 - o_2 + i_2)$. However, if search is completely directed with inflow rates non-differentiable, the Euler equation no longer characterizes the optimal choice and the equilibrium can be efficient. We prove this in Proposition 3.

Proposition 3. *Suppose endowments are homogeneous across islands. If search is completely directed with $I(u(c_2)) = 0$ for $c_2 < y$, the right-hand derivative of $I'(u(y)) = \infty$, and I differentiable elsewhere, then the open economy equilibrium with $\bar{q} = u'(y_2)/u'(y_1)\beta$ is constrained efficient.*

Note that we do not need any special restrictions on migration costs F or f as the overborrowing externality reflected in $(1 - o_2)/(1 - o_2 + i_2)$ goes away if $i_2 = 0$. In general, the more elastic net migration is to bond holdings, i.e., the larger $\partial n_2/\partial b_2$ is, the less incentive the government has to over-borrow.

With a closed economy, there is a different way that the economy can be efficient, as stated in Proposition 4. In this case, the desire for all the islands to overborrow causes equilibrium bond prices to fall. With homogeneity, these lower bond prices reduce the incentive to overborrow uniformly. With heterogeneity, the overborrowing incentive will differ across islands and a single price cannot undue this. Consequently, the equilibrium will not be constrained efficient. These are stated in the next two propositions.

Proposition 4. *If the islands have identical endowments and populations, then in any symmetric closed economy equilibrium the equilibrium is Pareto optimal and $\bar{q} = \beta(1 - F(0))u'(y_2)/u'(y_1)$.*

Proposition 5. *Suppose there are two island types. If both types have the same first period endowments and population but different second period endowments, then the closed economy equilibrium is not constrained efficient.*

3 Data and institutions

Using data collected from different sources, we discuss some relevant empirical features that will help us when calibrating our model and undertaking some counterfactual analysis. Among the issues we discuss are the connection between borrowing and migration, borrowing limits, bankruptcy law and recovery rates, borrowing costs, and some event studies.

3.1 Borrowing

Table 1 reports the results of fixed effects regressions using U.S. county-level data on deficits per person and migration rates (we only have migration data at the county-level, so we use county-level deficits to be consistent).⁷ The results coincide well with the two-period Euler equation (2) established in the previous section. Specifically, a regression of deficits on effective discount rates defined as $(1 - o)/(1 - o + i)$ show a statistically significant negative correlation between discount rates and deficits, consistent with the theory. For in-migration rates—which determine the strength of the overborrowing externality—there is also a statistically significant positive correlation, significant with the theory. The magnitude is such that going from a 0% to 10% in-migration rate would cause deficits to increase by almost \$500 per person.

	(1) Deficit	(2) Deficit	(3) Deficit	(4) Deficit	(5) Deficit
Eff. discount rate	-5221.8* (3047.8)				
In-migration rate		4974.9* (2798.8)			5013.0* (2791.5)
Out-migration rate			-1053.6 (1945.3)		-1210.7 (1892.5)
Net-migration rate				3108.2** (1405.4)	
Observations	7618	7618	7618	7618	7618
R^2	0.014	0.014	0.007	0.012	0.015

Standard errors in parentheses

Constant and year dummies included in estimation; standard errors clustered at county level

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1: Fixed-effects regressions of deficits per person on migration rates

Interestingly, the out-migration rate is not statistically significant. Note that the weaker significance is also a prediction of the theory. To see this, consider that the effective discount factor is $(1 - o)/(1 - o + i)$ or approximately $1 - i/(1 - o)$. Since i is around 5% in the data, a 10 percentage point increase in the out-migration rate (say from 0 to .1) should only make the effective discount factor go from around .950 to .944. In contrast, if o is 5% and i increase from 0 to .1, the effective discount factor should go from 1 to .894. Consequently, the effects of in-migration rates should have a much stronger and easily detectable impact on borrowing, which agrees with the effect of out-migration being statistically insignificant.

Higher net-migration rates also should cause increased borrowing since the effective discount factor can be written $(1 - o)/(1 + net)$ where net is the net-migration rate, and indeed they do.

⁷If one does not cluster the errors, the pattern of significance is similar. We report the results for this alternate assumption in Table 9 in the appendix (the point estimates are the same).

Further, when including both in and out-migration rates as regressors, the results still have in-migration rates as positive and significant and for out-migration rates as insignificant.

While these regressions estimates are simply suggestive, they are consistent with the model's theoretical predictions and suggest a connection between borrowing and migration. Later, we will use these regression results to validate our calibrated model.

3.2 Borrowing limits

The theoretical results in the next sections suggest that borrowing constraints could be welfare improving. And in fact, many states have statutory limits on how much cities can borrow. To show the variety both in sizes and types of limits, we report in Table 2 borrowing limits for five states. (The appendix gives a more comprehensive list documenting borrowing limits for 30 states). Clearly, there is a wide variety of rules with some interesting variations. E.g., California (CA) limits are tied to spending or revenue that year (effectively, it is something like a balanced budget with a one-year delay). Michigan (MI) uses a limit that incorporates debt service costs relative to previous revenues. And where MI uses revenues, Massachusetts (MA), New York (NY), and Ohio (OH) borrowing limits are based on valuations. Qualitatively, several of these, and in particular CA and MI could produce an incentive to have big budgets in order to borrow more (and of the defaulting cities in our sample, most of them are in CA and MI). MA and OH's limits do not inherit this feature.

State	Limit	Exceptions	Source
CA	Indebtedness less than revenue that year	Authorization by referendum, special projects	Harris (2002)
MA	5% of taxable property valuation last year		
MI	Debt service less than 45% of revenues of previous year		
NY	Roughly 10% of the property valuation over the previous 5 years		
OH	Net indebtedness less than 5.5% (or 10.5% with vote) of tax valuation	Self-supporting projects for water facilities, airports, public attractions, et al.	Ohio Municipal Advisory Council (2013, p. 50)

Table 2: Sample of statutory borrowing limits by state

As we do not have data on taxable property valuations, it is hard to examine how close cities are to their borrowing limits in states like Massachusetts, New York, and Ohio. However, the proximity of cities in California and Michigan to their statutory borrowing limits is illustrated in Figure 1. The top panel shows that many cities in CA, including very large ones, are borrowing beyond the revenue per person limit (which could reflect spending on special projects or borrowing after a referendum). The bottom panel shows that while not as many cities in Michigan are at or above the



Figure 1: Statutory borrowing limits and closeness to the limits

limit, it still seems to be binding for a number of cities including the largest, Detroit. While Flint is far away from the limit, it is worth noting that a state-appointed city manager had control over Flint's finances in 2002-2004 and 2011-2015, so the observed debt level is not necessarily consistent with the level the municipality would independently choose.

3.3 Case studies

Defaults at the regional/municipal level are infrequent given the large number of municipalities in the country (more so if compared to sovereign default [Chatterjee and Eyigungor, 2012](#)). Yet, as the recent defaults by Detroit and Puerto Rico show, defaults tend to be large financial events for cities and their population. In this section, we document and expand some facts about cities/regions that have defaulted or experienced financial difficulties recently. To put them in context, we also report data from other cities in the country that have a more sound financial situation. The data come from a variety of sources that are described in Appendix A. We concentrate on indebtedness, revenues and taxes, population, and debt premium in municipalities in the U.S. As we will see, default episodes are highly heterogeneous in that they differ significantly across cities/regions in the U.S.

The first left panel in Figure 2 displays the dynamics of debt in 2010 U.S. dollars per person since the late 1980s. One can see that financially struggling cities tend to have debt far above average (black solid line). (We include Chicago, which has not defaulted, among the "defaulters" because of the significant newspaper coverage the city's finances have received.)⁸ For example, while the average city owes less than \$1,000 in 2011, Chicago and Detroit owe about \$8,000 and \$12,000, respectively. Importantly, debt in these cities has been trending up since the 1990s. Overall, there is little or no trend in debt in municipalities in the U.S.

Regarding inlays and outlays (upper right panel and left middle panel in 2, respectively), we observe that defaulters' expenditures tend to outstrip their tax revenues, but not always. Furthermore, defaulters have larger-than-average budgets (large expenditures). In contrast, typical cities seem to run close to balanced budgets, which is consistent with the comparatively low average debt per person.

The data reveal a secular decline in interest rates over the past decades and show the financial crisis pushed up the borrowing costs of defaulters in our sample. (The data for "Other cities" is plotted only in years ending in 2 or 7, which is when the coverage is almost universal. Consequently, the short run variation is missed. See Appendix A.5 for details.) This spike in interest rates most likely contributed to the wave of defaults at the end of our sample. Furthermore, the recent increase in the federal fund rates raises the question whether borrowing costs will go back to their higher levels during the 1990s. This possibility will guide one of the counterfactual experiments we run in the quantitative section.

When turning to population, the data is perhaps more interesting. While cities like Detroit, Flint, and Chicago have been losing population, others like San Bernardino (CA) have seen pop-

⁸In the appendix, we provide a list of news on actual and potential defaults across the U.S.

ulation gains. This dichotomy suggests that defaults are associated with adverse events (low productivity) and population outflows as well as other situations like poor financial planning. Overall, population growth is slowing, which introduces demographic pressure on cities' financial situations. Like population, productivity reflects a mixed pattern with cities defaulting during periods of productivity gains (Chicago or Vallejo) but also when facing adverse productivity shocks (Detroit or Flint).

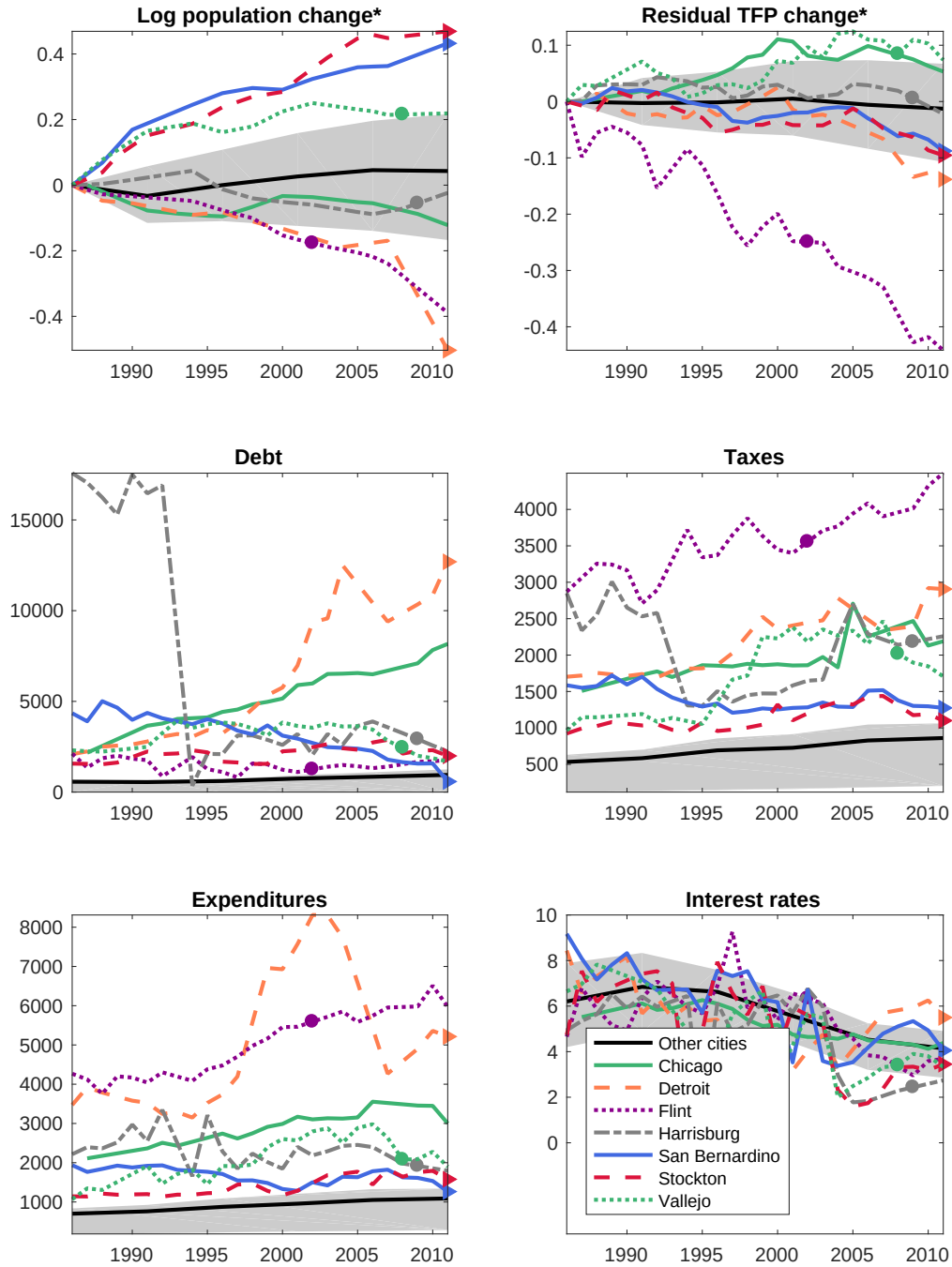
In summary, our case studies uncover the existence of multiple paths to default. These paths are quite heterogeneous with defaults happening during booms and busts. As we will show, the model we propose is rich enough to capture these heterogeneous default episodes.

3.4 Default and Chapter 9 bankruptcy

According to a Moody's report (US Municipal Bond Defaults and Recoveries, 1970-2012), there have been 73 municipal bond defaults (of bonds rated by Moody's) since 1970. Of those defaults, 93% (68 defaults) has been on non-backed debt (non-General Obligation debt). These figures translates into a default rate of roughly one municipality defaulting every 4.3 years. Of the five General Obligation defaults, three have occurred since 2008 (or a default rate of one municipality per year). These very low default rates imply that municipal bonds carry a very low interest rate, as evidenced in figure 2.

While default rates have historically been low, the last decade has seen a substantial increase. This can be seen in Figure 3 that shows the default rates for speculative-grade municipal and corporate bonds over the past 40 years. The twelve-month moving average default rate on municipalities with speculative grade (rating Ba1 and below) has doubled since the onset of the Great Recession (going from 1% during 1991-2007 to 2% during 2008-2012).

Before moving to the model, we would comment on one institutional that will impact modeling decisions and its calibration. Specifically, the law places a great deal of emphasis on municipalities being sovereign entities. Because of this, Chapter 9 bankruptcy allows municipalities to discharge their debt while keeping essentially all their assets (in contrast to Chapter 7). This was seen in the courts' rejection of creditor demands that Detroit sell part of its art museum collection (US Bankruptcy Court, City of Detroit Case No. 13-53846). Moreover, as soon as a Chapter 9 petition is filed, creditors must cease all collection attempts (The automatic stay of section 362 of the Bankruptcy Code, [United States Court, 2018](#)). More recently, the default of Puerto Rico caused serious legal questions because it was legally unable to file for Chapter 9 bankruptcy but could not (or at least would not) pay its bills. Eventually, legal changes were introduced to deal with Puerto Rico's insolvency ([United States Congress, 2015](#)). Because of these features, we will focus on debt (not debt net of assets) in the calibration and treat bankruptcy as a complete discharge of debt with only non-pecuniary costs associated with it.



Note: changes are log differences relative to 1986 except for Chicago, which is relative to 1987; circles denote periods of acute fiscal stress such as defaults, bankruptcies, or emergency manager takeovers (the last only for Flint); triangles denote acute fiscal stress period occurs after 2011; “other cities” is not the universe of cities but covers 64% to 74% of the U.S. population over the time range; fiscal variables are in 2010 dollars per person; the interquartile range is given by the shaded area.

Figure 2: Case Study – Cities under Financial Stress

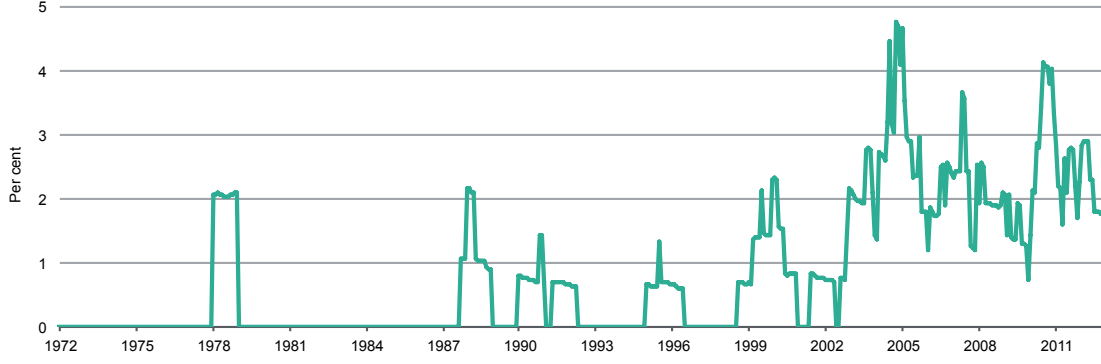


Figure 3: Default Rates on Speculative Grade Bonds (Source: Moody's)

4 Model

We first provide an overview of the model and its timing. Then, we describe the household, firm, and government problems. Finally, we define equilibrium.

4.1 Overview and timing

We model municipalities in the U.S. as a unit measure of islands. Each island consists of a continuum of households (whose measure in the aggregate is one), a benevolent local government, and a neoclassical firm. The government is a sovereign entity that issues debt, taxes its citizens, and provides government services. Households consume, work, and crucially decide whether to stay on the island or migrate to another one. Finally, there is a financial intermediary who buys portfolios of municipal debt as well as a risk-free bond.

The timing of the model is as follows. At the beginning of the period, all shocks are realized. Upon observing them, households make migration decisions. Given these choices, the government then sets its fiscal policy including debt issuance.⁹ Finally, households make consumption and labor decisions simultaneously with firms while taking prices and government policies as given.

4.2 Households

Let's define the state vector of a generic island as $\mathbf{x} := (b, n, z, f)$, where b is assets per person measured before migration, n is the population before migration, z is the island's productivity, and $f \in \{0, 1\}$ indicates whether the government is in a state of default. We assume z follows a finite-state Markov chain.

Households that choose to stay on the island receive lifetime utility $S(\mathbf{x})$ (specified below). If they move, they are assigned to another island, receive J in expected lifetime utility, and must pay a utility cost. This utility cost is idiosyncratic and distributed according to $\phi \sim F(\phi|z)$. The

⁹Having migration decisions before government policy decisions gives stability in the value function iteration process.

dependence on z allows us to capture, in a reduced form way, the notion that high income workers are more mobile than low income ones. The moving decision m is

$$V(\phi, \mathbf{x}) = \max_{m \in \{0,1\}} (1 - m)S(\mathbf{x}) + m(J - \phi). \quad (7)$$

The moving decision follows a cutoff rule $R(\mathbf{x})$ such that if $\phi < R(\mathbf{x})$, the household moves and she stays otherwise.

The utility conditional on staying is

$$\begin{aligned} S(\mathbf{x}) = & \max_{c \geq 0, l \in [0,1], h \geq 0} u(c, g(\mathbf{x}), h, \kappa(\mathbf{x})) + \beta \mathbb{E}_{\phi', \mathbf{x}' | \mathbf{x}} V(\phi', \mathbf{x}') \\ \text{s.t. } & c + r(\mathbf{x})h = w(\mathbf{x}) + \pi(\mathbf{x}) - T(\mathbf{x}) \end{aligned} \quad (8)$$

where $\kappa(\mathbf{x}) = \bar{\kappa} \max\{d(\mathbf{x}), f\}$ is a utility cost of default (like in [Arellano, Bai, and Bocola, 2017](#), and others), $w(\mathbf{x})$ is the island's wage; $\pi(\mathbf{x})$ is the per person profit from the island's firm; $g(\mathbf{x})$ is government services; $T(\mathbf{x})$ are lump sum taxes (which we think of loosely as property taxes); and h is a housing good, owned by the firm and rented to households at price $r(\mathbf{x})$.¹⁰ As will become clear, the nonseparability of the default cost in the utility function will help the model to match polar cases in the data (Figure 2) like Detroit/Puerto Rico (default with declining population) and San Bernardino (default without declining population). The expectation term $\mathbb{E}_{\phi', \mathbf{x}' | \mathbf{x}}$ embeds household beliefs about the local government's policies. For any u is continuously differentiable, strictly concave, strictly increasing, and satisfies the Inada conditions for its first three arguments.

We assume that if a household decides to move, they are randomly assigned to an island and must stay at that island for at least one period. Since we will assume inflows to an island with state $\mathbf{x}$ are given by a function $i(\mathbf{x})$, the value of moving is

$$J = \int S(\mathbf{x}) \frac{i(\mathbf{x})}{\int i(\mathbf{x}) d\mu(\mathbf{x})} d\mu(\mathbf{x})$$

where $\mu(\cdot)$ is the distribution of islands.

In many applications such as discrete choice models, preference shocks with a Type 1 extreme value distribution are used so that, if U_x denotes the utility from choice x , one has $\mathbb{P}(x) \propto \exp(\lambda U_x)$ for λ a parameter. Because we have a continuum of islands, micro-founding these choice probabilities is complicated.¹¹ Instead, we impose that inflows are proportional to $\exp(\lambda U_x)$. Specifically,

¹⁰Because default rates are small, using payments to creditors in place of psychic costs has very little effect on bond prices which are almost always near the risk-free rate. Additionally, payments to creditors in general equilibrium significantly complicates the model. Specifically, this is because (like in [Chatterjee et al., 2007](#)) a financial intermediary will hold debt contracts. The value of the defaulted debt contracts (like in [Chatterjee and Gordon, 2012](#)) will be pinned down by the net present value of payouts over an infinite horizon. The complication here is that—to ensure payments are always feasible—payments must depend on population (which may take any value in $\mathbb{R}^{++}$). Consequently, computing the net present value of these contracts requires integrating over population, and ensuring these integrals are well-defined is nontrivial. Numerically (ignoring these issues) we found including payments to creditors made virtually no difference after recalibrating. In the model specification here, we only need to ensure that the default region is measurable.

¹¹The usual specification is $V = \max_{x \in X} U_x + \varepsilon_x / \lambda$ where ε_x is iid across x and distributed according to a Type 1 ex-

we postulate

$$i(\mathbf{x}) = \left(\int nF(R(\mathbf{x})|z)d\mu(\mathbf{x}) \right) \frac{\exp(\lambda S(\mathbf{x}))}{\int \exp(\lambda S(\mathbf{x}))d\mu(\mathbf{x})} \quad (9)$$

Note that by construction the measure of people leaving equals the measure entering in aggregate, $\int i(\mathbf{x})d\mu(x) = \int nF(R(\mathbf{x}))d\mu(\mathbf{x})$. If $\lambda = 0$, people are uniformly assigned to each island (“random search”). As $\lambda \rightarrow \infty$, then the city with the largest $S(\mathbf{x})$ will receive all the inflows (“directed search”). The law of motion for population in an island with state vector $\mathbf{x}$ is

$$\dot{n}(\mathbf{x}) = n(1 - F(R(\mathbf{x})|z)) + i(\mathbf{x}), \quad (10)$$

where $\dot{n}(\mathbf{x})$ is the population after migration has taken place.

4.3 Firms

Each island has a firm operating the production function zL that owns the island’s housing stock $\bar{H}$ (which is in fixed supply and homogeneous across islands to prevent adding an extra state variable). Alternatively, $\bar{H}$ may be thought of as the island’s land. Firms solve

$$\dot{n}(\mathbf{x})\pi(\mathbf{x}) = \max_{L, H \leq \bar{H}} zL - w(\mathbf{x})L + r(\mathbf{x})H. \quad (11)$$

taking w and r competitively. From this problem, firms determine their labor demand, L^d , and housing supply. Note that if housing were taxed, say via $\tau r(\mathbf{x})H$ for $\tau \in [0, 1]$, the tax would effectively be lump sum, just reducing profits. Hence, $T(\mathbf{x})$ in the household’s budget constraint acts like a property tax, reducing a household’s non-labor income $\pi(\mathbf{x}) - T(\mathbf{x})$ in identical fashion. However, we do not restrict $T(\mathbf{x})$ to be less than $\tau r(\mathbf{x})\bar{H}$.

Since $\dot{n}(\mathbf{x})$ denotes the number of households remaining after migration, total labor supply on the island is $\dot{n}(\mathbf{x})$ (since each household supplies one unit of labor inelastically). Consequently, labor market clearing requires

$$L^d(\mathbf{x}) = \dot{n}(\mathbf{x}). \quad (12)$$

We have assumed there are no agglomeration or congestion effects in the production function.¹² Its absence could result in the model predicting a flat or negative relation between population and productivity. However, costly migration in our model introduces a sorting effect with workers tending to leave cities with low productivity and stay in those with high productivity. As a consequence, the model does have the ability to generate the positive correlation between city density and productivity found in the data (Glasser, 2010).

treme value distribution. The problem is that the support of ε_x includes all of $\mathbb{R}^+$. As the size of X increases, $\max_{x \in X} \varepsilon_x$ goes to infinity (in probability) and if U_x is bounded so does V .

¹²A simple way to introduce agglomeration is with the modified production function $zL\dot{n}^\varpi$, where N is population and $\varpi > 1$. Duranton and Puga (2004) provide micro-foundations for this type of agglomeration.

4.4 Local governments

Each government raises tax revenue lump sum via T . It uses the tax revenue on government services $g \geq 0$, which is partly non-rival. Specifically, to provide g services to each $\dot{n}$ household, the planner must only invest $\dot{n}^{1-\eta}g$ units of the consumption good. If $\eta = 0$ ($\eta = 1$), then g is completely rival (nonrival).

The planner is able to issue debt. At the beginning of the period, the total debt stock is $-bn$. After migration, the population goes from n to $\dot{n}(\mathbf{x})$, which changes debt per person. We use $\dot{b}(\mathbf{x}) := bn/\dot{n}(\mathbf{x})$ as the after-migration debt per person. We assume debt is short-term, which significantly simplifies the computation without changing the dynamics for most cities. (If default-risk premia are always zero, short and long-term debt are equivalent, and in the data we calibrate to default-risk spreads are very small.) As discussed in Section 3.4, a municipality's assets generally *cannot* be seized in default. Because of this, we will measure debt in the data using liabilities, not liabilities minus assets. We will also not model asset accumulation due since that would add a state variable.

In keeping with the statutory borrowing limits discussed in section 3, we impose a borrowing limit $b' \geq \underline{b}(z, \dot{n}, g)$. For the quantitative work, we further assume that

$$-b' \leq g\dot{n}^{-\eta}\delta \quad (13)$$

where $\delta \in \mathbb{R}^+$ controls how tight the limit is. Hence, we require total debt issued in a period be less than a fraction δ of total spending (measured in terms of the consumption good). Note that this limit is qualitatively closer to the standard limits in CA or MI than in MA, NY, and OH. However, the exemptions in many states allow for spending on projects, which this form permits. Given the large variation in laws across states, and the ability of cities to use unfunded pension and health obligations as a means of circumventing the standard legal constraints, we will choose δ to match observed debt levels rather than trying to choose it based on statutory law.

Part of the island's state is f , a flag indicating the city's stance with creditors. If $f = 0$, then the city is in good standing with its creditors and if $f = 1$ it is in bad standing. For a city in good standing, the city may default, $d = 1$. If the city defaults or is in bad standing $f = 1$, they go to $f' = 0$ with probability χ and $f' = 1$ with probability $1 - \chi$. Once the city transitions to good standing, its debt is gone, $b = 0$. However, for as long as the city defaults or is in bad standing, there is a psychic cost of default κ (the term $\kappa(\mathbf{x})$ in the household problem (8) equals $\kappa d(\mathbf{x})$) and the city is excluded from financial markets.

To define the government's problem, we need to specify how the economy will respond to deviations in government policies. To this end, we assume r and w adjust dynamically in response to the government policies (d , g , b' , and T) clearing the labor and housing markets and that households and firms—whose decisions are static except for migration—optimize given those prices and

implied profits. That is, we assume that c, l, h, r, w, π, L^d always solve the following equations¹³

$$u_c r = u_h, \quad c + r h = w l + \pi - T, \quad w = z, \quad \dot{n} \pi = z L^d - w \dot{n} + r \bar{H}, \quad \dot{n} = L^d, \quad \text{and} \quad \dot{n} h = \bar{H}. \quad (14)$$

Letting U denote the government's indirect flow utility associated with g, T , and $D := \max\{d, f\}$, one can show

$$U(g, T, D, \dot{n}, z) = u(z - T, g, \bar{H}/\dot{n}, \kappa D). \quad (15)$$

Now we can state the government's problem as

$$\tilde{S}(\mathbf{x}) = \begin{cases} \max_{d \in \mathbf{D}} (1 - d) S^N(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z) + d S^D(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z) & \text{if } f = 0 \\ S^D(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z) & \text{if } f = 1 \end{cases} \quad (16)$$

where

$$\begin{aligned} \tilde{S}^N(\dot{b}, \dot{n}, z) &= \max_{g \geq 0, b' \in \mathbf{B}, T} U(g, T, 0, \dot{n}, z) + \beta \mathbb{E}_{\phi', z'|z} \tilde{V}(\phi', b', \dot{n}, z', 0) \\ \text{s.t. } g \dot{n}^{1-\eta} + q(b', \dot{n}, z) b' \dot{n} &= T \dot{n} + \dot{b} \dot{n} \\ b' &\geq \underline{b}(z, \dot{n}, g) \\ T \dot{n} &\leq z \dot{n} \end{aligned} \quad (17)$$

and

$$\begin{aligned} \tilde{S}^D(\dot{b}, \dot{n}, z) &= \max_{g \geq 0, T} U(g, T, 1, \dot{n}, z) + \beta \mathbb{E}_{\phi', z'|z} \left(\begin{aligned} &\chi \tilde{V}(\phi', 0, \dot{n}, z', 0) \\ &+ (1 - \chi) \tilde{V}(\phi', \dot{b}, \dot{n}, z', 1) \end{aligned} \right) \\ \text{s.t. } g \dot{n}^{1-\eta} &= T \dot{n} \\ T \dot{n} &\leq z \dot{n} \end{aligned} \quad (18)$$

where $\tilde{V}(\phi, \mathbf{x}) = \max\{\tilde{S}(\mathbf{x}), J - \phi\}$. For the quantitative work and most of the theoretical results, we take $\mathbf{D} = \{0, 1\}$ so that the government can default. When this is the case, we restrict the bond choice b' to be in a finite set $\mathbf{B}$ that includes 0. For the derivation of the Euler equation, however, we will use full commitment, taking $\mathbf{D} = \{0\}$ and $\mathbf{B}$ as a closed interval $[\underline{b}, \bar{b}]$ containing 0.

4.5 Financial intermediaries

Following [Chatterjee et al. \(2007\)](#), we posit a competitive financial intermediary who purchase measures of contracts. To write the intermediary's problem, we think of governments and the intermediary as choosing contracts indexed by (b', n', z) . From the government's perspective, a contract costs $Q(b', n', z) := q(b', n', z) b' n'$ in the current period, yields $b' n'$ if the city does not default, and yields zero otherwise. The intermediary purchases a measure of contracts, and so, for him, there is no uncertainty: The contract costs $Q(b', n', z)$ and yields $\mathbb{P}(z'|z)(1 - d(b', n', z')) b' n'$ next period. The intermediary takes d as given and $\dot{n}$ (and $\dot{b}$) as given.

The intermediary decides the measure $M'(b', n', z)$ of contracts to maximize the net present

¹³In the special case of $T = z$, we assume the allocations are still such that labor and housing markets clear.

value of dividends D discounted at rate $\bar{q}$. The intermediary's problem is

$$\begin{aligned} W(B, M) &= \max_{D, B', M'} D + \bar{q}W(B', M') \\ \text{s.t. } D + \bar{q}B' + \int Q(b', n', z) dM'(b', n', z) &= B + \int \sum_z \mathbb{P}(z|z_{-1})(1 - d(b, n, z))(bn) dM(b, n, z_{-1}) \end{aligned} \quad (19)$$

with a no-Ponzi condition.

In equilibrium, we require that (1) the intermediary issues zero dividends each period $D = 0$; (2) the intermediary has zero wealth so that $W = 0$; (3) contract markets clear; and (4) the risk-free bond market clears. We assume the risk-free bond is in net supply $\bar{B}$, and so bond market clearing requires $B' = B = \bar{B}$. A consequence of the equilibrium condition (1) is that we do not need to specify who owns the intermediary.

Contract market clearing is more complicated. We assume the contracts are in zero net supply, which means the intermediary must be the counterparty to every contract purchased by cities. Formally, the market for non-defaulted debt contracts clears if

$$M'(\mathcal{B}, \mathcal{N}, z) = - \int \mathbf{1}_{[b'(b, n, z, 0) \in \mathcal{B}, \dot{n}(b, n, z, 0) \in \mathcal{N}]} (1 - d(b, n, z)) \mu(db, dn, z, 0) \quad (20)$$

for all $\mathcal{B} \times \mathcal{N}$ in a product Borel σ -algebra.

4.6 Equilibrium

A steady state recursive competitive equilibrium is value functions $S, V, \tilde{S}, \tilde{V}$, an expected value of moving J , household policies c, h , government policies g, T, b', d , prices and profit $\bar{q}, q, w, r, \pi$, labor demand L^d , the intermediary policies and value function D, M', B', W , an intermediary state M , a law of motion for population $\dot{n}$, and a distribution of islands μ , such that (1) household policies c, h and migration decisions are optimal taking V, S, J , prices, government policies, and Γ as given; (2) government policies g, T, b', d are optimal taking $\tilde{V}, \tilde{S}, J$, the population law of motion $\dot{n}(\mathbf{x})$, and prices q as given; (3) firms optimally choose $L^d(\mathbf{x})$ taking $w(\mathbf{x}), r(\mathbf{x})$ as given and optimal per person profits are $\pi(\mathbf{x})$; (4) the intermediary policies D, M', B' are optimal given $W, \bar{q}, q$, and d ; (5) beliefs are consistent: $S(\mathbf{x}) = \tilde{S}(\mathbf{x})$ and $V(\phi, \mathbf{x}) = \tilde{V}(\phi, \mathbf{x})$; (6) the distribution of islands μ is invariant; (7) the intermediary's portfolio is time-invariant, $M = M'(\bar{B}, M)$; (8) J, Γ , and $\dot{n}$ are consistent with μ , household, and government decisions; (9) the intermediary makes zero profits, $D(\bar{B}, M) = 0$ and $W(\bar{B}, M) = 0$; and (10) markets clear.

4.7 Centralization and the Euler equation

To characterize equilibrium, we first simplify the equilibrium conditions by providing some sufficient conditions for the intermediary's problem, bond-market clearing, and contract market-clearing to be satisfied. We then show how the government and household problems may be centralized into a single problem. Last, we derive the Euler equation.

Proposition 6. *If prices satisfy*

$$q(b', n', z) = \bar{q} \mathbb{E}_{z'|z}(1 - d(b', n', z')).$$

and if

$$\bar{B} = \int (1 - d(b, n, z)) b n \mu(db, dn, dz, 0)$$

then there exists prices and an optimal policy M' , with M' invariant, such that contract markets and the risk-free bond market clears and zero profits obtains (provided the other equilibrium conditions are met).

Note that if there is no default, this simply says $\bar{B} = \int b n d\mu$, so that in equilibrium the intermediary holds a portfolio / mutual fund of city assets (debt if negative).

Proposition 7 shows the government, household, and firm problem may be centralized into a single problem.

Proposition 7. *Suppose $\hat{S}$ satisfies*

$$\hat{S}(\mathbf{x}) = \begin{cases} \max_{d \in \mathbf{D}} (1 - d) \hat{S}^N(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z) + d \hat{S}^D(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z) & \text{if } f = 0 \\ \hat{S}^D(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z) & \text{if } f = 1 \end{cases}$$

where

$$\begin{aligned} \hat{S}^N(\dot{b}, \dot{n}, z) &= \max_{c > 0, g \geq 0, l \in [0, 1], b' \in \mathbf{B}} u(c, g, \bar{H}/\dot{n}, 0) + \beta \mathbb{E}_{\phi', z'|z} \max\{\hat{S}(b', \dot{n}, z', 0), J - \phi'\} \\ \text{s.t. } \dot{n}c + \dot{n}^{1-\eta}g + q(b', \dot{n}, z)b'\dot{n} &= z\dot{n} + \dot{b}\dot{n} \\ b' &\geq \underline{b}(z, \dot{n}, g) \end{aligned}$$

and

$$\begin{aligned} \hat{S}^D(\dot{b}, \dot{n}, z) &= \max_{c > 0, g \geq 0, l \in [0, 1]} u(c, g, \bar{H}/\dot{n}, \bar{\kappa}) + \beta \mathbb{E}_{\phi', z'|z} \left(\begin{aligned} &\chi \max\{\hat{S}(0, \dot{n}, z', 0), J - \phi'\} \\ &+ (1 - \chi) \max\{\hat{S}(\dot{b}, \dot{n}, z', 1), J - \phi'\} \end{aligned} \right) \\ \text{s.t. } \dot{n}c + \dot{n}^{1-\eta}g &= z\dot{n} \end{aligned}$$

with associated optimal policies $c(\mathbf{x}), g(\mathbf{x}), d(\mathbf{x}), b'(\mathbf{x})$ (with d and b' arbitrary for $f = 1$). Then (1) $\hat{S}$ is a solution to the household problem for an appropriate law of motion Γ and c, l are optimal policies; (2) $\hat{S}$ is a solution to the government problem and g, d, b' are optimal policies; and (3) there exists prices r, w such that labor and housing markets clear and firms optimize.

In what follows, we will use S, S^N, S^D in place of $\hat{S}, \hat{S}^N, \hat{S}^D$, respectively.

Proposition 8 characterizes the government Euler equation:

Proposition 8. *Consider the S^N problem at some state $(\dot{b}, n', z)$. Suppose that at the optimal choices the borrowing constraint is not binding and that locally about b' repaying is strictly preferred. If in addition $S_b^N(b' \frac{n'}{n''}, n'', z')$, $S_n^N(b' \frac{n'}{n''}, n'', z')$, and $\dot{n}(b', n', z', 0)$ exist locally for $n'' := \dot{n}(b', n', z', 0)$ about b' , then*

the Euler equation satisfies

$$u_c \bar{q} = \beta \mathbb{E}_{z'|z} \left[\left(\frac{1 - o'}{1 + i' - o'} \right) \left(1 - \frac{b'}{n''} \frac{\partial \dot{n}}{\partial b'} \right) u_c + (1 - o') S_n^N \left(b' \frac{n'}{n''}, n'', z' \right) \frac{\partial \dot{n}}{\partial b'} \right]$$

where o' is the outflow rate $F(R(b', n', z', 0)|z')$ and $i' = i(b', n', z', 0)/n'$ is the inflow rate next period.

Relative to the two-period model Euler in (2), there is an additional term connected to S_n^N . In the two period model, the *level* of population does not directly effect optimal consumption. Here it can through reduced housing per person ($\bar{H}/\dot{n}$) and partially non-rival government services (if $\eta > 0$).

5 Calibration

In this section, we show that the model can reproduce a large number of key empirical moments. We take a model period to be a year. in the data.

5.1 Productivity

As productivity (TFP) plays a vital role in the model, it is necessary to have an accurate process. To this end, we construct a TFP series in the data using the County Business Patterns (CBP), which is an annual panel dataset published by the Census covering the universe of counties dating back to 1986.¹⁴ To approximate TFP, we use Employees (in mid-March) over the Annual Payroll. Given our assumption of constant returns to scale, this is a model-consistent measure of TFP.

Let the log of TFP for a county-year pair be denoted z_{it} . We specify

$$z_{it} = \varsigma_i + \varpi_t + \tilde{z}_{it}$$

and obtain the residual $\tilde{z}_{it}$ using a fixed effects regression. To discretize ς_i , we non-parametrically break the estimates into bins corresponding to 0-10%, 10-50%, 50-90%, 90-99%, and 99-100%. The estimated fixed effects averaged within these bins are $-0.34, -0.13, 0.09, 0.37$, and 0.65 , respectively. We discard the time effects as we will only consider steady states.

For residual TFP, we deviate from the typical autoregressive (AR) specification used in the real business cycle or default literatures in order to better capture decade-long persistent movements in productivity such as what occurred in Detroit (see Figure 9 in Appendix A.4). Specifically, we use a Smooth Transition Autoregressive Process (STAR), which is essentially a regime-switching model with a continuum of regimes. It may be specified as

$$\tilde{z}_{it} = G(s_{i,t}) [(1 - \rho_1)\mu_1 + \rho_1 \tilde{z}_{i,t-1}] + (1 - G(s_{i,t})) [(1 - \rho_2)\mu_2 + \rho_2 \tilde{z}_{i,t-1}] + \sigma_z \varepsilon_{it}^z,$$

where $s_{i,t}$ evolves according to $s_{i,t} = \rho_s s_{i,t-1} + \sigma_s \varepsilon_{i,t}^s$.

¹⁴In fact, it goes back as far as 1946 but the data is not easily accessible. The sample is available at <https://www.census.gov/programs-surveys/cbp/about.html>. It covers about 6 million single-unit establishments and 1.8 million multi-unit establishments.

Among the STAR variants, we use ESTAR, which has an exponential transition function $G(s_t) = 1 - e^{-\zeta(s_t - c)^2}$ (van Dijk, Terasvirta, and Franses, 2002). We set $\rho_s = .95$ to have a long “regime persistence,” in keeping with the long booms and busts in the data. Having $c \neq 0$ allows for regimes to have different onset speeds and durations, as is illustrated in Figure 10 in Appendix A.6. Furthermore, ζ , c , and σ_s are tightly connected when determining the evolution of the transition probability $G(s_t)$. That is, halving c and σ_s , and increasing ζ fourfold would deliver a very similar transition as with the original parametrization, which complicates their joint identification. As result, we opt not to estimate these parameters and set $c = 1$, $\zeta = 0.01$, and $\sigma_s = 2$. We estimate the remaining parameters using maximum likelihood and a bootstrap particle filter with a population-weighted random sample of 50 counties, resulting in these estimates (standard deviations in parenthesis): $\rho_1 = 0.0169$ (0.01), $\mu_1 = 0.0003$ (0.004), $\rho_2 = 0.9817$ (0.01), $\mu_2 = 0.0441$ (0.06), and $\sigma_z = 0.0341$ (0.00) (see the appendix for more details). The estimation reveals that the first regime has no persistence and very low average growth, while the second regime is very persistent with high growth. The size of volatility in productivity is consistent with more aggregate measures (for example, HP-filtered U.S. labor productivity for the period 1986-2017 had a volatility of 3.3%). Appendix B.1 describes our method for discretizing this process.

5.2 Preferences and moving costs

The discount factor is set to $\beta = .96$, which is in line with an annual model. We take the utility function to exhibit constant relative risk aversion over a Cobb-Douglas aggregate of consumption, government services, and housing:

$$u(c, g, h, \kappa) = \frac{(c^{1-\zeta_g - \zeta_h} g^{\zeta_g} h^{\zeta_h})^{1-\sigma}}{1-\sigma} (1-\kappa)^{(1-\zeta_g - \zeta_h)(1-\sigma)}. \quad (21)$$

As ζ_g and ζ_h are relatively small, the constant relative risk aversion over consumption is approximately σ , which we take to be 2. The free parameters ζ_g and ζ_h are estimated jointly, strongly controlling the mean level of government expenditures and housing expenditures, respectively. While we will calibrate $\bar{\kappa}$ to match default rates, it is difficult to identify $\bar{\kappa}$ and χ (the probability of returning from autarky) separately. So, we set $\chi = 0.25$, which gives that default costs are spread out over 4 years on average (5 including the period of default). This seems a reasonable choice if we consider that Detroit’s bankruptcy filing spreads out default costs over 10+ years (see case No. 13-53846 from the United States Bankruptcy Court Eastern District of Michigan).

Our specification of the default cost has two benefits. First, it makes for easy interpretation of its magnitude with κ giving the consumption consumption equivalent flow cost. More importantly, it means default has the same cost (in a particular sense) whether the island is extremely poor or rich, which allows the model to capture that default occurs in both rich and poor cities. (This would not be the case for an additively separable specification which asymmetrically punishes those with high c .)

Note that having h be complimentary to consumption gives incentive for the planner to ma-

nipulate the bond choice to reduce the population on the island (and hence lower housing rent). There are several forces going the other way however. One force is the returns to scale due to g being partially nonrival. Another is that higher debt costs may increase housing per person but they also decrease consumption per person. For this reason, the utility from staying in the island, S , may be increasing in population, decreasing, or both in different regions of the state space.

We assume the moving cost is distributed

$$\phi|z \sim \begin{cases} \underline{\phi} & \text{w.p. } p_{\underline{\phi}}/2 \\ \text{Logistic}(\mu_{\phi} - \beta_{\phi} \log z, \varsigma_{\phi}) & \text{w.p. } 1 - p_{\underline{\phi}} \\ -\underline{\phi} & \text{w.p. } p_{\underline{\phi}}/2, \end{cases}$$

which is almost the logistic distribution with mean $\mu_{\phi} - \beta_{\phi} \log z$ and standard deviation $\varsigma_{\phi}\pi/\sqrt{3}$. Having the mean be contingent on z is meant to capture the idea that high productivity individuals have lower moving costs (in the calibration, $\beta_{\phi} \geq 0$).¹⁵ Having the $\pm \underline{\phi}$ shock means that, for a sufficiently large $\underline{\phi}$, every island's departure rate is in $[p_{\underline{\phi}}/2, 1 - p_{\underline{\phi}}/2]$, which ensures some minimal stability in the computation. We take $\underline{\phi}$ arbitrarily large, which gives

$$\int V(\phi, \mathbf{x}) dF(\phi|z) = p_{\underline{\phi}} J + (1 - p_{\underline{\phi}})(S(\mathbf{x}) + \varsigma_{\phi} \log(1 + e^{(S(\mathbf{x}) - J - \mu_{\phi} + \beta_{\phi} \log(z))/\varsigma_{\phi}})),$$

and we set $p_{\underline{\phi}} = 10^{-4}$.

The free parameters controlling moving costs μ_{ϕ} , β_{ϕ} , ς_{ϕ} and the parameter λ controlling how directed moving is (see (9)) are jointly estimated. We identify them using mean departure and arrival rates as well as coefficients from regressions of productivity (fixed and residual) and population on outflow rates in the data. Table 3 includes regressions with in-migration and out-migration rates in the data as functions of residual log TFP residual, log TFP fixed effects (FE), log population, and a constant. β_{ϕ} controls how the outflow rate varies with productivity, so we use the regression coefficient on log income for outflow rates. ς_{ϕ} controls how much the migration decisions vary with fundamentals, so we use the standard deviation of out-migration rates to discipline it. μ_{ϕ} controls the overall level of outflow rates, so we use the mean departure rate to discipline it. Note that higher residual productivity results in *higher* departure rates. In the model, this basically necessitates $\beta_{\phi} > 0$.

5.3 Fit of targeted and untargeted moments

Table 4 reports the targeted and untargeted statistics alongside the jointly calibrated parameter values. As one can see, our calibrated model closely matches the targeted statistics. The estimated debt limit, δ , allows cities borrow up to 50% of their expenditures, which is half the California limit. The consumption-equivalent flow cost of default, $\bar{\kappa}$, is estimated to be around 1%. The utility

¹⁵A more theoretically appealing way to do this would be having two types of individuals, one high-skilled and one low-skilled as in [Armenter and Ortega \(2010\)](#). However, besides the additional cost of notation, this requires the addition of a state variable and presumably leads to disagreement over the local government's optimal policy.

	(1) In mig. rate, county	(2) Out mig. rate, county
Log income res (county)	0.0288***	0.00887**
Log income FE (county)	-0.0204***	-0.00517**
Log population	0.00177***	-0.00283***
Constant	0.0471***	0.0923***
Observations	2661	2661
R^2	0.024	0.055

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: In- and out-migration rate determinants

shares ζ_g and ζ_h are close to the shares observed in the data. To match the volatility of population, the calibration assigns some degree of directed search, $\lambda > 0$, in migration flows. Roughly, the value implies a 10% increase in consumption equivalent variation results in a 2 percentage point increase in inflow rates.¹⁶ The provision of public goods is almost nonrival, $\eta \approx 1$. Finally, the large and positive value for β_ϕ implies that individuals with high productivity experience low migration costs.

The model gets most of the untargeted predictions qualitatively correct, but misses a few statistics such as the regression coefficients of outflow and inflow populations on population. The R^2 in the model regressions are significantly higher than those in the data because there are fewer drivers of fluctuations in the model than in the data.

As an additional validation step, we rerun the fixed effects regressions from Table 1 on simulated model. To convert the numeraire to dollars for this example, we multiply by 50,000, giving average output per person in our benchmark as \$81,601, roughly halfway between the median and mean household income in 2010.¹⁷ Table 5 reveals the model has similar patterns with the effective discount factor and in-migration significantly moving borrowing. One difference is that out-migration is statistically significant and in the direction the Euler equation suggests. Overall, the magnitudes are fairly similar to the data. The R^2 in our simulations is naturally larger than in the data as there are fewer determinants of spending in the model, but still these regressors explain only 10% of the variation. Hence, the low R^2 values from the data regressions should not be interpreted as evidence against migration-induced overborrowing.

¹⁶To see this, note that $\partial \log i / \partial S = \lambda$, i.e., the semi-elasticity of inflow-rates to the utility of staying S , is λ . For our parameterization, the average value of S is around -20 . Consequently, a 10% increase in consumption equivalent variation, given our CRRA utility is around 2, is an absolute increase in S of around 2. (Recall that for a CRRA utility coefficient of 2, the consumption equivalent difference between V_0 and V_1 is $(V_0/V_1 - 1)$). This results in a $2\lambda \approx 30\%$ change in inflow-rates or a 2% percentage point increase since average inflow rates are 6.6%.

¹⁷The mean income (for persons) in the model is 1.63 units of the consumption good. In 2010, median household income was \$49,276 while GDP per household was \$117,538. Our measure is roughly halfway in between these two.

Targeted Statistics	Data	Model	Parameter	Value
Default rate ($\times 100$) $\int dd\mu$	0.030	0.037	$\bar{\kappa}$	0.008
Interest rate $1/\bar{q} - 1$	0.040	0.040	δ	0.510
Debt / income $\int \frac{-bn}{z(\hat{n}l)^{1-\alpha}} d\mu$	0.023	0.023	$\bar{B}$	-0.033
Gov. expenditures / income $\int \frac{g\hat{n}^{1-\eta}}{z(\hat{n}l)^{1-\alpha}} d\mu$	0.045	0.047	ζ_g	0.041
Mean housing expend / GDP $\int r\bar{H}d\mu / \int yd\mu$	0.125	0.125	ζ_h	0.111
*Out rate mean $\int F(R)/nd\mu$	0.063	0.062	μ_ϕ	3.437
*Out rate st. dev.	0.021	0.021	ς_ϕ	0.576
Std. deviation of $\log n$	1.834	1.780	λ	1.530
*Out rate reg. coef., $\log z$	-0.002	-0.002	β_ϕ	3.682
Regression coef., $\log$ expenditures on $\log$ pop	1.119	1.105	η	0.997
Untargeted Statistics	Data	Model		
Out rate coefficient of variation	0.336	0.345		
*In rate reg. coef., $\log z$	-0.008	0.351		
*Out rate reg. coef., $\log z$ res	0.009	0.004		
*In rate reg. coef., $\log z$ res	0.029	0.346		
*Out rate reg. coef., $\log z$ FE	-0.005	-0.373		
*Out rate reg. coef., $\log n$	-0.003	0.030		
*Out rate reg. R^2	0.055	0.961		
*In rate mean	0.066	0.065		
*In rate st. dev.	0.027	0.030		
*In rate reg. coef., $\log z$ FE	-0.020	0.678		
*In rate reg. coef., $\log n$	0.002	-0.086		
*In rate reg. R^2	0.024	0.952		
Autocorrelation of $\log n$	0.999	1.000		
Std. deviation of net migration rates	0.021	0.025		
Correlation of $\log$ expenditures and $\log n$	0.858	0.999		
Std. deviation of $\log$ expenditures	2.388	1.967		
Note: parameters are listed besides statistics they strongly influence; * means the underlying data is county-level; in all cases, income measures are the county level; debt measures are gross, excluding any assets.				

Table 4: Calibration Targets & Parameter Values

	(1) Deficit	(2) Deficit	(3) Deficit	(4) Deficit	(5) Deficit
Eff. discount rate	-1909				
In-migration rate		1699			1297
Out-migration rate			-4730		-3198
Net-migration rate				1622	
R^2	0.067	0.067	0.055	0.083	0.089

Note: A constant is included in each regression; the largest standard error is 5.3, and all the values are significant at a 1% level; each regression has 15200000 observations.

Table 5: Fixed-effects regressions using model data

6 Quantitative results

With our calibrated model in hand, we run a battery of exercises to understand the causes of default, and the impact that the cost of migration, borrowing costs, and borrowing limits have on the cities' economic outcomes. Importantly, we analyze counterfactual scenarios like higher interest rates or the lack of migration.

6.1 What leads to and triggers default?

Marginal distributions, unconditional (white bars) and conditional (blue bars) on any default episode in the next 5 years, are reported in Figure 4. The negative skewness in the TFP distribution indicates that on average low levels of productivity makes cities more likely to default. However, conditional on that low level, temporarily high or low productivity is more likely to induce default (although, the large chunk of defaults comes from productivity events below the unconditional mean). This versatility of our model shows that it can generate default episodes consistent with those in Detroit (below average productivity) or Vallejo (above average productivity) as reported in Figure 2.

When we turn to population, we find that cities with low population are more likely to default (top right panel). As discussed in the introduction and data sections, default can be associated with population busts or population booms, and the model has this feature as well. In particular, the in-migration rate is shifted right (despite having lower productivity on average) and the out-migration rate is shifted far to the right. While the model can generate boom defaults, this calibration predicts the majority of them are bust defaults. The debt-output ratios are slightly higher when conditioning on a default in the next 5 years. Cities also spend more during default (bottom right panel).

The concentration of islands' tax-output and expenditure-output ratios at around .047 correspond to an undistorted share of expenditures equal to $\zeta_g/(1 - \zeta_h) = .046$.¹⁸ The higher tax-output

¹⁸The correct share is $\zeta_g/(1 - \zeta_h)$ not ζ_g . To see this, note that in the centralized problem, the flow utility in repayment is $u(c, g, \bar{H}/\bar{n}, 0) = (c^{1-\zeta_g-\zeta_h} g^{\zeta_g} (\bar{H}/\bar{n})^{\zeta_h})^{1-\sigma}/(1-\sigma)$. For a fixed state and b' , the optimal choice is the same as if the flow utility function were $c^{(1-\zeta_g-\zeta_h)/(1-\zeta_h)} g^{\zeta_g/(1-\zeta_h)}$.

ratios for islands conditional on defaulting correspond to higher debt service costs and manipulation of the borrowing constraint via increased expenditures.

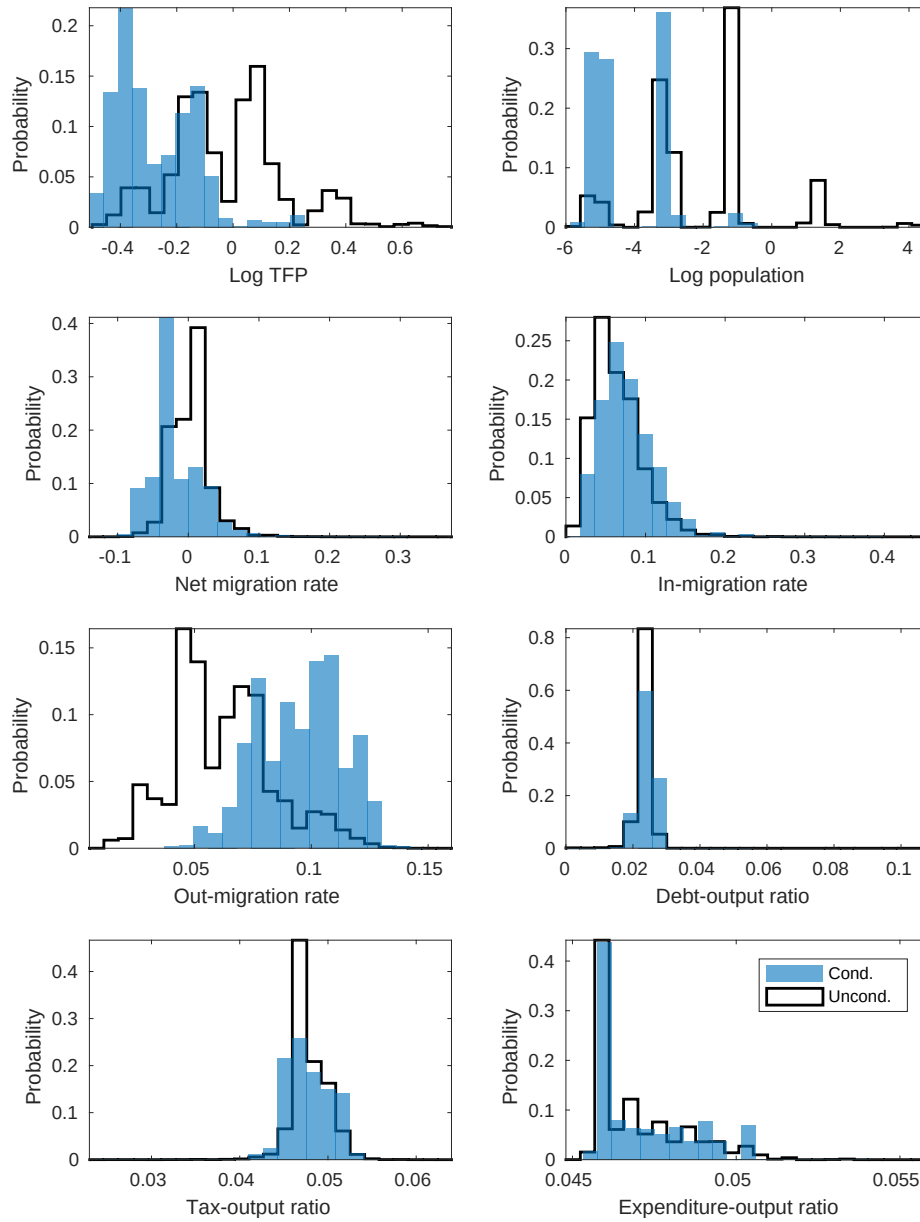


Figure 4: Distributions, unconditional and conditional on a default in the next 5 years

Default events, displayed in Figure 5, help interpret the above results (default occurs at period 0). We dissect default episodes into three cases: an average default event (blue line), a default during a technology boom (red dashed line), and a default during a technology bust (green circled line).¹⁹ On average, default episodes coincide with a sharp decline in productivity (a drop close to 10%), which leads to a reduction in income per person. This suggests some surprise is needed

¹⁹A bust (boom) is formally defined as having log productivity growth from 10 to 0 years before default above the 75th (below the 25th) percentile.

to trigger default in the model as otherwise utility maximization strongly dictates avoiding such states. Although on average population increases slightly pre-default, cities see their population drop below their average level just after default. The decline lingers in the short run and the city loses around 15% of their inhabitants within 5 years of defaulting. This is driven by an uptick in the out-migration rate and a contraction in the in-migration rate. Increasing expenditures prior to default are financed with higher debt (hence the higher interest rates) and taxes.

Looking at those defaults preceded by persistent adverse productivity, we see that these events coincide with a prolonged decline in population, that started well before default. This scenario is consistent with the experiences, for example, in Flint and Detroit. Our simulations show that the sovereign, in an attempt to weather the bad shocks, raises the debt-output ratio by about 25 % (from 0.022 to 0.028) in the years leading to default. The additional proceeds are used to increase expenditures. But as low productivity lingers and debt piles up, the cost of borrowing becomes too high and induces the sovereign to default. The interest rates in this case is roughly 70 bps above the peak rate under strong productivity (red dashes). Note how interest rates rises very quickly and peaks at higher levels than in the average default episode. This illustrates the impact of below average productivity and declining population have on the debt prices (as highlighted in sections 2 and 5.3).

Finally, our model (red dashed line) is capable of replicating defaults that were preceded by strong productivity and population growth like in Vallejo, CA. The combination of high productivity and in-migration induce the sovereign to increase borrowing (which is amplified by low interest rates). Default follows a boom-bust profile, characterized by a sudden and sharp decline in productivity. Population peaks before default and then slowly moves back to its average level. The population dynamics are driven by the out-migration rates, which are low pre-default but then increases.²⁰ Compared to the bust/low productivity scenario (green line), the cost of borrowing only rises on the eve of default; a reflection of benign conditions during the periods leading to default.

6.2 What should Detroit have done differently?

Since our model has city planners who maximize the welfare of current residents, the planner's response to shocks gives an optimal strategy for dealing with adverse (or beneficial) shocks. Hence, by feeding in Detroit's observed shock path in our simulation, our model provides a counterfactually optimal path for the city including policy prescriptions.²¹ We conduct this simulation by feeding in the observed fixed productivity, setting arbitrary initial conditions for debt and population, and simulating the economy for more than 900 years while assuming that the residual productivity

²⁰Note that the in-migration rates are very similar across the three default scenarios.

²¹Since we have data at the county level, we use Wayne county's labor productivity as a proxy for Detroit's.

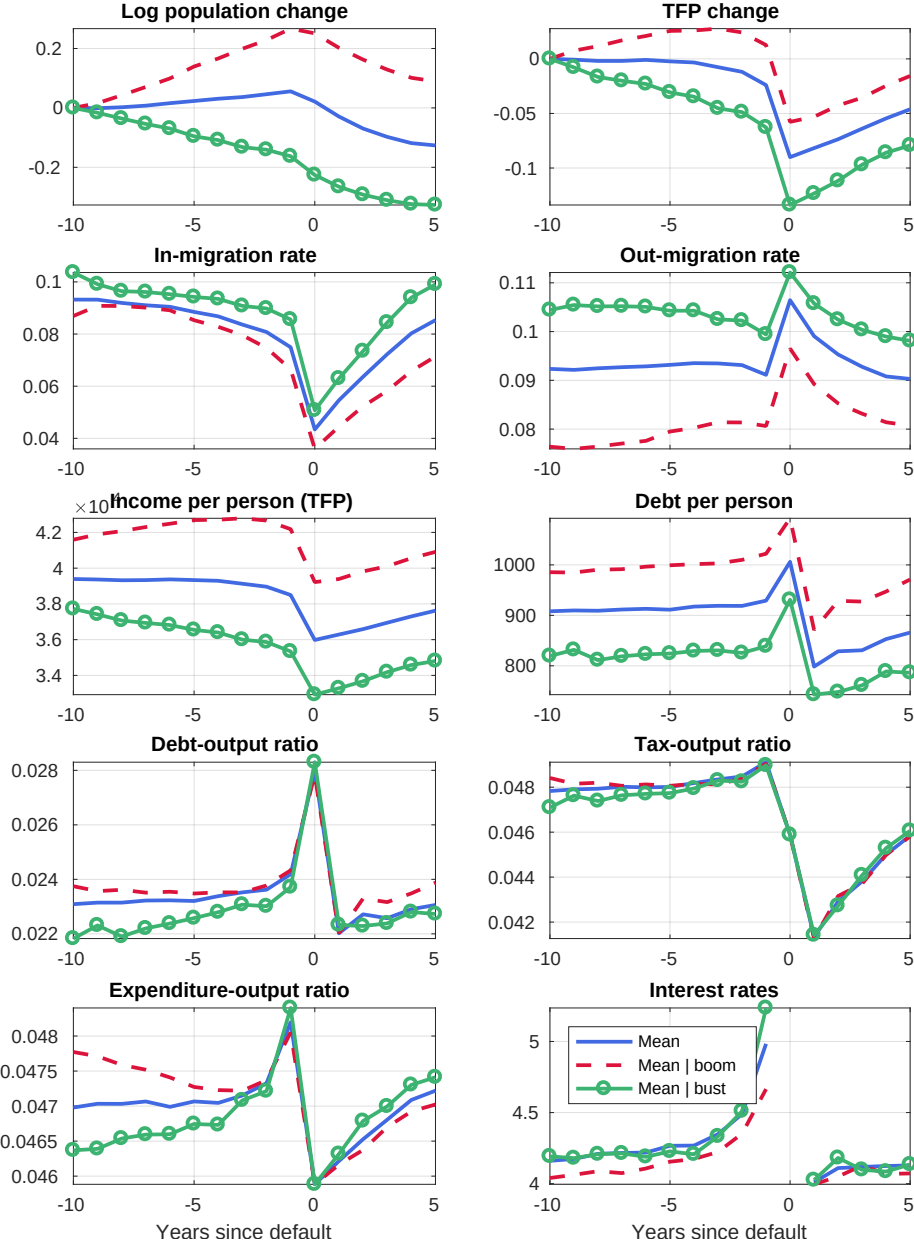


Figure 5: Default episodes

is 0.²² We then feed in the observed residual productivity process from 1986 to 2014.²³

Productivity (right upper panel in Figure 6) had some ups and downs but was roughly stable

²²If we feed in the observed debt and population levels as the initial conditions, the planner defaults right away and there is a secular decline in population for many periods. This is evidence of misspecification, which may be coming from a lack of unemployment risk or an ample stock of housing that had been built up over many years, or a belief that Detroit's fixed effect in productivity is higher than what the estimation says it should be. (If our data went back to the 1950s and 60s, it could result in a much higher estimated fixed effect).

²³The likelihood estimation produces filtered states s that have a mean varying from -2 to 0. Our discretization for s gives that the closest value over this time period is 0 (the next closest value is -6), so there is no regime switching in the simulation.

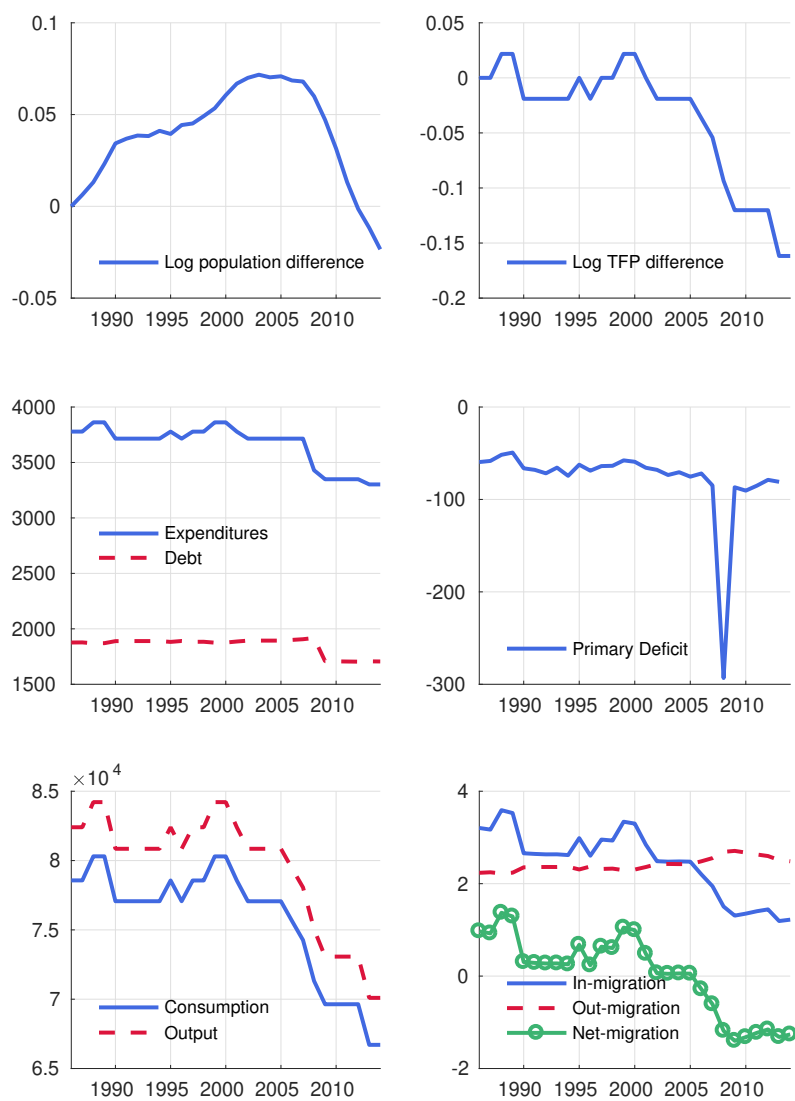


Figure 6: Optimal response to Detroit's productivity shocks

during the 1990s. In response to this productivity, the model predicts relatively flat expenditures and debt profiles, with the city running a small surplus per person (right middle panel). The city's disciplined financial management is rewarded with an increase in population (driven by high in-migration rates). The turn of the century brought a reversal of fortunes featuring a persistent decline in productivity. The optimal response is to reduce expenditures while keeping debt stable. The decline in productivity pushes down both output and consumption. The adverse shocks eventually reduce the in-migration rates, leading to a decline in population. When the financial crisis hits in 2007-2009 and productivity falls sharply, the optimal response is to drastically deleverage, reducing expenditures by \$1000 and running a significant surplus (on the order of \$300 per person) in 2008 (but notably *not* in 2007) to help bring down the debt. Doing so lets the city avoid default and its negative consequences. Surpluses stay higher than usual from 2009 and on.

Compared with the actual path Detroit took (which can be seen in Figure 2), there are significant differences. For example, there is little evidence of fiscal discipline, and especially so during the Great Recession. Rather than limiting expenditures, Detroit's spending grows during the sample, and at a fast rate during the 2000s. The city relied on debt issuance and taxation to finance the outlays. Given the declining population and tax base, debt per person increased in an unsustainable way and culminated in default.

6.3 Borrowing limits, interest rates, and migration costs

In this section, we explore the effect of directed search, moving costs, interest rates, and borrowing limits on the model economy. While the first two are for understanding the model mechanisms, the latter two give counterfactual predictions for a return to a high interest rate environment and how the economy would look if states did not impose municipal borrowing limits.

6.3.1 Random search

First we consider the role of directed search in our setup. To do this, we set $\lambda = 0$ so that households are allocated uniformly across cities (see (9)). The results are displayed in Table 6 which reports statistics from the benchmark (the first column) and the costly migration experiment (the column labeled $\lambda = 0$). The table distinguishes between two types of averages in our model: Averages across cities, $\int f(\mathbf{x})d\mu(\mathbf{x})$, and averages across households, $\int f(\mathbf{x})nd\mu(\mathbf{x})$. (Since the population is measure one, the latter is also the aggregate measure.)

Random search has a large impact on aggregate allocations. In the new steady state, output per person and consumption per person are 15% lower. Behind this result is the low utility conditional on moving (J) compared with the one from staying (S). For a given distribution of utility $S(\mathbf{x})$, lowering λ else equal lowers J . This has a ripple effect in that with lower J , households are more willing to stay on their current island. With more households staying on lower utility islands, the expected utility of moving J decreases further. Without the sorting effect of migration, people get stuck in low productivity cities, drastically lowering output.

The substantial reduction in in-migration and out-migration rates, which fall from roughly .065 to .0065, drives down the risk-free interest rate into negative territory. The reason is that the effective discount factor $\beta(1-o)/(1-o+i)$ goes from being roughly $.96(1-.065) \approx .90$ to $.96(1-.0065) \approx .95$. With this large increase in effective patience, the interest rate must fall to compensate cities for holding the debt $\bar{B}$. And in particular, with this .05 increase in the effective discount factor, the magnitude of the fall should be around 5%. In fact, this is the case as interest rates go from 4.0% to -1.2%.

6.3.2 High moving costs

With the strong role directed search plays in allocating households to productive islands, one might expect that making migration costs extremely large would have the same effect. However, this need not be true. To see this, consider what happens when we set μ_ϕ extremely high so that only $p_\phi = 10^{-4}$ of households move each period. The results are displayed in the column labeled $\mu_\phi = \infty$ of Table 6.

In contrast to the random search case, high out-migration costs have a much smaller impact on output and consumption per person, reducing them by a comparatively small 1.2%. The reason is simple. By allowing a small fraction of dwellers to move in the presence of high costs (which is necessary for the distribution to mix), people are still able to relocate to high productivity cities albeit at a very slow pace. In the very long run, individuals move to islands with the highest fixed effect levels of productivity. The 1.2% reflects the comparatively small loss of suboptimal allocation in response to short run productivity fluctuations.

6.3.3 Risk-free interest rate increases

In light of the recent increases in the federal funds rate, we assess the impact of higher borrowing costs on municipal borrowing. In particular, we increase the risk-free interest rate in the model from 4% to 6.5%—the latter corresponding to the interest rates in the early 1990s as can be seen in Figure 2—by reverse-engineering a risk-free bond supply $\bar{B}$ that delivers a 6.5% interest rate.

The results are displayed in column $\bar{q}^{-1} \uparrow$ of Table 6. As one would expect, more expensive borrowing reduces the incentives to issuing debt (almost by half), while doubling the default rate in the long run. The sovereign compensates the downfall with more taxes and lower expenditures. The negligible impact on output and consumption reflect that debt service costs are essentially unchanged when interest rates increase by 62.5% (from 4% to 6.5%) because the stock debt outstanding falls by half.

6.3.4 Loosened borrowing limits

Exploring the role of state-imposed municipal borrowing limits, we eliminate the borrowing constraint by setting δ to a large value. The results are displayed in column $\delta = \infty$ of Table 6. With the relaxed borrowing limits, cities who were constrained would like to borrow more. However,

market clearing requires aggregate bond holdings equal $\bar{B}$, so interest rates must rise to counteract this incentive. Although debt in the aggregate does not change (by construction), more debt is held by those with the strongest incentive to borrow. This, with the higher interest rates, triples the default rate. Output per person and consumption per person increase, possibly because with less debt held by the best islands there is more incentive to move to the best islands. But the magnitude of the changes is too small to say much definitively.

	Bench.	$\mu_\phi = \infty$	$\bar{q}^{-1} \uparrow$	$\delta = \infty$	$\pi_b = 1$	$\lambda = 0$	$\sigma(\tilde{z}_{it}) \uparrow$
Aggregate measures							
Output per person (TFP)	81601	80652	81934	81914	81578	69186	82143
Consumption per person	77765	76880	78112	78085	77743	65954	78280
Expenditures per person	3774	3748	3771	3755	3773	3252	3831
Taxes per person	3835	3772	3822	3829	3835	3232	3863
Debt per person	1642	1649	853	1649	1645	1645	1647
Income Gini coefficient	0.111	0.115	0.111	0.111	0.111	0.119	0.120
Interest rate (%)	4.00	1.46	6.50	4.80	4.06	-1.21	2.03
Tax for financing bailouts (%)	0.000	0.000	0.000	0.000	-0.056	0.000	0.000
Average across cities							
Default rate $\times 100$	0.036	0.000	0.071	0.091	0.044	0.000	0.152
Bailout rate $\times 100$	0.000	0.000	0.000	0.000	0.044	0.000	0.000
In-migration rate (%)	6.48	0.005	6.51	6.49	6.48	0.694	7.19
Out-migration rate (%)	6.22	0.005	6.26	6.23	6.22	0.670	6.77
Log population s.d.	1.78	1.64	1.78	1.78	1.78	1.49	1.78
The experiments are as follows: $\mu_\phi = \infty$ sets moving costs to be very high (a small amount still move each period to ensure stationarity); $\bar{q}^{-1} \uparrow$ increases the risk-free interest rate by 2.5 percentage points; $\pi_b = 1$ is anticipated bailouts where bailouts occur 100% of the time; $\delta = \infty$ removes the exogenous borrowing limit; $\lambda = 0$ uses random search; $\sigma(\tilde{z}_{it}) \uparrow$ increases the standard deviation of residual log labor productivity.							

Table 6: Stochastic Steady State under Counterfactual Experiments

6.4 Geographic-specific productivity changes

Kaplan and Schulhofer-Wohl (2017) show that interstate migration has secularly declined from 1991 to 2011, and they argue it has done so in part because of a decline in the geographic specificity of returns to occupations. While our dataset does not include occupation-specific productivity measures, it does reveal that the dispersion of residual log labor productivity $\tilde{z}_{it}$ has followed a U-shape over our sample. This can be seen in Figure 7, and holds whether looking at the standard deviation, the interquartile range, or the interdecile range.

We use our model to test the impact of an increase in the dispersion of residual labor productivity. Since populations are slow-moving and learning about this pattern may take a significant

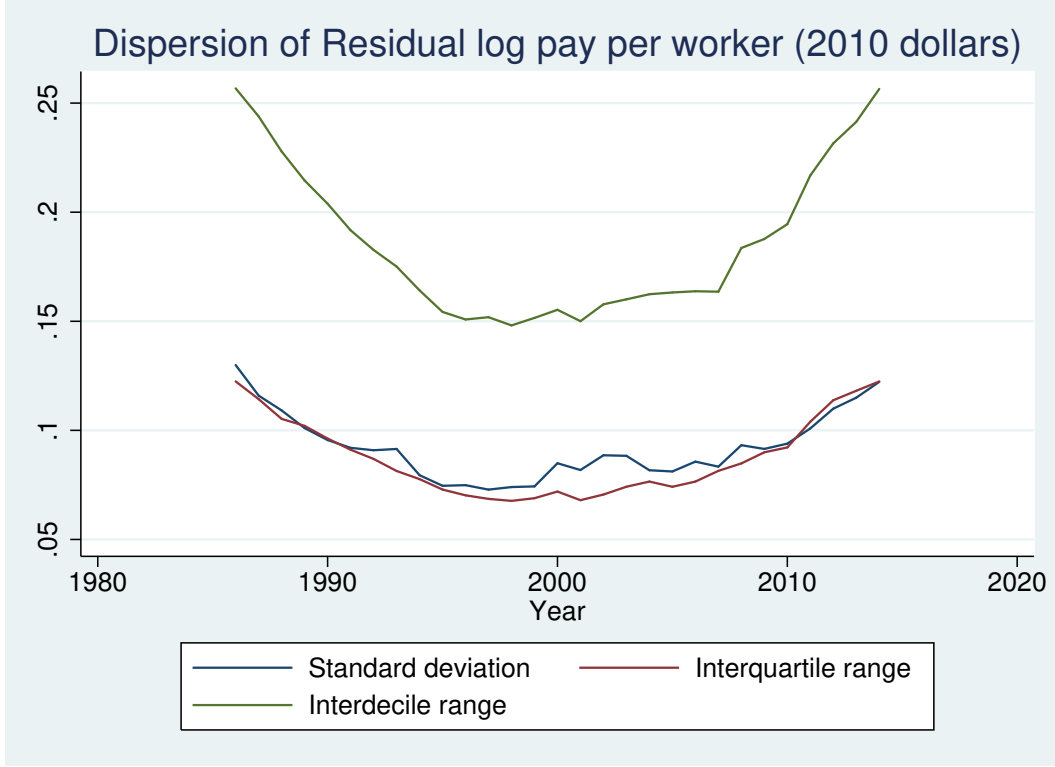


Figure 7: Changes in the dispersion of residual log labor productivity

amount of time, we do this by assuming $z_{it} = \varsigma_i + \frac{.125}{.075} \tilde{z}_{it}$, as if moving from the trough to the peak of this dispersion in productivity. In this experiment, we hold fixed moving costs by using $\varsigma_i + \tilde{z}_{it}$ for obtaining $\phi \sim F(\phi|z)$ rather than z_{it} . (Consequently, the results are not driven by exogenously changed moving costs.) The results are displayed in the column labeled $\sigma(\tilde{z}_{it}) \uparrow$ of Table 6.

The model predicts that out-migration rates increase by 0.6 percentage points with higher dispersion in residual labor productivity. Alternatively, this finding indicates that the secular decline in the volatility of productivity between the mid-1980s and the mid-2000s resulted in a decline of 0.6 percentage points in out-migration rates. Interestingly, [Kaplan and Schulhofer-Wohl \(2017\)](#) show using the CPS (IRS) that interstate-migration rates fell from 3% to 1.5% (2.8% to 2.2%). Accordingly, our model accounts for 40% (100%) of the decline in this rate. While of course there is a significant discrepancy in using intercity versus interstate migration rates here, our model provides additional evidence for the [Kaplan and Schulhofer-Wohl \(2017\)](#) hypothesis. Our results also suggest that the secular decline in migration rates may soon reverse since the dispersion of productivity has now recovered.

6.5 Bailouts

We conclude this section by assessing the role of bailouts. We will focus on the special case of ε -bailouts as made precise by the following definition:

Definition 2. An ε -bailout is an unconditional transfer of resources $\mathbf{b}$ (measured per person and after migration) that makes the government indifferent between repaying and default (and we assume they repay in such a case). Formally, $\mathbf{b}(\mathbf{x})$ is given by $S^N(\dot{\mathbf{b}}(\mathbf{x}) + \mathbf{b}(\mathbf{x}), \dot{\mathbf{n}}(\mathbf{x}), z) = S^D(\dot{\mathbf{n}}(\mathbf{x}), z)$.

To pay for these bailouts, we posit a federal government that uses a tax τ on purchases of the risk-free bond. Consequently, the intermediary (who is the only purchaser of the risk-free bond) has a new budget constraint:

$$D + \bar{q}(1 - \tau)B' + \int Q(b', n', z) dM'(b', n', z) = B + \int \sum_z \mathbb{P}(z|z_{-1})(1 - d(b, n, z))(bn) dM(b, n, z_{-1}).$$

This changes the equilibrium bond prices in Proposition 6 to

$$q(b', n', z) = \bar{q}(1 - \tau)\mathbb{E}_{z'|z}(1 - d(b', n', z')), \quad (22)$$

but the condition $\bar{B} = \int (1 - d(b, n, z))bn\mu(db, dn, dz, 0)$ is unchanged. The federal government's budget constraint holds provided

$$\tau\bar{q}\bar{B} = \int \mathbf{b}(\mathbf{x})\dot{\mathbf{n}}(\mathbf{x})\pi_b \mathbf{1}[S^N(b, \dot{\mathbf{n}}, z) < S^D(b, \dot{\mathbf{n}}, z)] d\mu(\mathbf{x}). \quad (23)$$

Since $\bar{B} < 0$, the “savings tax” $\tau \leq 0$ behaves like a savings subsidy / borrowing tax. However, quantitatively the number of bailouts is quite small in the experiments, and so the results are very similar to a partial equilibrium exercise where $\tau = 0$ and the transfers are for free (appear out of nowhere).

We assume bailouts occur with probability π_b (iid) known to the government, except for unanticipated bailouts where the planner places zero probability on there being a bailout. We also assume that households make migration decisions before seeing whether the city is bailed out or not. Hence, $\dot{\mathbf{n}}$ and $\dot{\mathbf{b}}$ are functions of b, n, z, f (as before), and do not depend on the iid bailout.

$$S(b, n, z, 0) = \pi_b \mathbf{1}[S^N(b, \dot{\mathbf{n}}, z) < S^D(b, \dot{\mathbf{n}}, z)] S^N(\dot{\mathbf{b}} + \mathbf{b}(b, n, z, 0), \dot{\mathbf{n}}, z) + \\ (1 - \pi_b \mathbf{1}[S^N(b, \dot{\mathbf{n}}, z) < S^D(b, \dot{\mathbf{n}}, z)]) \left(\max_d (1 - d) S^N(\dot{\mathbf{b}}, \dot{\mathbf{n}}, z) + d S^D(\dot{\mathbf{b}}, \dot{\mathbf{n}}, z) \right).$$

Figure 8 shows the dynamics of a surprise bailout (red dashed line), and an anticipated bailout. Broadly speaking, surprise bailouts look similar to default episodes (blue line). There is a mild improvement in income per person, resulting from those individuals that did not leave the city because default was averted. Moreover, averting default makes the city attractive once again and hence the planner can afford higher taxes to pay higher expenditures. At face value, this result means that surprise bailouts deliver mixed results. They do help avoid default but they seem not to change the city's fate post bailout.

Surprisingly, anticipated ε -bailouts differ very little from unanticipated ones. It is even more surprising given that we have focused on $\pi_b = 1$ so that bailouts are completely anticipated. There

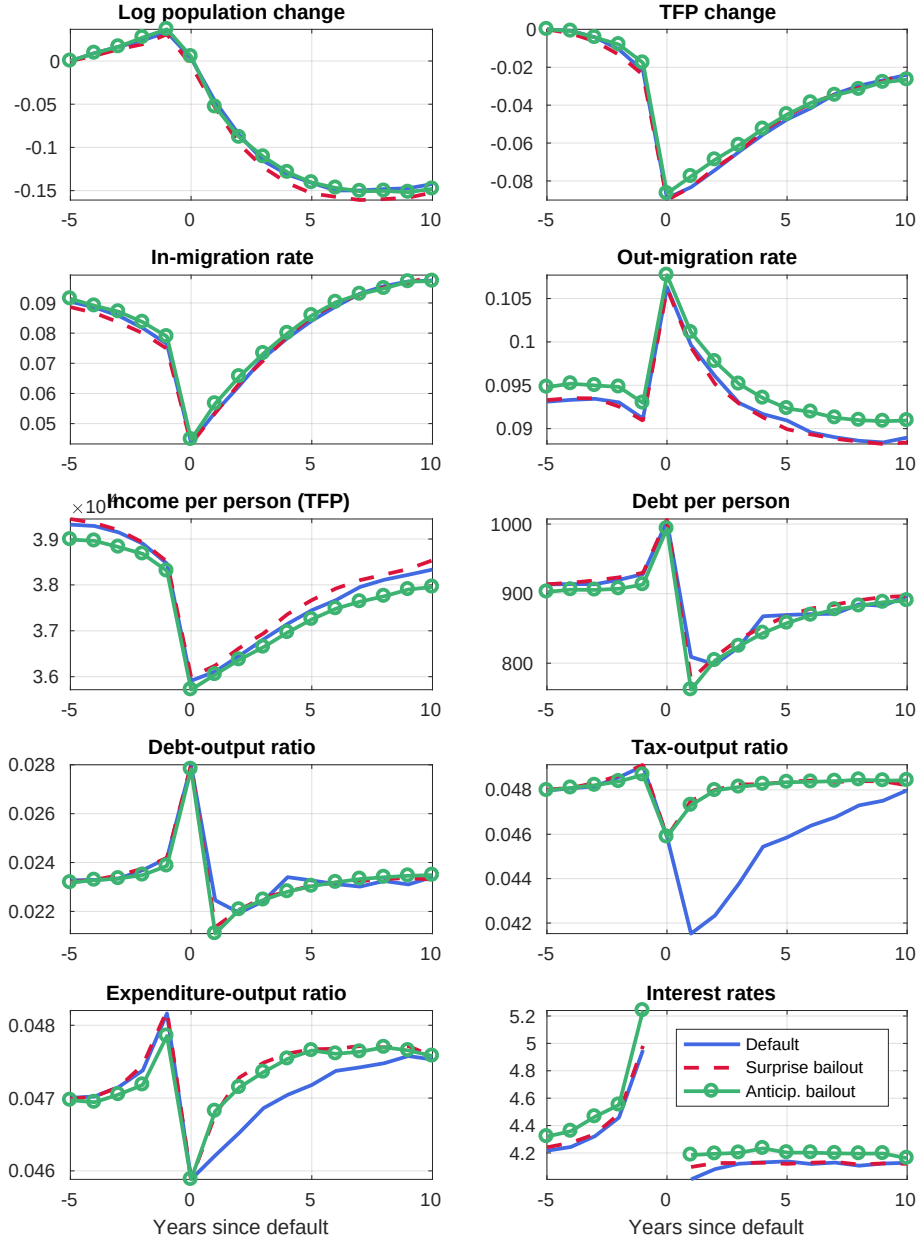


Figure 8: Comparison of Default and Bailout Episodes

are a few reasons for this. First, consider a case where anticipated bailouts could have a very large effect. Namely, suppose $\bar{q}$ was exogenous, there was no borrowing limit, and the utility function were not bounded above. Then, by sending b to $-\infty$, arbitrarily large amounts of resources could

be obtained in the current period and, with it, arbitrarily large amounts of utility.

However, the borrowing limit prevents this strategy provided $\delta < 1$ as it is in the calibration. Specifically, it requires that $-b'\dot{n} < g\dot{n}^{1-\eta}$. In this case, borrowing one dollar's worth of consumption good means that expenditures on government services must increase by more than dollar. In contrast, if $\delta > 1$, then borrowing one dollar would only require $1/\delta < 1$ expenditures on government services with the rest available for consumption.

Another reason anticipated bailouts have a small effect is that, by virtue of the very low municipal default rate, default costs in the calibration are high. With ϵ -bailouts, this means a bailout has the same cost as default, which is steep. Consequently, while there is a gain to borrowing, the cost associated with it in the next period is high.²⁴

7 Conclusion

We studied the interactions between regional borrowing, migration, and default from empirical, theoretical, and quantitative perspectives. Empirically, we documented that intercity migration rates are high in the U.S. (exceeding 6%), in-migration rates are negatively correlated with deficits, and that many cities appear to be at or near state-imposed borrowing limits. Additionally, we showed defaults can occur after booms or busts in labor productivity and population.

Our quantitative general equilibrium model was able to rationalize these features of the data in large part because of a key externality that induces over-borrowing. While migration induces this externality, it also greatly contributes to aggregate productivity, boosting GDP by 18% or more and reducing income inequality. A return to a high interest rate environment, while potentially doubling municipal default rates, has few other consequences. The observed decline in the dispersion of geographic-specific productivity that occurred from 1986 to 2000 can account for a large portion (potentially all) of the secular decline in migration rates from 1991 to 2011. Additionally, our model suggests that the optimal response to Detroit's large negative TFP shocks in 2007, 2008, and 2009 was to slash spending and deleverage in 2008 and thereby avoid default. Finally, perfectly anticipated ϵ -bailouts did not produce significant amounts of moral hazard in our setup in large part because of borrowing limits.

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²⁴A technical point is that with utility bounded above at zero, as in our calibration, there is a sufficiently large default cost such that—even with infinite consumption for a period—receiving a bailout would be suboptimal.

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A Additional data and calibration details [Not for Publication]

A.1 Borrowing limits in the U.S. states

Table 7 reports debt limits around states in the U.S.

A.2 Default and recovery rates

When defaults do occur, creditors are many times able to recover a substantial portion of the debt (although doing so may take several years). Table 8 reports for recovery rates on some recent defaults. The evidence varies over time. These have exhibited on average lower recovery rates but vary greatly from as little as 40% to as much as 100%.²⁵ There is also a large dispersion in the time to settle with some taking 15 years, most 2-3 years, and some only 3 months.

A.3 Migration rates and deficits

Table 9 reports the significance levels when not using clustered standard errors. The pattern is the same, but the significant variables become significant at a 1% level rather than a 10% (5% for net-migration rates) level.

A.4 Census County Business Patterns data

We use data from the Census' County Business Patterns (CBP) database over 1986 to 2014. The main measures we use are the annual payroll variable *ap* (converted to 2010 dollars using the standard CPI series obtained from FRED) and the mid-March employment variable *emp*, along with the FIPS codes. In the CBP database, missing or bad values are assigned a value of zero, so we treat *ap* and *emp* as missing whenever they are 0. Our overall productivity measure z_{it} is *ap*/*emp*. The data includes disaggregated employment levels by sectors (NAICS and SIC), so we keep only the observations corresponding to aggregates. The panel includes 91,800 year-county non-missing observations for z_{it} . Table 10 presents summary statistics for employment, payroll, and wages in the CBP database.

A.5 Annual Survey of State & Local Government Finances data

For our data on government finances, we use the Annual Survey of State & Local Government Finances (IndFin) compiled by the Census Bureau. Every 5 years (in years ending in 2 or 7), the aim is to construct a comprehensive record of state and local finances. (In practice, surveys are sent out for most cities and not all are returned, but the coverage is good enough to cover 64-74% of the U.S. population depending on the year). In intervening years, a non-representative sample is selected from the population. Some of the larger cities are "jacket units," and instead of surveys the Census sends its own workers to record the data. The data is aggregated at different levels, with

²⁵They may be gravitating towards the average corporate recovery rate of around 50% (according to Moody's). Hempel (1971) found that in the 1930s municipal defaults had a recovery rate of at least 84 percent.

Metric	State	Ceiling (percent)	Source
Debt-to-Personal Income	Georgia	3.5	Guideline
	Maryland	4.0	Guideline
	Minnesota	3.25	Guideline
	New York	4.0	Statute
	North Carolina	2.5 (Target)	Guideline
		3.0 (Cap)	
	Rhode Island	5.0 – 6.0	Guideline
	Vermont	5-Year Mean and Median of AAA-Rated States	Guideline
	West Virginia	3.1	Guideline
Debt-Services-to-Revenues	Alaska	8.0	Not clear
	Delaware	15.0	Statute
	Florida	6.0 (Target)	Statute
		7.0 (Cap)	
	Georgia	10.0	Constitution
	Hawaii	18.5	Constitution
	Louisiana	6.0	Constitution
	Maine	5.0	See note
	Maryland	8.0	Guideline
	Massachusetts	8.0	Guideline
	New Hampshire	10.0	Statute
	New York	5.0	Statute
	North Carolina	4.0 (Target)	Guideline
		4.75 (Cap)	
	Ohio	5.0	Constitution
	Oregon	0.0 – 5.0 (Capacity Available)	Guideline
		5.0 – 7.0 (Exceeds Prudent)	
		7.0 – 10.0 (Limits Reached)	
	Rhode Island	7.5	Guideline
	South Carolina	5.0	Constitution
	Tennessee	10.0	Statute
	Texas	5.0	Constitution
		2.0 (Target)	
		3.0 (Cap)	Guideline
	Vermont	6.0	Guideline
	Virginia	5.0	Guideline
	Washington	9.0	Constitution
	West Virginia	5.0	Guideline

Source: “Assessing the Affordability of State Debt,” Research Report 13, New England Public Policy Center, Federal Reserve Bank of Boston, 2013.

Note: In Maine’s case, the ratio of debt service-to-revenues is considered for discussion purposes but is not a statutory limit or official guideline. The values presented in this table may not be directly comparable across states due to differences in definitions of state debt, debt service, or revenues. Some states (e.g. Georgia, Minnesota, North Carolina, and West Virginia) have additional debt ceiling guidelines associated with alternative definitions of state debt or revenues.

Table 7: Summary of Selected State Government Debt Ceilings

City / Institution	Date	Recovery*	Note
City of Wenatchee, WA	2012	100%	3 months to resolve.
Choate-Symmes Hospitals, MA	1990	61%	Recovered in 8 months.
Vanceburg, KY	1987	100%	Par+interest received in 1988.
Belfield, ND	1987	55%	Settled in 1991.
Washington Public Power Supply System, WA	1983	40%	
Cleveland, OH	1978	100%	\$14 million, resolved in 1980.

*Recovery rates are approximate.
Source: Moody's US Municipal Bond Defaults and Recoveries, 1970-2012.

Table 8: Select Municipal Bond Defaults

	(1) Deficit	(2) Deficit	(3) Deficit	(4) Deficit	(5) Deficit
Eff. discount rate	-5221.8*** (870.5)				
In-migration rate		4974.9*** (788.8)			5013.0*** (789.1)
Out-migration rate			-1053.6 (790.4)		-1210.7 (787.6)
Net-migration rate				3108.2*** (566.8)	
Observations	7618	7618	7618	7618	7618
R^2	0.014	0.014	0.007	0.012	0.015

Standard errors in parentheses

Constant and year dummies included in estimation

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Fixed-effects regressions of deficits on migration rates, alternate standard errors assumptions

Year	Employment	Payroll	Wages
1986	8.51 (1.70)	11.85 (1.84)	3.35 (0.25)
1987	8.52 (1.71)	11.88 (1.86)	3.35 (0.24)
1988	8.55 (1.72)	11.90 (1.87)	3.35 (0.25)
1989	8.59 (1.72)	11.92 (1.87)	3.32 (0.25)
1990	8.62 (1.72)	11.92 (1.87)	3.30 (0.25)
1991	8.61 (1.73)	11.91 (1.87)	3.30 (0.24)
1992	8.63 (1.73)	11.94 (1.88)	3.32 (0.25)
1993	8.67 (1.72)	11.98 (1.86)	3.31 (0.24)
1994	8.71 (1.71)	12.04 (1.84)	3.33 (0.24)
1995	8.75 (1.71)	12.07 (1.85)	3.32 (0.23)
1996	8.77 (1.70)	12.11 (1.85)	3.33 (0.24)
1997	8.80 (1.70)	12.15 (1.84)	3.35 (0.23)
1998	8.83 (1.69)	12.20 (1.84)	3.37 (0.23)
1999	8.82 (1.72)	12.21 (1.87)	3.38 (0.24)
2000	8.86 (1.71)	12.24 (1.87)	3.38 (0.24)
2001	8.85 (1.72)	12.23 (1.88)	3.38 (0.24)
2002	8.83 (1.73)	12.23 (1.88)	3.40 (0.23)
2003	8.86 (1.71)	12.26 (1.85)	3.40 (0.24)
2004	8.86 (1.73)	12.27 (1.88)	3.41 (0.24)
2005	8.89 (1.71)	12.30 (1.86)	3.41 (0.23)
2006	8.92 (1.72)	12.33 (1.87)	3.41 (0.23)
2007	8.94 (1.71)	12.35 (1.88)	3.42 (0.23)
2008	8.95 (1.71)	12.34 (1.87)	3.42 (0.23)
2009	8.90 (1.70)	12.29 (1.86)	3.43 (0.22)
2010	8.88 (1.69)	12.30 (1.85)	3.45 (0.23)
2011	8.89 (1.70)	12.32 (1.85)	3.46 (0.23)
2012	8.90 (1.70)	12.34 (1.84)	3.46 (0.23)
2013	8.91 (1.71)	12.36 (1.85)	3.47 (0.23)
2014	8.92 (1.72)	12.39 (1.85)	3.49 (0.23)
<i>N</i>	91800	91950	91800

Note: Payroll and wages are in thousands of 2010 dollars, all variables are logged; standard deviations are in parentheses.

Table 10: Summary statistics in the CBP dataset

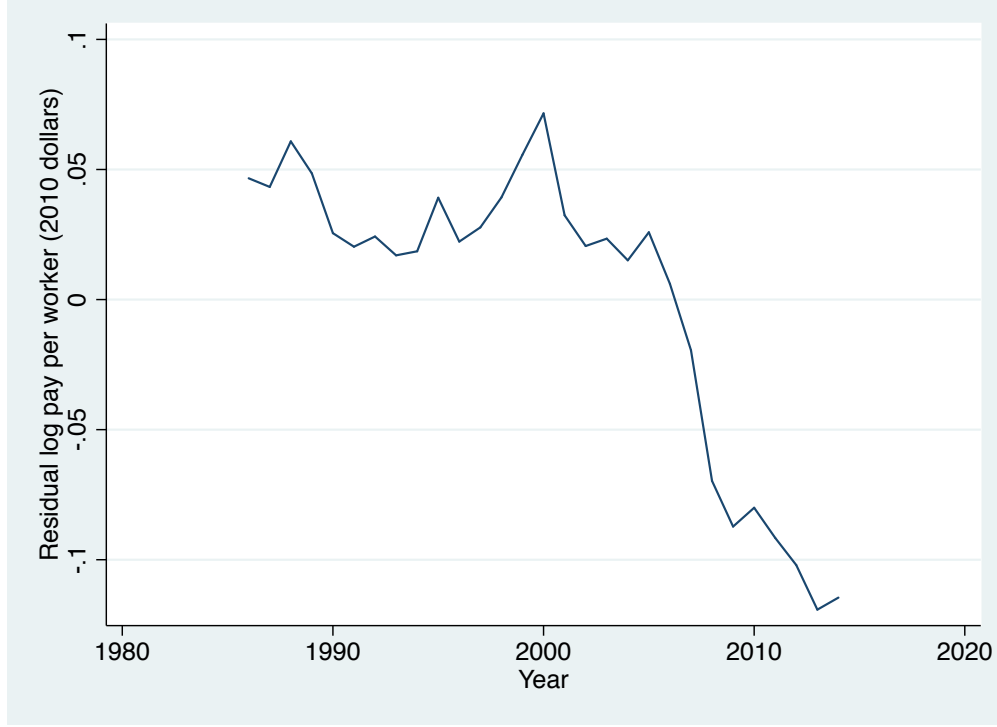


Figure 9: Wayne County (Detroit) residual productivity

“cities”—i.e., municipalities and townships—counties, and states. We consider two samples, one corresponding to cities (typecode equal to 1 or 2) and the other to counties (typecode equal to 3). Some of the data go back to 1967. However, the first population records begin in 1986 (survey year 1987), so we restrict ourselves to the 1987-2012 survey years.

The population is not recorded in each year (the data for it does not necessarily correspond to the survey year but is given by yearpop), and so we construct estimates. We restrict the sample so that each city/county has at least two population measures. We fill in missing observations using linear interpolation of the log population. We also allow for some extrapolation, but do not allow extrapolation beyond 5 years.

The raw sample consists of 390,557 year-county or year-city observations. We then use the sample restrictions as described in Table 11. We compute annual trust returns as $\text{totinstrustinvrev} / \text{insurtrustcash}$ less the CPI-measured inflation rate. We compute implied interest rates via the interest paid during the year over the total debt, short and long term: $100 * \text{totalinterestondebt} / (\text{stdebtendofyear} + \text{totallongtermdebtout})$. All financial variables are converted real 2012 dollars using the CPI.

A.6 Regime switching dynamics

To help visualize the dynamic impact of this regime switching, Figure 10 shows what happens as s_{it} moves from its mean 0 to 2 unconditional standard deviations above its mean over 20 years with y_{it} initially at μ_2 with it mean reverting afterwards. (We assume $\varepsilon_{i,t}^s = 0$ after the first 20 years and

Sample selection condition	Obs.
Raw	390557
Require non-missing name, require no id changes (idchanged=0), drop if “no data” (zerodata>0)	387963
Require yearpop not missing, drop if datayearcode=“N”, require at least two population observations	387219
Drop observations with non-missing investment annual returns on trust funds exceeding 30%	386723
Dropping missing population estimates	386515
Dropping observations where population growth rates could not be estimated	386511
Dropping Louisville, KY observations before 2003	386494
Require annual population growth rates of less than 25%	386494
Require revenue per person of less than \$25,000	386090
Require debt per person of less than \$30,000	376778
Require accounting identity for the evolution of long-term debt to nearly hold	363365
Require estimated interest rates be less than 40% annually	362122

Table 11: Sample selection in IndFin

$\varepsilon_{it}^z = 0$.)

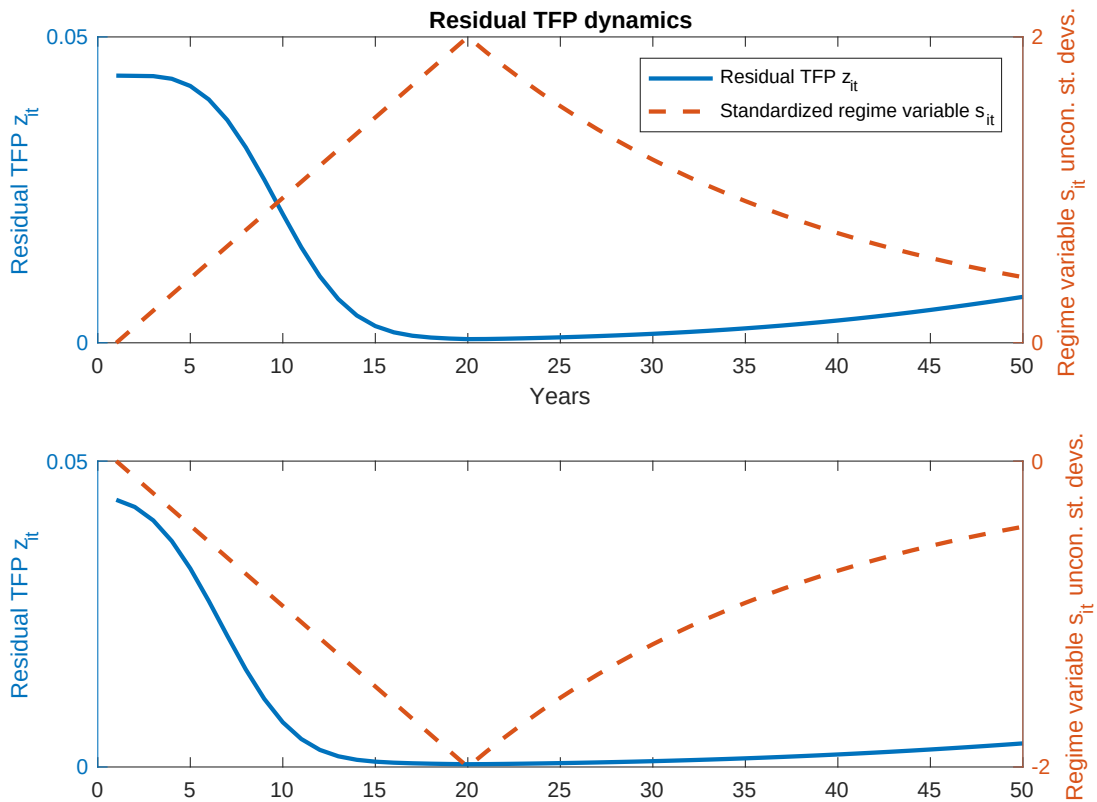


Figure 10: Estimated Residual TFP dynamics

For the first few years, nothing happens. Essentially, G is close to 0 and there is just a standard AR(1) process characterized by ρ_2, μ_2 moving $\tilde{z}_{it}$ around. But as shocks to the regime continue, a persistent decline takes over. While ρ_1 is close to 0, there is a great deal of persistence coming from G staying close to 1 and thus placing most of the weight on μ_1 . Only as s_{it} significantly mean reverts towards 0 does the economy begin to recover, and that takes decades. Consequently, the estimated process captures what one might intuitively expect to find: mostly normal times, punctuated for some cities with gradual persistent declines followed by stagnation.

A.7 Cities making Headlines

Here, we document cities/municipalities experiencing financial difficulties are reported by different news outlets. In quotations, we include excerpts of these news. To retrieve the source, click on the city's name.

U.S. Virgin Islands: *"With just over 100,000 inhabitants, the protectorate now owes north of \$2 billion to bondholders and creditors. That is the biggest per capita debt load of any U.S. territory or state - more than \$19,000 for every man, woman and child scattered across the island chain of St. Croix, St. Thomas and St. John. The territory is on the hook for billions more in unfunded pension and healthcare obligations."*

Chicago: *"Chicago's finances are already sagging under an unfunded pension liability Moody's has pegged at \$32 billion and that is equal to eight times the city's operating revenue. The city has a \$300 million structural deficit in its \$3.53 billion operating budget and is required by an Illinois law to boost the 2016 contribution to its police and fire pension funds by \$550 million."*

Cost-saving reforms for the city's other two pension funds, which face insolvency in a matter of years, are being challenged in court by labor unions and retirees.

State funding due Chicago would drop by \$210 million between July 1 and the end of 2016 under a plan proposed by Illinois Governor Bruce Rauner. "

Detroit: *" It is indeed a momentous day, U.S. Bankruptcy Judge Steven Rhodes said at the end of a 90-minute summary of his ruling. We have here a judicial finding that this once-proud city cannot pay its debts. At the same time, it has an opportunity for a fresh start. I hope that everybody associated with the city will recognize that opportunity."*

In a surprise decision Tuesday morning, Rhodes also said he will allow pension cuts in Detroit's bankruptcy. He emphasized that he won't necessarily agree to pension cuts in the city's final reorganization plan unless the entire plan is fair and equitable. Resolving this issue now will likely expedite the resolution of this bankruptcy case, he said. "

Flint

Puerto Rico: *"The Puerto Rican government failed to pay almost half of \$2 billion in bond payments due Friday, marking the commonwealth's first-ever default on its constitutionally guaranteed debt."*

New Jersey and other states: *The particular factors are as diverse as the states. But one thing is clear: More states are facing financial trouble than at any time since the economy began to emerge from the Great Recession, according to experts who say the situation will grow more dire as the Trump administration and GOP leaders on Capitol Hill try to cut spending and rely on states to pick up a greater share of expensive services like education and health care.*

On the Pension Crisis: [Forbes' article](#), and [Hoover Institution's article](#).

On the State Crisis: *States and cities around the country will soon book similar losses because of new, widely followed accounting guidelines that apply to most governments starting in fiscal 2018 – a shift that could potentially lead to cuts to retiree health benefits.*

Illinois: *“After decades of historic mismanagement, Illinois is now grappling with \$15 billion of unpaid bills and an unthinkable quarter-trillion dollars owed to public employees when they retire.”*

Hartford: *“Hartford’s biggest bond insurer said it had offered to help the city postpone payments on as much as \$300 million in outstanding debt, in a move designed to help prevent a bankruptcy filing for Connecticut’s capital. Under Assured Guaranty’s proposal, debt payments due in the next 15 years would instead be spread out over the next 30 years without bankruptcy or default. The city would issue new longer-dated bonds and use the proceeds to make the near-term debt payments.”*

B Computation [Not for Publication]

B.1 Discretization of the LSTAR productivity process

To discretize the LSTAR process, we use the following algorithm. Other than the LSTAR parameters, we require two inputs. One is the discretization of the number of regimes, n^S , and the other is the total number of TFP states desired in the end, n^Z . We require $n^Z \geq n^S$. In the calibration, we use $n^S = 5$ and $n^Z = 32$.

We first discretize the s process using the Rouwenhorst method ([Kopecky and Suen, 2010](#)). (This determines both the support and the transition probabilities). We then construct a 101 point grid for z linearly spaced from $\min\{\mu - 4\sigma(1 - \rho^2)^{-1/2}\}$ to $\max\{\mu - 4\sigma(1 - \rho^2)^{-1/2}\}$ where the min and max are over the two sets of parameters. Using a tensor product of the z grid and the s grid, we compute the probabilities $\mathbb{P}(z'|z, s, s')$ using Tauchen’s method and combine that with the already discretized transition probabilities $\mathbb{P}(s'|s)$ to get $\mathbb{P}(z', s'|z, s)$. We compute the invariant distributions $\mathbb{P}(z, s)$ and $\mathbb{P}(s)$ associated with this transition matrix.

For an efficient distribution of points, we use the invariant distribution $\mathbb{P}(s)$ to determine a number $m^Z(s) \geq 1$ for each of the s values (of which there are n^S) such that $\sum_s m^Z(s) = n^Z$. To

see the main methodology, first assume the values of the invariant distribution are unique. Define $\tilde{m}^Z(s; \alpha) := 1 + \text{round}(\alpha \cdot \mathbb{P}(s) \cdot (n^Z - n^S))$ where the rounding is to the nearest integer. Define an error function $\epsilon(\alpha) := \sum_s \tilde{m}^Z(s; \alpha) - n^Z$ so that $\epsilon(\alpha) = 0$ means that the number of points assigned to each regime $\tilde{m}^Z(s; \alpha)$ sum to n^Z . We then use bisection to find an α such that $\epsilon(\alpha) = 0$. When the values $\{\mathbb{P}(s)\}$ are unique, such an α is guaranteed to exist because a small enough increase (decrease) in α will cause $\epsilon(\alpha)$ to increase (decrease) by either 0 or 1. Having found such an α , set $m^Z(s) := \tilde{m}^Z(s; \alpha)$.

For the case $\mathbb{P}(s)$ having non-unique values, we perturb the values slightly to achieve uniqueness. Specifically, we loop through s and $\tilde{s} > s$ and replace $\mathbb{P}(s)$ with $\mathbb{P}(s) + 10^{-9}$ whenever $|\mathbb{P}(s) - \mathbb{P}(\tilde{s})| < 10^{-10}$. Similar results could be achieved by adding small random numbers to each $\mathbb{P}(s)$ value.

At this point, the number of grid points for each s , $m^Z(s)$, is known. We then loop through the s values and create a grid of z values for each one. We do so by computing the cdf $\mathbb{P}(z \leq \bar{z}|s)$ on the grid and using linear interpolation to find $z_i(s)$ such that $\mathbb{P}(z \leq z_i(s)|s) = \frac{i}{m^Z(s)+1}$ for $i = 1, \dots, m^Z(s)$. (This is similar to the idea in Adda Cooper.) Once the grid points are known, we use Tauchen's method as before to compute $\mathbb{P}(z'|z, s, s')$ using the regime-contingent grids $\{z_i(s)\}_{i=1}^{m^Z(s)}$. Finally, we multiply $\mathbb{P}(z'|z, s, s')$ by $\mathbb{P}(s'|s)$ to obtain $\mathbb{P}(z', s'|z, s)$.

B.2 Equilibrium computation

To compute the equilibrium, we guess on three objects: expected utility conditional on moving J , the riskfree price $\bar{q}$,²⁶ and the average inflows over a “normalization” term for the logit probabilities,

$$\bar{i} := \frac{\int nF(R(\mathbf{x})|z)d\mu(\mathbf{x})}{\exp(\lambda(S(\mathbf{x}) - \max_{\mathbf{x}} S(\mathbf{x})))d\mu(\mathbf{x})},$$

Subtracting off $\max_{\mathbf{x}} S(\mathbf{x})$ prevents overflows in the computation. Note that knowing $\bar{i}$, $i(\mathbf{x})$ can be obtained via

$$i(\mathbf{x}) = \bar{i} \exp(\lambda(S(\mathbf{x}) - \max_{\mathbf{x}} S(\mathbf{x}))).$$

B.2.1 Solving for the law of motion and value and price functions

With the tuple $(J, \bar{i}, \bar{q})$, the value function $S(\mathbf{x})$, the law of motion $\dot{n}(\mathbf{x})$, and the price schedule $q(b', \dot{n}, z)$ are solved for in the following way:

1. Construct discrete grids of debt per person $\mathcal{B}$, population $\mathcal{N}$, and productivity $\mathcal{Z}$.

For $\mathcal{B}$, we use 20 linearly spaced points from -0.08 to 0. Since average income across cities is normalized to 1 and the debt-output ratio is around .02, this allows for a given city to hold roughly 4 times as much debt as the average and it is not binding in the benchmark. (This grid

²⁶For the bailout case, we guess on $\bar{q}(1 - \tau)$ rather than $\bar{q}$ as this is the relevant object for households and cities. Having computed the equilibrium value of $\bar{q}(1 - \tau)$, we then compute τ using the invariant distribution and bailout amounts and use it to recover $\bar{q}$.

is coarse relative to those used in Bewly-Huggett-Aiyagari type models, but the dispersion in debt holdings is much more concentrated for cities.) For $\mathcal{N}$, we use 64 *log-linearly* spaced grid points over $\pm 5 * 1.8$ since the standard deviation of the log population is roughly 1.8. For $\mathcal{Z}$, we discretize the LSTAR process as described in Section B.1 and tensor product it with the non-parametrically discretized permanent shocks. We also scale the process to be mean 1 (in levels).²⁷

2. Fix tolerances (tol_q, tol_n, tol_S) .

We use $(tol_q, tol_n, tol_S) = (10^{-3}, 10^{-5}, 10^{-7})$.²⁸

3. Guess on $S(\mathbf{x}), \dot{n}(\mathbf{x}), q(b', \dot{n}, z)$.

The initial guess we use is $S(\mathbf{x}) = 0, q(b', \dot{n}, z) = \bar{q}$, and $\dot{n}(\mathbf{x}) = n$.

4. Solve for $S^N(\dot{b}, \dot{n}, z)$ via grid search and update $S^D(\dot{b}, \dot{n}, z)$.

For this, we use the analytic solution—conditional on b' —of the intratemporal problem. Whenever we interpolate, we use linear interpolation.

5. Solve for $d(\mathbf{x})$ and an update $S^*(\mathbf{x})$ by comparing S^N and S^D evaluated at $(\dot{b}(\mathbf{x}), \dot{n}(\mathbf{x}), z)$.

6. Compute an update $q^*(b', \dot{n}, z)$ using $d(\mathbf{x})$.

7. Compute an update $\dot{n}^*(\mathbf{x})$ using $S^*(\mathbf{x})$ and J .

8. Determine whether the convergence criteria $\|q^* - q\|_\infty < tol_q, \|\dot{n}^* - \dot{n}\|_\infty < tol_n$, and $\|S^* - S\|_\infty < tol_S \cdot \|S\|_\infty$ are satisfied. If so, stop. Otherwise, update the guesses as $S := S^*, \dot{n} := \dot{n}^*$, and $q := q^*$ and go to Step 4.

We found relaxing the updates was not necessary.

B.2.2 Solving for the invariant distribution and key equilibrium object updates

Given the converged values for $\dot{n}(\mathbf{x})$, the bond policy $b'(\dot{b}, \dot{n}, z)$ (from the S^N problem), and the default decision $d(\mathbf{x})$, we compute the invariant distribution $\mu(\mathbf{x})$ and updates $J^*, \bar{i}^*, \bar{q}^*$ as follows:

1. Fix a tolerance tol_μ .

We use $tol_\mu = 10^{-10}$.

2. Guess on μ .

Our initial guess is $\mu(0, 1, z, 1) = \mathbb{P}(z)$ with $\mu = 0$ elsewhere. (Consequently, the mass of households is 1 initially.) On subsequent invariant distribution computations, we use the previously computed μ .

²⁷For the experiment with residual productivity, we first compute $\mathcal{Z}$ grid as described above and then adjust the residual shocks. This higher standard deviation makes the mean be slightly above 1, as reflected in Table ??.

²⁸These are the final tolerances we use and do not declare convergence without them. However, earlier in the search for equilibrium values we use loose tolerances and progressively tighten them.

3. For all $\mathbf{x}$, compute the out-migration rate $o(\mathbf{x}) := F(R(\mathbf{x})|z)$ where $R(\mathbf{x}) = S(\mathbf{x}) - J$.
4. Using $o(\mathbf{x})$, $\bar{i}$, $\mu(\mathbf{x})$, compute updates $\dot{n}^*(\mathbf{x})$, J^* , $\bar{i}^*$.
5. Using $\dot{n}^*(\mathbf{x})$, and $\mu(\mathbf{x})$, the bond and default policies, compute an update on the invariant distribution $\mu^*(\mathbf{x})$.

Again, we use linear interpolation to distribute the mass from μ to μ^* . (An important advantage of linear interpolation is that it keeps the number of *households* the same on each iteration, i.e., $\int \mu(\mathbf{x}) ndx = \int \mu^*(\mathbf{x}) ndx$.) We do not linearly interpolate the bond policies, which are discontinuous because they are computed via grid search. Rather, we compute the 4 sets of linear interpolation weights and knots for $\dot{b}$ and $\dot{n}$ then evaluate $b'(\dot{b}, \dot{n}, z)$ four distinct times at the knots.

6. Determine whether the convergence criteria $\|\mu^* - \mu\|_\infty < tol_\mu$ is satisfied. If so, continue to the next step. Otherwise, update the guess $\mu := \mu^*$ and go to Step 3.
7. For the updates J^* and $\bar{i}^*$, use the values associated with the computed invariant distribution μ . For an “update” on $\bar{q}$, there is no natural fixed point update. However, construct a “pseudo-update” by defining $\bar{q}^* := \bar{q} - 10(\bar{B} - \int (1 - d(\mathbf{x}))(bn)d\mu(\mathbf{x}))$.

Note that if cities are borrowing too little in that $\int (1 - d(\mathbf{x}))(bn)d\mu(\mathbf{x}) > \bar{B}$, this makes $\bar{q}^* > \bar{q}$, lowering interest rates and making borrowing more attractive. The reason we multiply by 10 is because $\bar{B}$ is on the order of .001-.004, so if $\int (1 - d(\mathbf{x}))(bn)d\mu(\mathbf{x}) = 0$ this implies $\bar{q}^*$ would be increased by .01-.04 (i.e., a few percentage point increase in the interest rate).

B.2.3 Solving for the key equilibrium objects

With the initial guesses $J, \bar{i}, \bar{q}$ and the updates $J^*, \bar{i}^*, \bar{q}^*$, produce new initial guesses as follows:

1. Fix tolerances $(tol_J, tol_{\bar{i}}, tol_{\bar{q}})$. Fix an initial step size $\delta_{\bar{q}} > 0$. Fix $\xi_J > 0$ and $\xi_{\bar{i}} > 0$.
We use $(tol_J, tol_{\bar{i}}, tol_{\bar{q}}) = (10^{-7}, 10^{-5}, 10^{-3})$. Our $\delta_{\bar{q}}$ varies based on the experiment (with larger values when the equilibrium value is suspected to be far away), but in the benchmark we use $\delta_{\bar{q}} = .01$. Our initial values for ξ_J and $\xi_{\bar{i}}$ are 1.5 and 1, respectively.
2. Check whether $|J^* - J| < tol_J \cdot |J|$, $|\bar{i}^* - \bar{i}| < tol_{\bar{i}} \cdot \max\{|\bar{i}|, .01\}$, and $|\bar{q}^* - \bar{q}| < tol_{\bar{q}}$. If so, STOP: an equilibrium has been computed. Otherwise, go on.
3. Save the $d_J^* := J^* - J$, $d_{\bar{i}}^* := \bar{i}^* - \bar{i}$, $d_{\bar{q}}^* := \bar{q}^* - \bar{q}$ and—before doing so—store the previous changes (except on the first iteration) as d_J , $d_{\bar{i}}$, and $d_{\bar{q}}$.
4. Update the equilibrium values:
 - (a) J according to $J := \xi_J J^* + (1 - \xi_J)J$
 - (b) $\bar{i}$ according to $\bar{i} := \xi_{\bar{i}} \bar{i}^* + (1 - \xi_{\bar{i}})\bar{i}$

(c) $\bar{q}$ according to $\bar{q} := \bar{q} + \text{sign}(\bar{q}^* - \bar{q}) \min\{\delta_{\bar{q}}, |\bar{q}^* - \bar{q}|\}$.

5. If not the first iteration and if $d_{\bar{q}}d_{\bar{q}}^* < 0$, replace $\delta_{\bar{q}}$ with $\delta_{\bar{q}} := 0.5 \cdot \delta_{\bar{q}}$.

The update on $\delta_{\bar{q}}$ is necessary. To speed the computation, we also increase (decrease) ξ_J when $d_{\bar{q}}d_{\bar{q}}^* \geq 0$ ($d_{\bar{q}}d_{\bar{q}}^* < 0$) and similarly for $\xi_{\bar{i}}$, but this is not necessary.

If convergence has not been obtained, the new guesses on $J, \bar{i}, \bar{q}$ are used to solve for the value functions, price functions, law of motion, invariant distribution, and key equilibrium objects as described in Sections B.2.1 and B.2.2.

C Omitted proofs and results [Not for Publication]

C.1 Two-period model proofs

C.1.1 The Euler equation

The term $\frac{1-o_2}{1-o_2+i_2}$ reflects that the planner is seeking to maximize the welfare of those currently on the island. The term is present because if the planner borrows $\bar{q}$ units of consumption good (total) in the first period, then next period 1 unit of consumption good will need to be repaid (total). This cost will be born equally by all on the island. The fraction of this burden paid by existing residents is precisely $\frac{1-o_2}{1-o_2+i_2}$.²⁹ The rest of the burden is born by new entrants to the island whom the planner does not care about. Note that this should be the political outcome as households, if they could choose the planner's policy, would seek to do this and all agree on the best policy (since there is no heterogeneity among individuals except for the iid moving cost).

The term $1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2}$ is, essentially, one minus the elasticity of next period's population with respect to debt issuance.³⁰ It reflects that for each person attracted to the island through less borrowing, the overall debt burden per person falls. (Conversely, if $b_2 > 0$, each additional entrant reduces assets per person.) Hence, a rational government, internalizing the effects of city finances on migration decisions, should exercise more financial discipline else equal to attract individuals to the islands to reduce debt per person. Of course, for most households, this elasticity is probably quite small. However, for fiscally distressed cities, the effect may be non-negligible.

From the perspective of current residents, there is no "over-borrowing." In fact, the government is exactly maximizing current resident welfare. However, from the perspective of the population next period, the government is over-borrowing if the elasticity satisfies $\frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} > -\frac{i_2}{1-o_2}$. In the appendix, we show that if debt per capita is smaller than the threshold $\bar{b} \equiv \left(\frac{n_2}{n_1}\right)^2 [F'(\cdot)u'(\cdot)]^{-1}$,

²⁹One interesting deviation of this from reality is that new entrants may have a lower homeownership rate than existing households. If property taxes are the main source of revenue, then this would skew the debt burden towards those who stayed rather than new entrants.

³⁰Assuming $b_2 < 0$ and making the dependence of n_2 on b_2 explicit, note that

$$\frac{\partial \log n_2(b_2)}{\partial \log(-b_2)} = \frac{\partial \log n_2(-e^{\log(-b_2)})}{\partial \log(-b_2)} = -\frac{1}{n_2(b_2)} \frac{\partial n_2}{\partial b_2} \frac{\partial e^{\log(-b_2)}}{\partial \log(-b_2)} = \frac{b_2}{n_2(b_2)} \frac{\partial n_2}{\partial b_2}.$$

then lower deficits (less debt) increases population in period 2 in the model with random island assignment for out-migrants. This means that for sufficiently low deficits, the elasticity condition $\frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} > -\frac{i_2}{1-o_2}$ is satisfied. Similarly, large in-migration flows help to meet this condition. In contrast, the absence of in-migration in the second period eliminates the excessive borrowing.

The excessive borrowing can be seen from considering a social planner problem, who maximizes the welfare of a continuum of identical islands, indexed by j , subject to the islands' resources.

$$\begin{aligned} \max_{c_{j,1}, c_{j,2}} \quad & \int u(c_{j,1})dj + \beta \int u(c_{j,2})dj \\ \text{s.t.} \quad & \int c_{j,1}dj + \bar{q} \int c_{j,2}dj = y(1 + \bar{q}). \end{aligned}$$

Here, we assume that all islands are endowed with y units of the consumption good each period and that the cost of transferring resources across time is $\bar{q}$. Optimality requires that consumption be equated across islands in each period, $c_{j,t} = c_{j',t} = c_t^*$, and

$$u'(c_1^*) = \bar{q}^{-1} \beta u'(c_2^*). \quad (24)$$

Under the restriction on the elasticity stated above, the effective discount factor of the island's government is lower than the central planner's discount factor:

$$\beta^{eff} \equiv \beta \frac{1 - o_2}{1 - o_2 + i_2} \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right) < \beta.$$

As a result, the euler equations 2 and 24 imply that $\frac{c_2^*}{c_1^*} > \frac{c_2}{c_1}$, which shows that there is over-borrowing in the decentralized economy. Note that this result is derived under the assumption of random island assignment for departing workers. In the appendix, we show that the threshold condition for debt in the case of directed search for departing workers is $\bar{b}^d \equiv \left(\frac{n_2}{n_1} \right)^2 \left[\tilde{F}'(\cdot) u'(\cdot) \right]^{-1}$, with $\tilde{F}'(\cdot) > F'(\cdot)$. One can see that the debt threshold becomes smaller when the sovereign internalizes the impact that her actions have on the inflow of workers to her island. In other words, allowing for directed search ameliorates the over-borrowing distortion.

Proposition 9. *The two-period model's Euler equation may be written*

$$\bar{q} u'(c_1) = \beta \frac{1 - o_2}{1 - o_2 + i_2} u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right)$$

Proof. The objective function may be written

$$u(c_1) + \beta \left((1 - o_2) u(c_2) + \int_{-\infty}^{J - u(c_2)} (J - \phi) f(\phi) d\phi \right)$$

Using Leibniz' rule,

$$\begin{aligned}
0 &= u'(c_1) \frac{\partial c_1}{\partial b_2} + \beta \left((1 - o_2) \frac{\partial u(c_2)}{\partial b_2} + u(c_2) \frac{-\partial o_2}{\partial b_2} + \frac{\partial(J - u(c_2))}{\partial b_2} (J - \phi) f(\phi) \Big|_{\phi=J-u(c_2)} \right) \\
&= u'(c_1) \frac{\partial c_1}{\partial b_2} + \beta \left((1 - o_2) \frac{\partial u(c_2)}{\partial b_2} + u(c_2) \frac{-\partial o_2}{\partial b_2} + \frac{\partial(J - u(c_2))}{\partial b_2} u(c_2) f(J - u(c_2)) \right) \\
&= u'(c_1) \frac{\partial c_1}{\partial b_2} + \beta \left((1 - o_2) \frac{\partial u(c_2)}{\partial b_2} - u(c_2) \frac{\partial F(J - u(c_2))}{\partial b_2} + \frac{\partial(J - u(c_2))}{\partial b_2} u(c_2) f(J - u(c_2)) \right) \\
&= u'(c_1) \frac{\partial c_1}{\partial b_2} + \beta \left((1 - o_2) \frac{\partial u(c_2)}{\partial b_2} - u(c_2) f(J - u(c_2)) \frac{\partial(J - u(c_2))}{\partial b_2} + \frac{\partial(J - u(c_2))}{\partial b_2} u(c_2) f(J - u(c_2)) \right) \\
&= u'(c_1) \frac{\partial c_1}{\partial b_2} + \beta(1 - o_2) u'(c_2) \frac{\partial c_2}{\partial b_2} \\
&= -\bar{q} u'(c_1) + \beta(1 - o_2) u'(c_2) \frac{\partial b_2^{\frac{n_1}{n_2}}}{\partial b_2} \\
&= -\bar{q} u'(c_1) + \beta(1 - o_2) u'(c_2) \left(\frac{n_1}{n_2} + b_2 n_1 \frac{\partial n_2^{-1}}{\partial b_2} \right) \\
&= -\bar{q} u'(c_1) + \beta(1 - o_2) u'(c_2) \left(\frac{n_1}{n_2} + b_2 n_1 (-1) n_2^{-2} \frac{\partial n_2}{\partial b_2} \right) \\
&= -\bar{q} u'(c_1) + \beta(1 - o_2) u'(c_2) \left(\frac{n_1}{n_2} - b_2 \frac{n_1}{n_2} \frac{1}{n_2} \frac{\partial n_2}{\partial b_2} \right) \\
&= -\bar{q} u'(c_1) + \beta \frac{n_1}{n_2} (1 - o_2) u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right) \\
&= -\bar{q} u'(c_1) + \beta \frac{n_1}{n_1(1 - o_2 + i_2)} (1 - o_2) u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right) \\
&= -\bar{q} u'(c_1) + \beta \frac{1 - o_2}{1 - o_2 + i_2} u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right)
\end{aligned}$$

Consequently, the Euler equation reads

$$\bar{q} u'(c_1) = \beta \frac{1 - o_2}{1 - o_2 + i_2} u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right).$$

□

C.1.2 Constrained efficiency

Proof of Proposition 3. Under these assumptions, the Pareto optimal allocation is $c_1 = c_2 = y$. In this case, the inflow-rates are not differentiable at $b_2 = 0$ and so the Euler equation is not valid at that point.

First note that whenever the derivative $\partial n_2 / \partial b_2$ exists, one has

$$\begin{aligned} \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} &= \frac{b_2}{n_2} n_1 (\bar{i} I'(u(c_2)) + f(J - u(c_2))) u'(c_2) \frac{\partial c_2}{\partial b_2} \\ &= b_2 u'(c_2) \left(\frac{n_1}{n_2} \right)^2 (\bar{i} I'(u(c_2)) + f(J - u(c_2))) \end{aligned}$$

Because I is increasing and f is positive, this has the same sign as b_2 .

First we will show that $b_2 < 0$ is not optimal. Given no inflows for $b_2 < 0$, borrowing is not optimal because the Euler equation (which is valid locally here) requires

$$u'(c_1) = u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right) \geq u'(c_2).$$

However, with $y_1 = y_2 = y$ and $b_2 < 0$, one has $c_1 = y - \bar{q}b_2 > y + \frac{b_2}{n_2} = c_2$, which gives $u'(c_1) < u'(c_2)$, which is a contradiction.

Now we will show that $b_2 > 0$ is not optimal. The Euler equation in this case reads

$$u'(c_1) = \frac{1 - o_2}{1 - o_2 + i_2} u'(c_2) \left(1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \right) \leq u'(c_2)$$

because $\frac{1 - o_2}{1 - o_2 + i_2} \leq 1$ and $1 - \frac{b_2}{n_2} \frac{\partial n_2}{\partial b_2} \leq 1$. However, with $y_1 = y_2 = y$ and $b_2 > 0$, one has $c_1 = y - \bar{q}b_2 < y + \frac{b_2}{n_2} = c_2$, which gives $u'(c_1) > u'(c_2)$, a contradiction.

Since $b_2 < 0$ and $b_2 > 0$ are not optimal, all that remains to show is that an optimal choice exists. Without loss of generality, we can restrict the choice set to $b_2 \in [-\delta, \delta]$ for δ arbitrarily small such that every choice is feasible. Then, with a continuous objective function being maximized over a compact set, a maximum exists, which must be $b_2 = 0$. $\square$

Consequently, the island with the largest immigration-induced overborrowing incentive will be a net borrower while the island with the least immigration-induced borrowing incentive will be a net lender. Lemma 1 establishes this.

Lemma 1. *If there are two island types with homogeneous first period endowments and heterogeneous second period endowments, then in equilibrium the island with a larger second period endowment has strictly greater second period consumption and strictly borrows.*

The next proposition establishes that the equilibrium with heterogeneity is not constrained efficient because marginal rates of substitution will not be equated across islands (and hence not across individuals either).

C.2 The intermediary's problem

For the intermediary problem, we consider a slightly more general formulation from that in the main text, allowing for a proportional tax on risk-free bond holdings τ . Consequently, the interme-

diary's problem is

$$W(B, M) = \max_{D, B', M'} D + \bar{q}(1 - \tau)W(B', M')$$

$$\text{s.t. } D + \bar{q}(1 - \tau)B' + \int Q(b', n', z)dM'(b', n', z) = B + \int \sum_z \mathbb{P}(z|z_{-1})(1 - d(b, n, z))(bn)dM(b, n, z_{-1})$$

We will first prove the following, with Proposition 6 following as an immediate corollary:

Proposition 10. *If prices satisfy*

$$q(b', n', z) = \bar{q}(1 - \tau)\mathbb{E}_{z'|z}(1 - d(b', n', z'))$$

and if

$$\bar{B} = (1 - d(b, n, z))(bn)\mu(db, dn, dz, 0)$$

then there exists prices and an optimal policy M' , with M' invariant, such that contract markets and the risk-free bond market clears and zero profits obtains (provided the other equilibrium conditions are met).

Proof of Proposition 10. To characterize the intermediary's problem, first consider its first order conditions (FOCs). The FOC for B' is trivially satisfied for any B' .

From the FOC for $M(b', n', z)$ one must have

$$Q(b', n', z) = \bar{q}(1 - \tau) \sum_{z'} \mathbb{P}(z'|z)(1 - d(b', n', z'))(b'n').$$

Replacing $Q(b', n', z)$ with $q(b', n', z)b'n'$ and simplifying for $b' \neq 0$, this becomes

$$q(b', n', z) = \bar{q}(1 - \tau)\mathbb{E}_{z'|z}(1 - d(b', n', z')).$$

$$q(b', n', z) = \bar{q}(1 - \tau)\mathbb{E}_{z'|z}(1 - d(b', n', z')).$$

Hence, in equilibrium, if prices satisfy the above equations, then the indifferent is intermediary over all feasible contract, bond holding, and dividend distribution schemes.

Contract market clearing as stated in (20) dictates what M' must be as a function of the distribution μ , household policies b', d , and law of motion $\dot{n}$. Additionally, $B'(\bar{B}, M)$ must equal $\bar{B}$ for risk-free bond market clearing. The other equilibrium conditions pertaining to intermediary are that (1) M must be invariant ($M' = M$) and (2) that the intermediary makes zero profits. To satisfy the first, we take $M = M'$.

To satisfy zero profits, first, note that for any $\mathcal{B} \cap \{0\} = \emptyset$ and any integrable function $g(b', n', z')$,

$$\begin{aligned}
& \sum_z \int \mathbb{P}(z'|z) g(b', n', z') \mathbf{1}_{[(b', n') \in \mathcal{B} \times \mathcal{N}]} M'(db', dn', z) \\
&= - \int g(b', n', z') \mathbb{P}(z'|z) \mathbf{1}_{[(b'(b, n, z, 0), \dot{n}(b, n, z, 0)) \in \mathcal{B} \times \mathcal{N}]} (1 - d(b, n, z)) d\mu(b, n, z, 0) \\
&= - \int_{\mathcal{B} \times \mathcal{N}} g(b', n', z') \mu(db', dn', z', 0)
\end{aligned} \tag{25}$$

which follows from μ being invariant and $\mathbb{P}(z'|z) \mathbf{1}_{[(b'(b, n, z, 0), \dot{n}(b, n, z, 0)) \in \mathcal{B} \times \mathcal{N}]} (1 - d(b, n, z))$ being the transition probability from b, n, z to b', n', z' as long as $b' \neq 0$ (for $b' = 0$, there is an additional arrival coming from cities that transition from $f = 1$ to $f = 0$).

Now we need to show the intermediary makes zero profits supposing that the other conditions hold. Consider the intermediary's budget constraint assuming zero dividends and bond market clearing:

$$\begin{aligned}
& (1 - \bar{q}(1 - \tau)) \bar{B} \\
&= \int Q(b', n', z) dM'(b', n', z) - \int \sum_z \mathbb{P}(z|z_{-1}) (1 - d(b, n, z)) (bn) dM(b, n, z_{-1}).
\end{aligned} \tag{26}$$

If this holds, then zero dividends is feasible and hence optimal. Then one has

$$\begin{aligned}
& \int Q(b', n', z) dM'(b', n', z) \\
&= \bar{q}(1 - \tau) \sum_{z'} \int (1 - d(b', n', z')) (b'n') \mathbb{P}(z'|z) dM'(b', n', z) \\
&= -\bar{q}(1 - \tau) \sum_{z'} \int (1 - d(b', n', z')) (b'n') \mu(db', dn', z', 0) \\
&= -\bar{q}(1 - \tau) \int (1 - d(b', n', z')) (b'n') \mu(db', dn', dz', 0)
\end{aligned} \tag{27}$$

where the first equality follows from equilibrium pricing of $Q(b', n', z)$, the second from (25), and the third is just different notation.

From the hypothesis that $\bar{B} = \int (1 - d(b, n, z)) (bn) \mu(db, dn, dz, 0)$ and (27), we have $\int Q(b', n', z) dM'(b', n', z) = -\bar{q}(1 - \tau) \bar{B}$. So, (26) will hold as long as

$$\bar{B} = - \int \sum_z \mathbb{P}(z|z_{-1}) ((1 - d(b, n, z)) bn) dM(b, n, z_{-1})$$

From M being invariant, we can replace M with M' so this condition is equivalent to

$$\bar{B} = - \int \sum_{z'} \mathbb{P}(z'|z) ((1 - d(b', n', z')) b'n') dM'(b', n', z)$$

Rewriting and using (25), this is

$$\begin{aligned}
\bar{B} &= - \sum_{z'} \int \mathbb{P}(z'|z) ((1 - d(b', n', z'))b'n') dM'(b', n', z) \\
&= - \sum_{z'} \left(- \int ((1 - d(b', n', z'))b'n') \mu(db', dn', z', 0) \right) \\
&= \int ((1 - d(b', n', z'))b'n') \mu(db', dn', dz', 0)
\end{aligned}$$

which holds from the hypothesis. □

Because the $q(b', n', z)$ prices are pinned down by $\bar{q}(1 - \tau)$, exactly what $\bar{q}$ and τ are is irrelevant for them. However, given the equilibrium value of $\bar{q}(1 - \tau)$, one then finds $\bar{q}$

Proof of Proposition 6. The result follows from Proposition 10 taking $\tau = 0$. □

C.3 The centralized problem

Proof of Proposition 7. First note that separability with u_g increasing From the household problem, optimality requires $u_h/u_c = r$, so the housing market clears by taking r to be the marginal rate of substitution. If $u_l < 0$, then from the FOC for labor in the $\hat{S}$ problem, $-u_l/u_c = (1 - \alpha)z(\dot{n}l)^{-\alpha}$, so taking w as this value clears the labor market and has firms optimize. If $u_l = 0$ globally, then $l = 1$ is optimal in the $\hat{S}$ and S problems and taking $w = (1 - \alpha)z(\dot{n} \cdot 1)^{-\alpha}$ clears the labor market and has firms optimize.

At these prices, firm profits are $\dot{n}\pi = z(\dot{n}l)^{1-\alpha} - w\dot{n}l + r\bar{H}$. Substituting in the equilibrium profit into the household budget constraint $\dot{n}c + rh\dot{n} = w\dot{n}l + \pi\dot{n} - T\dot{n}$ then gives $\dot{n}c = z(\dot{n}l)^{1-\alpha} - T\dot{n}$. So, if T is consistent with T from the government problem, then c and l are feasible at the prices above. The T implied by the no-default problem gives $\dot{n}T = \dot{n}\pi - q(b', \dot{n}, z)b'\dot{n}$ and T implied by the default problem is $\dot{n}T = -p(\dot{b}, \dot{n}, z)\dot{n}$. Plugging these in, the household budget constraint holds because the budget constraint of the $\hat{S}^N$ and $\hat{S}^D$ problems hold. By the same reasoning, the government constraint holds at the optimal b', d, T, g taking household policies as given.

We have so far established that the policies in the household policies are feasible and that their FOCs are satisfied at the prices above. Because the household problem is static (given government policies), the c and l policies from the household problem are optimal given the law of motion that corresponds to government policies and stochastic transitions. Hence, $\hat{S}$ is a solution to the household problem and c, l are optimal policies.

The argument for the optimality of government policies is somewhat more complicated. First

consider that $\hat{S}^N$ could alternatively be written

$$\begin{aligned}\hat{S}^N(\dot{b}, \dot{n}, z; \mathbf{x}) = & \max_{g \geq 0, l \in [0,1], b' \in \mathbf{B}, T} \left(\max_{c, l} u(c, l, g, \overline{H}/\dot{n}) + \beta \mathbb{E}_{\phi', z'|z} \max\{\hat{S}(b', \dot{n}, z', 0), J - \phi'\} \right) \\ & \text{s.t. } \dot{n}c = z(\dot{n}l)^{1-\alpha} - T\dot{n} \\ & \dot{n}^{1-\eta}g + q(b', \dot{n}, z)b'\dot{n} = \dot{b}\dot{n} + T\dot{n} \\ & -b'\dot{n} \leq g\dot{n}^{1-\eta}\delta \\ & T\dot{n} \leq z\dot{n}^{1-\alpha}\end{aligned}$$

(where the household budget constraint applies to the second maximization problem and the other constraints apply to the first maximization problem). Consequently,

$$\begin{aligned}\hat{S}^N(\dot{b}, \dot{n}, z; \mathbf{x}) = & \max_{g \geq 0, l \in [0,1], b' \in \mathbf{B}, T} U(g, T, \dot{n}, z) + \beta \mathbb{E}_{\phi', z'|z} \max\{\hat{S}(b', \dot{n}, z', 0), J - \phi'\} \\ & \text{s.t. } \dot{n}^{1-\eta}g + q(b', \dot{n}, z)b'\dot{n} = \dot{b}\dot{n} + T\dot{n} \\ & -b'\dot{n} \leq g\dot{n}^{1-\eta}\delta \\ & T\dot{n} \leq z\dot{n}^{1-\alpha}\end{aligned}$$

From this, it is obvious from inspection of (17) that $\hat{S}^N = S^N$ if $\hat{S} = S$. An identical argument applies to the $\hat{S}^D$ problem. Hence, if $\hat{S}$ is a solution to the government problem and g, b', d are optimal given it. □

C.4 Overborrowing

Proof of Proposition 8. With repayment strictly preferred, default rates are zero next period, $q(b', \dot{n}, z) = \bar{q}$. Also, note that for the same reason S^N inherits the differentiability S . Additionally, the continuation utility of the decentralized problem $S^N(\dot{b}, n', z)$ —to avoid confusing we are using n' as the state rather than $\dot{n}$ —may be written

$$\beta \mathbb{E}_{\phi', z'|z} \max \left\{ S^N \left(\frac{b'n'}{\dot{n}(b', n', z', 0)}, \dot{n}(b', n', z', 0), z' \right), J - \phi' \right\} dF(\phi'),$$

which is valid for any b' locally. Equivalently,

$$\beta \mathbb{E}_{z'|z} \left(\int_{R(b', n', z', 0)}^{\infty} S^N \left(\frac{b'n'}{\dot{n}(b', n', z', 0)}, \dot{n}(b', n', z', 0), z' \right) dF(\phi'|z') + \int_{-\infty}^{R(b', n', z', 0)} (J - \phi') dF(\phi'|z') \right).$$

Using Leibniz's rule and noting $S^N = J - R$, the derivative with respect to b' is

$$\beta \mathbb{E}_{z'|z} (1 - F(R(b', n', z', 0)|z')) \left(S_b^N \left(\frac{n'}{\dot{n}} + b'n' \frac{\partial \dot{n}^{-1}}{\partial b'} \right) + S_n^N \frac{\partial \dot{n}}{\partial b'} \right).$$

where the arguments for S_b^N and S_n^N are $(\frac{b'n'}{\dot{n}(b', n', z', 0)}, \dot{n}(b', n', z', 0), z')$ and the argument for $\dot{n}$ is $(b', n', z', 0)$. The envelope condition gives $S_b^N(b', n', z) = u_c$. Also, $\partial \dot{n}^{-1} / \partial b' = -\dot{n}^{-2} \dot{n}_{b'}$. Plugging these in,

$$\begin{aligned} & \beta \mathbb{E}_{z'|z} (1 - F(R(b', n', z', 0)|z')) \left(u_c \left(\frac{n'}{\dot{n}} - b' n' \frac{1}{\dot{n}^2} \frac{\partial \dot{n}}{\partial b'} \right) + S_n^N \frac{\partial \dot{n}}{\partial b'} \right) \\ & \beta \mathbb{E}_{z'|z} (1 - F(R(b', n', z', 0)|z')) \left(u_c \frac{n'}{\dot{n}} \left(1 - \frac{b'}{\dot{n}} \frac{\partial \dot{n}}{\partial b'} \right) + S_n^N \frac{\partial \dot{n}}{\partial b'} \right) \end{aligned}$$

So, the FOC for b' is

$$u_c \bar{q} = \beta \mathbb{E}_{z'|z} (1 - F(R(b', n', z', 0)|z')) \left(u_c \frac{n'}{\dot{n}} \left(1 - \frac{b'}{\dot{n}} \frac{\partial \dot{n}}{\partial b'} \right) + S_n^N \frac{\partial \dot{n}}{\partial b'} \right)$$

Using the i' and o' notation from the hypothesis, note that $\dot{n}(b', n', z', 0)/n'$ is $1+i'-o'$ and $F(R(b', n', z', 0)|z') = o'$. Hence,

$$u_c \bar{q} = \beta \mathbb{E}_{z'|z} \left[\left(\frac{1 - o'}{1 + i' - o'} \right) \left(1 - \frac{b'}{\dot{n}} \frac{\partial \dot{n}}{\partial b'} \right) u_c + (1 - o') S_n^N \frac{\partial \dot{n}}{\partial b'} \right]$$

□

C.5 Quantitative testing of indeterminacy

To test for indeterminacy, we proceed by drawing 100 random starting guesses for J , $\bar{i}$, and $\bar{q}$ uniformly distributed about $\pm 50\%$ of the benchmark's computed equilibrium values. (For the definition of $\bar{i}$, see Section B.2.) We then compute the implied equilibrium solution. Figure 11 shows a scatter plot of the guesses in 3-dimensional space, and also reveals that they all converge to the same solution (up to small numerical differences). This suggests that in a wide-range about the computed benchmark equilibrium, the equilibrium is unique.

C.6 Partial equilibrium results

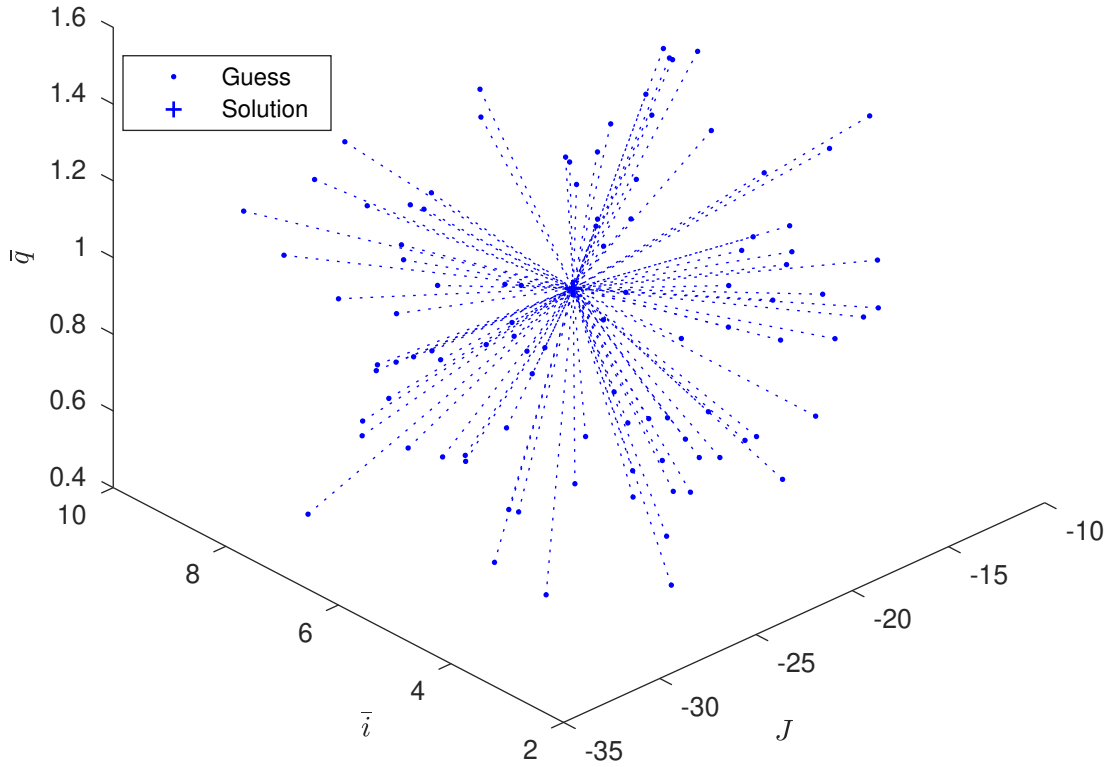


Figure 11: Quantitative testing of indeterminacy

	Bench.	$\mu_\phi = \infty$	$\bar{q}^{-1} \uparrow$	$\delta = \infty$	$\pi_b = 1$	$\lambda = 0$	$\sigma(\tilde{z}_{it}) \uparrow$
Aggregate measures							
Output per person (TFP)	81601	80641	81934	81728	81721	69173	82415
Consumption per person	77765	76898	78112	77911	77880	65956	78551
Expenditures per person	3774	3709	3771	3747	3779	3187	3814
Taxes per person	3835	3744	3822	3818	3841	3217	3865
Debt per person	1642	894	853	1891	1643	783	1372
Income Gini Coefficient	0.111	0.115	0.111	0.111	0.112	0.119	0.120
Interest rate (%)	4.00	4.00	6.50	4.00	4.05	4.00	4.00
Tax for financing bailouts (%)	0.000	0.000	0.000	0.000	-0.054	0.000	0.000
Average across cities							
Default rate $\times 100$	0.036	0.000	0.071	0.133	0.043	0.000	0.161
Bailout rate $\times 100$	0.000	0.000	0.000	0.000	0.043	0.000	0.000
In-migration rate (%)	6.48	0.005	6.51	6.48	6.48	0.696	7.20
Out-migration rate (%)	6.22	0.005	6.26	6.22	6.22	0.673	6.79
Log population s.d.	1.78	1.64	1.78	1.78	1.78	1.49	1.78
For notes, see the bottom of Table 6.							

Table 12: Partial Equilibrium: Stochastic Steady State under Counterfactual Experiments