The Dynamics of Municipal Spending: Theory and Evidence*

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August 2010

Abstract

This paper studies how municipal expenditures on locally provided public services respond dynamically to several types of shocks in an environment where politically organized public workers can influence policy decisions. We develop an infinite horizon model in which a politician has control over public good expenditures but can be influenced by offers of campaign support from public sector employees. Among other results, the theory indicates that when a particular service's workers, such as police officers, are politically organized, then expenditures on that service exhibit policy persistence: Cities experiencing a negative (positive) trend in population or household income spend more (less) on the service than an identical city with a constant trend. We test the model's implications using a panel of 609 US cities and find support for the theory: Policy persistence is present in law enforcement and fire protection services, two public goods whose workers are traditionally active in local elections. Our estimates indicate that households in cities experiencing population decline pay an additional premium equivalent to the cost of collective bargaining for fire and police services. In contrast, services with a less politically active workforce, such as park maintenance, exhibit no such persistence.

*We thank Alessandro Lizzeri for insightful guidance during this project. We also thank Saki Bigio, Raquel Fernández, Guillaume Fréchette, Alessandro Gavazza, Sanford Gordon, William Greene, Nicola Persico, Jesse Shapiro, Shing-Yi Wang and participants of the NYU Micro Student Workshop, the Columbia Political Economy Breakfast Seminar, the 2010 Public Choice Meetings and the 2010 Midwest Political Science Association Conference.

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1 Introduction

It is a well documented fact that many US cities are experiencing dramatic population changes: Between 1970 and 2000, for example, cities in the states of Michigan, Ohio and Pennsylvania experienced a median population growth rate of -14.8%, while cities in Arizona, Nevada and Texas grew at a rate of 85.2%. In this paper, we study how expenditures on several types of locally provided public services are influenced by shocks such as population change. Our theory indicates that when a particular service's workers, such as police officers, are politically organized, then expenditures on that service exhibit policy persistence: Cities experiencing a negative (positive) trend in population or household income spend more (less) on the service than an identical city with a constant trend. We also provide empirical support for this claim. Using a panel of 609 US cities spanning 1970 to 2000, we find that policy persistence is present in law enforcement and fire protection services, two public goods whose workers are traditionally active in local elections. In contrast, public services with a less politically active workforce, such as park maintenance and road construction, exhibit no such persistence.[1]

While many papers have analyzed the effect of collective bargaining rights on city expenditures, public employees can also influence policy decisions by providing political support to local politicians.[2] Both anecdotal and empirical evidence suggest that organized public workers are quite influential in local elections, and that some types of public workers often engage in electioneering activities.[3] Naturally, the effectiveness of these activities depends crucially upon the number of individuals engaged in the campaigning. A dynamic link thus exists between a city's *current expenditures* on a public service and the effectiveness of the respective public workers' *future campaign support*.[4] This mech-

[1] We do not include education in our analysis because public schools are typically run by local school boards. The services we study, on the other hand, are provided by nearly all city-level government bodies.

[2] A large empirical literature has documented that public sector wages and expenditures on local services are positively related to public workers having collective bargaining rights (see Freeman (1986) and references therein). Another literature has modeled the politician-bureaucrat relationship in a principal-agent framework similar to Grossman and Helpman (1996). Alternatively, other papers, such as Romer and Rosenthal (1979), have considered other political mechanisms that public workers may access to influence policy, such as agenda setting.

[3] Moe (2006) uses data from school board elections in California and shows that candidates supported by the local teachers union win 50% more often than candidates that fail to gain such support, a boost that is larger than the incumbency advantage. Given that candidates for local office typically have limited resources at their disposal, this suggests that campaign support and voter mobilization from local interest groups are particularly valuable in this environment.

[4] The Hatch Act of 1939 was created to limit federal employees' ability to engage in such behavior. Local bureaucrats, however, fall under this law *only if* they are paid or directly manage federally granted funds. In addition, the Act primarily restricts (i) electioneering during work hours and (ii) soliciting funds for specific candidates. In does not, however, restrict campaigning during non-working hours, canvasing for votes, contributing personal money to political campaigns or issuing official endorsements

anism should reveal itself dynamically in the form of policy persistence: Consider two cities that are identical in current demographics but differ in that one city had a larger population in the recent past. If a group of public workers are politically organized, then *current budget allocation* to the organized workers should be larger in the city with the larger past population (and thus larger past public workforce).

Our empirical analysis suggests that this is indeed the case. The median city in our sample spends about \$432 per household on law enforcement services each year. Cities experiencing a decline in population, however, spend about \$18 more (per household) on police protection relative to cities experiencing population growth, a difference of 4.2%. On the other hand, the median city spends about \$88 per household on the maintenance of public parks, and this cost is unrelated to population growth. For comparison purposes, the additional cost of \$18 for law enforcement is approximately equal to the additional cost imposed by police officers having the ability to bargain collectively over wages and benefits.[5]

Building upon these ideas, we develop a dynamic infinite horizon model that extends the static principal-agent modeling approach of papers such as Grossman and Helpman (1994).[6] We adopt the convention that politicians' preferences are increasing in both constituents' welfare and per-capita campaign support delivered by public workers. A public workers' association can thus influence the politician by mobilizing its members to engage in electioneering (at a cost), interpreted as door-to-door campaigning and campaign finance. Since it is easier for an association with a large membership to deliver a fixed level of campaign support, we assume that the association's marginal cost of delivering such support is decreasing in its status quo budget allocation, thus creating the dynamic link mentioned above. In addition, we model the city's population, median household income and the public sector wage as fluctuating exogenously through time, where we implicitly assume that the public sector wage is a function of (an exogenously determined) level of collective bargaining rights.[7]

for candidates.

[5]The literature on public sector bargaining rights implicitly assumes a McDonald and Solow (1981)-style framework in which workers and the city bargain over wages and employment decisions. In general, papers find that wages increase 5% when police officers have the right to bargain collectively, and 10% or more for other locally provided services. One notable exception in this literature is Lovenheim (2009), which examines teacher unions in three Midwest states and finds no relationship between collective bargaining and pay.

[6]Other similar papers include Baron (1994) and Grossman and Helpman (1996). Whereas Grossman and Helpman (1994) investigate a common agency framework, we model only one interest group. Coate and Morris (1999) also study policy persistence in a dynamic environment where an interest group can bribe the incumbent to distort a policy away from the voters' optimum. Our paper differs by introducing exogenous shocks and allowing the interest group's political power to evolve endogenously.

[7]Public sector bargaining rights are determined at the state level and vary considerably across states and time in the period we study (1970-2000). Given that these rights are determined in a process outside

Given this environment, we examine how public good expenditures respond to the various shocks. Our analytic results indicate that policy persistence occurs when cities face either population and income shocks, and that total expenditures on public goods are increasing in the public sector wage. In addition, we provide sufficient conditions for policy persistence to be *smaller in magnitude* when public sector wages are higher. Moreover, our calibrated model suggests that expenditure persistence is more severe when the city is faced with an income shock.

After presenting the theory, we test the model's implications using a panel of 609 US cities. As campaign support by individual worker groups is unobserved in our dataset, we test our hypotheses by comparing results across five locally provided services: Public administration, fire protection, law enforcement, park maintenance and road maintenance. Several sources and anecdotal evidence suggest that law enforcement and fire protection personnel are more politically active than workers that produce other types of public goods. For instance, in 1999 the International City/County Management Association conducted a survey of city governments that included a question concerning the prevalence of local public workers engaging in local elections. The results indicate that law enforcement and fire protection personnel are twice as likely to deliver campaign contributions and electioneer for local political candidates.[8] Moreover, regardless of collective bargaining rights, police and fire services workers are often represented by local organizations that handle grievances and organize political action. In North Carolina, for instance, police officers are banned from bargaining collectively, yet there are dozens of such police associations across the state.[9] In general, the other services we study do not have analogous associations at the local level. In addition, police and fire workers are each coordinated via powerful state and national associations that provide support, as is discussed in Najita and Stern (2001). Conversely, park, road and administrative employees do not have such organizations that cater to their interests.[10] Finally, on av-

of the city-worker relationship, we take these rights as exogenous, as is standard in the literature. We discuss this issue in more detail below.

[8]Unfortunately, when asked about financial contributions or other type of campaign support, the ICMA survey does not distinguish between respondents who chose not to answer the question and those who reported no political activity. This translates into levels of political activity that are most likely severely biased downwards. For instance, according to the survey police officers and fire protection workers each made financial contributions in about 22% of the cities who returned the survey. Still, if the bias is constant across services, the level of political participation is about half in other categories: road workers and an "other services" category reportedly made financial contributions in only 11% and 9% of cities, respectively.

[9]A listing is available from the North Carolina Police Benevolent Association website, `http://www.ncpba.org/`.

[10]The American Federation of State, County and Municipal Employees is a large union that represents public workers at the national level. It is comprised of many different kinds of services at various levels of government, however. In Najita and Stern (2001), the authors emphasize police, fire and teachers as the main public worker groups that drive policy.

erage, police and fire services each employ approximately three times as many workers, when compared to either of the other three services. Consequently, these two groups are in a better position to deliver valuable political support to local politicians.

As mentioned above, our empirical results confirm that policy persistence is most prevalent for fire protection and law enforcement services.[11] Collective bargaining, on the other hand, induces a positive level effect on expenditures for all services but, in some cases, dampens the effect of expenditure persistence.

For the empirical analysis, we utilize a dataset that is primarily constructed from the Census Bureau's Census of Governments and County and City Data Book. Several authors have used portions of this data for a variety of studies,[12] some of which have looked at the effects of unionization on public finance.[13] One related study is Ladd (1994), which uses county-level data from 1978 and 1985 to examine the relationship between population change and changes in aggregate public expenditures per capita. The author focuses in particular on counties experiencing population growth and provides evidence that such counties experience an increase in per capita public spending. With the exception of Ladd's work, however, we are unaware of another study that examines the interaction between dynamic shocks, such as changes in population and median household income, and local public finance decisions. In particular, we have not seen analysis identifying which local public services exhibit persistence, and why this may be the case.

In addition to the aforementioned literature, this work is also related to a recent set of papers examining how local politics and institutions influence public policy in cities. Both Coate and Knight (2009) and Vlaicu (2008) examine how a city's form of government influences policy, with Coate and Knight looking explicitly at the connection to city finances. Levin and Tadelis (2008), on the other hand, examine the outsourcing of locally provided public goods to private sector providers. In addition, our theoretical methods are related to the growing literature in political economy investigating dynamic models, such as Battaglini and Coate (2008) and Hassler, Mora, Storesletten and Zilibotti (2003).

The rest of the paper is organized as follows: The following section introduces the model, and Section 3 presents the theoretical analysis. Section 4 describes the data, empirical

[11]Given the question of interest, a natural concern is endogeneity: Namely, public good expenditures might drive population dynamics via Tiebout sorting. We discuss such concerns at length in the empirical section of the paper, where we provide estimates of a spatial model to correct for endogeneity issues that would otherwise render our estimates inconsistent.

[12]See for instance, Alesina, Baqir and Easterly (1999), Baqir (2002) and Glaeser, Scheinkman and Shleifer (1995).

[13]Two examples are Hoxby (1996) and Lovenheim (2009).

methodology and results, while Section 5 discusses policy implications. Section 6 discusses alternative mechanisms that could potentially drive the empirical results, while Section 7 concludes.

2 Theoretical Model

2.1 Model Overview

We begin by giving a brief overview of the model. Time is discrete and indexed by $t \in \{0, 1, ..., \infty\}$. There are two types of agents: An infinitely-lived association that represents public sector workers, which we refer to as "the union," and one period-lived politicians. The state variables at period t are denoted (g_{t-1}, s_t), where g_{t-1} represents the budget allocation to the union in period $t-1$ and s_t is a vector of (stochastic) exogenous states.

Each period, one politician holds office and has discretion over selecting the amount of money g_t that the city allocates to producing the public good. We assume that the politician's preferences are increasing in both (i) the welfare of a (infinitely-lived) representative citizen, $V(g_t, s_t)$, and (ii) the per capita level of campaign support delivered by the union. As is standard in the interest group literature, we endow the union with the ability to influence g_t by making a principal-agent style offer to the politician: A promise of (costly) campaign support, c_t, in exchange for a minimal level of public good expenditures. More specifically, the timing each t is as follows:

1. The state (g_{t-1}, s_t) is publicly observed.
2. The union offers $(\hat{g}_t, \hat{c}_t)$ to the politician: A binding promise of $\hat{c}_t$ campaign support if $g_t \geq \hat{g}_t$.
3. The politician selects g_t, and period payoffs are realized.

We interpret c_t as the intensity of voter mobilization drives, door-to-door campaigning, financial campaign contributions – actions that inherently depend on the number of public workers the union can mobilize, and the resources these members wield. We thus assume that the union's marginal cost of delivering c_t is strictly decreasing in its status quo level of resources, g_{t-1}. In other words, the greater the number of workers and financial resources the union has at its disposal, the cheaper it is to deliver a total level of support, c_t.

2.2 Primitives

2.2.1 State Variables

At the beginning of each period, the endogenous state $g_{t-1} \in G \subset \Re_+$ and a vector of exogenous states $s_t = (w_t, y_t, z_t) \in S = W \times Y \times Z \subset \Re^3_{++}$ are publicly observed. The element w_t denotes the wage paid to each public worker; y_t denotes a representative citizen's income; and z_t denotes the measure of citizens living in the city. We discuss the interpretation of these elements and, in particular, the exogeneity assumption for w_t, in Section 2.4.3, after we have outlined the entire model.

We assume that the state space S is compact and normalize $\underline{w} := \min\{w \mid w \in W\} \geq 1$. We also define the set of feasible public good expenditures, given s_t, as $G(s_t) = [0, y_t z_t]$, where $y_t z_t$ denotes the aggregate income of all citizens. Moreover, we assume that s_t evolves according to a time-invariant Markov process, with a continuous probability distribution $\Gamma(s_t \mid s_{t-1})$.

2.2.2 The Union

The union is infinitely-lived and discounts future utility by $\beta \in (0, 1)$. The union's period preferences are represented by the expression

$$u(g) \; - \; c \cdot \phi(g_{-1})$$

The function $u : \Re_+ \to \Re$ satisfies $u' > 0$ and $u'' \leq 0$ and represents the benefit the union receives from the current budget allocation, g.

The function $\phi : \Re_{++} \to [1, \infty)$ satisfies $\phi' < 0$ and $\phi'' > 0$ and represents how the union's status quo budget allocation, g_{-1}, influences the union's marginal cost of delivering one unit of campaign support, c. As mentioned above, $\phi' < 0$ implies that it is cheaper for large unions to deliver a given level of campaign support.[14] The restriction that $\phi(g_{-1}) \geq 1$ implies that the union's marginal cost of delivering c is bounded below by 1. For much of the paper, we adopt the functional form $\phi(g_{-1}) := (\eta/g_{-1})^{\alpha}$, where $\alpha > 0$ and η is sufficiently large to ensure that $\phi(g_{-1}) \geq 1$.

As mentioned above, each period, the union plays $(\hat{g}_t, \hat{c}_t)$, which is implicitly a promise of $\hat{c}_t$ support to the politician, conditional on the politician playing $g_t \geq \hat{g}_t$. In this paper, we restrict attention to the class of equilibrium strategies that are stationary:

[14] One could equivalently model the politician's marginal benefit of campaign support c as increasing in the resources at the union's disposal.

Definition 1. *A **stationary strategy** for the union is a pair of functions* $(g^*, c^*) : G \times S \rightarrow G \times \Re_+$.

This restriction implies that each period, the union's equilibrium strategy depends only upon the current state, (g_{t-1}, s_t).[15] In what follows, (g^*, c^*) will denote a stationary strategy for the union, while $(\hat{g}_t, \hat{c}_t)$ will denote a general time t offer.

2.2.3 Politicians

There is a measure $\mathcal{P}$ of (identical) potential politicians. At the beginning of each period, one politician is randomly selected from $\mathcal{P}$ and is endowed the ability to select $g_t \in G(s_t)$. We assume that each potential politician is in power for at most one period, and that politicians receive a payoff of 0 when out of office.[16] Hereafter, the phrase "the politician" will implicitly refer to the agent directly selecting g during the period under discussion.

As mentioned above, the politician's payoff depends on both the welfare of an (infinitely-lived) representative citizen and the per capita campaign support delivered by the union. The representative citizen is forward-looking and has expectations over the future evolution of public good expenditures: Namely, the citzen expects that future policy outcomes will follow a stationary process $g^f : G \times S \rightarrow G$ mapping future states (g_{t+j-1}, s_{t+j}) to an expenditure level g_{t+j}, where g^f is continuous.[17]

Given a current state $s \in S$, a current policy selection $g \in G(s)$, current campaign support $c \in \Re_+$ and citizen expectations about the future evolution of expenditures g^f, the politician's period payoff is

$$\theta \cdot V(g, s; g^f) \; + \; (1 - \theta) \cdot \left(\frac{c}{z} \right)^{1/\kappa}$$

where $V : G \times S \rightarrow \Re$ is the value function of a representative citizen, discussed below; $\kappa > 1$ is a parameter implying that the politician's payoff is strictly increasing and strictly concave in per capita campaign support; and $\theta \in (0, 1)$ is a parameter denoting the relative weight the politician places on citizen welfare.

Below, we formally define $V(\cdot)$ and show that $V(\cdot, s; g^f)$ is continuous. Since $V(\cdot, s; g^f)$ is continuous and $G(s)$ is compact, then the politician's objective is well-defined: Given

[15] Without restricting attention to the class of stationary strategies, (g^*, c^*) could in principle depend on the entire history of play.

[16] See Section 2.4.1 for a discussion and defense of this modeling approach. Also, note that an equivalent modeling approach would be that there is one politician that is myopic by not take the future path of play *directly into account*.

[17] We assume g^f is continuous so that the politician's objective is well-defined. See below.

s, g^f and a union offer $(\hat{g}, \hat{c})$, the politician solves

$$\max_{g \in G(s)} \quad \theta \cdot V(g, s; g^f) \; + \; (1-\theta) \cdot \mathbf{1}_{g \geq \hat{g}} \cdot \left(\frac{\hat{c}}{z}\right)^{1/\kappa}$$

where $\mathbf{1}$ is the indicator function. Note that regardless of the union's offer, the politician can always achieve the state-dependent "outside option" payoff

$$\theta \cdot \tilde{V}(s; g^f) \quad := \quad \theta \cdot \max_{g \in G(s)} V(g, s; g^f) \tag{1}$$

We can thus define the politician's participation constraint as

$$\max_{g \in \{g \in G(s) \;|\; g \geq \hat{g}\}} \left\{ \theta \cdot V(g, s; g^f) \; + \; (1-\theta) \cdot \left(\frac{\hat{c}}{z}\right)^{1/\kappa} \right\} \quad \geq \quad \theta \cdot \tilde{V}(s; g^f)$$

which the union must satisfy in order for the politician to select $g \geq \hat{g}$. This is equivalent to

$$\hat{c} \quad \geq \quad z \left\{ \left(\frac{\theta}{1-\theta}\right) \left[\tilde{V}(s; g^f) - \max_{g \in \{g \in G(s) \;|\; g \geq \hat{g}\}} V(g, s; g^f) \right] \right\}^{\kappa} \tag{2}$$

2.2.4 Utility of the Representative Citizen

We assume that the representative citizen is infinitely-lived and discounts future utility by $\beta \in (0, 1)$. Each period, the citizen receives utility from two sources: The per capita production of the public good,[18] and consumption of a private good. Production of the public good is increasing in the number of public sector workers hired, and citizens are assumed to pay a proportionate share of the production cost. Note that the per capita number of public workers hired equals $g/(wz)$, while consumption on the private good equals $y - (g/z)$.[19] We take the representative citizen's period preferences as represented by the utility function

$$v(g, s) \quad = \quad v_1\left(\frac{g}{wz}\right) \; + \; v_2\left(y - \frac{g}{z}\right) \tag{3}$$

[18]Given the public goods we study (police and fire protection, road maintenance, etc), quality inherently depends upon per capita production, and thus the per capita number of workers hired. For instance, a city's crime rate depends on the number of patrolling officers per resident.

[19]Recall that (w, y, z) are interpreted as the public sector wage, the representative citizen's income and city population, respectively.

where $v_i' > 0$, $v_i'' < 0$ and $\lim_{x \to 0} v_i'(x) = \infty$ for $i \in \{1, 2\}$. Given these assumptions, it is straightforward to see that, for all $s \in S$, there exists a unique expenditure level $\tilde{g}(s) \in (0, yz)$ that maximizes $v(\cdot, s)$.[20] In addition, we assume that citizen preferences are *inelastic in the public good*, so that $\partial \tilde{g}(s)/\partial w > 0$.[21] In other words, as the current public sector wage w increases, then citizen demand for public good *expenditures* increases.[22]

Returning to the representative citizen's value function, we define $V(g_t, s_t; g^f)$ as the period t utility the citizen enjoys, $v(g_t, s_t)$, plus the discounted sum of the citizen's expected future payoffs, which inherently depends on g^f. Formally,

$$V(g_t, s_t; g^f) \quad = \quad v(g_t, s_t) \ + \ \sum_{j=1}^{\infty} \beta^j \int_{G \times S} v(g_{t+j}, s_{t+j}) \ \ d\Gamma^j_{g^f}\Big((g_{t+j}, s_{t+j}) \mid (g_t, s_t)\Big) \quad (4)$$

where $\Gamma^j_{g^f}((g_{t+j}, s_{t+j}) \mid (g_t, s_t))$ is the joint distribution function denoting the probability that the policy and exogenous state at $t + j$ are (g_{t+j}, s_{t+j}), given that policy evolves according to the stationary function $g^f : G \times S \to G$ and the time t outcome is (g_t, s_t).[23] The following Lemma proves that $V(\cdot, s_t; g^f)$ is continuous, which implies that the politician's objective function is well defined.[24]

Lemma 1. *For every $s \in S$ and continuous g^f, the function $V(g, s; g^f)$ is continuous in g.*

[20] Note that $\forall s \in S$, $v(\cdot, s)$ is strictly concave. The derivative of (3) with respect to g is

$$v_g(g, s) \quad = \quad \frac{1}{wz} v_1'\left(\frac{g}{wz}\right) \quad - \quad \frac{1}{z} v_2'\left(y - \frac{g}{z}\right)$$

By strict concavity, $v_g(\cdot, s)$ is strictly decreasing. Moreover, $\lim_{g \to 0} v_g(g, s) = \infty$ and $\lim_{g \to yz} v_g(g, s) = -\infty$. Consequently, $\exists! \tilde{g} \in (0, yz)$ satisfying $v_g(\tilde{g}, s) = 0$.

[21] Mathematically, this condition holds in our model if, $\forall x \in \Re_+$,

$$x > -\frac{v_1'(x)}{v_1''(x)}$$

When calibrating the model in Section 3.3, we adopt the functional form assumption that $v_1(x) = (1/\sigma)x^\sigma$. Inelastic demand occurs when $\sigma < 0$, which is quite standard.

[22] This assumption is supported by empirical evidence presented later in this paper. Moreover, the types of public goods we analyze (law enforcement, road maintenance, etc) are necessary to keep cities running effectively, suggesting demand is inelastic.

[23] Formally,

$$\begin{aligned} \Gamma^1_{g^f}\Big((g_{t+1}, s_{t+1}) \mid (g_t, s_t)\Big) \quad &= \quad \Gamma(s_{t+1} \mid s_t) \cdot \mathbf{1}_{g^f(g_t, s_{t+1}) = g_{t+1}} \\ \Gamma^2_{g^f}\Big((g_{t+2}, s_{t+2}) \mid (g_t, s_t)\Big) \quad &= \quad \int_{G \times S} \Gamma(s_{t+2} \mid s_{t+1}) \cdot \mathbf{1}_{g^f(g_{t+1}, s_{t+2}) = g_{t+2}} d\Gamma^1_{g^f}\Big((g_{t+1}, s_{t+1}) \mid (g_t, s_t)\Big) \end{aligned}$$

and so on.

[24] All proofs are located in Appendix A.

2.3 Equilibrium Concept

Without loss of generality, we restrict attention to the set of stationary union strategies that satisfy (2) at all states. This restriction is without loss of generality given that we study stationary strategies: Any strategy that fails (2) at some (g_{-1}, s) is payoff-equivalent to an alternative union strategy that sets $c^*(g_{-1}, s) = 0$ and $g^*(g_{-1}, s)$ equal to the argument maximizing (1).

In this setup, the union's value function $U : G \times S \to \Re$ is defined as[25]

$$U(g_{-1}, s) \;=\; \max_{(g,c)\in G(s)\times\Re_+} \left\{ u(g) \;-\; c\cdot\phi(g_{-1}) \;+\; \beta \int_S U(g, s')\, d\Gamma(s' \mid s) \right\} \tag{5}$$

subject to

$$c \;\geq\; z\left\{ \left(\frac{\theta}{1-\theta}\right)\left[\tilde{V}(s; g^f) - V(g, s; g^f)\right]\right\}^{\kappa} \tag{6}$$

The equilibrium definition is:

Definition 2. *A* ***Markov Perfect Equilibrium (MPE)*** *is a set of functions U, V and (g^*, c^*) such that for every $(g_{-1}, s) \in G \times S$,*

1. *U satisfies (5) - (6)*
2. *(g^*, c^*) is the solution to (5) - (6)*
3. *The politician enacts g^**
4. *$g^f = g^*$, where g^f is as appears in (4) and (6)*
5. *V satisfies (4)*

2.4 Discussion of Modeling Assumptions

2.4.1 The Modeling of Politicians

The model assumes that both the representative citizen and public sector union are forward-looking, whereas the incumbent politician is only (implicitly) forward-looking via a representative citizen's value function. Given that our data is observed every 10 years, we view this as a reasonable approximation: The union, as an institution, exists indefinitely in the city, while the majority of citizens will generally continue to reside

[25] Note that the max operator is dropped in (6) for notational convenience: If $\hat{c} > 0$, then the union will optimally set $\hat{g}$ greater than the argument maximizing (1).

in the city a decade in the future. Local politicians, however, typically hold office for less than a decade, either being constrained by term limits,[26] opting to pursue higher political office or exiting politics altogether.

In addition, the model takes the politician's payoff as increasing in the union's "campaign support." Though incumbent politicians may not hold elected office in the city in ten years, many stand reelection at least once. As mentioned in the Introduction, empirical and anecdotal evidence suggests politically organized public workers wield considerable influence in local elections. Consequently, we take the standard reduced form approach to capture the following stylized fact: Incumbents face a tradeoff between enacting the public's optimal policy and offering concessions to politically influential unions.[27]

2.4.2 Multiple Worker Associations Operate in a City

Cities provide a variety of public goods, and consequently there are often multiple worker associations that represent different groups of a city's public workforce. As presented, the theory only models one public worker union. The services we study in this paper, however, constitute about 60% of a typical city's annual budget, with individual services accounting for 4%-24% of the total. Consequently, the local public finance literature typically studies these services independently, as cities face a "soft" budget constraint: A marginal change to the budget allocation for one service need not necessarily influence the allocation to another service. It would nevertheless be interesting to investigate a common agency environment to examine how multiple unions compete or collude for resources. We leave such analysis for future research.

2.4.3 Exogeneity of (w, y, z)

The model takes city population and per capita income as exogenous, thus evolving independently of a city's level of public good expenditures. In the empirical section of the paper, we discuss, at length, the potential effect of local public good expenditures on a city's population and demographics. The demography literature has concluded that large-scale population movements are primarily driven by private sector job prospects and, to a

[26] Many cities in the US, such as New York City, Los Angeles, Houston and Philadelphia have term limits for city council members and mayor.

[27] Several papers, such as Grossman and Helpman (1996) and Prat (2002), have provided micro-foundations to justify this reduced form approach. Grossman and Helpman (1996) assume that there are two types of voters: Those who are informed about policy platforms of two candidates and vote based on this information, and those who are uninformed and are influenced by campaign spending. In Prat (2002), on the other hand, all voters are fully rational but have imperfect information about candidate quality. Special interest groups observe these dimensions, however, and offer campaign funds that, in equilibrium, serve as a quality signal for the voters.

lesser extent, weather. Moreover, when we control for the potential endogeneity between public expenditures and demographic shifts in our econometric analysis, the estimated effects remain relatively unchanged. Consequently, we view these exogeneity assumptions as appropriate.

The public sector wage also evolves exogenously. The main theoretical conclusions from this paper, however, can also be generated in an analogous model in which wage is also endogenously determined via the principal-agent framework defined above.[28] Nevertheless, a large empirical literature has shown that public sector wages are highly dependent upon public workers' collective bargaining rights. This empirical literature has documented the fact that wages are significantly higher when workers bargaining collectively. In the case of police, Freeman, Ichniowski and Lauer (1989) provide evidence that this wage premium is driven primarily by strong state laws guaranteeing workers the *right* to bargain collectively.[29]

There is considerable variability of such laws in the US across states, time and services. North Carolina, for instance, prohibits collective bargaining between cities and public workers, while New York guarantees this right for all public workers. Wyoming, on the other hand, only grants collective bargaining rights to fire protection workers. Given the facts discussed here, we implicitly assume that wage follows an exogenous process.

3 Theoretical Analysis

This section analyzes the model explained above. In 3.1, we examine the benchmark case where the politician acts as a social planner, maximizing the representative citizen's welfare. We interpret the results in this section as the outcome when a group of public workers are not politically organized. In 3.2, we present several analytic results under the assumption that the representative citizen is myopic. Under this restriction, we prove existence of a unique equilibrium and several comparative static results that we take to the data. Finally, we present the numerical solution to the full theoretical model in 3.3 and examine the equilibrium policy response under the aforementioned shocks.

[28] Results are available from the authors upon request.

[29] In particular, there exists a wage premium for unions that *do not formally bargain with their city* but are located in a state with strong laws ensuring public labor unions the *right to bargain*. The authors interpret this as a premium the union receives for having the ability to "threaten" organization.

3.1 Benchmark: No Politics

In the absence of politics, g does not influence future periods, as its only role in the model is reducing the union's future marginal campaign cost. Consequently, for all s, the politician simply acts as a social planner and solves

$$\max_{g \in G(s)} \; v(g, s)$$

As shown above, there exists a unique function $\tilde{g}(s)$ that solves this problem. In each period, the representative citizen thus receives a payoff of $\tilde{v}(s) := v(\tilde{g}(s), s)$. In particular, note that this function depends only upon the *current* exogenous state, s.

In what follows, we refer to s_{-1} as the *previous period's* realization of the exogenous state, and s_{-j} as the state realization j periods ago. We now highlight two (trivial) results for means of comparison with the political equilibrium:

Comment 1. *If the union cannot exert political influence, then for all $s_{-1}, s \in S$*

$$\frac{d\tilde{g}}{dy_{-1}} = 0 \qquad \textit{and} \qquad \frac{d\tilde{g}}{dz_{-1}} = 0$$

Conditional on the current state s, current expenditure $\tilde{g}(s)$ has no relationship with previous realizations of exogenous shocks: Expenditures fully adjust each period to the representative citizen's demand. In addition, we highlight a second (trivial) fact:

Comment 2. *If the union cannot exert political influence, then for all $s \in S$*

$$\frac{d\tilde{g}}{dw} > 0$$

This inequality simply reflects the fact that citizen preferences are inelastic in the public good. Consequently, the higher the wage in the current period, the higher the total expenditure level chosen by the politician.

3.2 Analytic Results Under Myopic Citizens

We now consider the equilibrium effects of the union's political influence, but restrict attention to the case where voters are myopic. Mathematically, this means that

$$\begin{aligned} V\left(g, s; g^f\right) &= v(g, s) \\ \tilde{V}\left(s; g^f\right) &= \tilde{v}(s) \end{aligned}$$

The purpose of this restriction is to facilitate the exposition of analytic solutions. Since the participation constraint in (2) will bind with equality, the union's recursive optimization problem is thus

$$U(g_{-1}, s) \;\; = \;\; \max_{g \in G(s)} \left\{ F(g, g_{-1}, s) \; + \; \beta \int_S U(g, s') \; d\Gamma(s' \mid s) \right\} \tag{7}$$

where

$$F(g, g_{-1}, s) \;\; = \;\; u(g) \; - \; z \cdot \phi(g_{-1}) \cdot \left[\left(\frac{\theta}{1-\theta} \right) \cdot [\tilde{v}(s) - v(g, s)] \right]^{\kappa} \tag{8}$$

Given this setup, we solve for a Markov Perfect Equilibrium (MPE), which consists of functions $U(g_{-1}, s)$ and $g^*(g_{-1}, s)$ that satisfy conditions 1-3 in Definition 2. Prior to proceeding, we make one parameter assumption that is sufficient to guarantee a unique equilibrium.

Assumption 1. *$\kappa \geq 1 + \alpha$.*

This assumption guarantees that the union's period payoff in (8) is strictly concave in (g, g_{-1}) by ensuring that the curvature of the "cost" parameter, κ, is sufficiently high.

Proposition 1. *A MPE exists and is unique. Moreover, for all $s \in S$, $g^*(\cdot, s)$ is continuous, while $U(\cdot, s)$ is strictly increasing, strictly concave and continuously differentiable.*

We now turn to analyze the unique MPE. As defined, $g^*(g_{-1}, s)$ does not depend *directly* on previously realizations of income or population. Nevertheless, the following proposition shows that $g^*(g_{-1}, s)$ depends *indirectly* on s_{-1} through the union's status quo budget allocation, g_{-1}.[30]

Proposition 2 (Politics and Persistence)**.** *If the union can exert political influence, then in equilibrium $g^*(g_{-1}, s) > \tilde{g}(s)$. Moreover, if s is iid,*[31] *then*

$$\frac{dg^*}{dy_{-1}} \; > \; 0 \quad \text{and} \quad \frac{dg^*}{dz_{-1}} \; > \; 0$$

In words, Proposition 2 states two things: First, if the union can influence the politician, then expenditures are strictly higher than the representative citizen's optimal policy. Second, if the exogenous state variables evolve according to an iid process, then ceteris

[30] As is standard, we assume that $U_{gg}(g_{-1}, s)$ exists. This assumption is not necessary to derive the following results, but it does simplify arguments in the proofs.

[31] We are currently working to derive conditions where the result holds when y and z follow a Markov process.

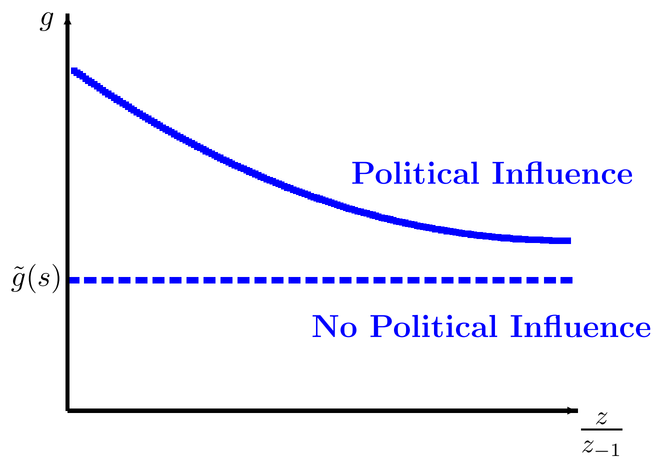


Figure 1: Politics and Persistence

paribus, current public good expenditures will be *strictly higher* in cities where per capita income or population was higher in the previous period. Equivalently, for a given per capita income y (population z), Proposition 2 states that public good expenditures should be *decreasing* in the income growth rate y/y_{-1} (population growth rate z/z_{-1}).[32] We interpret this relationship as a form of policy persistence: Relative to cities with a stable evolution of per capita income and population, cities that experience income or population decline (growth) spend more (less) on the public good.

Figure 1 depicts this result graphically for a particular $s \in S$. The horizontal axis denotes the population growth rate, while the vertical axis denotes current expenditures on the public good. The representative citizen's optimal policy, $\tilde{g}(s)$, is denoted by the dashed line: Recall from Comment 1 that $\tilde{g}(s)$ is set by the politician when the union cannot exert political influence. Conversely, the solid line represents the equilibrium outcome when the union can exert influence: Public expenditures are always higher than $\tilde{g}(s)$ and decrease as the population growth rate increases.

The intuition behind Proposition 2 is as follows. In any state, the union always finds it beneficial to incentivize the politician to set expenditures higher than $\tilde{g}(s)$: The union's marginal cost of doing this is 0 when $g = \tilde{g}(s)$, as can be readily seen in the (derivative of the) second term of (8). Consequently, $g^*(g_{-1}, s) > \tilde{g}(s)$.

Turning to the second half of the proposition, public good expenditures are strictly increasing in the union's status quo budget allocation in equilibrium. Higher g_{-1} implies that the union's marginal cost of providing campaign support is lower, and consequently

[32] We include the "growth rate" interpretation of Proposition 2 as our empirical methodology analyzes the relationship between g and both y/y_{-1} and z/z_{-1}.

$g^*(\cdot)$ is strictly increasing in g_{-1}. Under the iid assumption, it also follows that $g^*(\cdot)$ is also increasing in y and z, as the voter's marginal utility from the public good is increasing in both y and z. A larger population level implies that there are more individuals both accessing the good and bearing the cost of production, thus increasing the citizen's marginal benefit. Similarly, as income increases, the citizen would optimally divide the increase between both the public and private good. As the representative citizen's marginal utility for the public good increases, then it becomes marginally cheaper for the union to incentivize the politician to increase expenditures. Combining these effects yields the result.

Given the argument in Proposition 2, it is straightforward to show the following:

Corollary 1. *If the union can exert political influence and s is iid, then for all $j > 0$*

$$\frac{dg^*}{dy_{-j}} > 0 \quad \textit{and} \quad \frac{dg^*}{dz_{-j}} > 0$$

The "persistence" results in Proposition 2 have a permanent effect on the future path of expenditures through the evolution of g: A high population j periods before implies a higher level of expenditures, g_{-j}, which in turn implies a higher level of expenditures at g_{-j+1}, and so on.

The iid assumption in Proposition 2 and Corollary 1 is employed to deliver a definitive result about the sign of dg^*/dy_{-1} and dg^*/dz_{-1}. As explained in the previous paragraph, y and z have a *static effect* on the representative citizen's marginal benefit of the public good that suggests $dg^*/dy > 0$ and $dg^*/dz > 0$. When y and z follow a Markov process, however, both y and z have a *dynamic effect* as well, via the distribution $\Gamma(s' \mid s)$. Under the natural assumption that Γ is monotonic,[33] the dynamic and static effects work in opposite directions. The union's dynamic marginal benefit of g, $\int U_g(g, s')d\Gamma$, is *decreasing* in both y' and z'. The reason for this is that, from the union's point of view, g and (y', z') are substitutes in the future period. A higher value of g implies that it will be cheaper to influence the politician in the future period, while both y' and z' generate the same effect as well. Consequently, if the union expects y' or z' to be larger in the next period, then this reduces the union's marginal benefit of g, which leads to an effect that suggests $dg^*/dy < 0$ and $dg^*/dz < 0$. As a preview, in our numerical exercise, we observe that the static effect outlined in Proposition 2 strongly outweighs the dynamic effect discussed in this paragraph.

Before moving on, one important caveat worth mentioning regards the interpretation of

[33] Γ is monotonic if, for any nondecreasing function $f : S \to \Re$, the integral $\int_S f(s')d\Gamma(s' \mid s)$ is nondecreasing in s.

the word "persistence:" In cities experiencing (population or income) decline, the level of expenditures persists in the traditional sense, as the union exerts increasing influence on the politician so that total spending remains high. Expenditures in growing cities, on the other hand, are smaller than cities with stable population not because investment is lagging, but because *the union is relatively less influential*. In the political equilibrium, per capita expenditures are always "too high" relative to the citizen's optimum; in growing cities, this excess is simply smaller.

While the previous results dealt with the issue of policy persistence over time, the following proposition describes the effect of public sector wages on the level of government expenditures.

Proposition 3 (Expenditures and Public Sector Wages)**.** *If the union can exert political influence and s is iid, then*

$$\frac{dg^*}{dw} \;>\; 0$$

This proposition is in accordance with Comment 2: Expenditures on public goods are always strictly increasing in the public sector wage. Consequently, we expect to see higher expenditures on public goods in states that grant public sector workers the ability to bargain collectively over their wages and benefits. The intuition behind this result is similar to Proposition 2: As w increases, the representative citizen's marginal benefit of g increases as well by virtue of preferences being inelastic in the public good. Consequently, it is marginally "cheaper" for the union to influence the politician to increase expenditures, which results in $dg^*/dw > 0$. Note, however, that the iid assumption in Proposition 3 plays a similar role as above: Under a monotonic Markov process, $\int U_g(g, s')d\Gamma$ will decrease as wage increases, because a higher w' reduces the politician's "outside option" $\tilde{v}(s')$, thus reducing the dynamic benefit of g. As we will see in the numerical calibration, the static effect of w appears to dominate the opposing dynamic effect.

Given these results, we now study how persistence, as defined in Proposition 2, is related to w. Essentially, we wish to understand whether policy persistence is more prevalent in high wage environments (say, Massachusetts) or low wage environments (say, Kentucky). Addressing this questions requires studying the cross-partials $d^2g^*/(dwdy_{-1})$ and $d^2g^*/(dwdz_{-1})$. Given that these equations inherently depend upon third derivates, we must place additional structure on the model to deliver a definitive result. We first make a functional form assumption regarding the representative citizen's utility function:

$$v(g,s) \;=\; \gamma \cdot \frac{1}{\sigma} \cdot \left(\frac{g}{wz}\right)^{\sigma} \;+\; (1-\gamma) \cdot \frac{1}{\sigma} \cdot \left(y - \frac{g}{z}\right)^{\sigma} \tag{9}$$

where $\sigma < 0$ implies that the citizen has inelastic demand for the public good, and $\gamma \in (0, 1)$ is the weight the citizen places on the public good relative to the private good.

The following Proposition establishes sufficient conditions for $d^2 g^*/(dw dz_{-1}) < 0$. It should be noted that these conditions are by no means necessary and are chosen as they closely resemble the numerical exercise in the next subsection.

Proposition 4 (Persistence and Bargaining Rights)**.** *If the union can exert political influence and (1) the union is myopic;*[34] *(2)* $u(g) = g$*; (3)* $\kappa = 2$*; (4)* $\sigma = -1$*; and (5)* $\gamma = 0.5$*, then*

$$\frac{d^2 g^*}{dw dy_{-1}} < 0 \quad \textit{and} \quad \frac{d^2 g^*}{dw dz_{-1}} < 0$$

This proposition states that, under the stated assumptions, public good expenditures are *less responsive* to population change when public workers enjoy high wages. In other words, *persistence is smaller in magnitude* in locations where public sector wages are high.

Figure 2 displays this relationship graphically for population. As in Figure 1, the gross population growth rate is plotted along the horizontal axis, whereas public good expenditures are plotted on the vertical axis. The red (blue) lines represent the equilibrium outcome when the wage is high (low); the solid (dashed) lines, on the other hand, represent the case where the union can (cannot) influence the politician. Note that the slope of $g^*(\cdot)$ is strictly steeper in magnitude when wage is low.

The intuition is as follows: Proposition 2 established that expenditures in current periods are positively related to previous population levels. The driving mechanism was that higher populations lead to higher period expenditures, which in turn increases future expenditures by reducing the union's (future) cost of supplying campaign support. In other words, large populations (indirectly) make it marginally cheaper for the union to campaign in the future. An increase in current wage has an analogous effect: As the public sector wage increases, the politician's "outside option" falls, while the citizen's marginal benefit of the public good increases. When the public sector wage is high, the union's marginal benefit (or, perhaps more fittingly, marginal cost savings) of having a large status quo budget is smaller. Consequently, the derivative $d^2 g^*/(dw dz_{-1})$ is negative.

[34] The myopic union assumption is employed because otherwise, the cross-partials inherently depend on the third derivate of U. Unfortunately, we have not established analytic properties for this function.

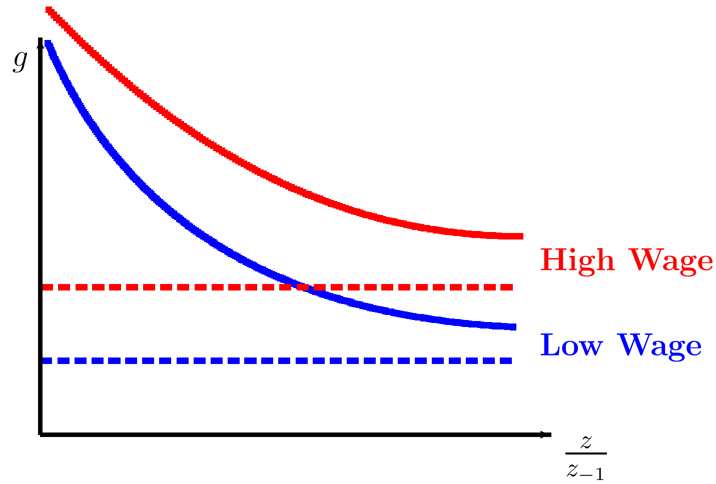


Figure 2: Persistence and Bargaining Rights

3.3 Model Calibration

We now present the numerical solutions to both the full model outlined in Section 2, as well as the model where the representative citizen is myopic. Forward-looking citizens internalize the effect of current expenditures on future periods via the union having more political power. Consequently, it's more costly for the union to achieve a given level of expenditures when the citizen is forward-looking. We begin by describing the parameter decisions we make regarding the model, and then proceed to present the results.

3.3.1 Parameterization

Our parameterization adopts several of the assumptions in the statement of Proposition 4. First, we assume that the union's utility function is linear in public expenditures, so that $u(g) = g$. This seems natural: The union, as an institution, has constant marginal utility for the size of its budget, and hence money.

We also adopt the explicit functional form for $v(g, s)$ as shown in (9), and assume that $\sigma = -1$, which is within the standard range of values often employed in similar exercises. We set the weight that the representative citizen places on the public good, γ, equal to 10^{-5}. In our data, cities spend in the range of $0.5\% - 2\%$ of an average citizen's annual income on wages and benefits for police protection. We calibrate γ so that $\tilde{g}(s)/(zy)$ is approximately equal to the lower portion of this range.

We assume the standard annual discount factor of 0.95. Given that one period in our model corresponds to 10 years, we thus set $\beta = 0.95^{10} = 0.6$. We set $\kappa = 2$, where κ can be interpreted as the convex cost parameter appearing in (6). We calibrate θ, the weight the politician places on citizen welfare, equal to 0.98. The value 0.98 has been estimated in several papers, such as Goldberg and Maggi (1999) [$\theta = .98$] and Eicher and Osang (2002) [$\theta = .96$].

Our parameterization of $\phi(g_{-1})$, the function that maps the union's status quo size to the marginal cost of campaigning, is somewhat ad hoc, as this function is unique to this paper. As discussed above, we posit that $\phi(g_{-1})$ takes the functional form $(\eta/g_{-1})^{\alpha}$, where $\alpha, \eta > 0$. We set $\alpha = 1$, which is in accordance with the concavity restriction that $\kappa \geq \alpha + 1$. An additional requirement of ϕ is that $\phi(g_{-1}) \geq 1$, so that marginal cost is bounded below by 1. To satisfy this requirement, we take $\eta = \overline{y} \cdot \overline{z}$, where $\overline{y} = \max\{y \in Y\}$ and $\overline{z} = \max\{z \in Z\}$. Clearly, this is sufficient to ensure that $\eta > g_{-1}$.

Finally, we calibrate the evolution of the exogenous states, $\Gamma(s' \mid s)$, to be in accordance with our data. Specifically, we assume that next period's income, $y' \sim N(y * 1.036, (y * 0.100)^2)$, whereas next period's population, $z' \sim N(z * 1.035, (z * 0.107)^2)$. We model the wage grid has having two points, $\overline{w} > \underline{w}$, where $\overline{w}$ ($\underline{w}$) represents the wage outcome when the union does (does not) have the right to bargain collectively with the city government. The following results assume that w is expected to remain constant through time.[35]

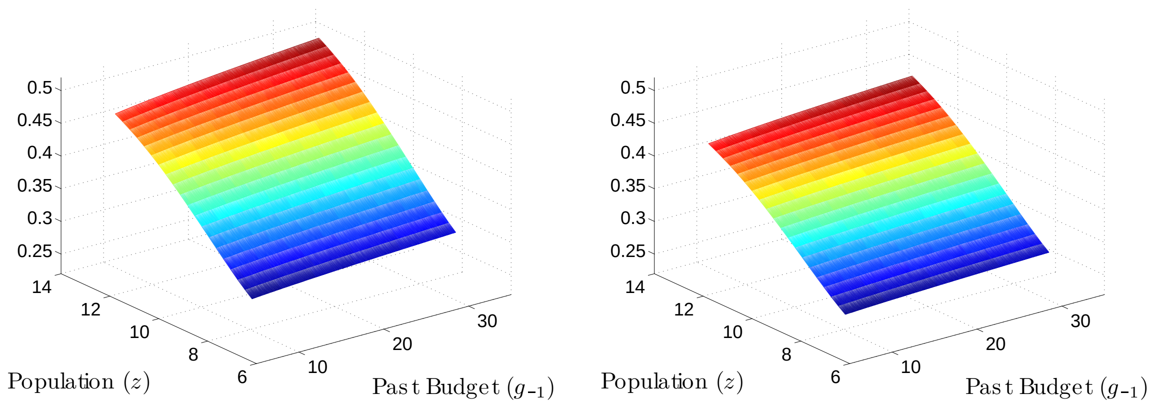
Table 1: Parameter Assumptions for Numerical Exercise

Parameter	α	β	η	γ	κ	σ	θ
Value	1	0.6	$\overline{y} \cdot \overline{z}$	10^{-5}	2	-1	0.98

Appendix B describes the algorithm used to compute the equilibrium. We calibrate the axes described therein to be roughly proportional for cities ranging in population from 72,000 to 128,000 inhabitants. Per capita income is centered about \$19,000 per inhabitant. The low public sector wage is set to \$41,000, while the high public sector wage is set to \$54,000. The public sector wage information was computed as a cities' average wage payment per police office in states (i) without and (ii) with public sector bargaining, respectively. These three axes are scaled down by a factor of 10,000.

One important point to highlight is that we do not prove existence of a MPE for the general model, as outlined in Definition 2. For a variety of initial guesses of the value and policy functions, however, our algorithm converges to (approximately) identical value and policy functions, all of which appear continuous and well behaved. In what follows, we provide the results from the numerical solution for both (i) the full model, as defined in Section 2, as well as the model where the representative citizen is myopic.

[35] We are working on updating this transition so that w changes with a strictly positive probability, and that the evolution of (w, y, z) follows a multivariate normal distribution.



(a) Myopic Citizen

(b) Forward-Looking Citizen

Figure 3: Union's Value Function

3.3.2 Results

We begin by presenting the union's value function, which appears in Figure 3. The model with a myopic representative citizen is presented on the left, whereas the general model with a forward-looking representative citizen is presented on the right. Both plots depict $U(\cdot)$ over $G \times Z$, the space of status quo union budgets and current population, fixing a given level of income and public sector wage. In both models, $U(\cdot)$ is increasing and concave in both z and g_{-1}: A higher status quo budget reduces the marginal cost the union pays, whereas higher population implies that the public naturally demands more of the public good. Moreover, the union's value is strictly lower when citizens are forward-looking: Citizens understand that higher expenditures today will lead to future costs, as the union will have increased political power. Consequently, the union must compensate the politician more for a given level of g.

Figure 4 depicts the representative citizen's value function, $V(\cdot)$, across the space $G \times Z$ of current expenditures and current population. Naturally, $V(\cdot)$ is decreasing in current spending g: Expenditures are always higher than the public's optimum in equilibrium, and higher expenditures today increase the union's political power tomorrow. Interestingly, the representative citizen's value is *also decreasing in current population*: Higher population today implies that the population is expected to be higher in the future. But higher populations are associated with larger total budget allocations to the union, which implies that the union's political power is expected to grow in the future.

The union's equilibrium strategy, $g^*(\cdot)$, is displayed in Figure 5 for both models. Again, $g^*(\cdot)$ is plotted over the $G \times Z$ space, implicitly fixing income and public sector wage. In both cases, policy is increasing in the status quo size of the union and population for the reasons discussed in Proposition 2. Both cases also reveal that the positive, static

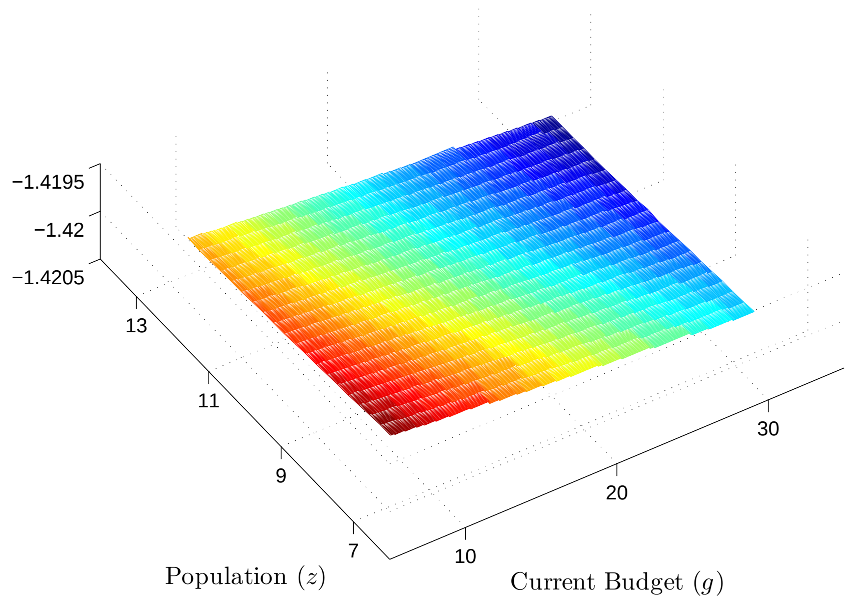
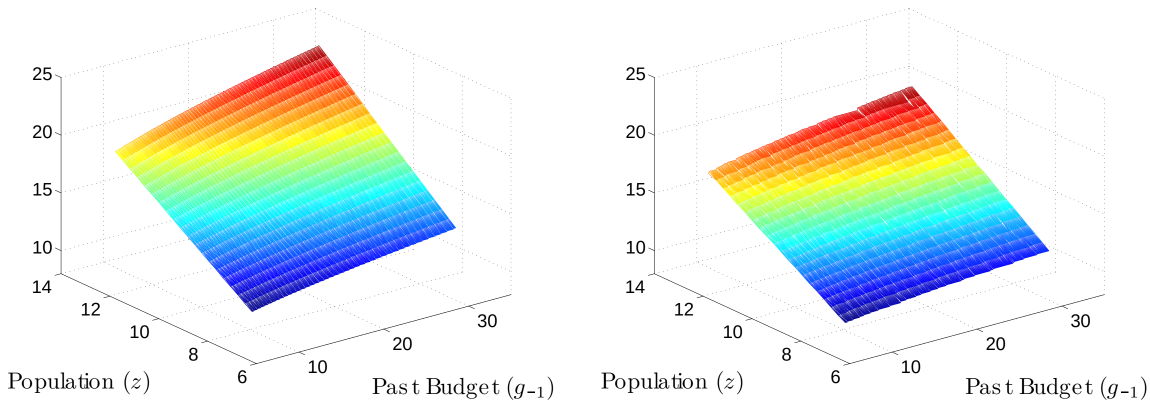


Figure 4: Citizen's Value Function

effect that population has on expenditures (via the representative citizen's preferences) dominates the negative dynamic effect (via the union's expectations that population will be higher tomorrow). Moreover, equilibrium policy is always strictly lower when the representative citizen is forward-looking for the same rationale discussed in the case of the union's value function: The citizen internalizes the dynamic costs of increasing current expenditures, which makes it more costly for the union to increase g.

The numerical equivalent to Figure 2, which plotted how current total expenditures are related to population growth, is presented in Figure 6. We omit the analogous figures for per capita income growth, as the results are qualitatively identical. The red lines depict the scenario when current public sector wage is high, whereas the blue lines depict low public sector wages. The two dashed lines represent the citizen's static optimal policy, $\tilde{g}([w, y, z])$, whereas the solid lines plot the equilibrium policy outcome when the union wields political influence, $g^*(\cdot)$. For the blue (low wage) curve, the only variable that fluctuates is z_{-1}. For each value z^i_{-1} on our grid, we compute the steady state level of expenditures that solves $g^i = g^*(g^i, [w, y, z^i_{-1}])$. We then induce an unexpected shock to population and plot the values of $g^*(g^i, [w, y, z])$ in Figure 6. For the red (high wage) curve, we take the same points $\{g^i\}$ and plot $g^*(g^i, [w', y, z])$, where $w' > w$ represents an unexpected positive shock to the public sector wage.

The numerical results confirm both Propositions 2 and 3: If the union can exert political influence, then total expenditures are *strictly decreasing* in the population growth rate



(a) Myopic Citizen

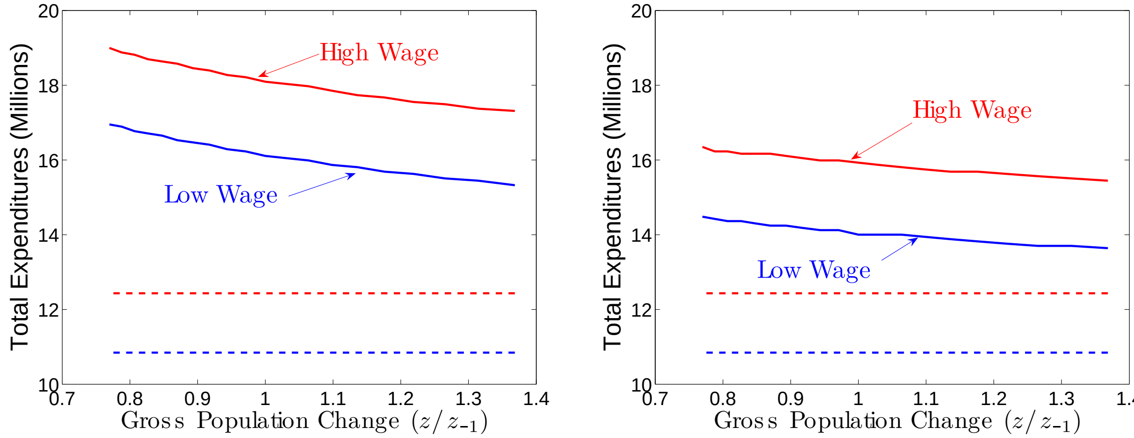
(b) Forward-Looking Citizen

Figure 5: Policy Function

and *strictly increasing* in the public sector wage. The models suggest that, even on a relative basis, union's political influence is quite costly. Consider cities A and B, both of which have current population of 100,000, and assume that A (B) just received a negative (positive) population shock resulting in a gross population growth rate of 0.85 (1.15). The graphs suggest that city A spends between \$0.48 and \$0.97 million dollars more on the public good than city B: This corresponds to a (relative) additional cost of between \$19.20 and \$38.80 for a family of four residing in city A.

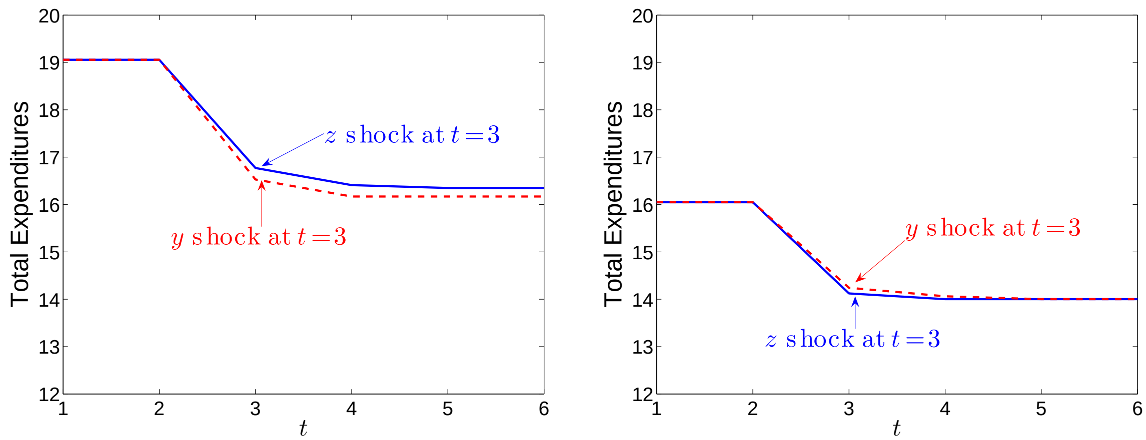
Conversely, we do not find evidence for Proposition 4: The gap between equilibrium expenditures in high and low wage states appears independent of population growth. This suggests that the cross partial result is highly dependent upon both functional form assumptions and the nature of agents' future expectations. Comparing across models, the slope of the expenditure line is smaller in magnitude when the citizen is forward-looking. As discussed above, when the public is forward-looking, total expenditures are lower. Consequently, the union exerts less influence dynamically, which mitigates the effect of population shocks.

While Figure 6 considers the static effect of a population shock, Figure 7 displays a (deterministic) impulse response. Time is indexed on the horizontal axis, while total expenditures are plotted on the vertical axis. The solid blue line represents the equilibrium outcome of an unexpected, negative shock to population, whereas the red dashed line represents the equilibrium outcome of a shock to per capita income. The shock occurs at $t = 3$ and is calibrated to be proportionate to typical shocks we see in our dataset: In both the distribution of growth rates for population and per capita income, the 10th percentile in these distributions correspond to -9.5%. Across the two models, expenditures converge to the new steady state in one or two periods, which corresponds to 10 or



(a) Myopic Citizen (b) Forward-Looking Citizen

Figure 6: Total Expenditures as a Function of Population Change



(a) Myopic Citizen (b) Forward-Looking Citizen

Figure 7: Impulse Response: Total Effect

20 years. Interestingly, the new steady states are quite similar in response to both types of shocks.

The more interesting interpretation of these results, however, appears in Figure 8: The vertical axis in these figures depict equilibrium expenditures *relative to steady state expenditures*. In periods 1 and 2, this ratio is 1, as the environment begins in steady state. At $t = 3$, however, the shock causes the steady state to shift. In fact, period expenditures are strictly larger than the steady state level when the shock occurs: About $1.75\% - 2.25\%$ higher in the case of per capita income, and $1\% - 2.5\%$ higher in the case of population. While the two shocks are similar in magnitude when public is myopic, the income shock induces a significantly higher effect under a forward-looking public.

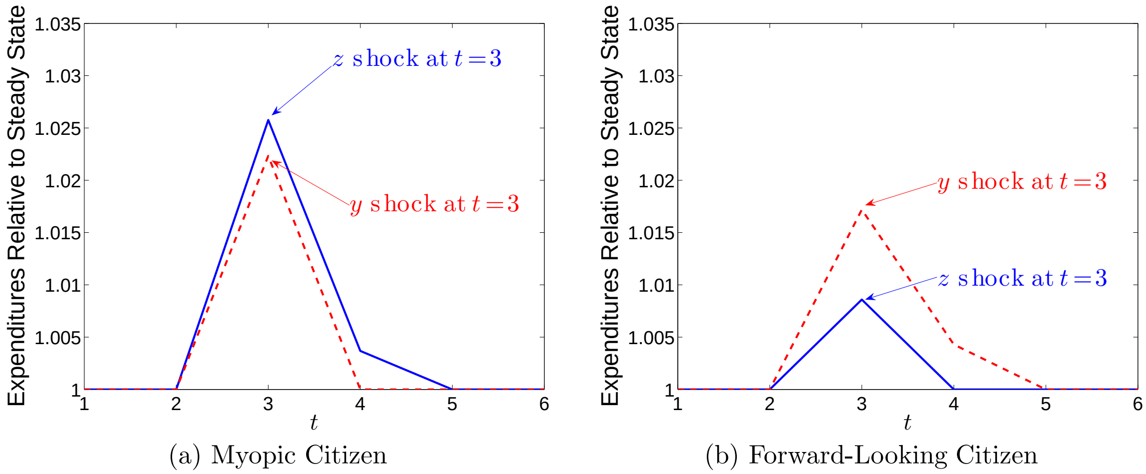


Figure 8: Impulse Response: Relative to Steady State

4 Empirics

We now turn to the data and investigate the theoretical predictions discussed above.

4.1 Data Overview

Our data is compiled from several sources, with the majority of the information coming from the US Census of Governments (CoG) and the County and City Data Book (CCDB). Since 1957, the CoG has been conducted every five years by the US Census Bureau. This data reports detailed finance and employment information for all government bodies within the US, such as states, cities and counties. For cities, information is disaggregated by service, so that the number of employees, wage outlay and total expenditures are reported separately for the police, fire and administrative departments, among others. We extract information on the number of full time employees, the wage bill paid to full time employees and operational expenditures for five services. Both the wage bill and operational expenditures are adjusted to reflect annual expenditures, reported in 2005 dollars. A brief description of each service, as summarized by the Census Bureau, is as follows:

Administrative: Handling of city finance, government-wide planning and legal matters.

Fire: Fire protection and prevention, as well as ambulance and rescue services.

Roads: Maintenance of roads, bridges and street lighting.

Parks and Recreation: Maintenance of public parks, museums, swimming pools and other recreational services.

Police: Enforcement of law and order.

These five services were chosen because the vast majority of cities in our sample directly produce these goods by hiring the capital and labor.[36] A small fraction of observations, particularly in the West, outsource these services to either another governmental body or the private sector. In several medium-size cities in California, for instance, fire protection is provided by county fire departments affiliated with the California Department of Forestry and Fire Protection.[37]

Our second main data source, the CCDB, is also produced by the Census Bureau and includes demographic information for cities and counties with population 25,000 and more. The demographic measures, such as city population, median household income, racial profile and education are derived from the decennial US Population Census, and consequently, demographic information is only observed every 10 years.[38] In addition to demographic measures, we also extract information on the city's land size and the number of serious crimes committed per capita, where "serious" entails both violent crimes and theft.

To create the panel with four observations, we merge the CCDB population and demographic information from 1960, 1970, 1980, 1990 and 2000 with the CoG finance and employment data from 1972, 1982, 1992 and 2002. We choose 1972 as the first year for the finance and employment data because the CoG altered its reporting format in this year. Demographic information from 1960 is used to compute lagged variables for 1970, while the CoG data from years ending in "7" is omitted because the corresponding city demographic information is not available.

While 1,302 cities appear at least once in both the CCDB and CoG, demographic information for many cities appears only once or twice, as city demographic information is only observed if population is greater than 25,000 in the year in which the census was conducted.[39] Given that our analysis is focused on large cities, we define our population

[36] In our sample, all but two cities provide administrative services; 89% provide fire protection services; 95% maintain roads directly; 92% maintain public parks; and 96% provide law enforcement services.

[37] Levin and Tadelis (2008) study the outsourcing of public goods by municipal governments and provide evidence from city managers that several of these services are difficult to outsource due to monitoring problems.

[38] The 2000 CCDB does not include education, income or poverty information. We added this information directly from the 2000 US Population Census via the website `http://factfinder.census.gov/`.

[39] For instance, the population of Key West, Florida, was 29,312 in 1970, 24,382 in 1980, 24,832 in 1990 and 25,478 in 2000. Consequently, Key West only appears in the 1970 and 2000 CCDB.

of interest as all cities with 25,000 people or more for the whole 1960-2000 period.[40] The final sample contains 609 cities, though not all cities in this group provide all five services we study (see Table 2 and Footnote 36).

Our econometric specification also requires geographical information obtained from from the National Oceanic and Atmospheric Administration.[41] Using the haversine formula for computing distances, we use the latitude and longitude information in the NOAA dataset to compute a matrix of distances between the cities in our panel.

Finally, we use the NBER Public Sector Collective Bargaining Law Data Set to construct a state-level measure for public workers' bargaining power. This dataset contains information from 1955 through 1984; we hand collected the required information to extend the dataset until 2002. This data distinguishes between seven degrees of collective bargaining legislature. Given this classification, we construct a binary variable, B_{it}^{j}, that equals 1 if public workers providing service j in city i at time t had the right to bargain collectively. Formally, we set $B_{it}^{j} = 1$ whenever state legislation implicitly or explicitly requires cities to bargain with the service's workers (at the union's discretion), and $B_{it}^{j} = 0$ otherwise. Note that by using this procedure, we allow for the possibility that a particular union in a city may be classified as having the right to bargain collectively, even if workers choose not to exercise this right. Empirical evidence established in Freeman, Ichniowski and Lauer (1989) suggests that such unions do indeed benefit from the *ability* to bargain collectively.

Table 2 lists summary statistics for the main variables of interest. From the CCDB, we include the following measures for each city: population, the percentage of population that is white and black, the percent of adults that completed college and high school, the unemployment and poverty rates, median household income and the percentage of population that is school-age (between the ages of 5 and 17) and elderly (65 years and older).

4.2 Methodology

We now present the empirical strategy that allows us to test the main comparative statics from the theory. First, we present a "naïve" reduced form model that captures the main features of the theory, but neglects certain estimation problems such as endogeneity. In

[40] By definition, we are not including cities that were below the 25,000 threshold in 1960 and increased their size later on, as well as cities that began the period larger than 25,000 and then declined below the threshold. As a robustness exercise, we defined the population of interest as cities with population 25,000 or more in the period 1970-2000, and then conducted our analysis with a panel with three time periods. The results we present are robust to this change in sample.

[41] This data can be downloaded at `http://www.nws.noaa.gov/noaaport/html/geoex.exe`.

Table 2: Summary Statistics

Variables	Mean	Median	10th	90th	Sample
Administration Wage Bill (per capita)	47.47	40.51	20.59	80.78	607
Fire Wage Bill (per capita)	92.44	84.46	54.60	140.06	541
Roads Wage Bill (per capita)	31.51	28.17	13.03	54.60	588
Parks Wage Bill (per capita)	23.53	20.47	5.26	54.42	559
Police Wage Bill (per capita)	121.93	108.02	68.32	186.36	582
Admin. Wage Bill (% of City Oper. Exp.)	8.62	9.10	3.51	35.46	607
Fire Wage Bill (% of City Oper. Exp.)	17.49	17.88	8.85	25.37	541
Roads Wage Bill (% of City Oper. Exp.)	6.55	5.91	1.94	11.83	588
Parks Wage Bill (% of City Oper. Exp.)	4.71	4.23	0.74	8.95	559
Police Wage Bill (% of City Oper. Exp.)	23.59	23.96	9.82	35.46	582
Population	135692	61872	32806	238629	609
Gross Population Growth Rate	1.082	1.034	0.905	1.289	609
Median Household Income	53769	51108	37218	79641	609
Gross Household Income Growth Rate	1.084	1.071	0.916	1.264	609
Unemployment Rate	0.057	0.052	0.028	0.094	609
Poverty Rate	0.128	0.122	0.050	0.215	609
% College Grad	0.183	0.156	0.076	0.325	609
% School Age (5-17)	0.196	0.189	0.146	0.257	609
% Elderly (65+)	0.123	0.122	0.074	0.169	609
% Black	0.142	0.073	0.004	0.391	609
% White	0.785	0.837	0.502	0.981	609
Serious Crime (per capita)	0.062	0.058	0.023	0.154	609

the next subsection we address these problems in detail and show how we modify the naïve methodology to deal with them.

The theory suggests that in equilibrium, per capita expenditures are a function of preference parameters, current state variables (w, y, z) and lagged state variables (y_{-1}, z_{-1}). We thus use the following reduced form equation to capture these effects:

$$\begin{aligned} \log(pay_{i,t}^{j}) &= \alpha_i + \tau_1 \log(z_{i,t}) + \theta_1 \log\left(\frac{z_{i,t}}{z_{i,t-1}}\right) + \tau_2 \log(y_{i,t}) + \theta_2 \log\left(\frac{y_{i,t}}{y_{i,t-1}}\right) + \theta_3 B_{i,t}^{j} \\ &\quad + \boldsymbol{\beta}\mathbf{X_{i,t}} + \boldsymbol{\vartheta}\mathbf{A_i} + \epsilon_{i,t} \end{aligned} \tag{10}$$

where $pay_{i,t}^{j}$ represents the payroll for fulltime employees of service j in city i at time t, $z_{i,t}$ represents city population, $y_{i,t}$ represents median household income and $B_{i,t}^{j}$ is as defined above. These three variables are meant to capture the effect of the past state (z_{-1} and y_{-1}) and current bargaining power ($B_{i,t}^{j}$) on current expenditures. Additionally, $\mathbf{X_{i,t}}$ and $\mathbf{A_i}$ are vectors of covariates to be described; and $\epsilon_{i,t}$ is a normally distributed iid random variable with mean zero and variance σ_e^2.

Following Bergstrom and Goodman (1973) and Alesina, Baqir and Easterly (1999), we take a partial equilibrium approach and implicitly assume that expenditures are independent across services. Though the local public goods we consider are precisely those that are provided by almost all cities, these services do not fully explain the budget. As shown in Table 2, the average city spends approximately 24%, 17%, 9%, 7% and 5% of its operational expenditures on police, fire, administration, highway and park services, respectively. In other words, the assumption on independence across services is equivalent to posing that if expenditure adjustments are required for some of the services we consider, then some other line in the budget (i.e. not related to these services) will be modified. Moreover considering that most cities face soft budget constraints, a change in the expenditures in any one of the considered services will most likely not be related to an adjustment in another.

As is shown in Comment 1, in a world without frictions and perfect certainty, a planner is free to select the first best optimum at each point in time. Consequently, in a frictionless world, the provision of public goods should not depend on either population change nor income change. As exemplified by the theoretical model, however, provision may depend on population and income changes when workers have the ability to influence the policy maker. The effect of political influence on expenditures can be tested by estimating $\boldsymbol{\theta} = [\theta_1 ... \theta_3]'$ and then comparing them for services with and without political influence. Notice that we can re-express (10) as presented in (11), so that if expenditures in services with political influence increase with last period's population level or income level (Proposition 2), then we would expect θ_1 and θ_2 to be negative and significant in those cases.

$$\begin{aligned} \log(pay_{i,t}^j) \; &= \alpha_i + (\tau_1 + \theta_1)\log(z_{i,t}) - \theta_1 \log(z_{i,t-1}) + (\tau_2 + \theta_2)\log(y_{i,t}) - \theta_2 \log(y_{i,t-1}) \\ &+ \theta_3 B_{i,t}^j + \boldsymbol{\beta}\mathbf{X_{i,t}} + \boldsymbol{\vartheta}\mathbf{A_i} + \epsilon_{i,t} \end{aligned} \tag{11}$$

We use our measure of bargaining power (B) to capture the effect of an exogenous change in wages (w). As it has been extensively documented in the literature (see Freeman (1986)), services with collective bargaining receive on average higher wages, and the magnitude of such effect will be captured by θ_3.

City-specific variables that change through time involve population, income and other variables that are indicative of preferences, which are included in the vector $\mathbf{X_{i,t}}$. The level of population may affect expenditures via two different channels: Nonlinearities in the production function and preferences. Including (the log of) population allows for the possibilities of economies or diseconomies of scale. Additionally, citizen preferences may depend on population size, if for example citizens demand more of a public good when the city is big. We also control for economic variables such as unemployment and poverty; and demographic characteristics including race (percentage of black, whites and other races), the percentage of citizens with college education, and variables related to population age (the share of people above 65 years of age and the share between the ages of 5 and 17) and crime, a variable we discuss in detail in the next paragraph. Covariates that do not change in time, such as state fixed effects or climate, are captured by the variables in $\mathbf{A_i}$. Since our estimation strategy of (10) will involve a transformation similar to the one required for the fixed effects within estimator, it will not be possible to identify ϑ and we will not need to specify the variables in $\mathbf{A_i}$ in order to get consistent estimates for the remaining coefficients.

The effect of crime is of particular relevance in the estimation of expenditures in police and fire services. It may well be the case that demand for police and fire protection services increase in declining cities because the prevalence of crime and arson are naturally higher (and conversely in growing cities). Since covariates, such as median income, unemployment and poverty rates; racial variables (percent white and black); and median education of constituents, which are included in $X_{i,t}$ are associated with crime and arson rates, the specification would already capture some of this effect. However, in order to treat this directly, we should also include a measure of total crime. Including a contemporaneous crime measure, though, introduces a simultaneity problem. In fact, the literature on crime (see for example the discussion in Levitt (2002)) has focused on estimating the impact of police expenditures on crime while dealing with the simultaneity effect of relevance in our estimation, namely that an increase in crime may lead the authorities to increase expenditures on police. We follow an approach in the spirit of Corman and Mocan (2000). Because it takes time to significantly increase police expenditures in response to crime our control for crime is not a contemporaneous measure, but one that involves a two year lag. In other words, what the specification in (10) captures as crime at time t measures crime two years before time t. [42]

4.3 Endogeneity

One potential concern with the empirical approach is endogeneity arising from residential sorting (Tiebout (1956), Fernandez and Rogerson (1996)). The concern is that households choose to move to (or away from) a certain city because of the quality and cost of public goods. In other words, there would be a simultaneity problem between $pay_{i,t}^j$ and $z_{i,t}$.

[42] Recall that $t-1$ is related to a lag of 10 years

If there is an endogeneity problem with the model as presented in (11), then there must be some omitted variables that are correlated with $z_{i,t}$. These omitted variables must play a significant role when individuals decide in which community to live. Our empirical strategy as described in this section consists on first identifying these omitted variables so that they are included to modify (11).

First, we consider migration between metropolitan areas, referred to as "long-distance internal migration." A voluminous literature surveyed in Greenwood (1997) considers employment as one of the main driving forces behind the decision to move to another metropolitan area. Herzog Jr and Schlottmann (1986) and Fox, Herzog Jr and Schlottman (1989) explicitly examine the effect of public goods on long-distance internal migration and conclude that there is a negative impact of spending per pupil on out-migration from US metropolitan areas.[43] Moreover, Glaeser, Scheinkman and Shleifer (1995), conclude that local public good spending is not significantly correlated with long-term population dynamics, whereas other economic variables such as employment prospects and education are strong predictors of population change. In short, the evidence suggests that the main determinants of internal migration are not related to the type of local goods that we will examine empirically. Consequently, if employment considerations are the main determinants of long distance migration, endogeneity has little or no role in metropolitan areas that are experiencing an exodus of citizens.

Endogeneity may occur, however, when households move within a labor market, or when households choose which municipality to locate in when moving to a new metropolitan area. Following McFadden (1978) we could think of an internal migration model in two steps: first a decision to migrate to another metropolitan area is taken, and then individuals decide where to live in the selected metropolitan area, where each city within a metropolitan area can be described by a list of K characteristics, $x_{i,k}$. It is easy to show that within this hierarchical model the decision-maker will decide where to live by comparing the characteristics across cities. Thus, the total number of immigrants to city i in a particular metropolitan area is affected not only by the characteristics of city i, but by the characteristics of all other communities as well.

In short, the relevant observation for our analysis is that the omitted variables in (10) involve the vector of attributes of other neighboring communities. Consequently we modify (10) to include spatial interactions, implying that a vector of characteristics of other

[43] More recently, Hunt and Mueller (2004) conclude that individuals locate to labor markets where the returns to their skills are highest. A series of papers that start with Day (1992) (see Day and Winer (2006) for a survey) studied the impact of public policies on migration between Canadian provinces. The authors conclude that the prime determinants of inter-provincial migration are differentials in earnings, employment prospects and moving costs. The impact of public policies, though, is small regardless of the specification employed.

cities will constitute an explanatory variable. As is standard in the spatial econometrics literature, the vector will be weighted by spatial closeness, with the particular weights being imposed prior to the estimation. In our setup of I cities, we define $w_{i,i'}$ as the weight given to the spatial relationship between cities i and i'. For each city i, the vector $\mathbf{w_i}$ groups all i weights where, naturally, the weight given to city i is zero. If $\mathbf{log(pay^j)}$ represents the $Ix1$ vector of city expenditures on service j and $\mathbf{X_t}$ represents a vector of characteristics of all I cities at time t, then estimating an equation that controls for the level of public goods provided in neighboring regions involves the model in (12).

$$\begin{aligned} \log(pay^j_{i,t}) &= \rho \cdot \mathbf{w_i'} \cdot \mathbf{log(pay^j_t)} + \boldsymbol{\eta} \cdot \mathbf{w_i'} \cdot \mathbf{F_t} \\ &+\alpha_i + \tau_1 \log(z_{i,t}) + \theta_1 \log\left(\frac{z_{i,t}}{z_{i,t-1}}\right) + \tau_2 \log(y_{i,t}) + \theta_2 \log\left(\frac{y_{i,t}}{y_{i,t-1}}\right) + \theta_3 B^j_{i,t} \\ &+\boldsymbol{\beta}\mathbf{X_{i,t}} + \boldsymbol{\vartheta}\mathbf{A_i} + \epsilon_{i,t} \end{aligned} \tag{12}$$

Where $\mathbf{F_t}$ is the vector with rows given by $\mathbf{F_{i,t}}$, and

$$\mathbf{F_{i,t}} = \left[\mathbf{X_{i,t}}\ \ \log(\mathbf{z_{i,t}})\ \ \log\left(\frac{\mathbf{z_{i,t}}}{\mathbf{z_{i,t-1}}}\right)\ \ \log(\mathbf{y_{i,t}})\ \ \log\left(\frac{\mathbf{y_{i,t}}}{\mathbf{y_{i,t-1}}}\right)\right] \tag{13}$$

In other words, the set of covariates for which we control spatially ($\mathbf{F_t}$) involves all covariates from other communities and only excludes collective bargaining, which is determined at a state level and are thus constant within a metropolitan area. The model, as presented in (12), is often referred to in the literature as Spatial Durbin Model and we discuss estimation details in the next section. The coefficient ρ captures the correlation between the level of public good provision in city i and the weighted vector of public good provision in all other cities and an identical interpretation is given to coefficient η with respect to other characteristics of the city. Notice that the specification imposes this correlation to be the same for all cities in the sample.[44]

An important variable that has been found to be relevant in community sorting estimations and we are omitting in $\mathbf{F(t)}$ is educational expenditures.[45] In the US, educational expenditures are decided by political units that are often different than the city and in most cases educational jurisdictions and city geographical divisions do not match. This feature makes it very difficult to determine which educational expenditure corresponds to a particular city. However, the econometric technique used for estimation has an appealing property that allows us to minimize the bias coming from this omission. As

[44]The spatial specification omits adding a spatial lag to the error structure. Kelejian and Robinson (1993) studies the spatial correlation of police expenditures at the county level, includes a spatial lag in the error term and find the corresponding coefficient not to be significant.

[45]Recent estimation of community choices identifies expenditures in education and crime as the main "public goods" components relevant for decision makers. See Epple and Sieg (1999).

discussed in Section 3.3 of LeSage and Pace (2009), the Data Generating Process (DGP) associated with spatially dependent omitted variables matches the DGP of the Spatial Durbin Model. In other words, the use of the Spatial Durbin Model in presence of omitted variables shrinks the bias relative to OLS estimates as long as the omitted variable is spatially correlated.[46]

At the same time, in order for estimation to be possible by standard techniques, a set of weights must be imposed. In this paper, we present results where the non-diagonal elements of the matrix have been computed using the spherical distance between the two cities. We first compute a matrix of based on distances, namely by simply taking the inverse of the distance, thus giving a higher weight to cities that are closer. In the results to be presented below we give a weight of one to all cities within a 50 mile radius and zero otherwise. Results are robust to other specifications that involve changing the radius or directly using the inverse of distance.

Finally, notice that although one important motivation for including a spatial lag is related to the potential endogeneity of intra-city migration, there are may be other reasons for ρ to be positive. For instance, it can directly capture the fact that public policy decisions in one city may directly affect the decisions of the leaders of other communities close by.

4.4 Econometric Estimation

As is extensively discussed in the spatial literature, the estimation of a model with a spatial lag on the dependent variable is endogenous by construction: since the dependent variable (pay^j) depends directly on the disturbance vector, the spatial lag of the dependent variable is correlated with the disturbance vector. We address this problem by using a Maximum Likelihood approach.

The econometric procedures to estimate a spatial lag in a panel data context are rather recent. Elhorst (2003) provides a first approach, but Anselin, Gallo and Jayet (2006) shows that the procedure leads to an incorrect estimation of standard errors. A transformation that allows for a consistent estimation of coefficients and standard errors in model that includes a spatial lag of the dependent variable is presented in Lee and Yu (2010). An extension of this methodology to the Spatial Durbin Model is discussed in Beer and Riedl (2009). As far as we know, this is the first applied estimation of a Spatial Durbin Model in a context with panel data using individual and time fixed effects.[47]

[46] Evidence that educational expenditures are spatially correlated can be found in Case, Rosen James, Harvey et al. (1993).

[47] We thank Christian Beer and Aleksandra Riedl for sharing their codes with us.

4.5 Results

We now report the estimation results of the models defined above. We present the full results in Tables 8 and 9, which are located in Appendix C, and discuss estimations related to the main theoretical results in this section. Table 8 presents the estimations corresponding to Spatial Durbin Model in (12), while Table 9 provides the corresponding fixed effects estimation. Notice incidentally that the results from the fixed effects estimation are quite similar to those that control for spatial features, suggesting that the endogeneity problem previously discussed is not so severe.

Table 3 allows us to test Proposition 2 and Comment 1. The estimates presented in Table 3 have been computed using the results from Table 8.[48] According to Proposition 2, services that are politically organized should display a significant, negative coefficient for both population change and per capita income change. In fact, upon inspection of the first and second columns of Table 3, we observe that services that are relatively more organized in political terms (police and fire) exhibit such a pattern with similar magnitudes across services: A 1% decrease in the gross growth rate leads to an increase of approximately 0.14% expenditures in the case of population and 0.22% expenditures for income. Moreover, with the exception of the coefficient for the growth rate of population in the regression for administrative services (that is significant at the 10% level), significance is not observed for services that are relatively less politically organized (highway, administration, parks). Finally, the last column of Table 3 shows the marginal effect of collective bargaining. As expected, the coefficient on bargaining rights is significant and positive for all services. Moreover, the values resemble previous estimates in the literature (see, for instance, Freeman (1986)).

Table 3: Persistence, Politics and Collective Bargaining

Service	Elasticity of (z/z_{-1})	Elasticity of (y/y_{-1})	Marginal Effect of B
Fire	-0.138***	-0.223***	0.056***
Police	-0.136***	-0.220***	0.051***
Administration	-0.127*	-0.023	0.123***
Park	-0.054	0.114	0.127**
Roads	0.002	-0.285	0.178***

*** significant at 1%, ** at 5%, * at 10%

One potential concern with these results is that our estimates for the rates of change may be capturing something else. In particular, if politicians are uncertain about future

[48] Notice that given the spatial lag, in order to report the direct effect of a covariate on the dependent variable, an additional calculation is required. See LeSage and Pace (2009) Chapter 2

population trends and learn over time, it may be that public employment in police and fire may persist when population or income change. In order to explore this alternative, we reproduce our analysis in a panel that covers the same time period, but where observations are only five years apart. Since the Census of Governments takes place every five years, we have information for our dependent variables on a five year basis. Covariates, however, are only available every ten years as these are derived from the decennial Census of Population.[49] In order to take the analysis to a five year period, we follow a common approach in the literature (see, for example, Coate and Knight (2009)) and interpolate the values for covariates that are available at ten year intervals. In order to compare these results to the ones presented in Table 3, we introduce a second lag on the rates of change: The first lags equal the change in population and income between year k and year $k-5$, whereas the second lags equal the change between year $k-5$ and $k-10$. The full results are presented in Table 12 of Appendix C, and the key coefficient estimates are summarized in Table 4.

Table 4: Results using 5-year panel with interpolated covariates

Service	Elast. (z/z_{-1})	Elast. (z_{-1}/z_{-2})	Elast. (y/y_{-1})	Elast. (y_{-1}/y_{-2})	Marg. Eff. B
Fire	-0.285***	-0.063	-0.023	-0.240**	0.058***
Police	-0.352***	-0.072*	-0.153*	-0.248***	0.056***
Admin.	-0.301***	-0.057	0.029	0.012	0.114***
Park	-0.406***	0.012	-0.541**	0.222	0.129***
Roads	-0.151	-0.045	-0.019	-0.298	0.144***

*** significant at 1% ** significant at 5% * significant at 10%

If uncertainty and learning are taking place, we would expect for it to show up in the first half of the ten year period. Indeed, we do observe significant, negative estimates for all services but roads in the case of population. A lag of five years allows us to capture persistence in a more traditional sense: Sluggishness due to traditional adjustment costs, and perhaps uncertainty over whether a shock is permanent or transitory. However, it is harder to argue that such adjustment costs are present over a longer, ten year time horizon. The political economy channel, however, offers a rationale for why adjustment would occur over longer periods of time for services that are politically active. Although we do observe persistence across services for the first five years, the coefficients for services that are less politically inclined are not statistically significant for the second lag. In the case of administration services, for example, Table 3 shows a coefficient that is significant at the 10% level, but results in Table 4 suggest that persistence is only present in the first five years: The p-value corresponding to the coefficient on the second lag is 0.4317.

[49] One exception is population, for which the Census Bureau computes every five years as well.

Contrarily, when we consider police services, the estimate for the second lag for population is significant at 10%, with an elasticity of approximately −7%, just a few points below the elasticity reported in Table 3 (−13%). As expected the pattern shows a reduction in persistence since the elasticity for the first half of the 10-year period is higher, but a significant effect is still present in the latter part of the period. With fire services, we observe a similar pattern: A relatively higher estimate for the first five years, and a lower elasticity for the second lag (-6%) of similar magnitude of that for police, that although not statistically significant at 10%, presents a p-value of 0.17.

When we turn to income, only police and fire services exhibit a statistically significant coefficient for the second lag. In fact, the elasticities are quantitatively on par with the ones reported in Table 3. Although some services (parks, police) exhibit a statistically significant coefficient for the first lag, relatively less politically active services show non-significant coefficients for the second lag.

Overall, the panel with interpolated covariates and five year difference between time observations supports our original conclusions. We observe persistence in longer periods of time only for those services that are well documented to be more politically active. The evidence suggests that while slow learning or sluggishness in adjustments may be a potential rationale for persistence in the short run (five years), such a mechanism is improbable over the course of a decade.

We know use the coefficients reported in Table 3 to quantify the additional cost households incur when their city suffers a negative shock. The first row of Table 5 presents the annual cost that the average household bears in the median city of our sample. For instance, a household in the median city of the sample spends $432 on police services. Next, we compute the how this figure changes when a city faces a population or an income shock. For each variable (population and income), we define "declining" a city whose rate of growth is the median among cities in the lower quarter of the distribution. Conversely, "growing" refers to a city with a growth rate equivalent to the median among those at the top quarter of the distribution. In the case of income, our calculations show that the average family spends around $14 and $11 more on police and fire protection, respectively, when their city faces a decline in household income. In the cases of administration, park and road services, negative shocks do not affect a household's disbursements nearly as much.

On the other hand, growing cities spend significantly less: The average household in a city experiencing income growth spends $13 less on police protection relative to the median municipality, and approximately $27 less relative to a city with declining household income. We observe a similar pattern for fire protection, and rather negligible effects for the remaining services. In the case of a change in the population growth rate, we observe a similar pattern, with figures somewhat lower: The average family saves approximately $18 on police expenditures if they live in a city with a positive population shock, relative to a city with a negative population shock. These figures are comparable to the effect of collective bargaining, which, according to our estimates, costs households approximately $19 and $17 for law enforcement and fire protection, respectively.

Table 5: Annual Wage Expenditures, per Household

		Fire	**Police**	**Admin**	**Parks**	**Roads**
	Median City	$343.92	$432.01	$161.23	$88.36	$114.95
y	Declining City	+$11.19	+$13.87	+$0.53	−$1.43	+$4.80
	Growing City	−$10.39	−$12.88	−$0.51	+$1.40	−$4.42
z	Declining City	+$5.78	+$ 7.15	+$2.49	+$0.58	−$0.03
	Growing City	−$8.86	−$10.97	−$3.83	−$0.90	+$0.04

4.6 Additional Results

Here, we report the estimation results for two alternative specifications. The first specification explores the claim in Proposition 4 and modifies (12) to include the interactions between collective bargaining rights and population and income growth. The second specification, on the other hand, will test the effect of 20 year lags in population change and income change. Both estimations are more demanding from our data set: In the case where we include the interaction, we will be using the change in state collective bargaining laws to identify 3 parameters: The level effect of collective bargaining, as well as the coefficients corresponding to the two interactive terms. In the 20-year lag case, we are constrained to using a panel of 3 periods for the period 1970-2000. Tables 10 and 11 in Appendix C report the full results for these two regressions.

When we include the interaction between collective bargaining and the rates of growth in population and income, the econometric equation is modified in the following sense.

$$\begin{aligned} \log(pay^j_{i,t}) \;&= \rho \cdot \mathbf{w_i'} \cdot \mathbf{log}\left(\frac{\mathbf{pay^j_t}}{\mathbf{z_t}}\right) + \boldsymbol{\eta} \cdot \mathbf{w_i'} \cdot \mathbf{F_t} \\ &+\alpha_i + \tau_1 \log(z_{i,t}) + \theta_1 \log\left(\frac{z_{i,t}}{z_{i,t-1}}\right) + \tau_2 \log(y_{i,t}) + \theta_2 \log\left(\frac{y_{i,t}}{y_{i,t-1}}\right) + \theta_3 B^j_{i,t} \\ &+\theta_4 \left[B^j_{i,t} \times \log\left(\frac{z_{i,t}}{z_{i,t-1}}\right)\right] + \theta_5 \left[B^j_{i,t} \times \log\left(\frac{y_{i,t}}{y_{i,t-1}}\right)\right] \\ &+\boldsymbol{\beta}\mathbf{X_{i,t}} + \boldsymbol{\vartheta}\mathbf{A_i} + \epsilon_{i,t} \end{aligned} \tag{14}$$

Proposition 4 considers the interaction between such an effect on wages and the state variables of income or population. In particular, it shows that under certain conditions if the service holds political influence and collective bargaining is allowed, then persistence should be lower. We find mixed evidence in support of this statement. For example, in the case of population, θ_4 is significantly positive while $(\theta_1 + \theta_4)$ is still negative and significant.

Table 6 presents the effects of the interaction between collective bargaining and population and income. In the case of police and fire when $B = 0$, the magnitudes are higher than those presented in Table 3, and when collective bargaining is allowed for the effect is smaller. Although the estimates for both services follow the same pattern for income and population, the coefficient on the interaction for the income case is not significant. These results are in line with the statement in Proposition 4.

Table 6: Persistence and Collective Bargaining

	Coefficient on $\log(z/z_{-1})$		Coefficient on $\log(y/y_{-1})$	
Service	$B = 0$	Added effect of $B = 1$	$B = 0$	Added effect of $B = 1$
Fire	-0.201***	0.163**	-0.278***	-0.093
Police	-0.176***	0.117*	-0.277***	-0.112
Administration	-0.120	0.042	-0.205	0.345**
Park	-0.019	0.045	-0.551***	0.817***
Roads	-0.203	0.474***	-0.307	0.102

*** significant at 1%, ** at 5%, * at 10%

For the other services, when collective bargaining is not available ($B = 0$) we observe no significance in the case of population and a negative significance with income for park services. When collective bargaining is allowed for ($B = 1$), however, there is either no change (administration) or a positive effect (parks and roads). In short, with the exception of the coefficient for income in the park services regression we verify the claim in Proposition 2. Moreover, though according to Proposition 4 we should expect no change (as in the regression for administrative services), if there is any effect to collective bargaining the net effect is positive.

The results for the second exercise are presented in Table 7. As with the previous case, a more demanding estimation makes it more difficult to precisely identify the coefficients and only the estimate for population in the regression for police services remains significant. From the numerical exercises, we would expect that, in the case of services that have political power, the effects for the second lags are smaller with respect to the first one and more lasting in the case of a change in population. The results, although probably with imprecise estimates, confirm the former pattern (first lags having a higher effect than second lags) and do not allow us to judge on the latter (population being more lasting).

Table 7: Persistence Over a Longer Time Period

Service	Elast. of (z/z_{-1})	Elast. of (z_{-1}/z_{-2})	Elast. of (y/y_{-1})	Elast. of (y_{-1}/y_{-2})
Fire	-0.085	-0.069	-0.137	-0.010
Police	-0.174**	-0.042	-0.109	-0.060
Admin.	-0.142	-0.049	-0.043	-0.096
Park	0.248	-0.146	-0.626	-0.264
Roads	0.102	0.029	-0.296	-0.115

** significant at 5%

5 Policy Implications

To be completed.

6 Other Potential Mechanisms

In this section, we present mechanisms that we have considered as alternative explanations for the empirical facts that are documented above.

Alternative 1: *Declining (growing) cities have excessive (deficient) levels of capital for fire and police services. Consequently, in equilibrium more (less) fire and police workers are hired.*

Of the five services under study, road maintenance is the most capital intensive. Thus, if such an effect was present, we would expect to observe it in the regression for roads. Nevertheless, our results indicate that the road wage bill is impervious to population and income changes. Moreover, much of the capital utilized in police and fire protection consists of buildings, automobiles and computers – all of which can be rented or resold on (relatively liquid) secondary markets.

Alternative 2: *Politicians are uncertain about future population trends and learn over time. Consequently, public employment in police and fire may persist when population or income change.*

Since we consider a 10 year time period, even if learning is slow, we would expect politicians to respond after longer periods of time. As reported in the robustness section, we also estimated the regressions including 20 year population and income lags. The sign and significance of the respective coefficients are the same as the ten year lag in all regressions, albeit with smaller point estimates for police and fire services. In other words, our evidence suggests that while slow learning could be a potential rationale in the short run, such a mechanism is improbable over the course of a decade. Given that cities in our sample rarely transition directly from population decline to growth (and vice versa), and that ten years is such a long horizon, a learning story seems unlikely.

Alternative 3: *When cities decline (grow), population density is lower (higher), which implies that more (less) fire and police workers must be hired.*

As a city's population increases, residents may push to live further from the city center, implying that the range of locations to patrol is larger. Consequently, when a city declines, more police and fire workers are needed given the disperse population base.

We test this by including a measure of population density in the regression analysis. Once we control for density, we would expect to see some relationship between population change and the road maintenance wage bill, at least in declining cities: Miles of road should be directly correlated with the dispersion of households. However, the inclusion of such variable does not alter the results.

7 Conclusion

In this paper, we study the dynamics of city public good expenditures and examine how politically organized public workers influence fiscal policy adjustment. A dynamic theoretical model is employed in which city population, household income and the public sector wage are stochastic and public expenditure decisions are determined by a politician that values campaign support from public workers. A public worker association can thus influence policy determination by offering the politician a principal-agent offer of high public expenditures in exchange for providing (costly) campaign support. This worker association's marginal cost of providing support, however, is decreasing in its status quo budget allocation, which creates a dynamic link through time and is revealed as a form of policy persistence. We test the model's implications using a panel of 609 US cities and show that that persistence does indeed occur for police and fire services when cities face shocks to population or median household income. Services that are traditionally less politically active, however, do not exhibit this dynamic relationship. We also estimate the cost this persistence imposes on a constituency, which is similar in magnitude to the cost of public workers holding collective bargaining rights.

Avenues for future research include studying the interaction between different services in a city. In this paper, we have viewed different services in isolation, and the question remains as to whether these departments collude or compete for resources. Moreover, this paper has focused exclusively on the dynamics surrounding public good expenditures; additional investigation of city debt, intergovernmental transfers, tax revenues and capital investment within a similar framework might yield insightful results. Finally, this methodology could be extended to study how the effects of population dynamics differ across cities with different institutions and forms of government.

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A Proofs

A.1 Proof of Lemma 1

Fix $s \in S$ and continuous $g^f \in G^{G\times S}$. By definition, $v(\cdot, s)$ is continuous over $G(s)$. First, consider

$$\int_{G\times S} v(g_1, s_1) \;\; d\Gamma^1_{g^f}\Big((g_1, s_1) \mid (g, s)\Big) \;\;=\;\; \int_S v\Big(g^f(g, s_1), s_1\Big) \;\; d\Gamma(s_1 \mid s)$$

which is continuous in g by g^f, v and Γ continuous. Second, consider

$$\int_{G\times S} v(g_2,s_2)\ \ d\Gamma^2_{g^f}\Big((g_2,s_2)\mid(g,s)\Big) \ \ = \ \ \int_S\int_S v\Big(g^f\big(g^f(g,,s_1),s_2\big),s_2\Big)\ \ d\Gamma(s_2\mid s_1)\ d\Gamma(s_1\mid s)$$

which is also continuous, as above. Continuing iteratively yields the result. □

A.2 Proof of Proposition 1

The problem posed in (7) is a single-agent stochastic dynamic programming problem. Moreover, the politician will always find it optimal to play g^*, given that g^* satisfies (2) with equality. We proceed by showing $\exists!\ U$ satisfying (7), $\exists!\ g^*$ solving (7) and that the stated properties are satisfied.

Recall that S is compact, $\Gamma(\cdot)$ is continuous, $G(s)$ is a compact-valued, continuous correspondence and $\beta\in(0,1)$. Moreover, F defined in (8) is continuous, but not necessarily bounded. Note, however, that any optimal g for the union will be bounded away from both 0 and yz: First, as $g\to 0$, we have $\lim_{g\to 0} v_g(g,s)=\infty$ while $u'(\cdot)>0$. Second, as $g\to yz$, we have $\lim_{g\to yz} v_g(g,s)=-\infty$, while $u''(\cdot)\le 0$ and $\phi(\cdot)\ge 1$. Consequently, for practical purposes, F is bounded. By Theorem 9.6 in Stokey, Lucas and Prescott (1989), $\exists! U$ satisfying (7).

Next, we show that $\forall s\in S$, $F(\cdot,\cdot,s)$ is strictly concave.

$$\begin{aligned}
F_{gg} &= u''+z\phi\kappa\left(\frac{\theta}{1-\theta}\right)^{\kappa}\Big[[\tilde v-v]^{\kappa-1}v_{gg}-(\kappa-1)[\tilde v-v]^{\kappa-2}(v_g)^2\Big]\\
F_{g_{-1}g_{-1}} &= -z\phi''\left(\frac{\theta}{1-\theta}\right)^{\kappa}[\tilde v-v]^{\kappa}\\
F_{gg_{-1}} &= z\phi'\kappa\left(\frac{\theta}{1-\theta}\right)^{\kappa}v_g[\tilde v-v]^{\kappa-1}
\end{aligned}$$

Note that $F_{gg}<0$ by $u''\le 0$, $v_{gg}<0$ and $\kappa>1$, while $F_{g_{-1}g_{-1}}<0$ by $\phi''>0$. To conclude,

$$\begin{aligned}
F_{gg}F_{g_{-1}g_{-1}}-[F_{gg_{-1}}]^2 &> \kappa[zv_g]^2\left(\frac{\theta}{1-\theta}\right)^{2\kappa}[\tilde v-v]^{2(\kappa-1)}\Big[(\kappa-1)\phi\phi''-\kappa(\phi')^2\Big]\\
&= \kappa[zv_g]^2\left(\frac{\theta}{1-\theta}\right)^{2\kappa}[\tilde v-v]^{2(\kappa-1)}\Big(\alpha\eta^{2\alpha}(g_{-1})^{2(-\alpha-1)}\Big)\Big[(\kappa-1)(\alpha+1)-\kappa\alpha\Big]\\
&\ge 0
\end{aligned}$$

where the last inequality follows from Assumption 1.

In addition, since $F_{g_{-1}}(g,g_{-1},s)>0$ by $\phi'<0$, it follows from Theorems 9.7, 9.8 and 9.10

in Stokey, Lucas and Prescott (1989) that g^* is uniquely defined and continuous, while $U(\cdot, s)$ is strictly increasing, strictly concave and continuously differentiable. □

A.3 Proof of Proposition 2

First, we show $g^*(g_{-1}, s) > \tilde{g}(s)$. The first order condition of (7) implies

$$u_g + v_g \cdot \left[\kappa z \phi\left(\frac{\theta}{1-\theta}\right)^{\kappa}\right] \cdot [\tilde{v} - v]^{\kappa-1} + \int_S U_g d\Gamma \;=\; 0 \tag{15}$$

Since $u_g > 0$ and $U_g > 0$, then $v_g(g^*(g_{-1}, s), s) < 0$, which implies that $g^*(g_{-1}, s) > \tilde{g}(s)$. Next, note that

$$\frac{dg^*}{dy_{-1}} = \frac{\partial g^*}{\partial g_{-1}} \cdot \frac{dg_{-1}}{dy_{-1}} \quad \text{and} \quad \frac{dg^*}{dz_{-1}} = \frac{\partial g^*}{\partial g_{-1}} \cdot \frac{dg_{-1}}{dz_{-1}}$$

We show these derivatives are positive. By the Implicit Function Theorem,

$$\begin{aligned} \frac{\partial g^*}{\partial g_{-1}} &= -\frac{v_g \cdot \phi' \cdot \left[\kappa z \left(\frac{\theta}{1-\theta}\right)^{\kappa}\right] \cdot [\tilde{v} - v]^{\kappa-1}}{F_{gg} + \int_S U_{gg} d\Gamma} \\ &> 0 \end{aligned}$$

where the inequality follows from the numerator being strictly positive [by $v_g < 0$ and $\phi' < 0$] and the denominator being strictly negative [by $F_{gg} < 0$, as is shown in the proof of Proposition 1, and $U_{gg} < 0$, from strict concavity of $U(\cdot, s)$]. The Implicit Function Theorem also yields[50]

$$\begin{aligned} \frac{dg^*}{dy} &= -\frac{\left[\kappa z \phi \left(\frac{\theta}{1-\theta}\right)^{\kappa} [\tilde{v} - v]^{\kappa-2}\right] \cdot \left[v_{gy}[\tilde{v} - v] \;+\; (\kappa - 1) v_g \frac{\partial[\tilde{v}-v]}{\partial y}\right]}{F_{gg} + \int_S U_{gg} d\Gamma} \\ &> 0 \end{aligned}$$

where the inequality follows from the numerator being strictly positive: Note that $v_{gy} = -(1/z)v_2'' > 0$ by $v_2'' < 0$. Consequently, $v_y(\tilde{g}(s), s) < v_y(g^*(g_{-1}, s), s)$ because $\tilde{g}(s) < g^*(g_{-1}, s)$, which implies that $\partial[\tilde{v} - v]/\partial y < 0$. Similarly,

[50] Note that the iid assumption enters into the following derivative: Under a general Markov process, the numerator would also have the term $\int U_g(g^*, s') d\Gamma_y(s' \mid s)$.

$$
\begin{aligned}
\frac{dg^*}{dz} &= -\frac{\left[\kappa\phi\left(\frac{\theta}{1-\theta}\right)^{\kappa}[\tilde{v}-v]^{\kappa-2}\right]\cdot\left[\frac{\partial(zv_g)}{\partial z}[\tilde{v}-v] \;+\; (\kappa-1)zv_g\frac{\partial[\tilde{v}-v]}{\partial z}\right]}{F_{gg}+\int_S U_{gg}d\Gamma} \\
&> 0
\end{aligned}
$$

where the inequality follows from the numerator being positive:

$$
\begin{aligned}
\frac{\partial(zv_g)}{\partial z} &= -\frac{g}{(zw)^2}v_1'' \;-\; \frac{g}{z^2}v_2'' \\
&= -gv_{gg} \\
&> 0
\end{aligned}
$$

by $v_{gg} < 0$. Moreover,

$$
\begin{aligned}
v_{gz} &= -\frac{1}{z^2w}v_1' \;+\; \frac{1}{z^2}v_2' \;-\; \frac{g}{z^3w^2}v_1'' - \frac{g}{z^3}v_2'' \\
&= -\frac{1}{z}\left[v_g\right] - \frac{g}{z}v_{gg} \\
&> 0
\end{aligned}
$$

by $v_g < 0$ and $v_{gg} < 0$. Consequently, $v_z(\tilde{g}(s),s) < v_z(g^*(g_{-1},s),s)$ because $\tilde{g}(s) < g^*(g_{-1},s)$, which implies that $\partial[\tilde{v}-v]/\partial z < 0$. $\square$

A.4 Proof of Corollary 1

Note that

$$
\begin{aligned}
\frac{dg^*}{dy_{-j}} &= \frac{dg_{-j}}{dy_{-j}}\cdot\prod_{i=1}^{j}\frac{\partial g_{-i+1}}{\partial g_{-i}} \\
&> 0
\end{aligned}
$$

and similarly for dg^*/dz_{-j}, where the inequality follows from $dg^*/dy > 0$ and $\partial g^*/\partial g_{-1} > 0$, as shown in the proof of Proposition 2. $\square$

A.5 Proof of Proposition 3

From (15), the Implicit Function Theorem yields

$$\begin{aligned}\frac{dg^*(\cdot)}{dw} &= -\frac{\left[\kappa z\phi\left(\frac{\theta}{1-\theta}\right)^{\kappa}[\tilde{v}-v]^{\kappa-2}\right]\cdot\left[v_{gw}[\tilde{v}-v] \;+\; (\kappa-1)v_g\frac{\partial[\tilde{v}-v]}{\partial w}\right]}{F_{gg}+\int_S U_{gg}d\Gamma} \\ &> 0\end{aligned}$$

where the inequality follows from the numerator being strictly positive: $v_{gw} > 0$ because citizen demand is inelastic in the public good. Consequently, $v_w(\tilde{g}(s), s) < v_w(g^*(g_{-1}, s), s)$ because $\tilde{g}(s) < g^*(g_{-1}, s)$, which implies that $\partial[\tilde{v} - v]/\partial w < 0$. □

A.6 Proof of Proposition 4

We begin by proving a Lemma.

Lemma 2. *If $v(g, s)$ takes the functional form in (9) and $\gamma = 0.5$, then $\forall g \in (\tilde{g}(s), yz)$, $v_{ggg}(g, s) < 0$.*

Proof. Note that

$$v_{ggg}(g,s) \;=\; \gamma(\sigma-1)(\sigma-2)\left\{g^{\sigma-3}(zw)^{-\sigma} - \frac{1}{z^3}\left[y-\frac{g}{z}\right]^{\sigma-3}\right\}$$

Since $\gamma(\sigma - 1)(\sigma - 2) > 0$, then it is sufficient to show that

$$\begin{aligned}\left(g^{\sigma-1}(zw)^{-\sigma}\right)\cdot g^{-2} &= g^{\sigma-3}(zw)^{-\sigma} \\ &< \frac{1}{z^3}\left[y-\frac{g}{z}\right]^{\sigma-3} \\ &= \left(\frac{1}{z}\left[y-\frac{g}{z}\right]^{\sigma-1}\right)\cdot\frac{1}{z^2}\left[y-\frac{g}{z}\right]^{-2}\end{aligned}$$

If $g > \tilde{g}(s)$, then $g^{\sigma-1}(zw)^{-\sigma} < (1/z)[y - g/z]^{\sigma-1}$ by $v_g(g, s) < 0$. Consequently, we only need to show that

$$g^{-2} \;<\; \frac{1}{z^2}\left[y-\frac{g}{z}\right]^{-2}$$

which is equivalent to $g > (zy)/2$. But note that

$$\begin{aligned}\tilde{g}(s) &= \frac{zy}{1+w^{-\frac{\sigma}{\sigma-1}}} \\ &\geq \frac{zy}{2}\end{aligned}$$

where the inequality follows from $w \geq 1$. □

We now turn to the main proof of Proposition 4. Note that

$$\frac{d^2 g^*}{dwdy_{-1}} = \frac{d^2 g^*}{dwdg_{-1}} \cdot \frac{dg_{-1}}{dy_{-1}} \quad \text{and} \quad \frac{d^2 g^*}{dwdz_{-1}} = \frac{d^2 g^*}{dwdg_{-1}} \cdot \frac{dg_{-1}}{dz_{-1}}$$

Recall from the proof of Proposition 2 that $dg_{-1}/dy_{-1} > 0$ and $dg_{-1}/dz_{-1} > 0$. Consequently, it is sufficient to show that $d^2 g^*/(dwdg_{-1}) < 0$. Under the assumption that the union is myopic, then from the proof of Proposition 3 we know that

$$\frac{dg}{dw} = -\frac{F_{gw}}{F_{gg}}$$

Consequently,[51]

$$\frac{d^2 g}{dwdg_{-1}} = -\left(\frac{dg}{dg_{-1}}\right)\left(\frac{F_{gg}F_{gwg} - F_{gw}F_{ggg}}{\left(F_{gg}\right)^2}\right)$$

Since $dg/dg_{-1} > 0$ from the proof of Proposition 2, a sufficient condition for $(d^2 g)/(dwdg_{-1}) < 0$ is thus $F_{gg}F_{gwg} > F_{gw}F_{ggg}$. The remainder of the proof will establish this inequality.

For notation ease, define $C(g; s) = [\tilde{v}(s) - v(g, s)]^\kappa$. Since $u(g) = g$, then

$$\begin{aligned}
F_{gg} &= z \cdot \phi \cdot \left(\frac{\theta}{1-\theta}\right)^\kappa \cdot \left\{C' v_{gg} - C''(v_g)^2\right\} \\
F_{gwg} &= z \cdot \phi \cdot \left(\frac{\theta}{1-\theta}\right)^\kappa \cdot \left\{C' v_{ggw} + C''\left[v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w} - 2v_g v_{gw}\right] - C'''(v_g)^2 \frac{\partial[\tilde{v}-v]}{\partial w}\right\} \\
F_{gw} &= z \cdot \phi \cdot \left(\frac{\theta}{1-\theta}\right)^\kappa \cdot \left\{C' v_{gw} + C'' v_g \frac{\partial[\tilde{v}-v]}{\partial w}\right\} \\
F_{ggg} &= z \cdot \phi \cdot \left(\frac{\theta}{1-\theta}\right)^\kappa \cdot \left\{C' v_{ggg} - C''(3v_g v_{gg}) + C'''(v_g)^3\right\}
\end{aligned}$$

[51]Note that g_{-1} does not enter into dg/dw directly, as the $\phi(g_{-1})$ terms divide in the numerator and denominator.

which implies that

$$
\begin{aligned}
\frac{F_{gg}F_{gwg} - F_{gw}F_{ggg}}{(z\varphi)^2\left(\frac{\theta}{1-\theta}\right)^{2\kappa}} \;=\;& \underbrace{(C')^2\Big[v_{gg}v_{ggw} \;-\; v_{gw}v_{ggg}\Big]}_{A_1} \\
&+ \underbrace{(C'')^2\Big[-(v_g)^2 v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w} \;+\; 2(v_g)^3 v_{gw} \;+\; 3(v_g)^2 v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w}\Big]}_{A_2} \\
&+ \underbrace{(C'C''')\Big[-(v_g)^2 v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w} \;-\; (v_g)^3 v_{gw}\Big]}_{A_3} \\
&+ \underbrace{(C''C''')\Big[(v_g)^4\frac{\partial[\tilde{v}-v]}{\partial w} \;-\; (v_g)^4\frac{\partial[\tilde{v}-v]}{\partial w}\Big]}_{A_4} \\
&+ \underbrace{(C'C'')\Big[(v_{gg})^2\frac{\partial[\tilde{v}-v]}{\partial w} \;-\; 2v_g v_{gg} v_{gw} \;-\; (v_g)^2 v_{ggw} \;+\; 3v_g v_{gg} v_{gw} \;-\; v_g v_{ggg}\frac{\partial[\tilde{v}-v]}{\partial w}\Big]}_{A_5}
\end{aligned}
$$

Note that $A_1 > 0$ by virtue of Lemma 2 and the properties of v. Second, note that $A_4 = 0$. Third, note that the third and fifth terms in the square bracket of A_5 are strictly positive by properties of v and C', $C'' > 0$. Consequently, it is sufficient to show that the following is positive:

$$
\begin{aligned}
&\underbrace{(C'')^2\Big[2(v_g)^3 v_{gw} \;+\; 2(v_g)^2 v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w}\Big]}_{A_2} \;+\; \underbrace{(C'C''')\Big[-(v_g)^2 v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w} \;-\; (v_g)^3 v_{gw}\Big]}_{A_3} \\
&\qquad\qquad\qquad\qquad\qquad\qquad + \underbrace{(C'C'')\Big[(v_{gg})^2\frac{\partial[\tilde{v}-v]}{\partial w} \;+\; v_g v_{gg} v_{gw}\Big]}_{A_5'}
\end{aligned}
$$

which equals

$$
\underbrace{\Big[v_g v_{gw} \;+\; v_{gg}\frac{\partial[\tilde{v}-v]}{\partial w}\Big]}_{A_6} \cdot \underbrace{\Big[2(C'')^2(v_g)^2 \;-\; (C'C''')(v_g)^2 \;+\; (C'C'')v_{gg}\Big]}_{A_7}
$$

We show that both $A_6 > 0$ and $A_7 > 0$ when $g \in (\tilde{g}(s), zy)$.

$A_6 > 0$: $\forall s \in S$, $v_g(\tilde{g}(s), s) = 0$ (by definition of $\tilde{g}(s)$) and $(\partial[\tilde{v} - v])/(\partial w)(\tilde{g}(s), s) = v_w(\tilde{g}(s), s) - v_w(\tilde{g}(s), s) = 0$. Consequently, $A_6 = 0$ when $g = \tilde{g}(s)$. But for $g > \tilde{g}(s)$, the derivative of A_6 with respect to g is

$$
\begin{aligned}
v_{gg}v_{gw} \;+\; v_g v_{gwg} \;+\; v_{ggg}\frac{\partial[\tilde{v}-v]}{\partial w} \;-\; v_{gg}v_{wg} \;&=\; v_g v_{gwg} \;+\; v_{ggg}\frac{\partial[\tilde{v}-v]}{\partial w} \\
&>\; 0
\end{aligned}
$$

where the inequality follows from $v_g < 0$ and $v_{ggg} < 0$ when $g \in (\tilde{g}(s), zy)$, and

$v_{gwg} < 0$ and $\partial[\tilde{v} - v]/\partial w < 0$. Consequently, $A_6 > 0$ when $g \in (\tilde{g}(s), zy)$.

$A_7 > 0$: By assumption, $C''' = 0$ by $\kappa = 2$, and thus the middle term of A_7 equals 0. Thus, it is sufficient to show that

$$\Big[2(\kappa - 1)(v_g)^2 + [\tilde{v} - v]v_{gg}\Big] \quad \geq \quad 0$$

An argument similar to the case of A_6 establishes that $A_7 = 0$ when $g = \tilde{g}(s)$. For $g > \tilde{g}(s)$, the derivative of the terms inside the square brackets in A_7 with respect to g is

$$4(\kappa - 1)v_g v_{gg} - v_g v_{gg} + [\tilde{v} - v]v_{ggg} \quad = \quad [4\kappa - 5]v_g v_{gg} + [\tilde{v} - v]v_{ggg}$$

which equals

$$\begin{aligned}
(\sigma - 1)\Bigg\{(4\kappa - 5) \quad \cdot \quad & \Big\{\underbrace{g^{2\sigma-3}(wz)^{-2\sigma} \quad - \quad \frac{1}{z^3}\Big[y - \frac{g}{z}\Big]^{2\sigma-3}}_{B_1} \\
& + \underbrace{g^{\sigma-1}(wz)^{-\sigma}\frac{1}{z^2}\Big[y - \frac{g}{z}\Big]^{\sigma-2} \quad - \quad g^{\sigma-2}(wz)^{-\sigma}\frac{1}{z}\Big[y - \frac{g}{z}\Big]^{\sigma-1}}_{B_2}\Big\} \\
+ \frac{\sigma - 2}{\sigma} \quad \cdot \quad & \Big\{\underbrace{-g^{2\sigma-3}(wz)^{-2\sigma} \quad + \quad \frac{1}{z^3}\Big[y - \frac{g}{z}\Big]^{2\sigma-3}}_{B_3} \\
& \underbrace{-g^{\sigma-3}(wz)^{-\sigma}\Big[y - \frac{g}{z}\Big]^{\sigma} \quad + \quad g^{\sigma}(wz)^{-\sigma}\frac{1}{z^3}\Big[y - \frac{g}{z}\Big]^{\sigma-3}}_{B_4} \\
& + \underbrace{g^{\sigma-3}(wz)^{-\sigma}\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma} \quad - \quad \tilde{g}(s)^{\sigma}(wz)^{-\sigma}\frac{1}{z^3}\Big[y - \frac{g}{z}\Big]^{\sigma-3}}_{B_5} \\
& + \underbrace{g^{\sigma-3}\tilde{g}(s)^{\sigma}(wz)^{-2\sigma} \quad - \quad \frac{1}{z^3}\Big[y - \frac{g}{z}\Big]^{\sigma-3}\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma}}_{B_6}\Big\}\Bigg\}
\end{aligned}$$

This term is strictly positive: Under the assumption that $\kappa = 2$ and $\sigma = -1$, $(4\kappa - 5) = (\sigma - 2)/\sigma$. Given this, note that $B_1 + B_3 = 0$, $B_2 + B_6 < 0$ and

$B_4 + B_5 < 0$:

$$\begin{aligned} B_2 + B_6 &= \frac{1}{z^2}\Big[y - \frac{g}{z}\Big]^{\sigma-2}\Big(g^{\sigma-1}(wz)^{-\sigma} - \frac{1}{z}\Big[y - \frac{g}{z}\Big]^{-1}\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma}\Big) \\ &+ g^{\sigma-2}(wz)^{-\sigma}\Big(g^{-1}\tilde{g}(s)^{\sigma}(wz)^{-\sigma} - \frac{1}{z}\Big[y - \frac{g}{z}\Big]^{\sigma-1}\Big) \\ &< \frac{1}{z^2}\Big[y - \frac{g}{z}\Big]^{\sigma-2}\Big(\tilde{g}(s)^{\sigma-1}(wz)^{-\sigma} - \frac{1}{z}\Big[y - \frac{g}{z}\Big]^{-1}\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma}\Big) \\ &+ g^{\sigma-2}(wz)^{-\sigma}\Big(\tilde{g}(s)^{\sigma-1}(wz)^{-\sigma} - \frac{1}{z}\Big[y - \frac{g}{z}\Big]^{\sigma-1}\Big) \\ &< \frac{1}{z^2}\Big[y - \frac{g}{z}\Big]^{\sigma-2}\Big(\tilde{g}(s)^{\sigma-1}(wz)^{-\sigma} - \frac{1}{z}\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma-1}\Big) \\ &+ g^{\sigma-2}(wz)^{-\sigma}\Big(\tilde{g}(s)^{\sigma-1}(wz)^{-\sigma} - \frac{1}{z}\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma-1}\Big) \\ &= 0 \end{aligned}$$

where the first inequality follows from $\tilde{g}(s) < g$, the second inequality follows from $[y - \tilde{g}(s)/z] > [y - g/z]$ and the final equality follows from $v_g(\tilde{g}(s), s) = 0$.

$$\begin{aligned} B_4 + B_5 &= (wz)^{-\sigma}\frac{1}{z^3}\Big[y - \frac{g}{z}\Big]^{\sigma-3}\Big(g^{\sigma} - \tilde{g}(s)^{\sigma}\Big) \\ &+ g^{\sigma-3}(wz)^{-\sigma}\Big(\Big[y - \frac{\tilde{g}(s)}{z}\Big]^{\sigma} - \Big[y - \frac{g}{z}\Big]^{\sigma}\Big) \\ &< 0 \end{aligned}$$

where the inequality follows from $\tilde{g}(s) < g$, $[y - \tilde{g}(s)/z] > [y - g/z]$ and $\sigma < 0$. □

B Algorithm

This appendix briefly outlines the algorithm employed to compute the numerical solution discussed in Section 3.3. The algorithm iterates over the value functions U and V until convergence. This section is preliminary and will be expanded soon.

Step 1: A grid is defined along the four dimensions: Expenditures (g) and exogenous states (x, y, z). Nodes along each dimension are denoted $\{g_i\}_{i=1}^{n_g}$, $\{w_i\}_{i=1}^{n_w}$, $\{y_i\}_{i=1}^{n_y}$ and $\{z_i\}_{i=1}^{n_z}$. A tolerance level, $\epsilon = 10^{-3}$, is also set.

Step 2: The conditional distribution function for exogenous variables, $\hat{\Gamma}$, is computed for the grid points. The distribution is calibrated from the data, assuming that the data generating process is normal.

Step 3: A vector of period payoffs for the citizen, $\mathbf{v}(\mathbf{g}, \mathbf{s})$, is computed for each grid point.

Step 4: Initial guesses, U_0, V_0 and g_0^*, are made for the value functions and the policy function.

Step 5: The integral $\int_s U d\Gamma$ is computed using U_0 and $\hat{\Gamma}$.

Step 6: Given g_0^* and $\hat{\Gamma}$, a transition matrix $\hat{\Gamma}_{g_0^*}((g', s') \mid (g, s))$ mapping the probability of transition from (g, s) to (g', s') is computed over the grid. The citizen's value function is then computed as $V_1 = \mathbf{v}(\mathbf{g}, \mathbf{s}) + \beta(I - \beta\hat{\Gamma}_{g_0^*})^{-1}\mathbf{v}(\mathbf{g}, \mathbf{s})$ over the space of grid points (g, s). The vector $\tilde{V}_1 = \max_{g\in\{\{g_i\}_{i=1}^{n_g} | g_i \in G(s)\}} V_1$ is computed for each state s on the grid.

Step 7: At each state (g_{-1}, s), the union's value function is updated as

$$U_1 \;=\; \max_{g\in\{\{g_i\}_{i=1}^{n_g} | g_i \in G(s)\}} \left\{ u(g) \;-\; z\phi(g_{-1}) \left\{ \left(\frac{\theta}{1-\theta} \right) \left[\tilde{V}_1 - V_1 \right] \right\}^{\kappa} \;+\; \int_s U_0 \; d\hat{\Gamma} \right\}$$

and g_1^* is updated as the argument maximizing the right hand side.

Step 8: If

$$\max \left\{ \frac{||U_1 - U_0||_\infty}{||U_0||_\infty}, \; \frac{||V_1 - V_0||_\infty}{||V_0||_\infty} \right\} \;<\; \epsilon$$

then exit the routine. Otherwise, return to Step 5 with the updated functions U_1, V_1 and g_1^*.

C Tables

Table 8: Estimation Results

	Police		Fire		Roads		Administration		Parks	
Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
B	0.050	3.068	0.056	3.164	0.176	3.725	0.126	4.226	0.124	2.404
$\log(z/z_{-1})$	-0.134	-3.379	-0.136	-3.124	-0.001	-0.007	-0.126	-1.777	-0.054	-0.472
$\log(y/y_{-1})$	-0.225	-3.190	-0.236	-3.105	-0.277	-1.440	-0.027	-0.216	-0.114	-0.556
$\log(z)$	0.807	23.092	0.725	19.679	0.897	9.462	0.747	12.230	0.865	8.777
$\log(y)$	0.512	5.162	0.634	5.975	0.479	1.757	0.232	1.317	0.710	2.460
unem	-0.728	-2.316	0.004	0.012	-1.321	-1.516	-1.892	-3.364	-1.401	-1.497
poverty	-0.479	-2.100	-0.337	-1.383	-0.356	-0.558	-0.815	-1.987	-0.386	-0.580
college	-0.104	-0.733	-0.052	-0.339	0.327	0.839	0.302	1.197	-0.321	-0.775
schage	-0.352	-1.020	-0.137	-0.348	3.096	3.279	0.155	0.255	-1.925	-1.959
old	-0.439	-1.704	-0.022	-0.077	2.643	3.705	0.411	0.892	1.804	2.409
black	0.140	1.016	0.313	2.022	-0.037	-0.093	0.381	1.569	-0.142	-0.358
white	-0.252	-2.153	-0.228	-1.766	0.130	0.406	-0.111	-0.546	-0.055	-0.169
crime	0.045	3.367	0.040	2.823						
W-$\log(z/z_{-1})$	-0.008	-0.119	-0.001	-0.019	-0.271	-1.512	-0.041	-0.353	-0.067	-0.358
W-$\log(y/y_{-1})$	0.109	1.165	0.249	2.483	0.604	2.341	0.229	1.379	0.020	0.073
W-$\log(z)$	-0.058	-1.040	-0.021	-0.409	0.283	1.965	0.258	2.891	0.296	2.073
W-$\log(y)$	-0.055	-0.379	-0.588	-3.839	0.210	0.535	0.142	0.551	-0.712	-1.711
W-unem	-0.196	-0.474	0.036	0.080	0.575	0.504	0.572	0.775	-0.752	-0.622
W-poverty	-0.649	-1.830	-1.221	-3.331	-0.541	-0.554	-0.561	-0.894	-2.023	-1.960
W-college	-0.803	-3.705	-0.376	-1.655	-0.518	-0.916	-0.425	-1.146	0.370	0.607
W-schage	-0.315	-0.533	0.179	0.271	2.135	1.320	0.179	0.173	1.618	0.969
W-old	-0.998	-2.264	-0.080	-0.171	1.365	1.107	-0.118	-0.150	-0.082	-0.065
W-black	0.325	1.361	0.016	0.061	1.312	2.055	0.868	2.120	1.827	2.751
W-white	-0.128	-0.764	0.018	0.096	0.861	2.050	0.143	0.538	0.837	1.947
W-crime	0.080	3.034	0.020	0.687						
rho	0.173	5.979	0.213	29.940	-0.012	-0.246	0.076	2.745	0.082	2.760
Observations	582		541		581		607		559	

Table 9: Estimation Results: Fixed effects

	Police		Fire		Roads		Administration		Parks	
Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
B	0.067	3.810	0.083	4.080	0.178	3.990	0.131	3.960	0.152	3.010
$\log(y/y_{-1})$	-0.195	-4.660	-0.217	-4.160	-0.034	-0.320	-0.127	-1.890	-0.044	-0.420
$\log(z/z_{-1})$	-0.091	-1.560	-0.054	-0.880	0.137	0.960	0.135	1.570	-0.030	-0.210
$\log(z)$	0.896	21.260	0.841	18.230	1.030	12.110	0.870	14.430	1.017	10.040
$\log(y)$	0.565	5.400	0.474	3.950	0.301	1.410	0.551	3.490	0.310	1.240
unemployment	-0.550	-2.170	0.036	0.130	-0.585	-0.870	-1.303	-2.860	-1.678	-2.290
poverty	-0.731	-2.810	-0.703	-2.470	-0.747	-1.280	-0.852	-1.900	-1.024	-1.640
college	-0.394	-2.040	-0.140	-0.760	0.301	0.890	-0.128	-0.490	-0.144	-0.360
school age	0.308	0.760	0.738	1.380	3.464	3.340	0.964	1.320	-1.214	-1.090
old	-0.710	-2.230	0.075	0.180	2.644	3.080	0.561	1.110	1.900	2.580
black	0.141	1.020	0.371	2.340	0.291	0.850	0.367	1.660	0.345	0.950
white	-0.330	-3.240	-0.177	-1.590	0.369	1.410	-0.321	-1.890	0.383	1.250
crime	0.061	3.750	0.051	3.290						
Observations	582		541		590		609		561	

Table 10: Estimation Results: Including Interaction between Collective Bargaining and rates of growth

	Police		Fire		Roads		Administration		Parks	
Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
B	0.038	2.206	0.044	2.371	0.156	3.178	0.100	3.242	0.062	1.160
$\log(z/z_{-1})$ x B	0.115	1.773	0.161	2.257	0.474	2.593	0.040	0.345	0.050	0.260
$\log(y/y_{-1})$ x B	0.111	1.447	0.093	1.122	0.111	0.522	0.353	2.613	0.817	3.688
$\log(z/z_{-1})$	-0.177	-3.541	-0.201	-3.681	-0.203	-1.438	-0.120	-1.334	-0.020	-0.132
$\log(y/y_{-1})$	-0.277	-3.398	-0.278	-3.168	-0.307	-1.383	-0.206	-1.434	-0.532	-2.253
$\log(z)$	0.796	22.664	0.712	19.252	0.865	9.096	0.735	11.977	0.842	8.542
$\log(y)$	0.498	5.022	0.613	5.786	0.442	1.621	0.196	1.112	0.617	2.143
unem	-0.744	-2.367	-0.005	-0.015	-1.319	-1.513	-1.990	-3.537	-1.641	-1.756
poverty	-0.440	-1.922	-0.317	-1.297	-0.302	-0.471	-0.683	-1.659	-0.076	-0.113
college	-0.122	-0.859	-0.064	-0.417	0.302	0.776	0.296	1.176	-0.311	-0.754
schage	-0.466	-1.345	-0.267	-0.675	2.771	2.925	0.010	0.017	-2.234	-2.267
old	-0.444	-1.727	-0.012	-0.044	2.647	3.718	0.373	0.811	1.697	2.275
black	0.115	0.836	0.281	1.814	-0.079	-0.201	0.322	1.324	-0.282	-0.711
white	-0.271	-2.315	-0.246	-1.906	0.088	0.276	-0.152	-0.747	-0.146	-0.447
crime	0.042	3.100	0.037	2.606						
W-$\log(z/z_{-1})$)	0.005	0.069	0.009	0.136	-0.250	-1.384	0.004	0.034	0.028	0.149
W-$\log(y/y_{-1})$	0.085	0.905	0.229	2.276	0.566	2.175	0.168	1.009	-0.121	-0.440
W-$\log(z)$	-0.065	-1.161	-0.026	-0.495	0.280	1.927	0.216	2.392	0.208	1.456
W-$\log(y)$	-0.061	-0.424	-0.603	-3.945	0.183	0.467	0.147	0.573	-0.676	-1.629
W-unem	-0.310	-0.749	-0.076	-0.169	0.240	0.210	0.369	0.499	-1.188	-0.983
W-poverty	-0.616	-1.735	-1.205	-3.294	-0.498	-0.511	-0.438	-0.698	-1.745	-1.695
W-college	-0.832	-3.844	-0.408	-1.797	-0.572	-1.014	-0.439	-1.185	0.306	0.504
W-schage	-0.441	-0.746	-0.009	-0.014	1.782	1.100	-0.099	-0.096	1.013	0.607
W-old	-1.067	-2.414	-0.106	-0.226	1.352	1.094	-0.311	-0.394	-0.431	-0.344
W-black	0.243	1.010	-0.091	-0.350	1.134	1.765	0.667	1.613	1.364	2.036
W-white	-0.191	-1.134	-0.061	-0.324	0.643	1.509	-0.010	-0.037	0.512	1.175
W-crime	0.073	2.751	0.013	0.447						
rho	0.170	5.925	0.210	29.697	-0.019	-0.389	0.073	2.701	0.068	2.557
Observations	582		541		581		607		559	

Table 11: Estimation Results: Including 20-year lags

	Police		Fire		Roads		Administration		Parks	
Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
B	0.067	2.888	0.079	3.293	0.151	2.322	0.158	4.110	0.079	1.043
$\log(z/z_{-1})$	-0.174	-2.752	-0.082	-1.229	0.102	0.583	-0.142	-1.335	-0.199	-1.067
$\log(z_{-1}/z_{-2})$	-0.043	-0.972	-0.069	-1.428	0.029	0.236	-0.050	-0.665	-0.053	-0.404
$\log(y/y_{-1})$	-0.108	-1.003	-0.144	-1.263	-0.296	-1.029	-0.043	-0.244	0.252	0.787
$\log(y_{-1}/y_{-2})$	0.061	0.678	-0.017	-0.170	-0.115	-0.472	-0.097	-0.646	0.149	0.547
$\log(z)$	0.766	14.097	0.697	12.504	0.635	4.361	0.733	8.278	0.756	4.859
$\log(y)$	0.254	1.757	0.299	1.951	0.544	1.379	0.174	0.731	0.256	0.600
unem	-0.635	-1.711	0.122	0.312	0.122	0.119	-1.429	-2.284	0.270	0.236
poverty	-0.352	-1.318	-0.312	-1.116	-0.258	-0.345	-0.506	-1.118	0.036	0.045
college	-0.019	-0.112	0.186	1.026	0.215	0.455	0.595	2.055	0.399	0.771
schage	-1.178	-2.191	-1.026	-1.747	3.395	2.309	-1.986	-2.233	-3.790	-2.384
old	-1.063	-3.218	-0.879	-2.496	2.168	2.400	-0.264	-0.479	1.243	1.268
black	0.112	0.536	0.236	1.013	0.372	0.633	0.413	1.198	-0.035	-0.057
white	-0.161	-0.988	-0.133	-0.726	0.173	0.381	-0.157	-0.583	0.186	0.386
crime	0.026	1.590	0.012	0.725						
W-$\log(z/z_{-1})$	-0.109	-1.103	-0.167	-1.621	-0.317	-1.200	-0.142	-0.878	0.256	0.899
W-$\log(z_{-1}/z_{-2})$	-0.053	-0.691	-0.161	-2.023	-0.547	-2.550	-0.275	-2.127	-0.141	-0.613
W-$\log(y/y_{-1})$	-0.023	-0.139	0.299	1.690	1.347	2.932	0.028	0.101	-0.644	-1.259
W-$\log(y_{-1}/y_{-2})$	0.024	0.164	0.193	1.259	0.868	2.153	0.048	0.197	-0.274	-0.617
W-$\log(z)$	-0.152	-1.815	-0.005	-0.060	0.505	2.300	0.052	0.405	-0.104	-0.452
W-$\log(y)$	0.244	1.034	-0.301	-1.196	-0.563	-0.872	0.636	1.624	0.029	0.041
W-unem	0.354	0.686	0.217	0.400	-0.750	-0.535	0.218	0.254	-1.116	-0.727
W-poverty	-0.593	-1.403	-1.079	-2.543	0.193	0.168	0.350	0.501	-1.968	-1.558
W-college	-1.240	-4.765	-0.855	-3.248	-0.799	-1.165	-0.947	-2.241	0.386	0.510
W-schage	-1.566	-1.629	0.001	0.001	0.260	0.099	1.472	0.931	3.015	1.068
W-old	-1.084	-1.951	0.398	0.685	1.991	1.305	-1.289	-1.397	0.336	0.211
W-black	0.076	0.202	-0.459	-1.129	0.700	0.704	0.743	1.230	0.940	0.873
W-white	-0.478	-1.844	-0.507	-1.752	0.007	0.010	0.191	0.475	0.335	0.468
W-crime	0.065	1.677	0.050	1.230						
rho	0.086	2.328	0.027	7.617	-0.013	-0.203	0.106	17.272	0.026	7.388
Observations	582		541		581		607		559	

Table 12: Estimation Results: Interpolation

	Police		Fire		Roads		Administration		Parks	
Variable	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
B	0.055	4.190	0.058	4.060	0.144	3.944	0.114	5.067	0.129	3.326
$\log(z/z_{-1})$	-0.352	-8.653	-0.285	-6.434	-0.151	-1.361	-0.301	-4.302	-0.406	-3.632
$\log(z_{-1}/z_{-2})$	-0.072	-1.708	-0.063	-1.370	-0.045	-0.394	-0.057	-0.786	0.012	0.101
$\log(y/y_{-1})$	-0.153	-1.749	-0.023	-0.236	-0.019	-0.081	0.029	0.197	-0.541	-2.216
$\log(y_{-1}/y_{-2})$	-0.248	-2.639	-0.240	-2.287	-0.298	-1.186	0.012	0.076	0.222	0.852
$\log(z)$	0.813	30.206	0.761	26.485	0.872	12.259	0.753	16.669	0.915	12.580
$\log(y)$	0.451	5.558	0.475	5.268	0.177	0.820	0.315	2.284	0.004	0.017
unem	-0.547	-1.938	0.046	0.148	-1.205	-1.595	-1.700	-3.520	-1.368	-1.685
poverty	-0.615	-3.180	-0.473	-2.248	-1.097	-2.103	-0.844	-2.552	-1.376	-2.577
college	-0.043	-0.343	0.175	1.304	0.965	2.967	0.226	1.079	0.567	1.667
schage	0.242	0.758	0.356	0.978	3.720	4.356	0.829	1.535	-1.108	-1.269
old	-0.257	-1.160	0.289	1.186	2.890	4.838	0.519	1.363	2.052	3.355
black	0.037	0.317	0.203	1.503	-0.200	-0.611	0.209	1.047	0.070	0.215
white	-0.347	-3.400	-0.186	-1.611	0.180	0.662	-0.273	-1.588	0.370	1.345
crime	0.049	4.018	0.029	2.238						
W-$\log(z/z_{-1})$	0.000	0.004	0.048	0.660	-0.428	-2.223	-0.077	-0.672	-0.073	-0.400
W-$\log(z_{-1}/z_{-2})$	-0.052	-0.709	0.027	0.351	-0.058	-0.285	-0.050	-0.406	-0.195	-0.980
W-$\log(y/y_{-1})$	0.197	1.680	0.153	1.185	0.364	1.153	0.237	1.192	0.131	0.402
W-$\log(y_{-1}/y_{-2})$	0.239	1.853	0.263	1.840	0.792	2.284	0.145	0.666	0.035	0.099
W-$\log(z)$	-0.059	-1.535	-0.042	-0.919	0.355	3.223	0.261	4.021	0.279	2.656
W-$\log(y)$	0.054	0.423	-0.420	-3.104	0.015	0.047	0.117	0.558	0.047	0.139
W-unem	-0.222	-0.596	0.193	0.476	0.602	0.605	0.311	0.492	0.351	0.332
W-poverty	-0.653	-2.094	-0.998	-3.096	-1.215	-1.423	-0.691	-1.332	-1.523	-1.826
W-college	-0.958	-4.735	-0.564	-2.923	-0.486	-1.051	-0.272	-0.895	0.452	0.904
W-schage	0.104	0.185	0.070	0.112	1.076	0.719	0.447	0.472	2.674	1.758
W-old	-1.112	-2.933	-0.271	-0.670	1.380	1.343	-0.184	-0.285	1.062	1.044
W-black	0.146	0.741	0.095	0.441	0.968	1.878	1.038	3.249	1.787	3.416
W-white	-0.057	-0.397	0.084	0.512	0.685	1.960	0.239	1.091	0.664	1.878
W-crime	0.056	2.334	-0.006	-0.218						
rho	0.134	32.724	0.188	8.636	-0.002	-0.058	0.045	18.491	0.040	16.454
Observations	577		521		575		605		547	