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# Governmental Systems and Economic Volatility in Democracies

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# Governmental Systems and Economic Volatility in Democracies\*

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June 6, 2018

## Abstract

Economic volatility varies substantially across democracies. We study how the difference between federal and unitary systems of government can contribute to these variations. We show empirically that a higher degree of federalism is associated with less volatility in both economic growth and fiscal policy. Motivated by these stylized facts, we develop a macroeconomic model of policy-making at the central and district levels. Policy at the central level is uncertain due to uncertainty about the identity of the winning coalition in a legislature of district representatives, while policy at the district level is more stable due to homogeneity within districts. We show that, in equilibrium, the decentralization of policy-making powers can mitigate overall policy uncertainty. This implies less volatility in fiscal policy and, hence, less volatility in economic growth, compared to those in a more unitary system.

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# 1 Introduction

Economic volatility and its determinants are one of the central issues in macroeconomics. In the political economy literature, it has been established that democracies, as compared to autocracies, are associated with less volatility in both economic growth and fiscal policy (e.g., [Rodrik 2000](#); [Acemoglu et al. 2003](#); [Henisz 2004](#)).

Nevertheless, there exists a substantial variation in volatility *among* democracies. For example, economic growth in Greece is more than twice as volatile as in Austria. Likewise, government spending in Hungary is more than twice as unstable as it is in the Czech Republic.<sup>1</sup> The question this paper asks is, what accounts for such variations in volatility among democracies? A possible explanation lies in the variations inherent in governmental systems. Specifically, we explore how the division of policy-making powers between central and subnational governments can affect economic volatility.

At one extreme are unitary systems, such as those of the UK and Greece, where the central government has the ultimate decision-making power and subnational (regional) governments have minimal authority. In a federal system, such as those in the US and Germany, the division of powers between the central and subnational governments is specified in the constitution and, for many federations, subnational governments retain substantial residual powers. The Tenth Amendment to the United States Constitution, for example, states that “[t]he powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people.”

In this paper, we focus on the division of *fiscal* powers between central and subnational governments, for example, to levy taxes and invest in public infrastructure. In [Figure 1](#) we show that, among democracies, if subnational governments enjoy a higher degree of regional authority, the volatility of economic growth in that country tends to be lower.<sup>2</sup>

It has been established, in the literature, that policy volatility contributes to growth volatility (e.g., [Ramey and Ramey 1995](#); [Fatás and Mihov 2003](#)). We, thus, conjecture that federal systems, compared to unitary systems, are associated with less volatility in fiscal policy. [Figure 2](#) plots the volatility of fiscal policy against the regional authority allocated to subnational governments. The figure shows a similar, negative relationship, which seems

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<sup>1</sup>By our calculation, the interquartile range of growth rates is 4.5% for Greece, but only 1.8% for Austria. The interquartile range of government spending is 4.6% of GDP for Hungary, but only 2.1% for the Czech Republic.

<sup>2</sup>See [Section 2](#) for more details on the empirical findings mentioned in this section.

to confirm our conjecture.

Motivated by these two stylized facts, we develop a simple model of fiscal policy-making for a country's central and subnational governments. Here, fiscal policy is used to provide local infrastructure, which has a productivity effect on final output. Our model predicts that allocating greater policy-making power to subnational governments leads to less volatility in fiscal policy and, consequently, less volatility in economic growth.

In the model, the economy consists of two districts and is jointly governed by a central government and two district governments. Each district elects a legislator to represent them in the government's national assembly, which is characterized by the two elected legislators. For each district, both the central and respective district governments have the ability to provide local infrastructure (transportation, energy supply, etc.), which, in turn, augments both labor (employment) and private capital in production.

The provision of local infrastructure is determined by the respective legislator of each district government, while the assembly determines the infrastructure the central government provides. The policy-making process in the assembly has uncertainty, where each legislator is equally likely to dominate the other and be in charge of the central governments fiscal policy.

The interaction between the central and district governments depends on whether the governmental system is federal or unitary. In a *federal* system, (i) the central government (i.e., the legislator in charge) moves first and decides on the provision of local infrastructure in both districts; (ii) the district governments (the respective legislators) move second and provide additional local infrastructure in their own districts. In a *unitary* system, the timing is the opposite—the central government moves second and has the final say on the fiscal policy that affects both districts. The idea here is that in a unitary system the central government holds the ultimate decision-making power, which is unlike in a federal system.

We interpret the timing as capturing the relative policy-making power between the central and district governments. In particular, whoever moves second can be considered as having the “residual power.” We show that the difference in the timing of the policy-making leads to the difference in the volatility in the resulting fiscal policy. In a federal system, legislators decide on their district's policies *after* the uncertainty about the assembly's policy-making is resolved. For each legislator, if they are in charge in the first stage, they will use the central government's funds and provide a large amount of local infrastructure in their own district because doing so is in the interests of their constituency. But even if the legislator is

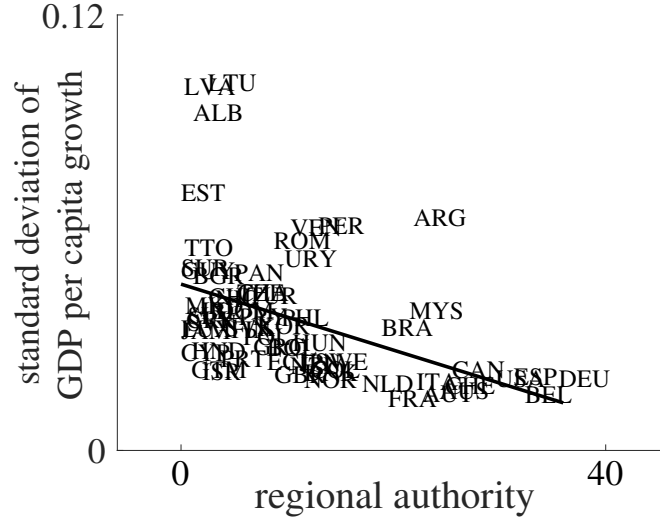


Figure 1: Regional Authority and Growth Volatility in 62 Democracies, 1981-2010  
 Sources: [Hooghe et al. \(2016\)](#) and the World Bank's *World Development Indicators*.

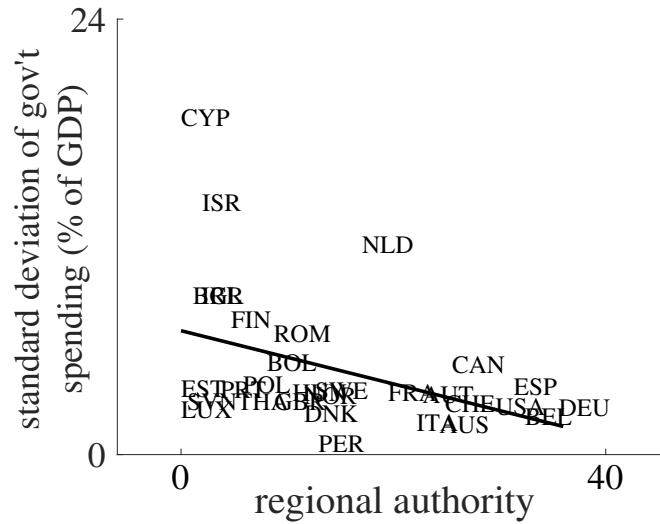


Figure 2: Regional Authority and Government Spending Volatility in 30 democracies, 1981-2010

Sources: [Hooghe et al. \(2016\)](#) and the IMF's *Government Finance Statistics*.

sidelined in the assembly, they will still have an opportunity, as a second mover, to provide a modest amount of local infrastructure *ex post*. Therefore, whether or not the legislator is indeed in charge in the assembly does not make a lot of difference in the total amount of local infrastructure provided to their district.

In contrast, in a unitary system, each legislator decides on their district's fiscal policy *before* knowing whether they will be in charge in the assembly. Since this uncertainty has not yet been resolved, each legislator now anticipates the possibility of being in charge and chooses to provide only a smaller amount of local infrastructure *ex ante*. Thus, whether or not the legislator turns out to be in charge now makes a bigger difference in the (realized) infrastructure provision in their district.

In other words, when deciding district policies, the legislators in a unitary system are *optimistic* because they might be the dominant member in the assembly later on. However, if it turns out that they are sidelined, then this optimism will lead to the under-provision of local infrastructure. Since the central policy is uncertain, such under-provision hinders the legislators from mitigating the policy uncertainty their districts face. Consequently, fiscal policy in a unitary system is more uncertain than it is in a federal system.

Finally, since local infrastructure has a productivity effect on final output, higher uncertainty about fiscal policy in a unitary state directly leads to higher uncertainty about economic growth. The results, therefore, match the two stylized facts.

The rest of this paper is organized as follows. The next subsection reviews the related literature. Section 2 shows that a more federal system is associated with lower volatility in both economic growth and fiscal policy. In Section 3, we then set up a model to explain the above stylized facts. The determination of fiscal policy in each governmental system is analyzed in Section 4. We then compare the volatility of both economic growth and fiscal policy between the two governmental systems in Section 5. The last section concludes. The details on the data sources and the omitted proofs are relegated to the [Appendix](#).

## 1.1 Related Literature

Our paper is related to several strands of the empirical literature. The first is the studies on the relationship between the degree of democracy and the volatility of economic growth (Rodrik 2000; Quinn and Woolley 2001; Almeida and Ferreira 2002; Klomp and de Haan 2009). The findings show that economic volatility is negatively correlated with the degree

of democracy. In [Acemoglu et al. \(2003\)](#) and [Mobarak \(2005\)](#), the causality between a more democratic system and a lower economic volatility is also established, using different instruments. Some authors also show that the degree of democracy is negatively correlated with the volatility of both fiscal and trade policies (e.g., [Henisz 2004](#); [Dutt and Mobarak 2016](#)).<sup>3</sup> Instead of looking at the difference between democracies and nondemocracies, our paper examines variations among democratic institutions.

The strand of literature that addresses variations in volatility under a democracy is much smaller. Using state-level panel data from the U.S., [Akai et al. \(2009\)](#) show that fiscal decentralization reduces economic volatility. These authors suggest a mechanism of risk diversification. They note that in a more decentralized system, policies and performance across districts are, overall, more diverse than in a unitary system where the success or failure of policies rests on the central government. Our paper differs from this one not only in the empirics—where we examine cross-country variations—but also in the causal channel.

[Furceri et al. \(2016\)](#) provide cross-country evidence that fiscal decentralization leads to lower volatility in government consumption. They suggest a causal channel similar to that of [Akai et al. \(2009\)](#) and use a sample that includes both democracies and nondemocracies. While our findings share a similar negative relationship, we caution that the mechanism through which federalism (or fiscal decentralization) affects economic volatility is often sensitive to institutional details. [Wibbels \(2000\)](#) is an interesting case in point. Using data on 46 developing countries—and no developed countries—he shows that federations are associated with *more* volatility in economic policies related to budget deficits, inflation, and debts, as compared to unitary states. They argue that, as the governmental system becomes more federal, the central government’s retained capacity is weakened in terms of its ability to deal with the economic challenges an emerging economy faces, thereby leading to very different results.

Democratic governments are also different in aspects other than the federal-unitary dimension. For example, [Béjar and Mukherjee \(2011\)](#) study differences in electoral systems and show that, among democracies, countries with a system of proportional-representation experience less volatility in economic growth and fiscal policy than those with a majori-

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<sup>3</sup>It is not surprising that the results for both growth volatility and policy volatility go in the same direction, given the findings in the literature that policy volatility increases growth volatility. For example, [Ramey and Ramey \(1995\)](#) show such a relationship, using a large sample of developed and developing countries. [Jonsson and Klein \(1996\)](#) find that fluctuations in fiscal policy account for some key features in business cycles in Sweden. [Fatás and Mihov \(2003\)](#) also show that governments that use fiscal policy aggressively increase the volatility of economic growth.



tarian system of government. There is a large literature on political business cycles—see [Drazen \(2000\)](#) and the references therein—which claims, empirically and theoretically, that the economic volatility under a democracy is in part due to the electoral cycle itself (e.g., pre-electoral manipulation of monetary and fiscal policies). This literature, however, does not focus on a comparison *among* democracies.

In the theoretical literature, the papers most related to ours are [Alesina and Tabellini \(1990\)](#) and [Besley and Coate \(2003\)](#). [Alesina and Tabellini \(1990\)](#) study a dynamic model of government debt policy in which, as a result of electoral outcomes, policy-makers with different preferences alternate their time in office. The authors show that if the disagreement among the policy-makers is more pronounced, the equilibrium debt level is higher. [Besley and Coate \(2003\)](#) study the effect of decentralization on uncertainty in local public goods provision. They model decentralization as a system in which only subnational governments exist and centralization as a system in which only the central government exists. They show, among other results, that uncertainty in local public goods provision is smaller in a decentralized system. Our model is built upon theirs as we investigate an environment in which *both* central and subnational governments exist and play a role in policy-making; further, we model the federal and unitary systems as having different timing in the policy-making process.

## 2 Stylized Facts

In this section, we establish two stylized facts that motivate our theory: that federal systems are associated with both less economic volatility and less fiscal policy volatility. We also provide some robustness checks for these results.

The degree of federalism is central to establishing the stylized facts. Here, we use [Hooghe et al. \(2016\)](#)'s Regional Authority Index (RAI),<sup>4</sup> which measures the power a country's subnational governments exercise in two realms: (1) its authority over (regional) policy-making within their own territories, and (2) the authority it shares, over national policy-making, with other subnational government units. These two aspects, together, fit the way we model the interaction between central and subnational governments in the next section. Therefore, for the purpose of our paper, we interpret the RAI as a measure of the degree of federalism.

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<sup>4</sup>See the [Appendix](#) for details on the data sources used in this section.

It is worth noting that there is a subtle difference between regional authority and fiscal decentralization, the latter of which measures the extent of subnational revenues or expenditure relative to those of the central-government counterpart. While generally correlated with measures of regional authority, subnational revenues or expenditures do not necessarily imply the autonomy of subnational governments (see [Hooghe et al. 2016](#), ch.2, for more details). In Scandinavian countries, for example, the system is politically centralized but fiscally decentralized in that the central government determines the fiscal policy and the subnational governments merely implement them.

## 2.1 Findings

Figure 1 shows that, among democracies, having a higher degree of regional authority is associated with less volatility in economic growth, as measured by the standard deviation of growth rates of GDP per capita. This relationship is of economic importance because it shows that moving from the most unitary system to the most federal system would reduce the volatility of economic growth by over 0.03.

We next explore what might be the force behind the above negative relationship. We conjecture that federal systems are associated with less volatility in fiscal policy. Figure 2 plots the policy volatility (as measured by the standard deviation of government spending as a percentage of GDP) against the regional authority. The figure conforms with our conjecture. This finding is also economically important because it shows that moving from the most unitary system to the most federal system would reduce the volatility in fiscal policy by over 5% of GDP.

## 2.2 Robustness of Stylized Facts

First, we address the robustness of the negative relationship established in Figure 1. We run linear regressions on the volatility of economic growth against the fiscal authority of subnational governments, using five control variables: the level of economic development (measured by GDP per capita, PPP, log-scaled); the size of the economy (measured by GDP, PPP, log-scaled); the degree of trade openness (measured by trade as a percentage of GDP); the degree of democracy; and the size of the government (measured by government

spending as a percentage of GDP).<sup>5</sup> These controls are meant to address the concern that less volatility in economic growth may be due to a higher level of development, a larger economy, less openness to trade (hence, less vulnerability to shocks), more democratic institutions, or a larger government.

Table 1 reports all of the regression results. The coefficient of the regional authority is significant when the controls are applied separately.<sup>6</sup> In addition, a lower volatility in economic growth is associated with a higher level of development (see regression (2)), more democratic institutions (see regression (5)), or a larger government (see regression (6)).

Second, we address the robustness of the negative relationship established in Figure 2. Similar to the above, we run linear regressions on the volatility in fiscal policy against the subnational governments’ regional authority, while using the same set of control variables.

Table 2 reports all of the regression results. Here, the relationship, although still negative, is less pronounced on fiscal policy than the previous one on growth volatility. The coefficient of fiscal authority is significant with the level of development as the control variable but not otherwise. However, none of the control variables themselves are significant in the regressions.

### 3 Model

Motivated by the stylized facts, we establish a model that shows why federal systems might lead to less economic volatility. The model is built on that of centralized versus decentralized systems in Besley and Coate (2003), and we follow the standard modeling approach of (productive) infrastructure found in the macroeconomics literature (e.g., Agénor 2012).

#### 3.1 Households

The economy is divided into two geographic districts,  $i \in \{1, 2\}$ . Each district has a continuum of households<sup>7</sup> with a unit mass. Each household is identical within and across districts, and each derives utility  $u(c)$  from consumption  $c$ .

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<sup>5</sup>All of the control variables, except the degree of democracy, are obtained from the World Development Indicators, while the degree of democracy is from Polity IV.

<sup>6</sup>When the controls are applied altogether—a case that is omitted here—no variable is significant.

<sup>7</sup>Throughout the paper, we use the terms “households” and “citizens” interchangeably.

Table 1: Effect of Regional Authority on Volatility in Economic Growth

Dependent variable: standard deviation of GDP per capita growth.

	(1)	(2)	(3)	(4)	(5)	(6)
Regional Authority Index	-0.0009*** (-3.85)	-0.0008*** (-3.00)	-0.0006* (-1.80)	-0.0009*** (-3.59)	-0.0007*** (-2.96)	-0.0008*** (-3.20)
GDP per capita, PPP, log-scaled		-0.0057* (-1.78)				
GDP, PPP, log-scaled			-0.0030 (-1.62)			
Trade (% of GDP)				0.00001 (0.11)		
Degree of democracy					-0.0030** (-2.47)	
Size of government						-0.0005** (-2.31)
Constant	0.0458*** (14.5)	0.0997*** (3.28)	0.1201** (2.63)	0.0452*** (7.22)	0.0683*** (7.13)	0.0625*** (7.57)
observations	62	61	61	62	62	51
R-squared	0.198	0.280	0.274	0.198	0.274	0.281

*t* statistics in parentheses

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$

Table 2: Effect of Regional Authority on Volatility in Fiscal Policy.

Dependent variable: standard deviation of government spending (% of GDP).

	(1)	(2)	(3)	(4)	(5)	(6)
Regional Authority Index	-0.1466** (-2.38)	-0.1579** (-2.38)	0.1399 (0.98)	0.1359 (1.28)	0.1117 (1.13)	0.1499 (1.63)
GDP per capita, PPP, log-scaled		0.5796 (0.50)				
GDP, PPP, log-scaled			0.1224 (0.12)			
Trade (% of GDP)				-0.0104 (-0.36)		
Degree of democracy					0.8844 (1.23)	
Size of government						0.1397 (1.58)
Constant	6.8288*** (6.48)	1.0824 (0.09)	17.549 (0.67)	21.678*** (6.53)	13.143** (2.09)	14.826*** (3.71)
observations	30	30	30	30	30	30
R-squared	0.168	0.176	0.086	0.090	0.134	0.163

*t* statistics in parentheses

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$

Each household can supply one unit of labor and has  $x$  units of initial endowment of some final good. The representative household in district  $i$  faces budget constraint

$$c_i + k_i \leq x - \tau_i + r_i k_i + w_i, \quad (1)$$

where  $c_i$  and  $k_i$  represent the consumption and capital choices,  $\tau_i$  is a uniform lump-sum tax levied by the government,  $r_i$  is the rate of return to capital, and  $w_i$  is the wage rate.

Given the tax  $\tau_i$  and the factor prices  $r_i$  and  $w_i$ , each household maximizes utility  $u(c_i)$ , subject to (1). The first-order condition of the Lagrangian with respect to  $k_i$  is given by

$$r_i = 1. \quad (2)$$

### 3.2 Firms

Each district has a continuum of identical firms with a unit mass. The firms produce the final good, using local infrastructure, capital, and labor. The production function of an individual firm in district  $i$  takes the form

$$\tilde{y}_i = \left( A_i \frac{g_i}{k_i} \right)^\beta \tilde{k}_i^\alpha \tilde{l}_i^{1-\alpha}, \quad (3)$$

where  $g_i$  is the stock of local infrastructure in district  $i$ ;  $k_i$  is the (aggregate) capital stock in district  $i$ ;  $\tilde{k}_i$  and  $\tilde{l}_i$  are the firm-specific capital and labor; and  $A_i > 0$  parameterizes the productivity effect of the local infrastructure. The two districts are identical, except that the local infrastructure has a larger productivity effect in district 2 than in district 1, where  $A_2 > A_1$ .<sup>8</sup> We also assume that  $\alpha \in (0, 1)$  and  $\beta > 0$ .

Equation (3) implies that local infrastructure  $g_i$  is subject to *congestion*, which means its productivity effect in the use of capital stock  $k_i$  is diminishing. The example includes transportation systems, energy and water supply, etc. As will become clear later on, this setup ensures that, in equilibrium, the indirect utility of households as a function of the local infrastructure is strictly concave, and that the problem of finding the optimal level of provision is nontrivial.<sup>9</sup>

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<sup>8</sup> The difference between  $A_1$  and  $A_2$  represents, in practice, the heterogeneity among a country's different regions that is not captured by the simple setup of our model.

<sup>9</sup>More generally, one may assume that production takes the form  $\tilde{y}_i = \left( A_i \frac{g_i}{(k_i)^\gamma} \right)^\beta \tilde{k}_i^\alpha \tilde{l}_i^{1-\alpha}$ , where  $\gamma \geq 0$ .

Markets are competitive. Each firm’s problem is to maximize profits, taking as given the stocks of local infrastructure  $g_i$  and capital  $k_i$ , and the factor prices  $r_i$  and  $w_i$ :

$$\max_{\tilde{k}_i, \tilde{l}_i} \tilde{y}_i - r_i \tilde{k}_i - w_i \tilde{l}_i.$$

Given that firms are identical, in a symmetric equilibrium, the first-order conditions for the firms are given by the following:

$$r_i = \alpha \frac{y_i}{k_i}, \tag{4}$$

$$w_i = (1 - \alpha) y_i. \tag{5}$$

### 3.3 Policies

The governmental system has two layers: a central government and two district governments (one for each district).

The central government is able to provide the local infrastructure  $(g_1^c, g_2^c)$  for both districts 1 and 2. Spending is financed uniformly by taxing all citizens *across* the two districts  $((g_1^c + g_2^c) / 2$  per capita). In addition, each district government  $i$  is able to provide the local infrastructure  $g_i^d$  for its own district and this spending is financed uniformly by taxing all citizens *within* the district  $(g_i^d$  per capita).

Government units cannot issue bonds and, hence, must run a balanced budget. For each district  $i$ , the stock of local infrastructure and the amount of lump-sum tax satisfy two equalities, respectively:

$$g_i = g_i^c + g_i^d; \tag{6}$$

$$\tau_i = \frac{g_1^c + g_2^c}{2} + g_i^d. \tag{7}$$

Therefore, for each district, using central-government funds to finance the local infrastructure, if possible, is half as cheap as using district-government funds.

We use the vector  $(g_1^c, g_2^c; g_1^d, g_2^d)$  to denote a policy profile—the provision of local infrastructure across districts by all government unites. For convenience, we also refer to  $(g_1^c, g_2^c)$  as the “central policy” and each  $g_i^d$  as the “district policy.”

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Under such a setup, the households’ indirect utility function would be strictly concave if and only if  $\gamma > 1 - \frac{1-\alpha}{\beta}$ .

### 3.4 Politics

We model the political process, following the citizen-candidate approach. According to this approach, policy-makers are elected citizens who maximize their own utility, and voters elect candidates with the preferences most similar to theirs. In our model, in each district, citizens elect a single legislator from among themselves. Since citizens are homogeneous, the legislator is simply the representative household in the district. The legislator in district  $i$  will be in charge of the district government and decide the district policy  $g_i^d$ . The legislator will also be part of the central government and can affect the national policymaking.<sup>10</sup>

The central government consists of an assembly of the two legislators who come from the two districts, respectively. We model the policy-making process in the assembly following the minimum winning coalition approach in the studies of distributive politics (à la [Besley and Coate 2003](#)). The idea is that, under majority rule, a coalition of just more than half of the legislators could form and consequently be able to concentrate the central government's funds on projects in their home districts. In our setup, each of the two legislators constitutes a minimum winning coalition on their own, and there are two equally likely minimum winning coalitions—legislator 1 alone and legislator 2 alone. Each of the two legislators is selected, with probability  $\frac{1}{2}$ , of being in charge of the central government and choosing the central policy  $(g_1^c, g_2^c)$ .<sup>11</sup>

We study two governmental systems: federal and unitary. The two systems differ in the timing of policy-making between the central and district levels:

- In a *federal* system: (i) first, the assembly meets and selects one legislative member to choose the central policy, denoted by  $(g_1^{c,F}, g_2^{c,F})$ , for both districts; (ii) then, each legislator  $i$  simultaneously chooses the district policy, denoted by  $g_i^{d,F}$ , for their own district.
- In a *unitary* system: (i) first, each legislator  $i$  simultaneously chooses the district policy,  $g_i^{d,U}$ ; (ii) then, the assembly meets and selects one legislative member to choose the

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<sup>10</sup> As such, a legislator in our model merges two roles into one agent. While the distinction matters in practice—such as the different roles Senators and Representatives play in the US government—it is not important for our theoretical results.

<sup>11</sup> More generally, one may consider an assembly with  $N \geq 2$  legislators representing  $N$  districts. Any minimum winning coalition has a size of  $\lceil N/2 \rceil$  members. For any single legislator, the probability of being in a minimum winning coalition is given by  $\binom{N-1}{\lceil N/2 \rceil - 1} / \binom{N}{\lceil N/2 \rceil} = \frac{\lceil N/2 \rceil}{N}$ . We derive our main results using the simplest case: the two-member assembly.

central policy,  $(g_1^{c,U}, g_2^{c,U})$ .

The idea behind this formulation is that, in practice, the central government in a unitary state has the ultimate decision-making power. In federations, however, the constitution outlines the division of power between the two government levels and, for many federations, the subnational governments retain the residual powers. In the model, we formalize the holder of the ultimate power as the second mover in the inter-governmental interaction.

Since the policy-making process in the assembly faces uncertainty, the difference in timing between the two systems implies that, in a federal system, the district policies are *contingent* on which legislator is in charge of the assembly, while in a unitary system, the district policies must be made *before* the uncertainty in the assembly is resolved.

### 3.5 Timeline

For each governmental system, the events unfold according to the following timeline:

1. The central and district governments decide on the policy profile  $(g_1^c, g_2^c; g_1^d, g_2^d)$ .
2. In each district, the stock of the local infrastructure  $g_i$  and the lump-sum tax  $\tau_i$  are determined according to (6) and (7).
3. Households and firms make their individual decisions in competitive markets.

## 4 Policy Determination

In this section, we examine the policy determination in different governmental systems, using backward induction. The omitted proofs are relegated to the [Appendix](#).

### 4.1 Competitive Equilibrium

For each district  $i$ , given local infrastructure  $g_i$  and lump-sum tax  $\tau_i$ , the competitive equilibrium is characterized by the first-order conditions for households, (2), and firms, (4) and (5). In equilibrium, labor is equal to 1 and the capital stock is a function of local infrastructure:

$$k_i(g_i) = (\alpha)^{\frac{1}{1-\alpha+\beta}} (A_i g_i)^{\frac{\beta}{1-\alpha+\beta}}. \quad (8)$$



Since the production function has constant returns to scale in firm-specific inputs, each citizen's gross income,  $r_i k_i + w_i$ , is equal to the equilibrium output

$$y_i(g_i) = (\alpha)^{\frac{\alpha-\beta}{1-\alpha+\beta}} (A_i g_i)^{\frac{\beta}{1-\alpha+\beta}}, \quad (9)$$

which is also a function of the local infrastructure.

From each legislator  $i$ 's point of view, therefore, the local infrastructure and rate of return on capital as a pair  $(g_i, \tau_i)$  is associated with the indirect utility of the citizens in their district. This indirect utility function is given by the following:

$$\begin{aligned} v_i(g_i, \tau_i) &= x + y_i(g_i) - k_i(g_i) - \tau_i \\ &= x + m_i h(g_i) - \tau_i, \end{aligned}$$

where  $m_i \equiv \left( \alpha^{\frac{\alpha-\beta}{1-\alpha+\beta}} - \alpha^{\frac{1}{1-\alpha+\beta}} \right) (A_i)^{\frac{\beta}{1-\alpha+\beta}}$ ,  $h(g_i) \equiv (g_i)^{\frac{\beta}{1-\alpha+\beta}}$ , and the second equality uses (8) and (9).<sup>12</sup> Note that  $h$  is strictly concave, which is due to the presence of congestion in the use of the local infrastructure.

## 4.2 Policy Determination in a Federal System

In a federal system, the district policies are made after the central policy is decided on. By backward induction, we suppose that legislator  $i$  was in charge in the assembly and has formulated the central policy,  $(g_i^{c,F}, g_{-i}^{c,F})$ . In the second stage, legislator  $-i$  (who was not in charge) chooses the district policy,  $g_{-i}^{d,F}$ , to maximize her objective function as follows:

$$\begin{aligned} &v_{-i} \left( g_{-i}^{c,F} + g_{-i}^{d,F}, \frac{g_{-i}^{c,F} + g_i^{c,F}}{2} + g_{-i}^{d,F} \right) \\ &= x + m_i h \left( g_{-i}^{c,F} + g_{-i}^{d,F} \right) - \left( \frac{g_{-i}^{c,F} + g_i^{c,F}}{2} + g_{-i}^{d,F} \right). \end{aligned}$$

The optimal  $g_{-i}^{d,F}$  is obtained from the first-order condition:

$$m_i h' \left( g_{-i}^{c,F} + g_{-i}^{d,F} \right) - 1 = 0$$

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<sup>12</sup>We omit in the expression the utility function  $u(\cdot)$  for households since, from the point of view of the legislators, maximizing indirect utility is equivalent to maximizing equilibrium consumption.

That is, not being in charge in the first stage, legislator  $-i$  is now on their own in providing the local infrastructure. At the optimum, they will provide local infrastructure until the marginal return (proportional to  $h'$ ) on this infrastructure is equal to its marginal cost, 1. Since  $h'$  is strictly monotonic, its inverse exists and we can write the optimal  $g_{-i}^{d,F}$  as a function of  $g_{-i}^{c,F}$ :

$$g_{-i}^{d,F} \left( g_{-i}^{c,F} \right) = (h')^{-1} \left( \frac{1}{m_i} \right) - g_{-i}^{c,F}. \quad (10)$$

Turning to the selection of the legislator in the assembly, if legislator  $i$  is selected, they will decide on not only the central policy,  $(g_i^{c,F}, g_{-i}^{c,F})$ , but also the district policy,  $g_i^{d,F}$  later on. The problem the legislator in charge faces is, hence,

$$\begin{aligned} & \max_{g_i^{c,F}, g_{-i}^{c,F}; g_i^{d,F}} v_i \left( g_i^{c,F} + g_i^{d,F}, \frac{g_i^{c,F} + g_{-i}^{c,F}}{2} + g_i^{d,F} \right) \\ &= \max_{g_i^{c,F}, g_{-i}^{c,F}; g_i^{d,F}} \left\{ x + m_i h \left( g_i^{c,F} + g_i^{d,F} \right) - \left( \frac{g_i^{c,F} + g_{-i}^{c,F}}{2} + g_i^{d,F} \right) \right\}. \end{aligned}$$

Two implications are immediate from the maximization problem: (i) it is optimal to set  $g_{-i}^{c,F} = 0$  because citizens in district  $i$  derive no utility from the local infrastructure provided in district  $-i$ ; (ii) it is optimal to set  $g_i^{d,F} = 0$  because, from the point of view of citizens in district  $i$ , it is always *half* as cheap to provide local infrastructure using central-government funds, as compared to using district-government funds. Therefore, the problem for legislator  $i$  is simplified to the following:

$$\max_{g_i^{c,F}} \left\{ x + m_i h \left( g_i^{c,F} \right) - \frac{g_i^{c,F}}{2} \right\}$$

and the solution is given by the first-order condition, as follows:

$$m_i h' \left( g_i^{c,F} \right) - \frac{1}{2} = 0 \Leftrightarrow g_i^{c,F} = (h')^{-1} \left( \frac{1}{2m_i} \right). \quad (11)$$

By (10) and (11), we establish the policy determination in a federal system as follows:

**Proposition 1.** *In a federal system, the equilibrium central policy is*

$$\begin{aligned} g_i^{c,F*}(i) &= (h')^{-1} \left( \frac{1}{2m_i} \right), \\ g_i^{c,F*}(-i) &= 0, \end{aligned}$$

*while the equilibrium district policy is*

$$\begin{aligned} g_i^{d,F*}(i) &= 0, \\ g_i^{d,F*}(-i) &= (h')^{-1} \left( \frac{1}{m_i} \right), \end{aligned}$$

where  $i \in \{1, 2\}$ , and the arguments of functions  $g_i^{c,F*}$  and  $g_i^{d,F*}$  specify the identity of the legislator in charge.

First, Proposition 1 shows that whichever legislator is in charge in the assembly will provide a large amount  $(h')^{-1} \left( \frac{1}{2m_i} \right)$  of local infrastructure to their own district. Moreover, this amount is financed solely by central-government funds. In other words, the central policy is skewed toward the winning legislator.

The proposition also shows that the district policy is contingent on the identity of the legislator in charge. In particular, the losing legislator will provide some amount  $(h')^{-1} \left( \frac{1}{m_i} \right)$  of local infrastructure, by using their district-government funds. This decision is made in response to *the lack of* infrastructure provision that occurred when the other legislator was in charge of the central policy. Therefore, as the second-mover in the game, district governments mitigate the skewness of central policy, to some extent.

### 4.3 Policy Determination in a Unitary System

In a unitary system, the district policies are made *before* the central policy is determined. Working backwards again, we suppose that the respective legislators have already decided on the district policies,  $(g_1^{d,U}, g_2^{d,U})$ . In the assembly, each legislator is selected with probability

1/2 to decide the central policy. If in charge, the objective of legislator  $i$  is to maximize

$$\begin{aligned} & v_i \left( g_i^{c,U} + g_i^{d,U}, \frac{g_i^{c,U} + g_{-i}^{c,U}}{2} + g_i^{d,U} \right) \\ &= x + m_i h \left( g_i^{c,U} + g_i^{d,U} \right) - \left( \frac{g_i^{c,U} + g_{-i}^{c,U}}{2} + g_i^{d,U} \right) \end{aligned}$$

by choosing  $g_i^{c,U}$  and  $g_{-i}^{c,U}$ . Since citizens in district  $i$  derive no utility from the local infrastructure provided to district  $-i$ , it is optimal for legislator  $i$  to set  $g_{-i}^{c,U} = 0$ . Furthermore, the optimal  $g_i^{c,U}$ , as a function of  $g_i^{d,U}$ , is given by the first-order condition as follows:

$$m_i h' \left( g_i^{c,U} + g_i^{d,U} \right) - \frac{1}{2} = 0 \Leftrightarrow g_i^{c,U} \left( g_i^{d,U} \right) = (h')^{-1} \left( \frac{1}{2m_i} \right) - g_i^{d,U}. \quad (12)$$

Thus, legislator  $i$  provides local infrastructure to (and only to) their own district, until the marginal return is equal to the marginal cost,  $\frac{1}{2}$ . As in a federal system, doing so is half as cheap as it is when using district-government funds.

Turning to the determination of district policies in the first stage, note that the two legislators are equally likely to be selected in the assembly later on. When deciding the district policy, therefore, each legislator  $i$ 's objective is to maximize the expected utility as follows:

$$\begin{aligned} \max_{g_i^{d,U}} \frac{1}{2} & \left\{ v_i \left( g_i^{c,U} \left( g_i^{d,U} \right) + g_i^{d,U}, \frac{g_i^{c,U} \left( g_i^{d,U} \right)}{2} + g_i^{d,U} \right) \right. \\ & \left. + v_i \left( 0 + g_i^{d,U}, \frac{g_{-i}^{c,U} \left( g_{-i}^{d,U} \right)}{2} + g_i^{d,U} \right) \right\}, \end{aligned}$$

where the first part inside the parenthesis corresponds to the scenario of being in charge in the assembly. By substituting (12) into the objective, we derive from the first-order condition the optimal  $g_i^{d,U}$  as follows:

$$-\frac{3}{2} + m_i h' \left( g_i^{d,U} \right) = 0 \Leftrightarrow g_i^{d,U} = (h')^{-1} \left( \frac{3}{2m_i} \right). \quad (13)$$

Here, by (12) and (13), we establish the policy determination within a unitary system.

**Proposition 2.** *In a unitary system, the equilibrium district policy is*

$$g_i^{d,U^*} = (h')^{-1} \left( \frac{3}{2m_i} \right),$$

*while the equilibrium central policy is*

$$\begin{aligned} g_i^{c,U^*}(i) &= (h')^{-1} \left( \frac{1}{2m_i} \right) - (h')^{-1} \left( \frac{3}{2m_i} \right), \\ g_i^{c,U^*}(-i) &= 0, \end{aligned}$$

*where  $i \in \{1, 2\}$ , and the argument of function  $g_i^{c,U^*}$  specifies the identity of the legislator in charge.*

Proposition 2 shows that, first, the legislator in charge (say,  $i$ ) will provide a large amount of the *total* stock of the local infrastructure  $g_i^{c,U^*}(i) + g_i^{d,U^*} = (h')^{-1} \left( \frac{1}{2m_i} \right)$ , which is jointly financed by central- and district-government funds. The central policy is still skewed toward the winning legislator, as it is in a federal system.

Second, note that the district policy in a unitary system must be made *before* the uncertainty in the assembly's policy-making is resolved. Therefore, for each legislator (say,  $i$ ), the district policy  $g_i^{d,U^*}$  partially mitigates the skewness of the central policy, but only if the other legislator,  $-i$ , turns out to win the control of the assembly. If the legislator in charge is  $i$  themselves, then the earlier provision  $g_i^{d,U^*}$  will be a waste of money because the infrastructure could have been financed solely by central-government funds.

## 5 Comparing Governmental Systems

In the previous section we showed that the policy-making process in the assembly generates uncertainty in the equilibrium policy for both governmental systems. In what follows, we compare the *magnitude* of uncertainty in both policy and output across the two systems.

First, we examine the policy uncertainty. For each governmental system (say, a federal system), we are interested in the uncertainty in three policy variables: (i) the stock of local infrastructure that exists in each of the two districts,  $i$ , i.e.,

$$g_i^{F^*}(\cdot) \equiv g_i^{c,F^*}(\cdot) + g_i^{d,F^*}(\cdot);$$

(ii) the stock of local infrastructure *in the entire economy*, i.e.,

$$g^{F*}(\cdot) \equiv g_1^{F*}(\cdot) + g_2^{F*}(\cdot).$$

All three are random variables that are dependent on which legislator is in charge of the assembly. We measure the magnitude of policy uncertainty by the range of values each of the three random variables could take when there is political turnover; i.e., the identity of the winning legislator changes. For example, the magnitude of policy uncertainty for district  $i$  is given by the absolute value  $|g_i^{F*}(i) - g_i^{F*}(-i)|$ . The three policy variables in a unitary system are defined in the same way.

The following proposition is this paper's first main result. It establishes that, for any of the three variables, the policy uncertainty is smaller in a federal system.

**Proposition 3.** *The uncertainty in the provision of local infrastructure, nationally or sub-nationally, is smaller in a federal system than in a unitary system. Formally,*

$$|g^{F*}(i) - g^{F*}(-i)| < |g^{U*}(i) - g^{U*}(-i)|,$$

and, for each  $i \in \{1, 2\}$ ,

$$|g_i^{F*}(i) - g_i^{F*}(-i)| < |g_i^{U*}(i) - g_i^{U*}(-i)|.$$

The part of the result related to subnational policies delivers the following intuition: For each district  $i$ , the stock of local infrastructure attains two possible values. The higher value corresponds to the case of which legislator is in charge, and the total provision is a large amount  $(h')^{-1} \left( \frac{1}{2m_i} \right)$  regardless of the governmental system. The lower value, however, is dependent on the governmental system. Compared to a federal system, legislators in a unitary system are *optimistic* when they decide their district policies because the uncertainty about who will be in charge is not yet resolved and they are both likely to win. This optimism, in turn, will result in the *under*-provision of infrastructure if, when the uncertainty is resolved, the legislator turns out to lose the contest in the assembly. The possibility of under-provision, therefore, leads to a larger magnitude of policy uncertainty in the district.

In addition, the first part of the proposition amounts to showing that the above intuition also holds up when we look at the policy uncertainty at the national level. Therefore, the policy for the entire economy is less uncertain in a federal system than in a unitary system.

If we interpret the policy uncertainty in the model as *the policy volatility* we see in the data, then this result matches the second stylized fact.

Next, we study how policy uncertainty affects output uncertainty. Similar to the above, for a federal system we define three output variables: (i) the output in each district  $i$ , i.e.,  $y_i(g_i^{F^*}(\cdot))$ , where the output function  $y_i$  is given by (9); and (ii) the output *in the economy*, i.e.,

$$y^{F^*}(\cdot) \equiv y_i(g_i^{F^*}(\cdot)) + y_{-i}(g_{-i}^{F^*}(\cdot)).$$

The counterpart for a unitary system is similarly defined.

Analogous to Proposition 3, the second main result of the paper shows that the output uncertainty, for any of the three variables, is also smaller in a federal system, which leads us to our next proposition:

**Proposition 4.** *The uncertainty in output, nationally or subnationally, is smaller in a federal system than in a unitary one. Formally,*

$$|y^{F^*}(i) - y^{F^*}(-i)| < |y^{U^*}(i) - y^{U^*}(-i)|,$$

and, for each  $i \in \{1, 2\}$ ,

$$|y_i(g_i^{F^*}(i)) - y_i(g_i^{F^*}(-i))| < |y_i(g_i^{U^*}(i)) - y_i(g_i^{U^*}(-i))|.$$

Proposition 4 can be understood as a direct consequence of Proposition 3. For each district  $i$ , given any equilibrium stock of local infrastructure  $g_i$ , the equilibrium output  $y_i$  is as given in equation (9):

$$y_i(g_i) = (\alpha)^{\frac{\alpha-\beta}{1-\alpha+\beta}} (A_i g_i)^{\frac{\beta}{1-\alpha+\beta}},$$

which is an increasing function of  $g_i$ . Proposition 4 shows that, given the model's simple economic environment, the uncertainty in policy  $g_i$  is directly passed on to the uncertainty in output  $y_i$ . Again, with the interpretation of output uncertainty in the model as *growth volatility* in the data, this result also matches the first stylized fact.

## 6 Concluding Remarks

This paper contributes to a less explored literature on the relationship between governmental systems (federal versus unitary) and economic volatility in democracies. Two stylized facts

are established: both economic growth and fiscal policy are less volatile in a more federal system than in a more unitary one. We have developed a theory to match these facts. In our theory, the central government's stipulated policy is more volatile because, in this system, it is more uncertain as to who assumes power compared to the situation in district governments. In a federal system, fiscal policy is less volatile because district governments have more power to overcome the volatility in central government policy-making. Lastly, policy volatility leads to growth volatility because fiscal policy affects the provision of infrastructure which has a productive effect on final output.

The current analysis is more than just positive; it also has interesting implications for institutional design. Our result suggests that, when we consider whether a governmental system should be federal or unitary, in addition to factors that have already been suggested in previous literature (e.g., externality versus diversity considerations), we need to take into account that a unitary system might lead to more economic volatility. Alternatively, when a unitary state devolves into a federation, our theory suggests that volatile economic condition might be a contributing factor.

Some extensions of the paper are worth pursuing further. For example, this paper focuses on democratic countries; it would be interesting to extend both the empirical and theoretical exploration to nondemocratic countries. Furthermore, the current analysis uses a static model for tractability reasons, but the analysis could be extended to a fully dynamic version. We leave these extensions to future work.



# Appendix

## A.1 Data Sources

### List of Democracies

We use the democracy indicator in the Polity IV database (on a scale from 0 to 10). The indicator measures the extent to which (1) political participation is competitive (2) executive recruitment is open and competitive, and (3) constraints on the chief executive are stringent.<sup>13</sup> We include a country as a democracy in the sample if its democracy indicator was at least 5 for at least 15 years during the period 1990-2013.

The full list of democracies for which the RAI data are also available is as follows: Albania, Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, El Salvador, Estonia, Finland, France, Germany, Greece, Guatemala, Guyana, Honduras, Hungary, Ireland, Israel, Italy, Jamaica, Japan, Latvia, Lithuania, Luxembourg, Macedonia, Malaysia, the Netherlands, New Zealand, Nicaragua, Norway, Panama, Paraguay, Peru, the Philippines, Poland, Portugal, the Republic of Korea, Romania, the Slovak Republic, Slovenia, Spain, Suriname, Sweden, Switzerland, Thailand, Trinidad and Tobago, Turkey, the United Kingdom, the United States, Uruguay, and Venezuela.

### Regional Authority

The Regional Authority Index is obtained from [Hooghe et al. \(2016\)](#), which has annual data from 1950 to 2010 for 81 countries. The majority of these countries are considered democracies, according to the aforementioned criterion. Figures 1 and 2 use data averaged over the period 1981-2010.

### Volatility of Economic Growth

The data for growth volatility are based on the World Bank's World Development Indicators database. In Figure 1, for each country, we calculate the standard deviation of the growth rate of GDP per capita over the period 1981-2010.

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<sup>13</sup>The database provides an autocracy indicator and also a combined measure, the polity score, which is derived by subtracting the autocracy indicator from the democracy indicator. Using the polity score as an alternative measure yields the same qualitative results.

## Volatility of Fiscal Policy

The data for fiscal policy volatility are based on the IMF's Government Finance Statistics database. In Figure 2, for each country, we calculate the standard deviation of government spending (as a percentage of GDP) over the period 1981-2010.

## A.2 Omitted Proofs

### A.2.1 Proof of Proposition 3

Part 1: First, we show inequality  $|g^{F^*}(i) - g^{F^*}(-i)| < |g^{U^*}(i) - g^{U^*}(-i)|$ . Using Propositions 1 and 2, we rewrite  $g^{F^*}(i)$  and  $g^{U^*}(i)$  as

$$\begin{aligned} g^{F^*}(i) &= (h')^{-1} \left( \frac{1}{2m_i} \right) + (h')^{-1} \left( \frac{1}{m_{-i}} \right), \\ g^{U^*}(i) &= (h')^{-1} \left( \frac{1}{2m_i} \right) + (h')^{-1} \left( \frac{3}{2m_{-i}} \right). \end{aligned}$$

For a federal system, the magnitude of policy uncertainty is given by the following

$$\begin{aligned} & |g^{F^*}(i) - g^{F^*}(-i)| \\ &= \left| \left[ (h')^{-1} \left( \frac{1}{2m_i} \right) + (h')^{-1} \left( \frac{1}{m_{-i}} \right) \right] - \left[ (h')^{-1} \left( \frac{1}{2m_{-i}} \right) + (h')^{-1} \left( \frac{1}{m_i} \right) \right] \right| \\ &= \left| \left[ (h')^{-1} \left( \frac{1}{2m_i} \right) - (h')^{-1} \left( \frac{1}{2m_{-i}} \right) \right] - \left[ (h')^{-1} \left( \frac{1}{m_i} \right) - (h')^{-1} \left( \frac{1}{m_{-i}} \right) \right] \right|, \end{aligned}$$

where the second equality follows by rearranging the terms. Similarly, the magnitude of policy uncertainty in a unitary system is given by the following

$$\begin{aligned} & |g^{U^*}(i) - g^{U^*}(-i)| \\ &= \left| \left[ (h')^{-1} \left( \frac{1}{2m_i} \right) + (h')^{-1} \left( \frac{3}{2m_{-i}} \right) \right] - \left[ (h')^{-1} \left( \frac{1}{2m_{-i}} \right) + (h')^{-1} \left( \frac{3}{2m_i} \right) \right] \right| \\ &= \left| \left[ (h')^{-1} \left( \frac{1}{2m_i} \right) - (h')^{-1} \left( \frac{1}{2m_{-i}} \right) \right] - \left[ (h')^{-1} \left( \frac{3}{2m_i} \right) - (h')^{-1} \left( \frac{3}{2m_{-i}} \right) \right] \right|. \end{aligned}$$

To compare the two magnitudes, we first claim that, for any  $z > 0$ ,  $(h')^{-1}(z)$  is positive and strictly decreasing. This is because

$$h'(g) = \frac{\beta}{1 - \alpha + \beta} g^{-\frac{1-\alpha}{1-\alpha+\beta}} \Leftrightarrow (h')^{-1}(z) = \left( \frac{1 - \alpha + \beta}{\beta} z \right)^{-\frac{1-\alpha+\beta}{1-\alpha}}.$$

Next, we define for any  $t_2 > t_1 > 0$  a new function as follows

$$H(z; t_1, t_2) \equiv (h')^{-1}(t_1 z) - (h')^{-1}(t_2 z).$$

We claim that (i)  $H(z; t_1, t_2)$  is positive, which is due to  $(h')^{-1}$  being strictly decreasing; and (ii)  $H(z; t_1, t_2)$  is strictly decreasing in  $z$ , because

$$\begin{aligned} & \frac{\partial H}{\partial z}(z; t_1, t_2) \\ = & -\frac{1 - \alpha + \beta}{1 - \alpha} \left( \frac{1 - \alpha + \beta}{\beta} \right)^{-\frac{1-\alpha+\beta}{1-\alpha}} z^{-\frac{1-\alpha+\beta}{1-\alpha}-1} \left[ (t_1)^{-\frac{1-\alpha+\beta}{1-\alpha}} - (t_2)^{-\frac{1-\alpha+\beta}{1-\alpha}} \right] < 0, \end{aligned}$$

where the inequality is due to  $(t_1)^{-\frac{1-\alpha+\beta}{1-\alpha}} > (t_2)^{-\frac{1-\alpha+\beta}{1-\alpha}}$ . Therefore, we can rewrite the two magnitudes as follows

$$\begin{aligned} |g^{F^*}(i) - g^{F^*}(-i)| &= H\left(\frac{1}{2}; \frac{1}{m_2}, \frac{1}{m_1}\right) - H\left(1; \frac{1}{m_2}, \frac{1}{m_1}\right), \\ |g^{U^*}(i) - g^{U^*}(-i)| &= H\left(\frac{1}{2}; \frac{1}{m_2}, \frac{1}{m_1}\right) - H\left(\frac{3}{2}; \frac{1}{m_2}, \frac{1}{m_1}\right), \end{aligned}$$

where the notation for the absolute value is removed due to  $m_2 > m_1$  and  $H$  being strictly decreasing. It immediately follows that  $|g^{F^*}(i) - g^{F^*}(-i)| < |g^{U^*}(i) - g^{U^*}(-i)|$  if and only if

$$H\left(\frac{3}{2}; \frac{1}{m_2}, \frac{1}{m_1}\right) < H\left(1; \frac{1}{m_2}, \frac{1}{m_1}\right)$$

which holds because  $H$  is strictly decreasing.

Parts 2: In a federal system, the magnitude of policy uncertainty in district  $i$  is rewritten as follows:

$$\begin{aligned} |g_i^{F^*}(i) - g_i^{F^*}(-i)| &= \left| (h')^{-1}\left(\frac{1}{2m_i}\right) - (h')^{-1}\left(\frac{1}{m_i}\right) \right| \\ &= (h')^{-1}\left(\frac{1}{2m_i}\right) - (h')^{-1}\left(\frac{1}{m_i}\right), \end{aligned}$$

where the absolute value notation is removed due to  $(h')^{-1}$  being strictly decreasing. Similarly, the magnitude of policy uncertainty in a unitary system is given by the following:

$$\begin{aligned} |g_i^{U^*}(i) - g_i^{U^*}(-i)| &= \left| (h')^{-1} \left( \frac{1}{2m_i} \right) - (h')^{-1} \left( \frac{3}{2m_i} \right) \right| \\ &= (h')^{-1} \left( \frac{1}{2m_i} \right) - (h')^{-1} \left( \frac{3}{2m_i} \right). \end{aligned}$$

It follows that  $|g_i^{F^*}(i) - g_i^{F^*}(-i)| < |g_i^{U^*}(i) - g_i^{U^*}(-i)|$  if and only if

$$(h')^{-1} \left( \frac{3}{2m_i} \right) < (h')^{-1} \left( \frac{1}{m_i} \right)$$

which, in turn, holds because  $(h')^{-1}$  is strictly decreasing. *Q.E.D.*

## A.2.2 Proof of Proposition 4

Part 1: We first show inequality  $|y^{F^*}(i) - y^{F^*}(-i)| < |y^{U^*}(i) - y^{U^*}(-i)|$ . Using Propositions 1 and 2, we rewrite  $y^{F^*}(i)$  and  $y^{U^*}(i)$  as follows:

$$\begin{aligned} y^{F^*}(i) &= y_i \left( g_i^{c,F^*}(i) + g_i^{d,F^*}(i) \right) + y_{-i} \left( g_{-i}^{c,F^*}(i) + g_{-i}^{d,F^*}(i) \right) \\ &= y_i \left( (h')^{-1} \left( \frac{1}{2m_i} \right) \right) + y_{-i} \left( (h')^{-1} \left( \frac{1}{m_{-i}} \right) \right), \\ y^{U^*}(i) &= y_i \left( g_i^{c,U^*}(i) + g_i^{d,U^*}(i) \right) + y_{-i} \left( g_{-i}^{c,U^*}(i) + g_{-i}^{d,U^*}(i) \right) \\ &= y_i \left( (h')^{-1} \left( \frac{1}{2m_i} \right) \right) + y_{-i} \left( (h')^{-1} \left( \frac{3}{2m_{-i}} \right) \right). \end{aligned}$$

By (9) and the functional form of  $(h')^{-1}$  (derived in the proof of Proposition 3), we derive the expression of  $y^{F^*}(i)$  as follows:

$$\begin{aligned} y^{F^*}(i) &= \alpha^{\frac{\alpha-\beta}{1-\alpha+\beta}} \left( A_i (h')^{-1} \left( \frac{1}{2m_i} \right) \right)^{\frac{\beta}{1-\alpha+\beta}} + \alpha^{\frac{\alpha-\beta}{1-\alpha+\beta}} \left( A_{-i} (h')^{-1} \left( \frac{1}{m_{-i}} \right) \right)^{\frac{\beta}{1-\alpha+\beta}} \\ &= \alpha^{\frac{\alpha-\beta}{1-\alpha+\beta}} \left( \frac{1-\alpha+\beta}{\beta} \right)^{-\frac{\beta}{1-\alpha}} \left[ \left( A_i (2m_i)^{\frac{1-\alpha+\beta}{1-\alpha}} \right)^{\frac{\beta}{1-\alpha+\beta}} + \left( A_{-i} (m_{-i})^{\frac{1-\alpha+\beta}{1-\alpha}} \right)^{\frac{\beta}{1-\alpha+\beta}} \right] \\ &= \Gamma \times \left[ (2A_i)^{\frac{\beta}{1-\alpha}} + (A_{-i})^{\frac{\beta}{1-\alpha}} \right], \end{aligned}$$

where  $\Gamma \equiv \alpha^{\frac{\alpha-\beta}{1-\alpha+\beta}} \left(\frac{1-\alpha+\beta}{\beta}\right)^{-\frac{\beta}{1-\alpha}} \left(\alpha^{\frac{\alpha-\beta}{1-\alpha+\beta}} - \alpha^{\frac{1}{1-\alpha+\beta}}\right)^{\frac{\beta}{1-\alpha}}$  is a constant. Therefore, the magnitude of output uncertainty in a federal system is given by the following:

$$\begin{aligned} & |y^{F^*}(i) - y^{F^*}(-i)| \\ &= \Gamma \times \left| \left[ (2A_i)^{\frac{\beta}{1-\alpha}} + (A_{-i})^{\frac{\beta}{1-\alpha}} \right] - \left[ (2A_{-i})^{\frac{\beta}{1-\alpha}} + (A_i)^{\frac{\beta}{1-\alpha}} \right] \right| \\ &= \Gamma \times \left( 2^{\frac{\beta}{1-\alpha}} - 1 \right) \times \left| (A_i)^{\frac{\beta}{1-\alpha}} - (A_{-i})^{\frac{\beta}{1-\alpha}} \right|. \end{aligned}$$

Similarly, we derive  $y^{U^*}(i) = \Gamma \times \left[ (2A_i)^{\frac{\beta}{1-\alpha}} + \left(\frac{2}{3}A_{-i}\right)^{\frac{\beta}{1-\alpha}} \right]$ , and the magnitude of output uncertainty in a unitary system is given by the following:

$$|y^{U^*}(i) - y^{U^*}(-i)| = \Gamma \times \left( 2^{\frac{\beta}{1-\alpha}} - \left(\frac{2}{3}\right)^{\frac{\beta}{1-\alpha}} \right) \times \left| (A_i)^{\frac{\beta}{1-\alpha}} - (A_{-i})^{\frac{\beta}{1-\alpha}} \right|.$$

It immediately follows that  $|y^{F^*}(i) - y^{F^*}(-i)| < |y^{U^*}(i) - y^{U^*}(-i)|$ .

Part 2: Similar to Part 1, for each district  $i$ , we rewrite and simplify the magnitude of output uncertainty as follows:

$$\begin{aligned} |y_i(g_i^{F^*}(i)) - y_i(g_i^{F^*}(-i))| &= \left| y_i \left( (h')^{-1} \left( \frac{1}{2m_i} \right) \right) - y_i \left( (h')^{-1} \left( \frac{1}{m_i} \right) \right) \right| \\ &= \Gamma \times \left( 2^{\frac{\beta}{1-\alpha}} - 1 \right) \times (A_i)^{\frac{\beta}{1-\alpha}} \end{aligned}$$

for a federal system, and

$$\begin{aligned} |y_i(g_i^{U^*}(i)) - y_i(g_i^{U^*}(-i))| &= \left| y_i \left( (h')^{-1} \left( \frac{1}{2m_i} \right) \right) - y_i \left( (h')^{-1} \left( \frac{3}{2m_i} \right) \right) \right| \\ &= \Gamma \times \left( 2^{\frac{\beta}{1-\alpha}} - \left(\frac{2}{3}\right)^{\frac{\beta}{1-\alpha}} \right) \times (A_i)^{\frac{\beta}{1-\alpha}} \end{aligned}$$

for a unitary system. It follows that  $|y_i(g_i^{F^*}(i)) - y_i(g_i^{F^*}(-i))| < |y_i(g_i^{U^*}(i)) - y_i(g_i^{U^*}(-i))|$ .  
*Q.E.D.*

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