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Theory and Quasi-Experimental Evidence

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Abstract

In this paper, we take a step towards understanding the role of democratic institutions on the level of pollution taxation. The theory predicts that presidential-congressional regimes set lower pollution taxes than parliamentary regimes. This results from the checks and balances built into the former, and the higher degree of legislative cohesion in the latter. We test the prediction using the method of propensity score matching along with data on gasoline prices from 86 democratic countries. The empirical evidence is consonant with the theory: we find that ceteris paribus the average price of super gasoline is \$0.14 – \$0.20 less per liter in presidential-congressional systems; the average price of diesel gasoline is \$0.11 – \$0.14 less per liter.

Key words: Government Regimes, Taxation, Propensity Score Matching
JEL **classifications:** Q28, D7, H1

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I. Introduction

Positive theories of environmental policy seek to explain policy outcomes using a variety of

models of voting and lobby groups (see Oates and Portney (2001) for a recent survey).[1]

However, to our knowledge, this literature continues to ignore the role of constitutional

arrangements.[2] In this paper, we ask how underlying political institutions influence legislative

decisions concerning the taxation of environmental externalities. In particular, does the presence

of a presidential, as opposed to parliamentary, regime affect pollution taxes in democracies?

Perhaps the most common form of taxation utilized around the globe to influence the

level of environmental externalities is gasoline taxes. However, tax differentials across

countries, especially for gasoline, are quite substantial. For example, in Venezuela, the average

price of super gasoline was $0.17 per liter in year 2000, whereas in Norway and Uruguay the

price was $1.19 per liter. In the United States, the same liter of super gasoline costs $0.47, while

the price was $1.17 per liter in the United Kingdom.[3] What role do political institutions play in

explaining this substantial variation?

While the main contribution of this paper is empirical, we motivate the empirics through

a straightforward application of the theoretical model in Persson, Roland, and Tabellini (PRT)

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[1] Examples include Oates and Schwab (1988), Aidt (1998), Goel and Nelson (1999), Brett and Keen (2000), Marsiliani and Renström (2000), Damania (2001), and Siqueira (2003).

[2] There is a large and rapidly growing literature on the effects of constitutions on other economic policy outcomes, however. For example, North and Weingast (1989), Roubini and Sachs (1989), Keefer and Knack (1997) study the effects of checks and balances and executive constraints on economic development, and Bennedsen and Feldmann (2002) and Helpman and Persson (2002) discuss the effect of presidential and parliamentary systems on lobbying behavior by special interest groups. Persson and Tabellini (PT) (1999), Austen-Smith (2000), Lizzeri and Persico (2001), and and Milesi-Ferretti et al. (2002) analyze the impact of majoritarian, proportional, and other types of electoral rules on public good provision and redistribution. See also Haggard and McCubbins (2000) and PT (2002b).

[3] While the figures represent differences in *prices*, not *taxes*, the correlation between prices and tax rates for both gasoline and diesel fuel are extremely high as the non-tax component of gas prices is fairly constant across countries for which explicit data on gas tax rates are available (see OECD/IEA 2000, Figs. 16 and 18, pp. 29 and 31; available at http://www.iea.org/books/countries/2000/comp2000.pdf as of January 2003). The constancy of net-of-tax gas prices across countries for both commodities is attributable to the fact that oil is traded internationally at the world

(2000) to the case of pollution taxes.[4] The model contrasts pollution taxes in presidential-congressional (hereafter, PC) and parliamentary systems, in the presence of an (exogenous) income tax. In each of the two regimes, a legislature determines the level of pollution taxation, the level of publicly funded environmental clean-up expenditures, revenue redistribution amongst districts, and rents claimed by politicians. This extension of the PRT (2000) model contains three aspects that, to our knowledge, have not heretofore been integrated into a cohesive positive model of *environmental* policymaking: (i) a legislature comprised of self-interested politicians, (ii) the delegation of political decisions to a handful of representatives (i.e., the absence of direct democracy), and (iii) a lack of commitment by politicians to their election promises (as there is no outside enforcement of the environmental policy proposals made by politicians prior to election). This creates an agency problem between voters and politicians.[5]

The model allows politicians from both regimes to capture pollution (and income) tax revenues for their own consumption. However, politicians may disagree about the allocation of these rents, either because they represent constituencies with opposing interests, or because they have divergent personal interests. In either case, since political constitutions are incomplete contracts, such conflicts are resolved differently under the two governmental systems. Two attributes of each system are crucial for determining the level of environmental taxation in our extended model of PRT (2000): (i) the degree of *separation of powers* and (ii) the level of *legislative cohesion*. Separation of powers, in the current context, is created by constitutional rules that empower different politicians with the power to (a) propose a pollution tax rate, (b)

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price and is a homogenous good. Moreover, in practice tariffs on gasoline do not seem common. We will return to this point again in Section IV.

[4] PRT (2000) contains components from Ferejohn (1986), Baron and Ferejohn (1989), PRT (1997), and Diermeier and Feddersen (1998).

[5] Special interest lobbying is an important feature omitted from the model in PRT (2000). Incorporating informational lobbying (as in Bennedsen and Feldmann, 2000) into an institutional model of environmental policy

propose an allocation of the resultant tax revenues, and (c) veto legislation. This system of checks and balances creates conflicts of interest between politicians that can be used by voters to reduce the agency problem. Legislative cohesion refers to disciplined voting by members of a legislative majority in order to avoid the disintegration of a coalition. Constitutional rules outlining the procedures to be followed after the dissolution of the government are important factors affecting the degree of legislative cohesion (see Lupia and Strom, 1995; Baron, 1998; Diermeier and Feddersen, 1998; Diermeier and Merlo, 2000).

In PC systems, direct election of the executive and the legislature creates accountability to the voters. This regime entails greater separation of powers and less legislative cohesion than parliamentary regimes. In PC regimes, the power to set agendas are often held by congressional committees established to oversee specific policy arenas, such as taxation and spending. The separation of powers within the legislature creates variation in legislative majorities from one issue to another, and no stable majority coalition is needed for the executive (PRT, 2000).

In contrast, the executive under a parliamentary system requires the support of a legislative majority. Government ministers have agenda-setting rights until a no confidence vote dissolves the government. The existence of such votes limits the coalition members' bargaining power since dissolution of the government risks the loss of the incumbent politicians' agenda-setting rights, thus acting as a disciplining mechanism (Diermeier and Feddersen, 1998).

The theoretical model yields the following prediction: the pollution tax rate is lower in PC regimes, conditional on the income tax.[6] While voters in both regimes have an incentive to limit the tax rate, and thereby limit the rents going to politicians as well as the level of inter-district redistribution, the separation of powers within PC regimes enables voters to discipline

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determination appears to be a fruitful topic for future research. See, for example, Aidt (1998) and Damania (2001) for models of lobbying on environmental policies (but where constitutional design is omitted).

politicians more effectively. In parliamentary systems, on the other hand, legislative cohesion leads to higher pollution tax rates, greater redistribution, and more rents allocated to politicians.[7]

In our empirical work, we test this prediction using the semi-nonparametric method of propensity score matching (Rosenbaum and Rubin (RR), 1983). Specifically, we assess whether countries with PC systems have higher gasoline prices *ceteris paribus*, which we argue reflect cross-country gasoline tax rates. The data contain current and historical information on 86 democratic countries from the late 1990s, and come from Persson and Tabellini (PT) (2002a), augmented as necessary data for the present analysis. Our results are striking. Consonant with our theory, we find that ceteris paribus the average price of super gasoline is $0.14 – $0.20 less per liter in PC systems; the average price of diesel gasoline is $0.11 – $0.14 less per liter.

The paper is organized as follows. Sections II and III apply the framework of PRT (2000) to environmental policy, contrasting the expected level of pollution taxation under PC and parliamentary regimes. Section IV discusses the empirical technique and data. Section V reports the results, and Section VI provides concluding remarks. Proofs are relegated to the Appendix.

II. The Presidential-Congressional Regime

The PC regime entails a legislature characterized by separation of powers, where legislators are agenda-setters over separate dimensions of policy. Such separation is obtained through sequential voting over each dimension of a given policy. The budget constraint is determined initially, and legislators with control over subsequent dimensions of the policy are bound by this budget constraint. As a unique politician is responsible for each aspect of the policy, each agenda-setter is held accountable by voters in different electoral districts, who together directly elect the executive. Coalition formation in the legislature is consequently

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[6] PRT (2000) show that the income tax is lower in PC regimes.

unconstrained, and there is no incentive for legislative cohesion since the executive can keep her power without a majority in the legislature (Congress).

The theoretical modeling follows PRT (2000), but focuses on the taxation of an externality (rather than an income tax, which is taken herein as exogenous). The economy has three electoral districts, $i = 1, 2, 3$, each populated by a continuum of identical voters normalized to one. The model has an infinite horizon with discretely measured time periods t. The preferences of a voter located in district i at time j are given by

$$u_j^i = \sum_{t=j}^{\infty} \delta^{(t-j)} [c^{xi} + c_t^{yi} - D(p_t)] = \sum_{t=j}^{\infty} \delta^{(t-j)} [\lambda + 1 - \xi - \theta\tau_t + r_t^i - D(p_t)], \qquad (1)$$

where $\delta < 1$ is the discount factor, c^{xi} is the private consumption of the (polluting) good x, and c_t^{yi} is the private consumption of a clean good y. Consumption c^{xi} is assumed fixed in each period, which causes a constant gross pollution flow θ. The prices of both good x and good y are assumed equal to unity. Pollution is transboundary across districts. The aggregate damage from pollution is given by the function $D(p_t)$, where $D' > 0$, $D'' < 0$, and p_t is the *net* aggregate flow of pollution at time t, which takes into account public spending on environmental clean-up, g_t. Formally, $p_t = 3\theta - \gamma g_t$, where γ is a coefficient reflecting the (per-unit) impact of public spending on pollution clean-up on the pollution externality. λ is each individual's non-taxable income component, which is assumed sufficiently large to ensure that $u_j^i \geq 0$ for each individual in every period. $\xi (< 1)$ is the exogenous income tax, τ_t is the common endogenous pollution tax, and r_t^i is a transfer payment to district i. [8,9,10] Public policy also controls the amount of

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[7] PRT (2000) also show that the level of public good provision is greater under the parliamentary regime. Analogously, in our framework the environmental clean-up expenditures are greater under this system.
[8] As discussed in Sterner (2003), examples of the direct provision of public goods by the government financed by the general budget includes the cleaning of public streets, the responsibility for major environmental threats, the

resources diverted (wasted) by the politicians in the legislature, in addition to τ_t, g_t, and $\{r_t^i\}$.

The resources channeled to legislator l are denoted by $\{s_t^l\}$. Forms of diversion include the

financing of political parties or campaigns, and the private consumption of legislators.

To balance the budget, the government must satisfy

$$3(\xi + \theta\tau_t) = \sum_i r_t^i + \sum_i s_t^l + g_t \equiv r_t + s_t + g_t, \tag{2}$$

where aggregate expenditures on redistribution and diverted resources are given by r_t and s_t,

respectively. The incumbent legislator l has preferences given by

$$v_j^l = \sum_{t=j}^{\infty} \delta^{(t-j)} s_t^l \beta_t^l, \tag{3}$$

where β_t^l is an indicator variable equal to one if legislator l holds office in period t, and zero

otherwise. The legislators' payoffs are derived endogenously from holding office and setting

policies. Voters hold them accountable by retrospective voting, which may cause their removal

from the legislature. This forces the politicians to serve their constituencies almost perfectly.

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provision of national parks, the multitude of control actions undertaken by environmental protection agencies, and research on environmentally friendly technologies (sponsored by, for example the, U.S. EPA).

In the US, gasoline tax revenues have historically been used for highway construction (see Patashnik, 2000) (this practice may potentially be viewed as a transfer payment in the current model). In the UK and France, special road funds were created in 1909 and 1952, respectively, but funds have consistently been diverted for other purposes (Sterner, 2003) (the French road fund was abolished in 1981). Pollution tax revenues are, however, also frequently used for pollution control and similar projects. For example, Fullerton (1996) reports that the LUST fund uses fuel tax revenues for repairs of leaking underground storage tankers. Moreover, Superfund uses taxes on chemicals and petroleum for environmental damage caused by these products (Brett and Keen, 2000). See Marsiliani and Renström (2000) for a model of tax earmarking as a commitment device. Note also (below) that in our model, tax revenues may be used for three distinct purposes.

[9] The pollution level is completely inelastic with respect to the tax. Thus, with fixed consumption of the polluting good, changes in the pollution tax affect consumption only of the clean good in the model. We ignore the effect of pollution taxes on pollution intensity and the total pollution level since our focus is on comparing policy outcomes in different legislative systems. However, we do note that reductions in air pollution from higher gasoline taxes – the taxes analyzed below in the empirics – have been shown to be fairly minimal, as gasoline demand is highly inelastic, especially in the short-run (Sipes and Mendelsohn, 2001). Dahl and Sterner (1991) review the literature.

[10] With two endogenous taxes proposed simultaneously by one agenda setter, the individual tax rates would be indeterminate; only the aggregate level of taxation would be comparable. Therefore, we opt to study the endogenous determination of the pollution tax conditional on the income tax. This assumption corresponds to the discussion in the literature on pollution taxation in the presence of preexisting distortions (although we are here only

An election using plurality rule is held in each voting district at the end of each period. The incumbent legislator faces an opponent randomly drawn from a large number of candidates, all of whom have identical preferences once in office. The voters in each district use retrospective voting rules that are conditional on whether their elected representative was an agenda-setter in period t. We assume that each district's voters coordinate on their voting rule, and set their reservation utilities conditional on the role their representative played during the last session. No coordination occurs across districts. In particular, how the vote is cast depends on whether the politician was the agenda-setter for pollution taxes ($i = a_\tau$), for the allocation of spending ($i = a_g$), or neither ($i = 0$):

$$\beta_{t+1}^l = 1 \quad \text{if} \quad \left[\lambda + 1 - \xi - \theta\tau_t + r_t^i - D(p_t)\right] \geq b^i, \ i = l \text{ at } t. \tag{4}$$

The timing of the game is as follows:

1. Among the incumbent legislators, nature randomly selects agenda-setters for the pollution tax (a_τ) and for spending allocation (a_g), where $a_\tau \neq a_g$.

2. Voters set the reservation utilities for their voting rules, b^i.

3. The agenda-setter for the pollution tax, a_τ, proposes a pollution tax rate, τ.

4. Congress votes on the pollution tax proposal. If the proposal has the support of at least two representatives, the pollution tax policy is implemented. Otherwise, a default pollution tax rate $\tau = \sigma < (1 - \xi)/\theta$ is implemented.

5. The agenda setter for spending, a_g, proposes $\left[g, \{s^i\}, \{r^i\}\right]$, subject to the budget constraint $3(\xi + \theta\tau) \geq r + s + g$.

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interested in the impact of democratic institutions on the level of pollution taxes, not revenue recycling); see, for example, Bovenberg and De Mooij (1994) and Goulder et al. (1997).

6. Congress votes on the spending proposal. If at least two legislators are in favor, the policy is implemented. Otherwise, a default policy with $g = 0$, $r^i = 0$, and $s^i = \xi + \theta\tau$ is implemented.

7. Elections are held.

Note that in the event of a disagreement over spending at stage six, the tax decision taken at stage four is binding. This is an important feature of the model. Legislative behavior in stages three and four depends crucially on whether they expect to be inside or outside (that is, the probability of being included in) the winning coalition in stage six.

We now define the equilibrium in the PC regime (denoted by a superscript C).

Definition 1: An equilibrium of the presidential-congressional regime is a policy vector

$$\left[\tau_t^C(\mathbf{b}_t), g_t^C(\tau_t^C(\mathbf{b}_t), \mathbf{b}_t), \left\{s_t^{iC}(\tau_t^C(\mathbf{b}_t), \mathbf{b}_t)\right\}, \left\{r_t^{iC}(\tau_i^C(\mathbf{b}_t), \mathbf{b}_t)\right\}\right], \tag{5}$$

and a vector of reservation utilities $\mathbf{b}_t^C$ such that in any given period t all players take the expected equilibrium outcomes in periods $t+k$, $k \geq 1$, as given: (*i*) for any given $\mathbf{b}_t$ at stage four, at least one legislator $i \neq a_\tau$ is weakly better off by accepting pollution tax proposal τ_t^C, given the expected equilibrium spending proposals and voting decisions at stages five and six; (*ii*) for any given $\mathbf{b}_t$, a_τ is better off proposing τ_t^C rather than any other tax policy τ_t that satisfies condition *i*, given the expected equilibrium spending proposals and voting decisions at stages five and six; (*iii*) for any given $\mathbf{b}_t$ and τ_t at stage six, at least one legislator $i \neq a_g$ is weakly better off by accepting spending proposal $g_t^C(\tau_t^C(\mathbf{b}_t), \mathbf{b}_t), \left\{s_t^{iC}(\tau_t^C(\mathbf{b}_t), \mathbf{b}_t)\right\}, \left\{r_t^{iC}(\tau_i^C(\mathbf{b}_t), \mathbf{b}_t)\right\}$; (*iv*) for any given $\mathbf{b}_t$ and τ_t at stage five, a_g prefers the spending proposal $g_t^C(\tau_t^C(\mathbf{b}_t), \mathbf{b}_t), \left\{s_t^{iC}(\tau_t^C(\mathbf{b}_t), \mathbf{b}_t)\right\}, \left\{r_t^{iC}(\tau_i^C(\mathbf{b}_t), \mathbf{b}_t)\right\}$ to any other proposals satisfying condition *iii* and the budget constraint; (*v*) the reservation utilities $\mathbf{b}_t^{iC}$ are optimal for the voters in each

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district *i* when taking into account that current period policies will be set according to (5), and takes as given the other regions' reservation utilities $\mathbf{b}_t^{-iC}$, and the identity of a_τ and a_g.

We are now in a position to state the following proposition.

Proposition 1: *In the unique stationary equilibrium of the presidential-congressional regime, the pollution tax rate is given by* $\tau^C = \dfrac{1-\xi-\delta(1+2\xi)/3}{\theta(1+2\delta/3)}$. *All incumbent legislators are reelected.*

In PC systems, the built-in checks and balances limit the rate of the pollution tax. The voters in the district represented by a_g benefit from greater pollution tax revenues through redistribution. The voters in the district represented by the agenda setter a_τ have an incentive to restrict redistribution and rents. This is done by removing a_τ, unless she sets the minimum tax rate consistent with the optimal level of environmental clean-up. Note that an exogenous increase in the income tax rate, ξ, causes a reduction in the pollution tax rate, τ^C. Moreover, in the PC regime, less than the full amount of the taxable income is raised as revenues. Specifically, a share $(3-\delta)/(3+2\delta)<1$ is taxed in aggregate by the government.

III. The Parliamentary Regime

The next step is to modify the game to compare the pollution tax policy enacted in PC versus parliamentary regimes. In this section we seek to describe the parliamentary regime by letting nature pick two legislators (from parliament) in the beginning of each period. These two ministers form a majority coalition government with all the proposal powers. One minister becomes the agenda-setter and proposes a budget consisting of $\left[\tau_a, g_a, \left\{s_a^l\right\}\left\{r_a^i\right\}\right]$, which is voted on in parliament. Each of the two government ministers has a veto right, because the vote is also

an expression of confidence in the government. To stay in office throughout the election period, the government needs the majority's support in parliament.

In this model, a government crisis leading to the incumbent government's departure emerges if the junior partner casts a veto. A new government is subsequently formed: a new agenda-setter and her junior partner are selected at random from the three legislators. Voters then reformulate their reelection strategies, the legislator proposes a policy vector, and the legislative vote occurs. If supported, the policy vector is implemented. Otherwise, a default policy is implemented, and new elections are held. This game is meant to reflect the result of a vote of no confidence in parliamentary regimes as it captures the possible loss of the proposal powers that are associated with ministerial positions (see Huber, 1996; Diermeier and Feddersen, 1998). In parliamentary regimes, the legislators (parties) supporting the executive have strong incentives to preserve a stable majority when voting. The timing of the game is as follows:

1. Among the incumbent legislators, nature randomly selects two ministers that are coalition partners. One (a) is chosen to be the agenda-setter for the pollution tax and the spending allocation, the other is the junior partner (m).

2. Voters set the reservation utilities for their voting rule, $\{b^i\}$.

3. The agenda-setter, a_τ, proposes $\left[\tau_a, g_a, \left\{s_a^l\right\}\left\{r_a^i\right\}\right]$, subject to the budget constraint

$$3(\xi + \theta\tau_a) \geq r_a + s_a + g_a.$$

4. If the proposal from stage three is approved, the proposal is implemented and the game proceeds to stage nine. Alternatively, the junior partner in the coalition may veto the joint proposal. In this case, the government loses office and the game proceeds to stage five.

5. Nature randomly selects a new agenda-setter a' among the three legislators.

6. The voters set new reelection strategies, conditional on the role of their district's

representative in the collapse of the government.

7. The new agenda setter a' proposes a new policy vector $\left[\tau_{a'}, g_{a'}, \left\{ s_{a'}^l \right\} \left\{ r_{a'}^i \right\} \right]$.

8. The proposal is voted on. The proposal is implemented if the legislators approve it, otherwise the default policy $g = 0$, $r^i = 0$, and $s^i = \xi + \theta\tau$ is implemented.

9. Elections are held.

Legislators have objective functions given by (3). Before the elections are held at the end of each period, voters coordinate their retrospective voting strategies using (4), conditional on their representative's position during the period: If inside the government, what position did she take ($l = a,m,n$)? If the government endured a crisis, was she the agenda setter ($l = a'$, $l \neq a'$)?

In the Appendix, we define the equilibrium in the parliamentary (denoted by a superscript *P*) regime (Definition 2). We are now able to state the following proposition.

Proposition 2: *In the parliamentary regime, there is a continuum of equilibria with a pollution tax given by* $\tau^P = (1 - \xi)/\theta$, *where* $\tau^P > \tau^C$, *given the income tax. All politicians are reelected and a government crisis does not occur.*

Proposition 2 states that the pollution tax rate emerging from the parliamentary system is unambiguously greater than the one determined in the PC system, ceteris paribus. The veto right of the coalition partner is a crucial factor underlying this result. The veto right enables the voters in districts *a* and *m* to require a large share of distribution (a distribution toward the majority) without risk of a government crisis. Politicians also capture more rents in this regime as the lack of separation of powers facilitates collusion among the coalition members.[11]

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[11] It can also be shown that the level of public goods is higher than in the presidential-congressional regime because the effect on voters in two districts (as opposed to one) is taken into consideration (see PRT, 2000).

Note also, similar to the PC system, that an increase in the income tax rate, ξ, causes a reduction in the pollution tax rate, τ^P. In the parliamentary regime, this results because all remaining taxable revenues are extracted using the pollution tax and there is less revenue available for pollution taxation. Thus, the government extracts all taxable income.

IV. Empirical Model and Data

To test the theoretical prediction from the preceding sections, we utilize the method of propensity score matching. Not only does the method offer several advantages over standard parametric regression techniques for the estimation of average treatment effects, but, as argued in PT (2002a), the method is particularly well-suited to the current application as variation in constitutional rules falls under the classification of "selection on observables."

Propensity Score Matching: General Case. Propensity score matching, originally developed in RR (1983), is an increasingly popular method for evaluating treatment effects.[12] The goal of the matching method is to identify the effect of a particular treatment on an outcome of interest despite the unavailability of experimental data. Blundell and Costa-Dias (2002) provide an excellent introduction, concluding, "matching methods have been extensively refined in the recent evaluation literature and are now a valuable part of the evaluation toolbox."

The fundamental problem in identifying treatment effects is one of incomplete information (RR, 1983). While one observes whether the treatment occurs and the outcome conditional on the treatment, the counterfactual is unobserved. Let y_{i1} denote the outcome of observation i if treatment occurs (given by $T_i = 1$) and y_{i0} denote the outcome if treatment does not occur ($T_i = 0$). If both states of the world were observable, the average treatment effect, τ,

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[12] A few notable applications include Heckman et al. (1997, 1998), Dehejia and Wahba (DW) (1999, 2002), PT (2002a), List et al. (2002), and List et al. (2003).

would equal $\bar{y}_1 - \bar{y}_0$. However, given that only y_1 or y_0 is observed for each observation, generally $\tau \neq \bar{y}_1 - \bar{y}_0$ unless treatment assignment is random.

The solution advocated in RR (1983) is to find a vector of covariates, Z, such that

$$y_1, y_0 \perp T \mid Z, \qquad pr(T = 1 \mid Z) \in (0,1) \qquad (6)$$

where $\perp$ denotes independence. If condition (6) holds, then treatment assignment is said to be "strongly ignorable" (RR, 1983, p. 43). To estimate the average treatment effect (on the treated), only the weaker condition

$$E[y_0 \mid T=1,Z] = E[y_0 \mid T=0,Z] = E[y_0 \mid Z] \qquad pr(T = 1 \mid Z) \in (0,1) \qquad (6')$$

is required. Thus, the treatment effect is given by $\tau = E[\bar{y}_1 - \bar{y}_0 \mid Z]$, implying that – conditional on Z – assignment to the treatment group mimics a randomized experiment.

Several details of this estimation procedure require further explanation. First, for condition (6) or (6') to hold, the appropriate conditioning set, Z, should be multi-dimensional. Consequently, finding observations with identical values for all covariates in Z may be untenable. However, RR (1983, 1985a) prove that conditioning on $p(Z)$ is equivalent to conditioning on Z, where $p(Z) = pr(T = 1 \mid Z)$ is the propensity score. Typically $p(Z)$ is estimated using a standard logit or probit model.

Second, after estimating the propensity score, a matching algorithm is required in order to estimate the missing counterfactual, y_0, for each treated observation. The simplest algorithm is single nearest-neighbor matching, whereby each treated observation is paired with the control

observation whose propensity score is closest in absolute value (DW, 2002).[13] Unmatched

controls are discarded. The average treatment effect on the treated (TT) is given by

$$\tau_{TT} = E[E[y_1 \mid T=1, p(Z)] - E[y_0 \mid T=0, p(Z)]] = E[E[y_1 - y_0 \mid p(Z)]] \qquad (7)$$

where the outer expectation is over the distribution of $Z \mid T = 1$. Confidence intervals are obtained

via bootstrapping (details below).

The fact that unmatched control observations are discarded is one of the main distinctions

between the method of matching and standard regression analysis; the matching method identifies a

sub-sample of the full set of controls that better approximates the treatment group in terms of

potentially confounding influences. As a result, using data from actual randomized experiments

(where the treatment effect is known), Bratberg et al. (2002) and DW (2002) verify that matching

provides a significantly closer estimate of the treatment effect than standard regression techniques.

The third issue one confronts under the matching technique is known as the common support

condition. Specifically, the estimated treatment effect is only defined over the region of common

support of the propensity score. As such, we exclude observations lying outside this range (DW,

1999; PT, 2002a). Fourth, the method of matching outlined herein is applicable to situations of

"selection on observables." If unobservable attributes affect both treatment assignment and the

outcome of interest, the reliability of the matching estimates is questioned. The greater the

dimension of Z, then, the less likely key attributes are omitted. In addition, implicit in the notion of

matching on the propensity score – as opposed to the variables in Z – is the fact that the propensity

score represents a "summary" measure of each observation. As the propensity score is a function of

the coefficients obtained from the first-stage regression, such coefficients will reflect the effects of

both observable and unobservable attributes to the extent that the included covariates are correlated

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[13] Typically, nearest-neighbor matching is performed *with replacement*, implying that a given control observation
may be matched with multiple treatment observations. DW (2002) verify that matching with replacement fares at

with the omitted unobservables. While such correlation renders the coefficients inconsistent in the usual sense, such inconsistency is not problematic in the current context, as one is not interested in any causal interpretation of these estimated parameters.

Fifth, upon completing the matching, a "balancing" test is conducted. Balancing refers to the fact that after conditioning on the propensity score, the distribution of the conditioning variables, Z, should not differ across the treatment and control group in the matched sub-sample. If the first moment of any of the conditioning variables differs across the matched treatment and control groups, the estimated treatment effect, τ_{TT}, will be biased if differences in such attributes also impact the outcome of interest. In such situations, two solutions are available. First, one may attempt alternative specifications of the first-stage to facilitate balancing.[14] Alternatively, one may use a regression adjustment, whereby the outcome of interest is regressed (via weighted least squares, where the control observations are weighted according to the number of times they are used as a match) on a treatment dummy and the unbalanced variables in Z using only the matched sub-sample (Rubin, 1973; 1979).[15] The coefficient on the treatment dummy is the regression-adjusted treatment effect (on the treated), $\tau_{TT,RA}$.

Finally, two additional benefits of matching estimators versus typical parametric (OLS) estimates heretofore not mentioned are: (i) fewer distributional assumptions and (ii) matching allows for nonparametric interactions between all the covariates in Z in the determination of the outcome of interest (Bratberg et al., 2002).

Application to Constitutional Regimes. Before addressing the application of the matching method in the current context, it is worth exploring why one should treat data related to

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least as well as matching without replacement, and possibly better.

[14] DW (2002) advocate inclusion of higher order and interaction terms.

constitutional regimes as non-experimental. In other words, why do political institutions not represent a "natural" experiment, given that comprehensive constitutional reforms (within democracies) are rare? As argued in PT (2002a), the assumption of strict exogeneity of institutional arrangements is unlikely given the historical development of such arrangements. Certain types of arrangements tend to be geographically concentrated (e.g., PC regimes are concentrated in the Americas, while continental Europe is dominated by parliamentary systems) and dictated by previous, colonial relationships. Thus, cross-country variation in such institutions does not conform to a natural experiment. However, the non-random assignment of institutional arrangements does appear to be a problem amenable to matching methods as attributes such a geographic location and colonial history are observable (hence, the problem is one of "selection on observables"). For other matching applications to analyses of political institutions, see Persson et al. (2000) and PT (2002b).

Proceeding to apply the matching technique to the present context, we define PC countries as the treatment group and countries with parliamentary systems as the control group. The first-stage is estimated via a standard probit model. The variables presumed to affect a country's propensity to maintain a PC regime include: two dummy variables indicating if the country was a former colony of (i) the United Kingdom or (ii) France or another country besides Spain, geographic dummy variables if the country is located in (i) Latin America, (ii) Africa, or (iii) East Asia, a dummy variable for OECD countries, years of independence since 1748, an index of civil liberties and political rights, per capita GDP (and its square), proportion of the population under 15 and over 65 years old (and their squares), population (and its square), population density, and the ratio of exports plus imports to total GDP (trade openness).

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[15] Alternatively, DW (1999, 2002) regress the outcome on a treatment dummy and all covariates regardless of whether or not they are balanced. In our analysis, this would unduly restrict the sample size of the regression since several variables are missing for a subset of observations.

Upon estimating the propensity score, the matching algorithm used is the single nearest-neighbor method proposed in DW (2002). The nearest-neighbor method finds the control observation with a propensity score closest to each treated observation. Consistent with DW (2002), we match with replacement (see footnote 13). Upon pairing countries, identification of the treatment effects rests on the mean comparison of several measures of environmental taxes across the matched pairs.

Data. We utilize the cross-sectional data set from PT (2002a) as a starting point.[16] Specifically, the PC and parliamentary classifications, colonial history, geographic dummies, federalism dummy, age distribution variables, Gastil index of civil liberties and political rights, and trade openness are borrowed from PT (2002a). The sample consists of 86 "democratic" countries, where democracies are defined by a score of five or below on the Gastil index.[17] The data are then augmented with additional variables relevant to the application at hand. Variables used as the outcome of interest are the prices of super and diesel gasoline in 1998 and 2000. While ideally we would have direct measures of the level of gasoline taxes, such data do not exist for a comprehensive group of countries. However, given that oil is traded at a uniform world price, differences in domestic gasoline prices reflect (i) demand factors, (ii) supply factors, (iii) tariffs, (iv) environmental factors, (v) lobbying pressures, and (vi) taxes. As illustrated in OECD/IEA (2000), taxes are responsible for an overwhelming share of the variation in gasoline prices (Figs. 16 and 18, pp. 29 and 31). To control for demand factors related to the price of gasoline, we utilize measures of population, per capita GDP, number of cars, number of commercial vehicles, number of total vehicles, and total gasoline consumption. In addition, age distribution variables proxy for

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[16] The data are available at http://www.iies.su.se/~perssont/. To be clear, the final data set we utilize is a cross-section, but some variables are taken from various years during the 1990s, while others (available in many years) are averaged over the years available). For further details, refer to PT (2002b) or Persson's web site.

the number of drivers. The number of cars, and especially the number of commercial vehicles, will also reflect lobbying pressures for lower fuel taxes: the more at stake, the greater the incentive and ability to undertake collective action will be by the transportation sector and vehicle owners (see Potters and Sloof, 1996). To control for supply factors and the level of tariffs, we utilize the level of trade openness – measured by the ratio of exports plus imports to GDP – as openness may affect the domestic supply of gasoline, and proxies for the distortions present in international trade.

As suggested by Parry and Small (2002), congestion and costs (damages) associated with driving are also likely determinants of gasoline prices/taxes. To measure congestion, we utilize measures of population density, total roads, percentage of paved roads, road density, urbanization, percentage of land covered by forest, and percentage of land used in agriculture. To proxy for the level of damages, we use measures of per capita carbon dioxide (as a general measure of environmental quality) and lead content of gasoline. Finally, consonant with theory, we utilize a measure of the top marginal tax rate in each country. Consequently, given the richness of our data, any residual variation in gasoline prices across countries is assumed to reflect tax differentials.

Table 1 contains summary statistics and the source of each variable. In addition, results are displayed from *t*-tests associated with the null hypothesis of no difference in the mean of each variable across countries with PC versus parliamentary systems. As indicated, many of the variables – including the prices of super and diesel gasoline – differ across the treatment and control countries utilizing the full sample. The goal of matching is to see if gasoline prices still differ after differences in these other variables are removed.

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[17] The Gastil index is compiled by Freedom House and ranges from one to seven, with lower scores suggesting more democratic regimes.

V. Empirical Results

Primary Results. To begin, results from the first-stage probits are displayed in Tables 2. Model I (Model II) is estimated using only those observations for which data on the price of super and diesel gasoline in 1998 (2000) are available. The right-hand side variables are chosen with two considerations in mind. First, we wish to include as many covariates as possible to facilitate the balancing of a wide range of attributes likely to affect gasoline and vehicle taxes. Second, because many of the covariates are not available for the full sample of countries, inclusion of such variables in the first-stage will unduly restrict the size of the sample with non-missing propensity scores. To balance these two factors, we select only those covariates for which data are available for nearly all of the countries in the sample. Note, however, that we can still test to see if the remaining attributes – those excluded from the first-stage – are balanced across matched pairs with non-missing data. In the end, there are 80 and 78 observations, respectively, in the two models, of which 33 and 32 are members of the PC regime.

Prior to examining the actual treatment effect estimates, we first need to be sure that the quality of matches is sufficiently high. As shown in the first row of Table 3, the average difference in propensity scores across matched pairs used to estimate the effect of PC systems on the price of super and diesel gasoline in 1998 (2000) is $-4.00*10^{-03}$ (–0.02). Thus, on average, the quality of the matches, as measured by the differences in propensity score, is quite good.[18]

In terms of the actual treatment effects, the estimates of τ_{TT} for each of the four dependent variables are reported in the second row of Table 3. Consonant with the theoretical prediction, countries with PC systems have lower gasoline prices, and three of the four results

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[18] To further emphasize this point, Fig. 2 plots the propensity score of each treated and matched control observation. While the quality of the matches are better for treatment observations with low propensity scores (as is to be expected given that the most potential controls have low propensity scores) in both Panels A (the 1998 sample) and B (the 2000 sample), the quality does not appreciably deteriorate at higher values of the propensity score.

are statistically significant at the 90% confidence level.[19]   The price of super gasoline in democracies with PC regimes was $0.22 ($0.17) per liter lower on average in 1998 (2000); the price of diesel gasoline was $0.15 ($0.14) per liter lower on average in 1998 (2000).

As stated in the previous section, for the estimated treatment effects to be consistent, potential confounding factors must be balanced across the matched pairs. Table 3 shows that while the vast majority of the covariates are balanced, a few remain statistically different even matching. In the models using super and diesel gasoline prices in 1998 (2000) as the outcome, the dummy variables for federalism, former U.K. colony, and former Spanish colony and income taxes (dummy variable for former Spanish colony and income taxes) are not balanced. To ensure that differences in these attributes are not driving the statistically significant, negative treatment effects in row two of Table 3, we employ the regression adjustment, regressing gasoline prices on a treatment dummy and the unbalanced variables using only the matched observations. The resulting estimates, $\tau_{TT,RA}$, are displayed in the last row of Table 3. While the point estimates for the impact of PC systems on gasoline prices in 1998 remain negative, they are no longer statistically significant. However, the point estimates for 2000 super and diesel gasoline prices are larger in absolute value, and remain statistically significant at the 95% level.

Sensitivity Analysis.   To assess the robustness of our findings, two types of sensitivity analyses are conducted. First, an issue that arises in the evaluation literature not heretofore mentioned is the distinction between homogeneous and heterogeneous treatment effects: is the effect of belonging to the PC regime identical for all treatment observations, or does the impact vary in some symptomatic way? As a straightforward means of assessing this point, Figures 3 (super gasoline) and 4 (diesel gasoline) plot the gasoline prices of the treatment and matched

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[19] Confidence intervals are obtained via the bias corrected and accelerated (BCa) bootstrap method, based on 1000 bootstrap repetitions (see Efron and Tibshirani, 1993).

controls as a function of the propensity score of the treated. The price difference between each treatment observation and its matched control is an estimate of the treatment effect for that particular observation. In all four plots the gasoline price in the treated country is below the price in its matched control for the majority of matched pairs. Cases where the reverse occurs appear random. Thus, the assumption of homogeneous treatment effects seems reasonable.

The second robustness check concerns the matching algorithm used to estimate the missing counterfactual for each treated observation. Single nearest-neighbor matching with replacement has the advantage of simplicity and minimizing bias since it only utilizes information on the control observation deemed *most* similar. However, this incurs some efficiency loss. Other matching algorithms have been proposed in the literature to better balance the bias-efficiency trade-off (see Smith and Todd (2003) for a nice review). Table 4 presents the estimated treatment effects utilizing some of these alternatives: (i) five and ten nearest neighbors, (ii) radius matching with a caliper of 0.05, 0.10, and 0.20, and (iii) kernel matching with a bandwidth of 0.04, 0.06, and 0.08. Five (ten) nearest-neighbor matching estimates the missing counterfactual for each treated observation as the average outcome in the five (ten) nearest neighbors, where each neighbor in the group is weighted equally. Radius matching estimates the missing counterfactual as the average outcome computed over *all* neighbors with propensity scores that differ by less than a specified amount (the caliper), where all neighbors in the radius are weighted equally. Finally, kernel matching estimates the missing counterfactual for each treated observation as the weighted average outcome of *all* control observations, where the weights are diminishing in the distance between the propensity scores.

The alternative algorithms all yield negative point estimates, and many are statistically significant at at least the 90% confidence level. In particular, the kernel matching technique

(based on a Gaussian kernel) yields statistically significant estimates for three of the four measures of gasoline prices, identical to Table 3.

VI. Concluding Remarks

The literature on the political economy of environmental policy has proliferated of late. However, the focus has been primarily on the impact of lobbying; the role played by underlying political institutions has largely been ignored. In an effort to explore this role, we present a straightforward extension to the model in PRT (2000) in order to contrast the expected level of pollution taxes in PC versus parliamentary regimes. The model unambiguously predicts that such taxes should be lower in countries with PC systems due to the greater separation of powers in the former, and the greater legislative cohesion in the latter.

To test the implication of the model, we utilize cross-sectional data on 86 democratic countries and the semi-nonparametric method of propensity score matching. Controlling for a vast array of factors likely to affect the development of political institutions and domestic gasoline prices, we find strong evidence suggesting that PC regimes do indeed have lower gasoline taxes on average. This result yields insights into the determinants of environmental taxation in democracies, suggesting that political institutions are an important factor that must be taken into consideration. Moreover, the role of constitutional regimes may also crucial to understanding the feasibility of international environmental agreements such as carbon taxation to reduce global warming. This appears to be an important topic for future research.

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Appendix

The proofs follow PRT (2000), applied to taxation of a consumption externality and adjusting for an exogenous income tax. Lemma 1 is used in the proofs of Propositions 1 and 2.

Lemma 1: *In equilibrium,* $r^{m_g} = r^{n_g} = 0,$ *where districts* $m_g, n_g \neq a_g.$ *Thus, in equilibrium* $r^{a_g} = r$, *if any redistribution takes place.*

Proof of Lemma 1: In any equilibrium, the winning coalition requires only majority, not unanimous, support (i.e. the agenda setter for clean-up spending, a_g, needs only the support of one other legislator). The supporting legislator, m_g, will be the one whose support is the least costly in terms of the resources that must be transferred to her, or her district. The third legislator, n_g, who is not in the winning coalition, receives nothing ($s^{n_g} = r^{n_g} = 0$). Since all legislators have identical default payoffs, the cheapest district depends only on the reservation utilities required by the voters. The voters in districts m_g and n_g will underbid each other for transfers from the agenda setter in a form of Bertrand competition game until $r^{m_g} = r^{n_g} = 0.$ ■

Proof of Proposition 1: We will present the proof in steps. *Step 1*: We begin at stages five and six, where the agenda setter for spending, a_g, takes τ and ξ as given. Let m_g be the legislator supporting a_g's proposal. If a_g seeks reelection, m_g will never be offered more than what makes her indifferent between (i) supporting the proposal and be reelected, and (ii) voting no, receiving the default payoff $\xi + \theta\tau = \sigma$, and losing the election. Thus, a_g offers m_g

$$s^{m_g} = \xi + \theta\tau - \delta W, \tag{A1}$$

where W is each legislator's expected continuation value at the beginning of each period, before the agenda setter has been chosen by nature.

On the other hand, suppose a_g does not seek reelection and makes a proposal that leads to election losses for all incumbents under the given voting rule. Then a_g must offer m_g at least the default payoff $\sigma = \xi + \theta\tau$ to gain support for her proposal. She can then ignore her voters and maximize s^{a_g} by setting $g = r = 0$. Thus, the agenda setter for spending seeks reelection *iff*

$$s^{a_g} + \delta W \geq 3(\xi + \theta\tau) - \sigma = 2(\xi + \theta\tau), \tag{A2}$$

where the LHS is her discounted lifetime utility if a proposal leading to reelection is made, while the RHS is her maximum payoff in the case where she concedes reelection, pays m_g the amount $\sigma = \xi + \theta\tau$, and keeps the remaining revenue herself. By rearranging (A1) and (A2) it follows that a_g and m_g are willing to accept a policy outcome that results in their own reelection *iff*

$$s = s^{m_g} + s^{a_g} \geq 3(\xi + \theta\tau) - 2\delta W. \tag{A3}$$

Voters are unable to use a voting rule that requires lower transfers to m_g and a_g than that implied by (A3) as they would be worse off by forcing legislators not to seek reelection. Since a policy consistent with reelection maximizes the utility of legislators m_g and a_g, they are consequently both reelected. From Lemma 1, we know that voters in districts n and m have the same reservation utility. The pollution tax rate, τ, and the level of environmental clean-up spending, g, are also identical for the two districts, and this implies that legislator n is reelected.

Expressions (2) and (A3) imply that the maximum redistribution and clean-up spending that voters may benefit from is given by

$$r + g \leq 2\delta W. \tag{A4}$$

Step 2: From Lemma 1 we know $r^{m_g} = r^{n_g} = 0$.

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Step 3: Consider stages three and four, where the pollution tax rate is determined. Since we have assumed $a_\tau \neq a_g$, the agenda setter for the pollution tax and the voters in her district are not the only beneficiaries of higher pollution taxes. This implies that the optimal voting rule must require a_τ to set the lowest possible pollution tax rate, subject to the incentive compatibility constraint that we will now discuss: At the time of the spending proposal by a_g in stage five, the remaining two legislators face an equal probability of becoming the junior partner. Thus, with probability one-half, a_τ ends up included in this coalition in the equilibrium subgame, or in an out-of-equilibrium subgame. Thus, for a_τ to chose the equilibrium policy, she must receive a payoff equal to:

$$s^m/2 + \delta W \geq v^d = 1/2, \tag{A5}$$

where the LHS is a_τ's equilibrium continuation value when proposing a pollution tax τ that is consistent with an equilibrium. The probability of being part of the winning coalition at the time spending decisions are made (stage five) equals one-half; hence this is the probability that a_τ receives s^m. She is then certain to be reelected.

The RHS of (A5) is a_τ's expected utility on a disequilibrium path after approval of a proposed pollution tax τ that does not meet the voters' required reservation utility. For a deviation to be profitable, the disequilibrium proposal τ^d must be greater than τ^C because it makes both a_τ and a_g better off. At the stages that follow, a_g would follow the disequilibrium path by proposing $r = g = 0$, $s^{a_g} = 2(\xi + \tau^d\theta)$, and $s^{m_g} = (\xi + \tau^d\theta)$. Since all incumbents are consequently not reelected, the optimal pollution tax equals $\tau^d\theta = 1 - \xi$, because a_g benefits

from greater revenues. Additionally, since the probability of inclusion in the winning coalition equals one-half, it follows that v^d equals $1/2$. Inserting (A1) into (A5) yields

$$\tau^C = (1 - \xi - \delta W)/\theta. \tag{A6}$$

Step 4: The agenda setter a_τ proposes the tax rate in (A6) as it is consistent with her voters' optimal voting rule. This pollution rate is supported by the legislator $i \neq a_\tau, a_g$ without agenda setting rights because if she votes no, the default rate $\tau = \sigma$ is implemented. There are two possibilities in this case. (i) This is self-defeating if $\sigma < (1 - \xi - \delta W)/\theta$, since she (along with the other two incumbents) benefits (in expected value) from a higher pollution tax rate. (ii) If $\sigma > (1 - \xi - \delta W)/\theta$, a no vote implies that all incumbent legislators lose their reelection bids, given the voters' equilibrium election strategies. Since we have assumed $\sigma < (1 - \xi)/\theta$, this option reduces utility compared with voting for the proposal. This argument is illustrated by (A5), where the LHS is strictly larger than the RHS in this case.

Step 5: Note that, given that all legislators are reelected in equilibrium, each legislator's expected equilibrium continuation value at the start of a period is defined by

$$W = s/3 + \delta W. \tag{A7}$$

Substituting (A6) into (A3), and the resulting expression into (A7) yields, after rearrangements:

$$W = 1/(1 + 2\delta/3). \tag{A8}$$

Inserting (A8) into (A6) yields $\tau^C = \dfrac{1 - \xi - \delta(1 + 2\xi)/3}{\theta(1 + 2\delta/3)}$. ∎

Definition 2: An equilibrium of the parliamentary regime is a policy vector $\left[\tau_t^P(\mathbf{b}_t), g_t^P(\mathbf{b}_t), \left\{s_t^{iP}(\mathbf{b}_t)\right\}, \left\{r_t^{iP}(\mathbf{b}_t)\right\}\right]$, and the vectors of reservation utilities $\mathbf{b}_t^P$ and $\mathbf{b}_t^{P'}$ such that in any period t, given the expected equilibrium outcomes in periods $t+k$, $k \geq 1$:

(*i*) Given the proposal made at stage three and for any given vector $\mathbf{b}_t$, at stage four the junior coalition partner decides whether to accept or reject the proposals, given the expected reservation utilities $\mathbf{b}_t^{P'}$ and the expected policy outcomes in stages 5'-8'; (*ii*) In the event of a government crisis in stage four, the reservation utilities $b_t^{iP'}$ are optimal for the voters in each district i, when one takes into account that policies will be set according to $\left[\tau_t^{P'}(\mathbf{b}_t), g_t^{P'}(\mathbf{b}_t), \left\{s_t^{iP'}(\mathbf{b}_t)\right\}\left\{r_t^{iP'}(\mathbf{b}_t)\right\}\right]$, and takes as given the reservation utilities in other regions, $b_t^{-iP'}$; (*iii*) For any given $\mathbf{b}_t$ and $\mathbf{b}_t'$, the coalition's agenda setter prefers $\left[\tau_t^{P}(\mathbf{b}_t), g_t^{P}(\mathbf{b}_t), \left\{s_t^{iP}(\mathbf{b}_t)\right\}\left\{r_t^{iP}(\mathbf{b}_t)\right\}\right]$, given conditions *i* and *ii* and the budget constraint of the government; (*iv*) The reservation utilities b_t^{iP} are optimal for the voters in district *i*, taking into account that current period policies will be set according to $\left[\tau_t^{P}(\mathbf{b}_t), g_t^{P}(\mathbf{b}_t), \left\{s_t^{iP}(\mathbf{b}_t)\right\}\left\{r_t^{iP}(\mathbf{b}_t)\right\}\right]$, taking the expected reservation utilities $\mathbf{b}_t^{P'}$ and the reservation utilities in other regions, $b_t^{-iP'}$, as given, and that policies will be set according to $\left[\tau_t^{P'}(\mathbf{b}_t^{P'}), g_t^{P'}(\mathbf{b}_t^{P'}), \left\{s_t^{iP'}(\mathbf{b}_t^{P'})\right\}\left\{r_t^{iP'}(\mathbf{b}_t^{P'})\right\}\right]$ as a result of a government crisis at stage four.

Proof of Proposition 2: We present the proof in steps. *Step 1*: Using backward induction, suppose a government crisis occurs and the subgame in stages 5'-8' is reached. Let *W* be the equilibrium value of political office in the parliamentary regime. If agenda setter *a'* seeks reappointment, she will offer the junior coalition partner *m* no more than

$$s^{m'} = \xi + \theta\tau - \delta W \tag{A9}$$

because *m'* is indifferent between supporting this proposal which yields reelection, and voting no which leads to an election loss and receiving the default payoff $\xi + \theta\tau$. If instead *a'* concedes reelection and proposes a policy that leads to election defeat for all legislators, she must offer *m*

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at least $\xi + \theta\tau$ to win support for the proposal. The agenda setter can claim all remaining resources as she has no interest in satisfying any voters. Thus, she sets $\tau = (1-\xi)/\theta$ and $g = r = 0$. The condition for a' to stand for reelection is given by

$$s^{a'} + \delta W \geq 3 - (\xi + \theta\tau), \tag{A10}$$

where the LHS is the agenda setter's lifetime utility if her proposal leads to reelection, and the RHS is the maximum utility if she concedes reelection and pays m' an amount $\xi + \theta\tau$. (A9) and (A10) imply that the coalition partners implement a policy consistent with their reelection *iff*

$$s' \geq 3 - 2\delta W. \tag{A11}$$

Note that, given the reelection strategies, a' alone is the one benefiting from the resources generated in period t. Thus, she has an incentive to maximize the resources channeled to herself. This is done by minimizing the resources going to m', and by satisfying the reelection constraints of districts a' and m' with equality. Thus, a' sets $\tau' = (1-\xi)/\theta$, given that this is consistent with her own reappointment.

Step 2: By Lemma 1, $r' = r^{a'}$. Legislator a' maximizes the utility of the voters in her district by maximizing $[\lambda + 1 - \xi + r' - \theta\tau' - D(p')]$, subject to the budget constraint (2), and (A11). The latter two constraints can be combined to $[3(\xi + \theta\tau - 1) + 2\delta W \geq r + g]$. The solution to this problem implies $\tau' = (1-\xi)/\theta$, $g' = \min[3\theta - D_p^{-1}(1/\gamma), 2\delta W]$, $r' = 2\delta W - g'$, and $s' = 3 - 2\delta W$. The equilibrium continuation value at this stage (with reappointment of all legislators) of the parliamentary regime game equals

$$s'/3 + \delta W, \tag{A12}$$

and the expected one-period continuation payoff of each district's voters equals

$$\lambda + r'/3 - D(p'). \tag{A13}$$

Next, note that at stage four, a condition for approval of a proposal (leading to reelection) by m is a payoff equal to her payoff after a government crisis has occurred. From (A12), the proposal must satisfy $s^m + \delta W \geq s'/3 + \delta W$, i.e. $s^m \geq s'/3$. Moreover, a minimizes her payments to legislators by setting $s^n = r^n = 0$. Since voters can reduce the legislators' total payoff to what they would receive after a government breakup,

$$s \geq s' = 3 - 2\delta W. \tag{A14}$$

Thus, $s^a \geq 2s'/3$. The weak inequalities will hold with equality since voters will minimize the rents going to legislators. Using (A7), we can now solve for W, which yields $W = 1/[1-(\delta/3)]$. Substituting into (A14), we find that in the parliamentary regime:

$$s^P = 3(1-\delta)/[1-(\delta/3)]. \tag{A15}$$

Step 3: Inserting (A15) into the budget constraint (2) yields

$$3(\xi + \theta\tau - 1) + 2\delta/[1-(\delta/3)] = r + g. \tag{A16}$$

The coalition partners could at most inflict $\tau' = (1-\xi)/\theta$ and $r = g = 0$ on the voters. However, this threat is implicit in (A14). Both coalition partners a and m will act such that their voters reach the necessary utility level.

For an equilibrium characterization, the equilibrium reservation utilities b^a and b^m must be determined, and each must be optimal given the level of the other. However, many combinations of b^a and b^m are mutually consistent under the relevant constraints because once a government coalition is formed, voters' reservation utilities are set simultaneously. The only policies that can be ruled out are those that the voters represented in the government coalition view as dominated by the policies that would emerge after a government breakup. This is the minimum expected value that voters can demand. Using (A13), the equilibrium reservation utilities and the equilibrium policies must hence satisfy

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$b^i \equiv \lambda + 1 - \xi + r^i - \theta\tau - D(p) \geq \lambda + r'/3 - D(p')$, $i = a,m$. The equilibrium is the solution to the problem of the agenda setter's constituency, given a b^m such that $b^a \equiv \lambda + 1 - \xi + r^a - \theta\tau - D(p) \geq \lambda + r'/3 - D(p')$:

$$\max_{\tau,g,r^a,r^m} [\lambda + 1 - \xi + r^a - \tau\theta - D(p)], \tag{A17}$$

subject to

$$\lambda + 1 - \xi + r^m - \theta\tau - D(p) \geq b^m \geq \lambda + r'/3 - D(p'), \tag{A18}$$

$$\theta\tau \leq 1 - \xi, \tag{A19}$$

$$r^a \geq 0, \tag{A20}$$

$$r^m \geq 0. \tag{A21}$$

Using (A16), we find $\tau = \left[3(1-\xi) - 2\delta/[1-(\delta/3)] + r^a + r^m + g\right]/3\theta$, which can be substituted into (A17) and (A18). Let η, ψ, μ^a, and μ^m be the Lagrange multipliers on constraints (A18) – (A21), respectively. Then we find the following FOCs with respect to r^a, r^m, and g, respectively:

$$1 - (1 + \psi + \eta)/3 + \mu^a = 0, \tag{A22}$$

$$\eta - (1 + \psi + \eta)/3 + \mu^m = 0, \tag{A23}$$

$$\gamma D_p(p^P)(1 + \eta) - (1 + \psi + \eta)/3 = 0. \tag{A24}$$

(A22) and (A24) yield $1 + \mu^a - \mu^m = \eta$, which with (A22) is substituted into (A24) to get:

$$D_p(p^P) = (1 + \mu^a)/\gamma(2 + \mu^a - \mu^m). \tag{A25}$$

If $\tau < (1-\xi)/\theta$, then $\psi = 0$, and from (A24), $D_p(p^P) = 1/3\gamma$. Using (A25), this implies $1 + 2\mu^a + \mu^m = 0$, which cannot hold. It follows that we must have $\tau = (1-\xi)/\theta$. To solve for the remaining variables, we refer to Appendix C in PRT (2000) due to space considerations. ∎

Table 1. Description of Variables

Variable	Mean (Std. dev.) [Mean: Pres., Mean: Parl.] {Observations}	Definition and source
Presidential-Congressional	0.38 (0.49) [1.00, 0.00] {86}	1 = yes; 0 = parliamentary system. Persson and Tabellini (2002a).
UK Colony	0.36 (0.48) [0.27, 0.42] {86}	1 = yes; 0 otherwise. Persson and Tabellini (2002a).
Spanish Colony	0.19 (0.39)[†] [0.48, 0.00] {86}	1 = yes; 0 otherwise. Persson and Tabellini (2002a).
French/Other Colony	0.31 (0.47)[†] [0.18, 0.40] {86}	1 = yes; 0 otherwise. Persson and Tabellini (2002a).
Years of Independence	113.86 (84.02) [119.91, 104.51] {86}	Years since 1748. *www.worldfactsandfigures.com/country_independence.php*.
Price of Super Gasoline, 1998	64.57 (27.82)[†] [51.70, 73.24] {82}	US cents per liter. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Price of Super Gasoline, 2000	69.88 (23.80)[†] [63.28, 74.27] {80}	US cents per liter. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Price of Diesel Gasoline, 1998	44.70 (23.88)[†] [33.21, 52.43] {82}	US cents per liter. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Price of Diesel Gasoline, 2000	52.51 (22.39)[†] [43.50, 58.52] {80}	US cents per liter. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Federalism	0.15 (0.36) [0.22, 0.12] {84}	1 = federalist system; 0 otherwise. Persson and Tabellini (2002a).
Gastil Index	2.47 (1.23)[†] [3.17, 2.03] {86}	Index of civil liberties and political rights. $1 - 5$, with lower scores suggesting more democratic regimes. Persson and Tabellini (2002a).
Population	38.35 (108.71) [40.79, 36.79] {85}	Total population (millions), 1996. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Population Density	0.20 (0.54) [0.11, 0.26] {85}	Total population per square km (1000s), 1996. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Age < 15	0.30 (0.10)[†] [0.36, 0.25] {85}	Proportion of population under age 15. Persson and Tabellini (2002a).
Age > 65	0.08 (0.05)[†] [0.05, 0.10] {85}	Proportion of population over age 65. Persson and Tabellini (2002a).
Per Capita GDP	11.58 (9.19)[†] [6.67, 14.63] {86}	Per capita gross domestic product (1000s US$), 2001. *www.worldfactsandfigures.com/gdp_country.php*.

Table 1 (cont.). Description of Variables

Variable	Mean (Std. dev.) [Mean: Pres., Mean: Parl.] {Observations}	Definition and Source
Openness	0.79 (0.47) [†] [0.60, 0.91] {86}	Ratio of exports + imports to GDP, 1990s. Persson and Tabellini (2002a).
Urbanization	0.63 (0.22) [†] [0.57, 0.66] {85}	% of urban population, 2000. *www.wri.org/wri/wr-98-99/pdf/wr98_ud1.pdf*.
Forest	0.31 (0.19) [†] [0.34, 0.30] {84}	% of land covered by forest, 2000. *www.worldbank.org/data/dataquery.html*.
Agriculture	0.21 (0.16) [0.17, 0.25] {78}	% of land used as cropland, 1997. *www.wri.org/wri/wr-00-01/pdf/af2n_2000.pdf*.
Automobiles	5.68 (16.40) [5.80, 5.60] {81}	Total passenger cars (millions), 1996. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Commercial Vehicles	2.03 (8.87) [3.11, 1.35] {80}	Total (millions), 1996. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Vehicles	223.35 (208.90) [†] [100.44, 310.76] {77}	Total four wheel motor vehicles per 1000 people, 1996. Metschies (2001); *www.zietlow.com/docs/Fuel%202000.pdf*.
Gasoline Consumption	12.25 (51.89) [18.83, 7.56] {77}	Billions of liters, 1995. *www.wri.org/wri/wr-98-99/pdf/wr98_hh6.pdf*.
Total Roads	2.66 (7.75) [3.60, 2.09] {84}	100,000s km, 1996. *International Road Federation (1998)*.
% Paved Roads	0.56 (0.32) [†] [0.32, 0.69] {81}	Proportion of roads that are paved, 1996. *International Road Federation (1998)*.
Per Capita CO_2	5.68 (5.03) [†] [2.79, 7.73] {77}	Per capita carbon dioxide (kg), 1996. *www.wri.org/wri/wr-00-01/pdf/ac1n_2000.pdf*.
Lead	0.31 (0.29) [†] [0.41, 0.23] {67}	Average lead content of gasoline (grams per liter), 1992-1996. *www.wri.org/wri/wr-98-99/pdf/wr98_hh6.pdf*.
Income Tax	6.25 (2.32) [†] [7.64, 5.38] {81}	Top marginal income tax rate, 2000. Gwartney and Lawson (2002).

Notes: † indicates that the mean of the variable is significantly different across presidential-congressional and parliamentary countries at the 10% level of significance using the full sample.

Table 2. Probit Estimates of the Determinants of Presidential-Congressional Systems

Independent Variable	Model I Coefficient (Std. Error)	Model II Coefficient (Std. Error)
UK Colony	-1.78* (0.95)	-1.88* (0.97)
French/Other Colony	-1.01 (0.87)	-1.11 (0.90)
OECD	-2.08 (2.83)	-2.10 (2.86)
Latin America	3.71* (1.38)	3.77* (1.41)
Africa	1.77 (1.44)	1.79 (1.45)
East Asia	1.35 (1.12)	1.59 (1.18)
Independence	-0.01 (0.01)	-0.01 (0.01)
Gastil Index	0.80* (0.39)	0.85* (0.39)
Per Capita GDP	-0.14 (0.18)	-0.12 (0.18)
(Per Capita GDP)^2	0.01* ($4.81*10^{-03}$)	0.01* ($4.73*10^{-03}$)
Openness	-0.02 (0.01)	-0.02* (0.01)
Age < 15	-0.23 (0.52)	-0.10 (0.52)
(Age < 15)^2	$2.47*10^{-03}$ (0.01)	$4.37*10^{-04}$ (0.01)
Age > 65	-0.38 (0.89)	-0.48 (0.88)
(Age > 65)^2	0.01 (0.05)	0.02 (0.05)
Population	$-1.15*10^{-03}$ (0.01)	$-2.80*10^{-03}$ (0.01)
(Population)^2	$-2.18*10^{-09}$ ($1.26*10^{-08}$)	$-6.33*10^{-10}$ ($1.22*10^{-08}$)
Population Density	-0.24 (0.93)	-0.29 (0.98)
Pseudo R^2	0.65	0.65
N	80	78

Notes: Dependent variable is equal to one if country has a PC system, zero otherwise. * indicates significant at the 10% level. Model I results used to generate the propensity score to examine the price of super and diesel gasoline in 1998. Model II results used to generate the propensity score to examine the price of super and diesel gasoline in 2000.

Table 3. Matching Estimates of Presidential-Congressional Versus Parliamentary Systems

Parameter	Dependent Variable			
	Price of Super Gasoline, 1998 (1)	Price of Diesel Gasoline, 1998 (2)	Price of Super Gasoline, 2000 (3)	Price of Diesel Gasoline, 2000 (4)
Propensity Score	$-4.00*10^{-03}$ {20}		-0.02 {17}	
τ_{TT}	-22.15* [-80.15, -9.20]	-14.55* [-76.33, -6.62]	-16.59 [-58.00, 0.54]	-14.00* [-90.33, -2.50]
Variables Balanced	roads, paved, road density, autos, commercial vehicles, vehicles, gas. consumption, age<15, age>65, per capita GDP, pop., pop. density, urban, openness, independence, Gastil, forest, ag., per capita CO_2, lead , French/other colony		roads, paved, road density, autos, commercial vehicles, vehicles, gas. consumption, age<15, age>65, per capita GDP, pop., pop. density, urban, openness, independence, Gastil, forest, ag., per capita CO_2, lead , French/other colony, UK colony, federalism	
Variables Not Balanced	federalism, UK colony, Spanish colony, income tax		Spanish colony, income tax	
$\tau_{TT,RA}$	-16.63 (12.05) {36}	-24.79* (9.54) {30}	-11.74 (9.29) {36}	-16.58* (7.38) {30}

Notes: Figures represent mean difference between treatment countries (PC) and control countries (parliamentary). 90% bias corrected and accelerated (BCa) bootstrap confidence intervals in brackets, based on 1000 repetitions. Standard errors are in parentheses. * indicates significant at the 10% level. "Variables Balanced" implies that means are not significantly different across the matched treatment and control group at the 10% level using a t-test; "Variables Not Balanced" implies the means are significantly different. Number of matched pairs or regression observations is in curly brackets.

Figure 1. Histogram of Estimated Propensity Score.
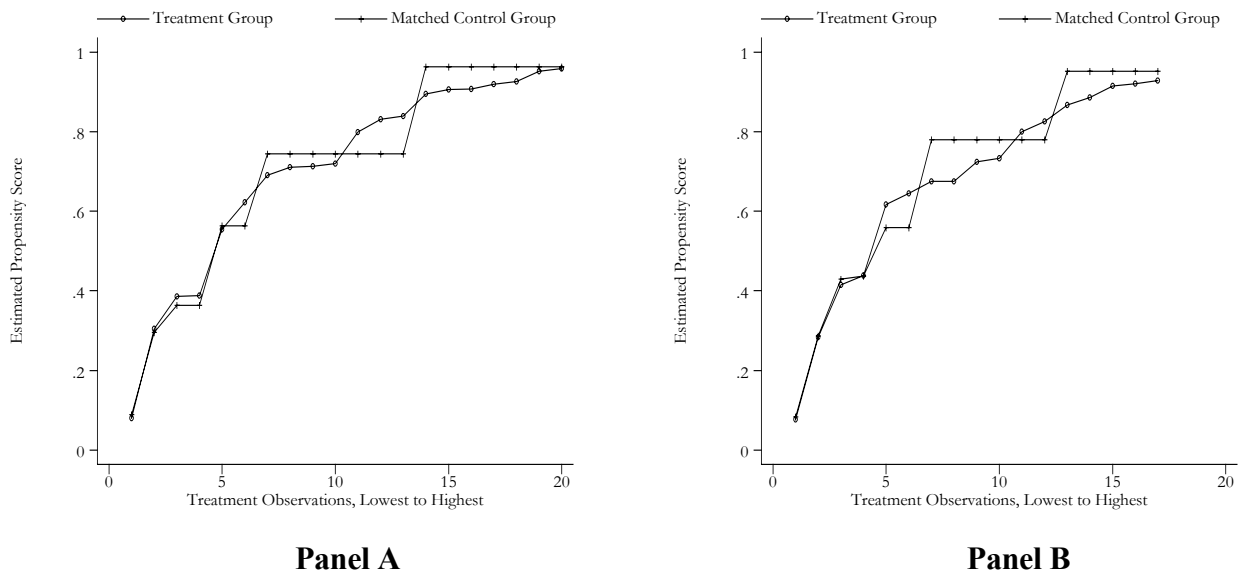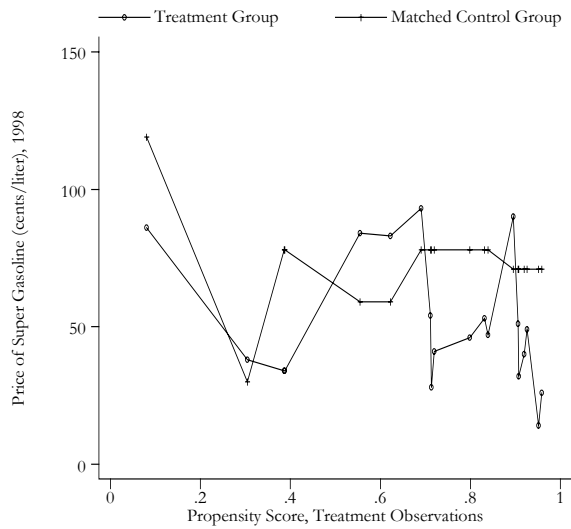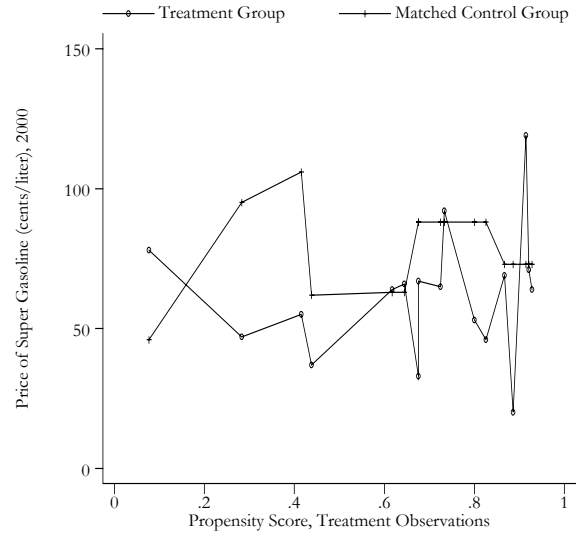

Panel A

Panel B

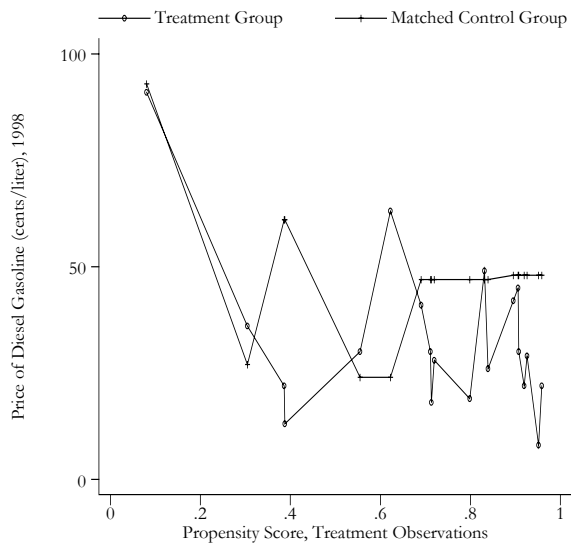**Figure 2. Propensity Score Comparisons Across Matched Pairs (Single Nearest Neighbor, With Replacement).**

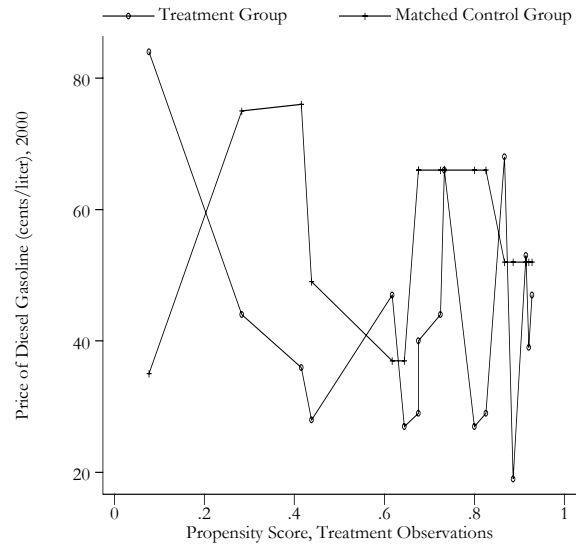**Figure 3. Super Gasoline Prices by Treatment Assignment & Propensity Score (Matched Pairs Only, Single Nearest Neighbor with Replacement).**

Figure 4. Diesel Gasoline Prices by Treatment Assignment & Propensity Score (Matched Pairs Only, Single Nearest Neighbor with Replacement).

Table 4. Sensitivity Analysis: Alternative Matching Algorithms

Matching Algorithm	Dependent Variable			
	Price of Super Gasoline, 1998 (1)	**Price of Diesel Gasoline, 1998** (2)	**Price of Super Gasoline, 2000** (3)	**Price of Diesel Gasoline, 2000** (4)
Nearest 5 Neighbors	-15.89 [-54.13, 0.82]	-10.36* [-52.50, -1.76]	-5.15 [-26.28, 20.28]	-5.18 [-29.92, 13.43]
Nearest 10 Neighbors	-10.13 [-38.98, 7.72]	-8.81 [-46.40, 1.82]	-5.71 [-27.90, 17.42]	-8.36 [-36.67, 7.82]
Radius Matching, Caliper = 0.05	-18.58 [-74.00, 9.87]	-10.29 [-56.00, 16.92]	-17.83 [-82.00, 7.56]	-11.53 [-71.00, 12.00]
Radius Matching, Caliper = 0.10	-18.58 [-74.00, 11.00]	-10.29 [-88.00, 12.00]	-17.83 [-82.00, 7.25]	-11.53 [-71.60, 11.38]
Radius Matching, Caliper = 0.20	-18.58 [-73.30, 11.00]	-10.29 [-55.00, 15.50]	-17.83 [-74.67, 5.00]	-11.53 [-79.00, 14.00]
Kernel Matching, Bandwidth = 0.04	-18.54* [-52.78, -5.90]	-11.05* [-52.84, -0.18]	-14.17 [-47.96, 3.64]	-12.28* [-45.58, -1.40]
Kernel Matching, Bandwidth = 0.06	-18.62* [-47.71, -5.72]	-11.39* [-57.00, -1.83]	-13.96 [-51.12, 2.17]	-12.28* [-48.35, -1.89]
Kernel Matching, Bandwidth = 0.08	-18.44* [-44.86, -5.15]	-11.33* [-50.48, -2.50]	-13.84 [-50.96, 1.81]	-12.30* [-35.95, -3.27]

Notes: Figures represent mean difference between treatment countries (PC) and control countries (parliamentary). Bias corrected and accelerated (BCa) bootstrap confidence intervals in brackets, based on 1000 repetitions. Kernel matching utilizes the Gaussian kernel. * indicates significant at the 10% level.