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REPLICATION STUDY: Hoover and Pecorino (Public Choice, 2005)

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Abstract: This paper replicates and analyses a study by Hoover and Pecorino on Federal spending in US states (Hoover and Pecorino, 2005; henceforth H&P). H&P followed on path-breaking research by Atlas et al. (1995) in which evidence was claimed in favour of the "small state effect;" namely, that since every state is represented by two Senators, small states have a disproportionate influence relative to their population size. H&P extended previous research by hypothesizing that if a small state effect existed, it should be most evident in Federal spending for (i) grants and (ii) procurement compared to other categories of Federal spending. They test this hypothesis using panel data of Federal spending in US states from 1983-1999. While we are able to closely replicate H&P's original findings, we argue that that research suffers from several specification problems. When these are corrected, the evidence is mixed, with a substantial number of contradictory results.

Keywords: Small state effect, Representation, US Senate, Replication study
JEL Classifications: H1, H5, C1
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I. INTRODUCTION.

This paper replicates and analyses a study by Hoover and Pecorino on Federal spending in US states (Hoover and Pecorino, 2005; henceforth H&P). H&P followed on path-breaking research by Atlas et al. (1995) in which evidence was claimed in favour of the "small state effect;" namely, that since every state is represented by two Senators, small states have a disproportionate influence relative to their population size. The problem with testing this hypothesis is that there is no variation in the number of Senators across states, so testing requires that one look at variation in the ratio of Senators per capita and assume that this variable captures the small state effect.

Recognizing this limitation of previous research, H&P hypothesized that if a small state effect existed, then it should be most evident in Federal spending for (i) grants and (ii) procurement compared to other categories of Federal spending. Their empirical evidence was generally supportive, leading them to conclude that political influence from senate representation influenced Federal spending across states.

The finding is an important one, because it suggests that the allocation of Federal funding is significantly affected by constitutionally embedded political constraints rather than welfare-improving allocation schemes. Together, the H&P and Atlas et al. studies have been widely influential in the literature. At the time of this writing, they have been cited 8 and 55 times in Web of Science, respectively.

Our study re-analyses the data underlying H&P. While we are able to closely approximate H&P's results, we argue that the original specifications suffer from a number of shortcomings. When these are corrected, a somewhat different picture emerges. We find some support for the small state hypothesis with a substantial minority of conflicting results.

The study proceeds as follows. Section 2 presents our replication of H&P's results. Section 3 identifies three specification issues with H&P's original analysis. Section 4 respecifies the main equations accordingly, and applies the same fixed effects estimation employed by H&P. Section 5 then discusses why fixed effects estimation may not be the appropriate methodology for identifying the small state effect given the characteristics of the

data. We explain why a panel data "between" estimator may be better, and then report the associated estimates. Section 6 formalizes H&P's hypotheses and presents the test results. Section 7 concludes.

2. REPLICATION OF HOOVER AND PECORINO (1985).

Description of H&P's main estimating equations. H&P's main estimating equations consist of fixed effects OLS regressions where the dependent variable is state-level, per capita Federal spending by budget category. A total of five Federal spending categories are investigated: (i) Retirement, (ii) Other, (iii) Wages, (iv) Grants, and (v) Procurement. Each of these categories is described in detail in Table 1 of H&P. Together these 5 categories include all Federal spending in states other than interest rate payments.

As their main measure of the small state effect, H&P use the variable *SENATE*, defined as $\left(\frac{2}{State\ Population}\right)$, the number of Senators per capita. If small states are more effective in securing Federal spending, then the sign of the coefficient of the *SENATE* variable should be positive. In other words, per capita Federal spending in a state should be inversely related to its population. Noting that there are other reasons why state spending could be inversely related to population, H&P say that evidence can be deduced by comparing the estimated effect of the *SENATE* variable <u>*across the different budget equations*</u> (H&P, p. 99):

> A priori, we expect that grants and procurement are the spending categories which will be most sensitive to our political variables. Our expectations for grants are informed by the previous work of Lee (1998, 2000). Procurement spending would seem to be particularly sensitive to political factors, as evidenced by numerous anecdotes of intervention by congressional representatives to prevent the Pentagon from killing a weapons project produced in his or her district. Retirement and disability and other direct payments should be least sensitive to our political variables, since they are mainly determined by eligibility factors such as age and income. We expect wages and salaries to be intermediate in the degree to which political variables affect the per capita spending figures. Clearly politics plays a major role in the initial decision about where to locate Federal projects and administrative offices which will generate wage and salary payments to Federal employees. Because many of these location decisions have a high degree of permanence, much of the political influence may be absorbed by the state fixed effects parameters which are included in our analysis.

The statement above predicts the following ordering of sensitivities to Senate representation across different categories:

- P1: $\beta_{SENATE,\ Wages} > \beta_{SENATE,\ Retirement}$
- P2: $\beta_{SENATE,\ Wages} > \beta_{SENATE,\ Other}$
- P3: $\beta_{SENATE,\ Grants} > \beta_{SENATE,\ Retirement}$
- P4: $\beta_{SENATE,\ Grants} > \beta_{SENATE,\ Other}$
- P5: $\beta_{SENATE,\ Grants} > \beta_{SENATE,\ Wages}$
- P6: $\beta_{SENATE,\ Procurement} > \beta_{SENATE,\ Retirement}$
- P7: $\beta_{SENATE,\ Procurement} > \beta_{SENATE,\ Other}$
- P8: $\beta_{SENATE,\ Procurement} > \beta_{SENATE,\ Wages}$

While H&P do not directly test these predictions, the predictions do inform H&P's discussion of their empirical results. In addition, H&P give special consideration to the category of procurements ("procurement spending would seem to be particularly sensitive to political factors"). Accordingly, our analysis will focus on assessing the empirical support for these eight predictions.

To control for state characteristics, H&P include variables for income per capita (*INCOME*), elderly share of the population (*ELDERLY*), and land area per capita (*LANDAREA*). Political control variables include the number of electoral votes assigned to a state (*ELECTORAL*), per capita House representation (*HOUSE*), the state's share of all representatives from the same party as the current U.S. President (*HOUSEP*), the number of Senators from the state belonging to the same party as the current President (*SENATEP*), the state's share of all representatives in the House's majority party (*HMAJOR*), the number of Senators belonging to the majority party in the Senate (*SMAJOR*), a dummy variable indicating whether the current President won the state (*VOTE*), the absolute size of the margin of victory for the President in that state (*MARGIN*), and the interaction of these two variables (*MARVOTE*). Also included is a dummy variable to indicate whether the governor of the state belongs to the same party as the President (*GOVP*), and dummy variables to indicate if the Senate majority leader (*MAJLEADER*) or Senate minority leader (*MINLEADER*) is from the state. For their data, H&P use annual Federal expenditures across all 50 states for the years 1983-1999. All explanatory variables were lagged by one year to account for the fact that spending decisions made in year *t* were not implemented until year *t+1*.

H&P's results and our replication. TABLE 1 reproduces the main results from H&P for each of the 5 Federal spending categories, plus the overall level of Federal spending per capita (*SPENDING*).[1] Immediately to the right of each column are the results from our

1. H&P's results are taken from their Table 4 (H&P, p. 104).

replication. Our replicated results are very close, albeit not identical, to H&P. We note that we interacted numerous times with one of the authors of the H&P study (Gary Hoover), who graciously assisted us in our replication efforts. While the original data for the H&P study are no longer available, Gary Hoover provided us with updated data that allowed us to closely match the original results.

The key variable in TABLE 1 is *SENATE*, measured in units of Senators per one million population. H&P deduce evidence for the small state effect by comparing the "sensitivity" of Federal spending to this variable across budget categories. They do this by weighting the respective *SENATE* coefficient estimate by the mean value of per capita Federal expenditures in that category. This calculation is performed in TABLE 2 for both the original and replicated results. H&P interpret these findings thusly (H&P, p. 110):

> "…we find the strongest effect in a spending category, procurement, where we expect political factors to play a large role. The next largest effect of senate representation is found in the wages and salaries spending category. Again, this is a category where we would expect politics to play at least a moderately important role. Senate representation also has an effect on grants spending … The effects of senate representation on expenditure are much smaller for retirement spending and the category OTHER. For these categories, we would not expect, a priori, that senate representation would play an important role for spending."

We note that H&P's original statement was that they expected *GRANTS* and *PROCUREMENT* to be most sensitive to the small state effect, *RETIREMENT* and *OTHER* to be least sensitive, and *WAGES* to be moderately sensitive. This is a strong prediction, and the empirical results do not exactly line up according to their prediction: *PROCUREMENT* and WAGES are estimated to be most sensitive to the small state effect, with *GRANTS* being moderately sensitive. As predicted, *RETIREMENT* and *OTHER* are least sensitive.

H&P interpret these results as "strong support" for the small state effect (H&P, p. 110). Our replication of their regressions confirms their empirical findings.

3. SPECIFICATION ISSUES.

Specification Problem 1: A near fall into the dummy variable trap. The first specification issue with the coefficients reported in TABLE 1 is that the estimating equations include *LANDAREA* (defined as land area divided by population) and a state fixed effect. Over this sample period no state experienced a change in its land area, so *LANDAREA* would be perfectly collinear with the state fixed effect if population did not vary. Similarly, the number of Senators is fixed for each state, so that the only variation in the *SENATE* variable arises

because *SENATE* varies inversely with population. If the specified regression equation had, instead, contained ln*SENATE* and ln*LANDAREA*, along with state fixed effects, then identification would have been impossible. Identification of the *SENATE* and *LANDAREA* coefficients thus relies entirely on the model being linear rather than log-linear in these variables. This is clearly seen by noting that a regression of ln*LANDAREA* on ln*SENATE* and state fixed effects produces an R^2 of 1. This strongly suggests that the estimates will be highly sensitive to reasonable alterations in model specification.

Specification Problem 2: Near perfect collinearity of the SENATE variable with the other included explanatory variables. While the linear specification of the model allows independent variation of the *SENATE* variable in the fixed effects specification, in fact the degree of collinearity with the other included variables is exceedingly high. When *SENATE* is regressed on the other explanatory variables in the original specification, the associated R^2 is 0.9972. In this case, it is not clear what the *SENATE* variable is actually measuring, as the effective variable is the associated residual with 99.72% of the original variation in *SENATE* removed.

Specification Problem 3: Absolute size versus relative share of state population. As noted above, *SENATE* is measured by $\left(\frac{2}{State\ Population}\right)$, the argument being that citizens of states with larger populations have less power per capita in the Senate. This specification suggests that if a small state increases in population over time, its "small state effect" will diminish even if its population increase is less than that of other states. This is not at all obvious. We suggest a better specification is a state's share of total US population. Define $SENATE2 = \left(\frac{US\ Population}{State\ Population}\right)$. According to this specification, if populations in all states increase by the same percentage the influence of that state in the U.S. Senate will remain the same. As with H&P's original specification, a positive coefficient for *SENATE2* is consistent with the small state effect.

Additional specification issues. As noted above, evidence in favour of the small state effect is to be found by comparing sensitivities of different spending categories to changes in the *SENATE* (or *SENATE2*) variable. As calculating elasticities is awkward in a linear specification, we use the natural log of the respective spending variable as the dependent variable. Then the coefficients on the *SENATE2* variable can be directly compared across specifications, and direct tests of prediction P1-P8 can be carried out. In a similar fashion, we trans-

form the income and land area variables using natural logs to facilitate interpretation of their coefficients.

4. ROBUSTNESS CHECK #1: FIXED EFFECTS ESTIMATION OF AN ALTERNATIVE SPECIFICATION OF THE SMALL STATE EFFECT.

We now check the robustness of H&P's results by substituting the *SENATE2* variable defined above for H&P's *SENATE* variable. Table 3A reports the results from estimating the alternative specification using fixed effects OLS. We focus on the coefficient for *SENATE2* and recall that $SENATE2 = \left(\frac{US\ Population}{State\ Population} \right)$, so that small states are characterized by larger values. To aid in interpreting the estimated coefficient for this variable, note that Maine, which is ranked at the 25th percentile in population, has a *SENATE2* value that is approximately 150 units larger than Massachusetts, which is ranked at the 75th percentile.

H&P found *PROCUREMENT* to be the spending category most sensitive to political influence. The estimates in TABLE 3A support this finding. According to the coefficient estimate of 0.0029, Maine would receive approximately 44% (= .0029*150) more Federal, per capita procurement expenditures than Massachusetts. The coefficient is significant at the 10% level. The second most sensitive budget category is *WAGES*. Using the same calculation as above, a relatively small state would receive approximately 29% more in Federal spending. These results are consistent with H&P's findings.

However, not all the results are confirming. There is no evidence of a small state effect for *GRANTS*. Even more puzzling is the fact that the estimated coefficient for *OTHER* is negative and significant, indicating that larger states are able to secure more non-retirement transfer payments per capita. This would appear to be a direct contradiction of the small state effect. However, as H&P point out, there could be other reasons why state population may affect Federal spending. For this reason, an appropriate test of the small state effect requires a comparison of coefficients across budget categories.

TABLE 3B repeats the previous analysis, but drops the other political variables to determine the extent to which these may be affecting the *SENATE2* estimates. *PROCUREMENT* and *GRANTS* show evidence of the greatest sensitivity to state size. The coefficient for *SENATE2* is still negative and significant for the *OTHER* category.

As indicated above, the puzzling finding for non-retirement, Federal transfer payments (*OTHER*) suggests that the *SENATE2* variable may be incorporating population effects not associated with senate representation. In fact, there is very little independent

variation in this variable over time. A regression of *SENATE2* on the state fixed effects produces an R^2 of 0.995. Thus, the "within estimates" of the coefficient for *SENATE2* in TABLES 3A and 3B are based on less than 0.5% of the variation in this variable. This raises concerns about what exactly the residual variation in *SENATE2* is measuring. Given that there is so little variation in *SENATE2* over time, we next turn to "between" estimates as a further robustness check.

5. ROBUSTNESS CHECK #2: PANEL DATA "BETWEEN" ESTIMATION OF THE ALTERNATIVE SPECIFICATION.

The small state effect is fundamentally a cross-sectional hypothesis. It says that small states will be disproportionately influential in the allocation of Federal funding, relative to larger states. Thus, the most natural test of this hypothesis is cross-sectional. Unfortunately, because identification of the *SENATE* and *SENATE2* coefficients depends on variations in population, and population may enter Federal funding decisions via numerous channels, there is reason for concern that state-specific omitted variables may cause bias in the estimates. This was the motivation for using fixed effects in the H&P study. However, there needs to be substantial within-state variation to obtain reliable fixed-effects estimates. As the previous section has shown, there is reason to question whether sufficient such variation exists in the H&P data set.

TABLE 4A reports the same specification used in TABLE 3A, except that estimation is now based on the OLS "between" procedure. As discussed above, one problem with the fixed effects estimates is that there is very little variation in the *SENATE2* variable that is not explained by the fixed effects. This is not the case in the between framework. When *SENATE2* is regressed on the other explanatory variables in the between regression the resulting R^2 is 0.6142. The trade-off in adopting the between estimator is that while it affords greater independent variation in the variable of interest, it does not address the concern that population size across states may be associated with other state characteristics not controlled for in the specification.

With respect to the small state hypothesis, the estimates in TABLE 4A provide both good news and bad news. The good news is that the coefficient on *GRANTS* is now positive and significant. A relatively small state (25^{th} percentile) is estimated to receive 27% more Federal grant funding per capita than a relatively large state (75^{th} percentile). Furthermore, the troubling negative and significant coefficient that was estimated for *OTHER* is now positive and insignificant. The bad news is that the evidence of a small state effect for

PROCUREMENT has now vanished. The estimated coefficient is now negative and marginally insignificantly different from zero (it is significant at the 12% level). Further, there is little change when the models are estimated without all the other political variables (see TABLE 4B). The *SENATE2* coefficient for *PROCUREMENT* remains negative and marginally insignificant (significant at the 11% level).

6. HYPOTHESIS TESTS.

The preceding analysis has produced four sets of estimates of the effect of population-based senate representation across budget categories. Arguments can be made for and against each set. To formalize the testing of the small state effect, we re-estimate each set of equations using seemingly unrelated regression and test for differences in the *SENATE2* coefficient across equations. The results are reported in TABLE 5.

Predictions P1-P8 imply that all the cells in the table should be positive. For example, P1 is $\beta_{SENATE,\ Wages} > \beta_{SENATE,\ Retirement}$. Evidence in favour of this prediction is that the estimated coefficient for the *SENATE2* coefficient in the ln*WAGES* regression should be larger than the estimated coefficient in the ln*RETIREMENT* equation. In TABLE 3A, the respective estimates are 0.0019 and -0.0001. The difference between these two estimates is 0.00201, which is consistent with the prediction. This difference value is reported in the top left cell in the table. The corresponding Z-value is reported directly below it. The other cells in the table are calculated in like manner. To test each of the predictions $\beta_{SENATE2,\ Column} > \beta_{SENATE2,\ Row}$, we form the null hypothesis $H_0 : \beta_{SENATE2,\ Column} \leq \beta_{SENATE2,\ Row}$. Rejection of the null hypothesis supports the existence of the small-state effect.

The results are mixed. Of the 32 differences in *SENATE2* coefficients, 24 are positive and 8 are negative. In the 32 tests reported in TABLE 5, the null is rejected a total of 15 times. This provides some support for H&P's predictions. However, there are a substantial number of conflicting results. Of the 8 negative values in the table, 7 are significant at the 5% level. Perhaps most damaging for the small state hypothesis, 6 of the 7 negative and significant differences are associated with *PROCUREMENT* spending.

Putting together (i) the hypothesis tests from TABLE 5; (ii) the individual regression results from TABLES 3 and 4, including negative and significant *SENATE2* coefficients for *OTHER* expenditures; and (iii) contradictory evidence for hypotheses having to do with *PROCUREMENT* spending, we conclude that the evidence for the small state effect is weak. In particular, the sensitivity of the results to different specifications and estimation

procedures, and the substantial minority of conflicting results, raise concerns that population affects Federal spending through multiple avenues. It may not be possible to separate out the effect of Senate representation from these other effects.

7. CONCLUSION.

This study replicates and analyzes research by Hoover and Pecorino (2005). H&P compare the sensitivity of different types of Federal spending to a variable measuring US Senators per capita for each state. Based upon previous research and their own understanding of the US political system, they hypothesize that Federal spending at the state level on grants and procurement will be most sensitive to this Senate representation variable; that spending on retirement and disability and other non-retirement transfer programs will be least sensitive; and that spending on wages and salaries will be moderately sensitive. Their empirical findings generally support this prediction, and our replication of their estimation produces very similar results.

Our contribution to this literature is that we identify three shortcomings in H&P's empirical analysis. We show that identification of the variable for Senate representation depends crucially on a linear rather than log-linear specification of the variables. When one expresses the key variables in logs, the data matrix is no longer full rank. Further, we argue that the Senate representation variable is itself misspecified, because it suggests a decline in the small state effect when a state's population increases, even if that increase is smaller than that of other states. Finally, we show that there is very little variation in the key Senate representation variable over time. These considerations lead us to reformulate the Senate representation variable and to calculate "between" panel estimates to compare with the fixed effect estimates.

Our analyses produce mixed results. In our fixed effects analyses, we obtain evidence that procurement spending is the category most sensitive to the Senate representation variable, consistent with the theory, but that spending on grants is not sensitive to the variable. We also estimate a negative and statistically significant effect for the category of non-retirement, transfer payments, which is inconsistent with the theory. When we switch to between estimation, we find that the only statistically significant estimate occurs in the equation for Federal grants. However, the respective coefficient in the procurement equation is of the wrong sign, and just misses statistical significance at the 10% level. Finally, when we perform an extensive set of hypothesis tests, while a majority of the tests support the small state

effect, we find that a substantial minority are contradictory. Of greatest concern is the poor performance of the hypothesis tests for *PROCUREMENT* spending in the between equations.

Like the proverbial glass half full, there are many ways to interpret our findings. Specific results are highly sensitive to model specification and estimation procedure. While the majority of our hypothesis tests support the small state effect, there are a substantial number of contradictory results. The existence of these contradictory results suggests that it may not be possible to adequately identify the small state effect from other channels by which population affects Federal spending across states.

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TABLE 1.
Replication of Hoover and Pecorino's Table 4 Results.

VARIABLE	*Dep. Variable = SPENDING*		*Dep. Variable = RETIREMENT*	
	H&P Estimates	*Replication*	*H&P Estimates*	*Replication*
INCOMES	-0.153*** (-9.70)	-0.148*** (-9.19)	-0.012*** (-6.95)	-0.013*** (-6.63)
ELECTORAL	-55.94*** (-5.51)	-53.66*** (-5.28)	-9.69*** (-8.11)	-9.32*** (-7.83)
ELDERLY	7169.97** (2.09)	7448.90** (2.19)	7440.42*** (18.40)	7458.01*** (18.71)
SENATE	962.20*** (6.03)	1189.45*** (6.72)	119.78*** (6.38)	150.79*** (7.27)
LANDAREA	586.27 (0.43)	-543.69 (-0.48)	71.64 (0.44)	-94.66 (-0.71)
HOUSE	-100.59 (-0.97)	-140.02 (-1.34)	-2.14 (-0.18)	-8.93 (-0.73)
GOVP	41.72* (1.72)	39.25 (1.63)	4.30 (1.51)	3.62 (1.28)
HOUSEP	70.42 (1.51)	59.35 (0.91)	6.39 (1.16)	-2.60 (-0.34)
SENATEP	14.60 (0.77)	16.34 (1.00)	-0.76 (-0.34)	-0.03 (-0.01)
HMAJOR	29.96 (0.74)	8.82 (0.13)	-1.1 (-0.23)	-12.23 (-1.51)
SMAJOR	-0.10 (-0.01)	1.60 (0.11)	0.73 (0.31)	3.30* (1.94)
VOTE	-236.69*** (-4.82)	-234.45*** (-4.80)	-11.4 (-1.97)	-10.33* (-1.81)
MARGIN	-2332.49*** (-4.46)	-2300.26*** (-4.42)	-37.59 (-0.61)	-27.84 (-0.46)
MARVOTE	2290.86*** (4.49)	2259.49*** (4.43)	-27.75 (-0.46)	-41.01 (-0.69)
MAJLEADER	107.18 (1.27)	108.95 (1.30)	4.32 (0.44)	4.95 (0.50)
MINLEADER	43.81 (0.46)	55.87 (0.59)	12.7 (1.14)	18.13 (1.63)
Adjusted R^2	0.915	0.916	0.979	0.980

TABLE 1.
Replication of Hoover and Pecorino's Table 4 Results (Continued)

VARIABLE	*Dep. Variable = OTHER*		*Dep. Variable = WAGES*	
	H&P Estimates	*Replication*	*H&P Estimates*	*Replication*
INCOMES	-0.023*** (-3.78)	-0.022*** -3.36	-0.005 (-1.38)	-0.005 (-1.28)
ELECTORAL	-2.54 (-0.63)	-1.95 (-0.47)	-14.05*** (-5.56)	-13.92*** (-5.46)
ELDERLY	5570.53*** (4.05)	5788.22*** (4.21)	-7326.8*** (-8.56)	-7323.96*** (-8.57)
SENATE	81.77 (1.28)	101.72 (1.42)	173.16*** (4.35)	230.69*** (5.19)
LANDAREA	804.76 (1.47)	548.88 (1.19)	-1244.3*** (-3.65)	-1204.45*** (-4.21)
HOUSE	-57.03 (1.37)	-60.46 (-1.43)	11.78 (0.46)	-0.39 (-0.01)
GOVP	9.13 (0.94)	7.03 (0.72)	-16.5*** (-2.73)	-14.12** (-2.33)
HOUSEP	1.24 (0.07)	19.51 (0.74)	2.59 (0.22)	-14.51 (-0.89)
SENATEP	4.82 (0.63)	2.87 (0.43)	-3.28 (-0.69)	-1.83 (-0.45)
HMAJOR	53.71*** (3.33)	49.19* (1.76)	-43.59*** (-4.34)	-37.54** (-2.17)
SMAJOR	6.72 (0.83)	4.76 (0.81)	-8.44 (-1.69)	-9.15** (-2.51)
VOTE	-65.21*** (3.32)	-67.16*** (-3.40)	-1.2 (-0.10)	1.72 (0.14)
MARGIN	-774.72*** (-3.70)	-804.248*** (-3.82)	-396.79*** (-3.05)	-350.81*** (-2.68)
MARVOTE	1090.59*** (5.33)	1119.40*** (5.43)	419.18*** (3.30)	375.99*** (2.94)
MAJLEADER	50.65 (1.50)	42.42 (1.25)	-19.12 (-0.91)	-9.49 (-0.45)
MINLEADER	11.48 (0.30)	5.51 (0.14)	-42.41* (-1.80)	-35.40 (-1.48)
Adjusted R^2	0.888	0.888	0.976	0.977

TABLE 1 (Continued)
Replication of Hoover and Pecorino's Table 4 Results.

VARIABLE	*Dep. Variable = GRANTS*		*Dep. Variable = PROCUREMENT*	
	H&P Estimates	*Replication*	*H&P Estimates*	*Replication*
INCOMES	-0.012*** (-3.17)	-0.012*** (-2.88)	-0.057*** (-4.87)	-0.060*** (-4.94)
ELECTORAL	-3.54 (-1.41)	-2.64 (-1.05)	-24.2*** (-3.21)	-24.59*** (-3.24)
ELDERLY	2639.55*** (3.10)	2953.03*** (3.50)	4186.66 (1.64)	3673.75 (1.45)
SENATE	108.39*** (2.74)	130.41*** (2.97)	247.55** (-2.09)	256.35* (1.94)
LANDAREA	-968.22*** (-2.85)	-792.68*** (-2.80)	2369.05** (2.33)	1841.10** (2.16)
HOUSE	37.7 (1.47)	21.92 (0.85)	-103.03 (-1.34)	-88.03 (-1.13)
GOVP	0.87 (0.14)	-1.24 (-0.21)	38.99** (2.16)	38.73** (2.15)
HOUSEP	44.77*** (3.86)	31.76** (1.97)	0.53 (0.00)	21.00 (0.43)
SENATEP	15.06*** (3.20)	16.06*** (3.96)	-5.27 (-0.37)	-4.64 (-0.38)
HMAJOR	24.68** (2.47)	-7.65 (-0.45)	-9.00 (-0.30)	26.18 (0.51)
SMAJOR	5.7 (1.14)	14.25*** (3.95)	1.65 (0.11)	-0.84 (-0.08)
VOTE	-16.68 (-1.37)	-14.95 (-1.24)	-108.36*** (-2.97)	-111.43*** (-3.06)
MARGIN	113.43 (0.88)	126.38 (0.98)	-688.1* (-1.77)	-721.81* (-1.86)
MARVOTE	20.93 (0.17)	-8.34 (-0.07)	568.74 (1.50)	622.10 (1.63)
MAJLEADER	4.44 (0.21)	0.22 (0.01)	78.63 (1.26)	79.58 (1.27)
MINLEADER	23.37 (1.00)	35.21 (1.50)	27.11 (0.39)	25.96 (0.37)
Adjusted R^2	0.942	0.943	0.868	0.868

NOTE: The t-statistics are presented in parentheses. All regressions include state and time fixed effects.

*,**,*** Denote significance at the 10, 5, and 1% levels, respectively.

TABLE 2.

Sensitivity of Federal Spending Categories to Senate Representation: Original and Replicated Results.

	RETIREMENT	*OTHER*	*WAGES*	*GRANTS*	*PROCUREMENT*
H&P'S RESULTS:					
(1) Estimated SENATE Coefficient	119.78	81.77	173.16	108.39	247.55
(2) Mean of Dependent Variable	1816.84	1193.41	565.01	992.29	644.65
(1) ÷ (2)	6.6%	6.9%	30.6%	10.9%	38.4%
REPLICATION RESULTS:					
(1) Estimated SENATE Coefficient	150.79	101.72	230.69	130.41	256.35
(2) Mean of Dependent Variable	1729.36	978.22	749.74	870.08	810.06
(1) ÷ (2)	8.7%	10.4%	30.8%	15.0%	31.6%

NOTE: TABLE 2 compares estimated sensitivity of Federal spending categories to state population size as reported in Hoover and Pecorino (2005, upper panel) to those obtained in the present replication (lower panel). The estimated coefficient in the first row of each panel indicates the estimated effect of a unit change in the SENATE variable on the amount of per-capita Federal spending in each category. The third row of each panel indicates the size of the effect of that unit change in SENATE as a percent of total spending.

TABLE 3A.
Robustness Check #1: FE OLS Estimation with Alternative Specification.

	DEPENDENT VARIABLE				
	ln*RETIREMENT*	**ln*OTHER***	**ln*WAGES***	**ln*GRANTS***	**ln*PROCUREMENT***
ln*INCOMES*	-0.1259*** (-4.97)	-0.5693*** (-4.23)	-0.1462 (-1.64)	0.0119 (0.13)	0.2275 (0.80)
ELECTORAL	0.0003 (0.36)	0.0039 (0.91)	-0.0077*** (-2.67)	0.0111*** (3.90)	0.0240*** (2.63)
ELDERLY	4.8804*** (20.79)	10.0254*** (8.04)	-2.6806*** (-3.24)	0.6803 (0.83)	8.9193*** (3.39)
SENATE2	-0.0001 (-1.05)	-0.0023*** (-3.20)	0.0019*** (3.81)	-0.0002 (-0.33)	0.0029* (1.87)
ln*LANDAREA*	0.3261*** (10.65)	0.0580 (0.36)	0.4066*** (3.77)	0.2954*** (2.77)	1.0860*** (3.16)
HOUSE	-0.0181*** (-2.61)	0.0702* (1.90)	-0.0767*** (-3.14)	0.0472* (1.95)	-0.3066*** (-3.94)
GOVP	0.0078*** (4.72)	0.0140 (1.59)	0.0142** (2.44)	-0.0043 (-0.74)	0.0598*** (3.22)
HOUSEP	-0.0027 (-0.63)	0.0075 (0.33)	-0.0150 (-0.99)	0.0434*** (2.91)	0.0678 (1.41)
SENATEP	-0.0036*** (-3.26)	-0.0049 (-0.84)	-0.0052 (-1.32)	0.0169*** (4.40)	0.0100 (0.80)

	DEPENDENT VARIABLE				
	ln*RETIREMENT*	**ln*OTHER***	**ln*WAGES***	**ln*GRANTS***	**ln*PROCUREMENT***
0.0502** (2.05)	-0.0460*** (-2.83)			0.0089 (0.55)	0.0811 (1.57)
SMAJOR	0.0004 (0.45)	-0.0017 (-0.32)	-0.0030 (-0.85)	0.0153*** (4.44)	0.0071 (0.64)
VOTE	-0.0019 (-0.58)	-0.0681*** (-3.88)	-0.0051 (-0.44)	-0.0298*** (-2.59)	-0.1211*** (-3.27)
MARGIN	-0.0111 (-0.31)	-0.7271*** (-3.86)	-0.0921 (-0.74)	-0.2972** (-2.41)	-1.0524*** (-2.65)
MARVOTE	-0.0642* (-1.86)	0.9675*** (5.29)	0.2612** (2.15)	0.2863** (2.39)	0.7580** (1.96)
MAJLEADER	0.0104* (1.82)	0.0327 (1.08)	-0.0042 (-0.21)	-0.0202 (-1.02)	0.0594 (0.93)
MINLEADER	0.0252*** (3.97)	-0.0119 (-0.35)	-0.0220 (-0.99)	-0.0345 (-1.56)	0.0172 (0.24)
Adjusted R^2	0.9826	0.9179	0.9788	0.9472	0.8917

NOTE: The t-statistics are presented in parentheses. All regressions include state and time fixed effects.

*,**,*** Denote significance at the 10, 5, and 1% levels, respectively.

TABLE 3B.
Robustness Check #1: FE OLS Estimation with Alternative Specification Omitting All Political Variables.

	DEPENDENT VARIABLE				
	ln*RETIREMENT*	**ln*OTHER***	**ln*WAGES***	**ln*GRANTS***	**ln*PROCUREMENT***
ln*INCOMES*	-0.1493*** (-5.57)	-0.4968*** (-3.79)	-0.0657 (-0.74)	0.0564 (0.64)	0.1179 (0.43)
ELDERLY	4.7366*** (18.84)	9.8461*** (8.02)	-2.1771*** (-2.61)	0.9404 (1.14)	9.0596*** (3.49)
SENATE2	0.0001 (0.90)	-0.0020*** (-3.04)	0.0005 (1.09)	0.0008* (1.77)	0.0045*** (3.26)
ln*LANDAREA*	0.2010*** (7.65)	0.0282 (0.22)	0.6971*** (8.00)	0.1625* (1.89)	0.1299 (0.48)
Adjusted R^2	0.9784	0.9135	0.9766	0.9419	0.8854

NOTE: The t-statistics are presented in parentheses. All regressions include state and time fixed effects.

*,**,*** Denote significance at the 10, 5, and 1% levels, respectively.

TABLE 4A.
Robustness Check #2: Panel Data "Between" Estimation with Alternative Specification.

	DEPENDENT VARIABLE				
	ln*RETIREMENT*	**ln*OTHER***	**ln*WAGES***	**ln*GRANTS***	**ln*PROCUREMENT***
ln*INCOMES*	-0.1927 (-1.60)	0.2819 (1.16)	0.3685 (0.59)	-0.0653 (-0.26)	0.7848 (0.91)
ELECTORAL	-0.0036** (-2.27)	0.0046 (1.44)	-0.0073 (-0.89)	0.0051 (1.55)	-0.0146 (-1.28)
ELDERLY	4.1384*** (6.20)	10.2845*** (7.62)	-10.1504*** (-2.92)	-1.7798 (-1.28)	-12.9765** (-2.70)
SENATE2	-0.0001 (-0.98)	0.0004 (1.47)	0.0009 (1.28)	0.0018*** (6.55)	-0.0016 (-1.61)
ln*LANDAREA*	-0.0218 (-1.50)	0.0550* (1.87)	-0.0331 (-0.44)	-0.0186 (-0.61)	-0.0640 (-0.61)
HOUSE	0.1054 (1.02)	-0.2237 (-1.07)	-0.8691 (-1.62)	0.0657 (0.31)	-0.8745 (-1.18)
GOVP	0.0107 (0.21)	-0.2325** (-2.21)	0.0684 (0.25)	-0.2115* (-1.95)	-0.5041 (-1.34)
HOUSEP	-0.0031 (-0.02)	0.0013 (0.00)	1.7531* (1.80)	1.0154** (2.61)	1.0354 (0.77)
SENATEP	0.0107 (0.18)	-0.1352 (-1.13)	-0.2606 (-0.85)	-0.1139 (-0.93)	0.2286 (0.54)

	DEPENDENT VARIABLE				
	ln*RETIREMENT*	**ln*OTHER***	**ln*WAGES***	**ln*GRANTS***	**ln*PROCUREMENT***
HMAJOR	0.0466 (0.33)	0.2438 (0.84)	1.1266 (1.51)	0.5407* (1.82)	0.1566 (0.15)
SMAJOR	-0.0224 (-0.30)	-0.1224 (-0.82)	0.1030 (0.27)	-0.0483 (-0.32)	0.0331 (0.06)
VOTE	-0.1476 (-1.32)	0.4818** (2.13)	-0.3439 (-0.59)	0.2783 (1.20)	0.3931 (0.49)
MARGIN	-2.8395** (-2.39)	6.4691** (2.69)	1.4991 (0.24)	2.4844 (1.01)	-0.5180 (-0.06)
MARVOTE	3.4736** (2.33)	-9.3482*** (-3.11)	-2.1731 (-0.28)	-4.9513 (-1.60)	2.3277 (0.22)
MAJLEADER	0.0471 (0.26)	-0.0597 (-0.16)	-0.4952 (-0.53)	-0.1290 (-0.34)	1.0810 (0.83)
MINLEADER	0.0200 (0.13)	0.1557 (0.51)	0.3700 (0.47)	0.0350 (0.11)	0.0755 (0.07)
R^2	0.7744	0.7506	0.4927	0.7256	0.4364

NOTE: The t-statistics are presented in parentheses. All regressions include state and time fixed effects.

*,**,*** Denote significance at the 10, 5, and 1% levels, respectively.

TABLE 4B.
Robustness Check #2: Panel Data Between Estimation with Alternative Specification Omitting All Political Variables.

	DEPENDENT VARIABLE				
	ln*RETIREMENT*	**ln*OTHER***	**ln*WAGES***	**ln*GRANTS***	**ln*PROCUREMENT***
ln*INCOMES*	-0.2168 (-2.33)	0.1922 (0.89)	0.2626 (0.54)	0.0840 (0.35)	0.9619 (1.49)
ELDERLY	4.4579 (7.30)	10.1101*** (7.10)	-10.0037*** (-3.14)	-1.7511 (-1.11)	-12.8263*** (-3.03)
SENATE2	-0.0000 (-0.02)	-0.0000 (-0.04)	0.0006 (1.05)	0.0012*** (4.52)	-0.0012 (-1.67)
ln*LANDAREA*	-0.0199 (-1.67)	0.0409 (1.47)	0.0220 (0.35)	-0.0107 (-0.35)	0.0033 (0.04)
R^2	0.6965	0.5528	0.3129	0.4271	0.2924

NOTE: The t-statistics are presented in parentheses. All regressions include state and time fixed effects.

*,**,*** Denote significance at the 10, 5, and 1% levels, respectively.

TABLE 5.
Tests of Predictions: $\beta_{SENATE2,\ Column} > \beta_{SENATE2,\ Row}$

	ln*WAGES*	ln*GRANTS*	ln*PROCUREMENT*
***Table 3a* (*Fixed Effects, Full Model*):**			
ln*RETIREMENT*	0.00201*** (4.97)	-0.00002 (0.00)	0.00305** (1.85)
ln*OTHER*	0.00420*** (4.23)	0.00218** (1.82)	0.00524*** (3.02)
ln*WAGES*	----	-0.00202 (2.45)	0.00104 (0.62)
***Table 3b* (*Fixed Effects, Restricted Model*):**			
ln*RETIREMENT*	0.00036 (1.10)	0.00065 (0.73)	0.00436*** (2.92)
ln*OTHER*	0.00245*** (2.67)	0.00274*** (2.22)	0.00645*** (4.07))
ln*WAGES*	----	0.00029 (0.35)	0.00400*** (2.70)
***Table 4a* (*Between, Full Model*):**			
ln*RETIREMENT*	0.00103*** (2.63)	0.001972*** (8.44)	-0.00143 (-2.79)
ln*OTHER*	0.00050 (1.04)	0.00144*** (4.41)	-0.00196 (-3.79)
ln*WAGES*	----	0.000939** (1.73)	-0.00246 (-5.09)
***Table 4b* (*Between, Restricted Model*):**			
LnRETIREMENT	0.00057 (1.02)	0.001223*** (3.81)	-0.00121 (-2.28)
LnOTHER	0.00058 (1.07)	0.001231*** (4.00)	-0.00120 (-2.36)
LnWAGES	----	0.000648 (1.15)	-0.00178 (-3.74)

NOTE #1: Predictions P1-P8 in the text imply that all the cells in the table should be positive. The appropriate null hypothesis for the prediction $\beta_{SENATE2,\ Column} > \beta_{SENATE2,\ Row}$ is $H_0 : \beta_{SENATE2,\ Column} \leq \beta_{SENATE2,\ Row}$. Rejection of the null supports the existence of the small-state effect.

NOTE #2: The numbers in the table equal the differences in the *SENATE2* coefficient from a given Column regression minus the *SENATE2* coefficient from the corresponding Row regression. For example, in TABLE 3A, the difference in the *SENATE2* coefficient in the ln*WAGES* regression minus the *SENATE2* coefficient in the ln*RETIREMENT* regression is 0.00201 (= 0.0019 - -0.0001). The numbers in parentheses are Z statistics.

*,**,*** Denote rejection of the null hypothesis, $H_0 : \beta_{SENATE2,\,Column} \leq \beta_{SENATE2,\,Row}$ at the 10, 5, and 1% levels, respectively.

APPENDIX
Sample Characteristics.

	MEAN	***MEDIAN***	***STD. DEV.***	***MIN***	***MAX***
ELDERLY	0.123	0.125	0.021	0.029	0.186
ELECTORAL	10.7	8	9.3	3	54
GOVP	0.399	0	0.490	0	1
GRANTS	870.08	800.67	296.27	401.04	3005.64
HMAJOR	0.57	0.57	0.28	0	1
HOUSE	1.76	1.75	0.21	1.08	2.50
HOUSEP	0.45	0.44	0.28	0	1
INCOME	23243	22710	3877	14099	38689
LANDAREA	0.0485	0.0125	0.1469	0.0009	1.2721
MAJLEADER	0.02	0	0.14	0	1
MINLEADER	0.02	0	0.14	0	1
MARGIN	0.140	0.120	0.104	0.000	0.522
MARVOTE	0.124	0.105	0.115	0.000	0.522
OTHER	978.22	942.47	344.76	244.09	2541.78
POPULATION	5078097	3408646	5500174	453690	33500000
PROCUREMENT	810.06	652.76	587.80	154.72	3812.50
RETIREMENT	1729.36	1735.33	238.42	777.75	2545.14
SENATE	1.04	0.59	1.04	0.06	4.45
SENATE2	130.1	71.6	130.5	8.3	566.2
SENATEP	1.00	1	7602331.00	0	2
SMAJOR	1.07	1	0.76	0	2
SPENDING	5231.76	5114.50	984.42	3502	8825
WAGES	749.74	635.45	469.31	261.01	3126.67
USPOPULATION	2.54E+08	2.52E+08	1.43E+07	2.33E+08	2.78E+08
VOTE	0.78	1	0.41	0	1