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Political Institutions and Public R&D Expenditures in Democratic Countries

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Abstract: While research and development (R&D) expenditure is crucial in a nation's competitive advantage, factors determining levels of public investment in R&D have yet to be examined. This paper seeks to fill this void, focusing on different democratic institutions such as presidential versus parliamentary systems, majoritarian versus proportional electoral systems, federal versus unitary systems, bicameral versus unicameral legislatures, and the effective number of parties. Using public R&D appropriations data from 18 OECD countries between 1981 and 2007, this article reports that democratic institutions do matter in the levels of public R&D spending. However, the effect is more complicated across the different types and performers of research than expected. Additionally, the effect of one institutional dimension is found to be moderated by the existence of the other dimensions, which makes it clearly more challenging to sort out different degrees and directions of the relationships between R&D expenditures and political institutions.

Key words: Democratic Institutions, Research and Development Expenditures, OECD Countries

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Introduction

Public research and development (R&D) programs are distinct from and much more subtle than ordinary distributive projects of localized benefits. Due to the nature of non-excludability and non-rivalry of scientific research products (Nelson, 1959), R&D expenditures benefit not only the recipients of public money, who may be either a special interest or an electoral district, but also the economy as a whole. Scientific research is "likely to generate substantial external economies" such that for-profit firms do not tend to undertake research to the socially desirable level (Arrow, 1962; Griliches, 1960; Nelson, 1959, p. 302). Externalities make it difficult to establish property rights on outputs of scientific research, rendering the performance of R&D a typical market failure problem (Dasgupta and David, 1984). This in part provides a ready-made rationale for governmental provision/financing of R&D activities.

However, as in other distributive policies, the degree of governmental intervention with R&D activities is a matter of various factors, including political institutions, political actors, and socio-economic conditions. Actually, a wide variation in public support of R&D is observed. For example, in 2007, governments in countries such as Canada, Japan, New Zealand, and United Kingdom spent less than 0.6% of their gross domestic products (GDP) on R&D activities (OECD, 2009). On the other hand, Finland, Iceland, Norway, South Korea, and United States spend more than 0.7% of the respective GDP in R&D activities. What causes these differences in R&D investment across countries? While comparative studies have tried to explain the level of a country's private investment in R&D, drawing upon different factors such as market size (Romer, 1996), industrial structure (Cohen, Levin, and Mowery, 1987; Lederman and Maloney, 2003), firm size and market structure (OECD, 2003;

Symeonidis, 1996), and public subsidies (Bloom, Griffith, and van Reenen, 2000; Hall and van Reenen, 2000), the variations in the level of public investment across countries have rarely drawn theoretical attention from economists and political scientists in the research policy literature.

The scope and size of government has been examined theoretically as well as empirically from the political economy perspective, with a focus on differently induced rules imposed by political institutions Different political institutions refer to electoral systems, the types of government, political party competition, legislative structure, and federalism. A unique profile of political institutions offers a particular set of rules for those in the system, which leads to specific mix of goods and services provided by governments at the national and sub-national levels. For example, a government with a majoritarian election system tends to provide less public goods and more social transfers (Austen-Smith 2000; Persson, Roland, and Tabellini, 1998; Persson and Tabellini, 1999). By instituting tougher competition among both politicians and voters, the presidential system is likely to result in a smaller government (Persson and Tabellini, 1999, 2001; Shelton, 2007). As for federalism, Peterson (1995) argues that redistributive policies tend to be administered by the national government.

Utilizing this body of literature on the "supply-side" determinants of the scope and size of government, this article investigates the cross-country variation in public R&D expenditures, focusing on the effect of different democratic institutions. Theoretically as well as empirically, a focus on "democratic" countries will be more meaningful since 1) public spending implications of these different institutions may be more fully realized in democracies without much distortion, 2) democratic countries are economically more advanced, and 3) a large variation of public spending on R&D activities is observed even among these countries. Only analyzing democratic countries, the effect from the degrees of democratization can be controlled.

This article is organized as follows. In reviewing studies on the levels of R&D expenditures in a democracy, the second section argues that a democratic government tends to spend less on R&D activities than at a socially efficient level. Hypotheses are introduced on the relationship between political institutions and public R&D expenditures, drawing upon the literature on political institutions and the size and scope of government. Then, analytical findings are reported with an accompanying discussion.

R&D Expenditures in a Democracy

The Downsian model of democracy (Downs, 1957, 1960) posits that the government budget in a democracy tends to be too small.[1] Downs' argument hinges upon differences in the information cost and the nature of public and private transactions. In private transactions, the *quid pro quo* relationship provides accurate estimation of both costs and benefits, which is not available with public transactions. Accordingly, there are differences in the levels of information gained about benefits and costs of public transactions. Benefits from government actions tend to be more remote in terms of time, space, or comprehensibility than are the costs involved in producing such benefits (Downs, 1960, pp. 551-2). Downs also noticed that if voters were to see costs more clearly than benefits, the actual budget would be smaller than the "about-right" size. Typically, benefits from government programs tend to be more uncertain than those from private transactions. Uncertainty involved in the calculation of expected values makes programs of highly uncertain benefits not as attractive to vote-seeking politicians as those promising for-sure benefits. Thus, the returns from public expenditures are to be more heavily discounted than private investments. Therefore, "a tendency toward elimination from the budget of all expenditures that produce hidden benefits" (Downs, 1960, 553) is highly probable.

[1] While controversial, the public budget of "about-right" size is defined as "the level that maximizes the utility of the representative citizen under full information" (Katsimi, 1999, p. 442).

This argument of a "too small budget" provides a starting point to consider the levels of public R&D programs. The practical utility from outputs of basic research is not easily determined (Greenberg, 1967; Sherwin and Isenson, 1967). It typically takes several years or decades for basic research to benefit practical applications (Adams, 1990; Branstetter, 2005; Gellman Associates, 1976; Mansfield, 1991, 1998). Furthermore, uncertainty is prevalent along the road from research to economic growth such that the utilization of research results depends on many contingencies. The production of knowledge is increasingly more dependent upon dynamic interactions of various actors in the process (Bozeman and Rogers, 2002; Rogers and Bozeman, 2001) whose outcomes cannot be determined *a priori*, and factors other than the knowledge itself are critical in the utilization and evolution of such knowledge (Nelson and Nelson, 2002).

Another argument of insufficient public expenditures in R&D comes from theories of majority voting and log-rolling (Buchanan and Tullock, 1962; Tullock, 1959, 1970). Under the system of majority voting, log-rolling is justified in part by the intensities of preferences. A minority voter who opposes a program with a strong intensity may benefit from vote trading with a majority voter who only slightly favors the program, where the former compensates the latter by changing his/her position on other issues. However, vote trading involves externalities, and if they are negative and large, the transaction would result in an efficiency loss (Mueller, 1976). Log-rolling can get a program supported whose benefits are highly concentrated on a small group with its costs borne by the general taxpayers. The result may involve over-expenditures on programs of special interests (Tullock, 1959). This problem will be more serious if the higher possibility of voters supporting candidates who promise programs of narrowly concentrated benefits is considered (Mueller, 1976; Olsen, 1965). Since interest groups have every incentive to propagate the merits of their pet programs, costs of benefit information on such programs will be much lower than on widely

diffused benefits.

For these reasons, politicians may turn away from expenditures on R&D programs, which are typically characterized by high externalities and uncertainty. Then, are public R&D activities not serving highly organized interests? The answer is a definitive YES. R&D programs are designated as distributive policies along with "most contemporary public land and resource policies; rivers and harbors ('pork-barrel') programs" (Lowi, 1964, p. 690; Meier, 1993). Some R&D programs involving industrial firms are often considered "corporate welfare," whose primary beneficiaries are large companies. The same is true of the U.S. federal R&D tax credits from which high-tech and large manufacturing firms benefit (OTA, 1995). As for federal support of university research in the U.S., during Fiscal Year (FY) 1971–2000, "the research, doctorate-granting, and medical institutions" received more than 90% of R&D funds for university research (NSF 2004); these funds are concentrated at top prestigious universities.

These considerations and evidence prove that R&D expenditures do serve special interests and reveal that R&D expenditures are themselves an arena of politics among interest groups, members of Congress, and bureaucrats. Although public R&D expenditures have generated a number of interested groups among the beneficiaries (Savage, 1999), there is also an extensive array of empirical studies on the knowledge spillover (Audretsch et al., 2002). It is a matter of not only giving away benefits but also creating externalities to those who are not direct beneficiaries of public money. As in this article, it may be beneficial to think through the issue in terms of the types and performers of R&D such that, with varying degrees of spillovers, different types of research would benefit different groups. Basic research conducted by government scientists may represent what can be called a "public good" and research grants to industrial laboratories may be viewed as what is closer to a "special interest" program.

Democratic Institutions and R&D Expenditures: Theories and Hypotheses

Theoretically, it is highly probable for a democratic government not to invest enough in R&D programs. However, this does not say much about specific levels of R&D expenditures of such governments. The concept of democracy has multiple dimensions, and each one may have unique implications for the levels of public expenditures. Some of the key dimensions of democratic institutions include the following: presidential vs. parliamentary, majoritarian vs. proportional electoral systems, federalism vs. non-federalism, unicameral vs. bicameral, and the number of effective political parties.

Although the literature of democratic institutions and the size and scope of government predicts specific relationships, as far as regarding R&D expenditures, it is a matter of empirical testing since R&D programs may be viewed as either public goods or social transfers, or as both. Therefore, for the purpose of empirical analysis, a tentative distinction is needed between R&D programs with high spillovers and those with high appropriability. The former type of R&D programs, which are termed "basic research," are mainly financed by the government and performed by governmental in-house laboratories and national research universities.

Taking the U.S. as an example, 59% of $64.4 billion total basic research expenditures were funded by the federal government in 2007. The industry-funded basic research expenditures were $10.3 billion, which was only 15.9% of the total domestic basic expenditures (NSF, 2008). The academic sector funded 10.7% of basic research expenditures while performing 60.2% of such research. The majority (65%) of the funding for academic basic research comes from the federal government. On the other hand, industrial firms funded 61.1% and performed 69.1% of applied research in 2007. The U.S. federal government's fiscal role for applied research is rather limited: it funded 31.3% and performed 9.7% of total

domestic applied research. Universities and colleges funded only 3% of domestic applied research while performing 14.5% of such research. The compositional difference is more conspicuous in support of industrial and academic research: 67.6% of governmental support of industry R&D programs was for applied research. The applied research portion of support for academic research was only 23.8%.

The observations from the U.S. case reveal that governmental expenditures on industry R&D programs tend to be for applied research, while those on academic R&D programs are more likely to fund basic research. Since the outputs from basic research are best characterized by non-excludability and non-rivalry, this paper regards them as public goods for the purposes of empirical analysis. On the other hand, governmental support for industrial research will be regarded as having high appropriability and thus treated as redistribution.

Presidential versus Parliamentary Systems

A presidential system of government is one where the executive branch is separate from the legislature for which it is not held accountable. In a parliamentary system, the formation and existence of the executive branch is dependent on the legislature. The presidential system is characterized by two institutional features (Persoon and Tasbellini, 1999). One is that decision-making powers are dispersed among politicians across legislative and executive branches of the government, including the president, the speaker, and committee chairpersons in the legislature. This enforces major politicians being held accountable separately, which in turn leads to a higher level of competition. Second, as a corollary of the first feature, executive politicians do not necessarily depend on legislative politicians to maintain their power since they are directly accountable to the voters. The coalition in the presidential system's legislative body is relatively weaker compared to its parliamentary counterpart,

rendering politicians in the presidential system into stiffer competition with each other.

The disjointed competition among politicians for decision-making power across legislative and executive branches of a presidential government does not apply to the parliamentary system, where the survival of the executive branch depends on the majority coalition in the legislature (Persson and Tabellini, 1999). This dependency induces legislative members to be cohesive in their voting. For this reason, British parliamentary members persistently vote together on different policy issues more than their U.S. Congress counterparts do (Diermeier and Feddersen, 1998).

Thus, with more competition both between politicians and between voters, democracies with the presidential system tend to provide "less public goods, less rents for politicians, [and] less redistribution" (Persson and Tabellini, 1999, p. 699) and lead to smaller and more efficient government. Moreover, multiple parties in the parliament seek to serve their respective constituents without due consideration of their collective effects on governmental spending. The main proponents of this argument report some evidence of lower public goods spending in presidential democracies (Persson and Tabellini, 1999). A more recent comprehensive empirical study provides some limited support. From an analysis of a panel set of more than 100 countries between 1970 and 2000, Shelton (2007) reports that countries with the presidential system spend significantly lower in education and general public services, although not in other service areas such as health, public safety, transportation, and defense. The theoretical argument and supporting evidence suggest that the presidential system countries spend less on R&D programs regardless of whether public R&D programs are public goods or transfers to special interests.

Hypothesis 1: Democracies with the presidential system will spend *less* on R&D programs than those with the parliamentary system.

Majoritarian versus Proportional Election Systems

Under the majoritarian election system the winner of the majority voter from each electoral district is elected to the legislature, while under the proportional election system the distribution of legislative seats is in part based on the proportion of votes garnered. There is an ongoing theoretical and empirical debate on what differences the electoral systems make in the size and scope of government (Persson, Gerand, and Tabellini, 2000, 2007; Persson and Tabellini, 1999, 2001; Tavits, 2004). The majoritarian electoral system tends to generate a two-party political system and a one-party government (Alesina and Perotti, 1999). On the other hand, the proportional system often produces a multiparty legislative body and a coalition or minority government (Persson, Gerard, and Tabellini, 2007). The majoritarian system, encouraging parties to focus on key "marginal districts," leads to higher competition among political parties. The proportional system tends to allow representatives favoring transfer spending to be elected.

These differences in institution-induced incentives are theorized to result in "less public goods, less rent for politicians, more redistribution and larger government" in the majoritarian system (Persson and Tabellini, 1999, p. 699). Subsequent empirical studies generally concur with the theoretical argument that governments with the majoritarian system tend to be associated with lower spending across different functional expenditure categories (Milesi-Ferretti, Perotti, and Rostagno, 2002; Shelton, 2007). An empirical study with a sample of 20 OECD and 20 Latin American countries found that the majoritarian system leads to a lower level of redistributional spending (Milesi-Ferretti, Perotti, and Rostagno, 2002). Additionally, reporting an analysis of a panel of 61 countries, Persson and Tabellini (2001) find that social transfers are also smaller in the majoritarian system than those in the proportional system.

Hypothesis 2: Democracies with the majoritarian election system will spend *less* on

R&D programs than those with the proportional system.

Federal versus Unitary Systems

Federalism is "the mode of political organization that unites separate polities within an overarching political system by distributing power among general and constituent governments in a manner designed to protect the existence and authority of both" (Elazar, 1972, p. 2). The theoretical discussion of the effects of fiscal federalism on sub-national government size provides an array of mixed evidence (Brennan and Buchanan, 1977, 1980; Dollery and Worthington, 1996; Grossman, 2004). However, a consensus seems to emerge that federalism may lead to a reduction in the size of central government through the delegation of assignments (Jin and Zou, 2002; Oates, 1985; Shadbigian, 1999; Wallis and Oates, 1988). In the federal system, the main responsibility of service delivery in the areas of education, health care, law enforcement, and social welfare is upon the sub-national governments, who have significant capabilities of their own source revenues. With a bigger portion of taxes spent by sub-national governments, the central government in the federal system will focus their spending on those services and goods that sub-national governments are not suited to provide. Thus, the composition of central government expenditures will change (De Mello, 2001): The shares of defense and R&D-related expenditures would be larger in the federalism countries. However, this does not lend any insight into the level of R&D expenditures compared to the unitary system countries. Therefore, we temporarily hypothesize that federalism countries may spend more on R&D activities.

Hypothesis 3: Democracies with the federal system will spend *more* on R&D programs than those with the unitary system.

Bicameral versus Unicameral Systems

Bicameralism refers to a political system where there are two houses/chambers in the legislature. The bicameral system is typically utilized to insulate the representative government from the whims of the general public, as in the American case (Madison, 2003 [1787]). A critical implication of bicameralism for governmental size is that there are more political actors in the legislatures, each playing a veto point. This can be theorized as either increasing or decreasing the size and scope of government. Higher transaction costs in arriving at negotiated outcomes among more participants may lead to a smaller government and lower capacity of producing policy change (Ricciuti, 2004; Tsebelis, 1995). However, more veto players may simply mean that they are all catalysts for higher spending. Bicameralism may result in a larger budget deficit because of the need to include projects preferred by each of the veto players (Heller, 1997).

On the other hand, how bicameralism affects the size of government is partially dependent on the control of the chambers and the executive branch. If the chambers are controlled by different parties, budget deficits tend to be higher (Schwarz, 2006). If the two chambers pursue separate budgetary decisions, the budget outcomes will be worse than those in the unicameral system (Persson, 1997). At the sub-national level, these insights are also found to be true. If two chambers at the state level are divided and controlled by different parties, the productivity of legislation decreases (Rogers, 2005) and the budgetary outcomes tilt toward the governor's preferences (Alt and Lowry, 2000).

This brief look at the literature on bicameralism indicates that no empirically conclusive evidence on the relationship between bicameralism and expenditure size has yet been reported. However, since the budget cycle of a high time-constraint enforces legislative actors to settle with compromises in a timely manner, this article tentatively follows the general argument that bicameralism with more veto points may increase government expenditures. In such cases, the expenditures are more likely to be on distributive programs for specific

organized groups and/or geographical districts. Therefore, we expect that bicameral governments may spend more to support industrial R&D and less to promote basic research than their unicameral counterparts. Along the same line of argument, bicameral governments would spend more on in-house government R&D activities than those with unicameral governments since the bureaucracies are one of the increasingly better organized interests in the policy process, including budgetary politics (Niskanen, 1971; Peters, 2009).

Hypothesis 4-1: Democracies with bicameralism will spend *less* on basic R&D programs than those with unicameralism.

Hypothesis 4-2: Democracies with bicameralism will spend *more* on in-house R&D programs than those with unicameralism.

Hypothesis 4-3: Democracies with bicameralism will spend *more* on industry R&D programs than those with unicameralism.

Effective Number of Political Parties and R&D Expenditures

The concept of the effective number of political parties (ENP) was originally proposed to provide a consistent measure of the variation in the share of votes/seats of parties in the legislature (Laakso and Taagepera, 1979). It is calculated as follows:

$$ENP = \frac{1}{\sum p_i^2}, \text{ where } p_i \text{ is the proportion of seats/votes of the } i^{\text{th}} \text{ party.}$$

The number of political parties is arguably an institutional factor since it provides a structure in the negotiation and compromise of the legislative process. Theoretically, the variation in the ENP may have impacts on the size and scope of government expenditures (Mukherjee, 2003). With more effective parties, coalitions tend to be less stable because of higher uncertainty and negotiability between coalition member parties and non-members. This is a similar problem to the instability of the minimum winning coalition of the

legislature (Weingast, 1979; Weingast, Shepsle, and Johnson, 1981). To keep the coalition from dismantling, the coalition will need to include projects that benefit its member parties in the budget proposals. With more participants in the process, the share of an individual decision-maker's burden for a spending program will be reduced. Governments of large coalitions will tend to spend more, incurring higher levels of deficit (Roubini and Sachs, 1989). Thus, a higher ENP comes along an increase in the size of government. More specifically, a higher ENP will result in a higher level of government expenditures on subsidies and transfers whose benefits are directed to specific geographical areas and/or specific organized groups. At the same time, expenditures on public goods whose benefits are widespread, such as basic research, will decrease.

Hypothesis 5-1: Democracies with a higher ENP will spend *less* on basic R&D programs.

Hypothesis 5-2: Democracies with a higher ENP will spend *more* on in-house R&D programs.

Hypothesis 5-3: Democracies with a higher ENP will spend *more* on industry R&D programs.

Methodology and Data

Operationalization of Variables

To make a distinction in government support of R&D activities, this article introduces several measures of the dependent variable, as shown in table 1. Since the theoretical interest is not in the relative importance of R&D expenditures vis-à-vis other functional public expenditures but in governmental R&D expenditures relative to the size of the economy, public R&D expenditures are measured in per capita terms. While per capita total government R&D appropriations may not be classified either as public goods or as redistribution, government

expenditures on basic research may be viewed as providing a public good since basic research is, by definition, conducted without any prior intentions of practical applications and its outputs are mainly public with the nature of non-excludability and non-rivalry. On the other hand, government-financed R&D performed by industries could be regarded better as redistribution. The main beneficiaries of public support of industrial R&D are larger firms that are well organized enough to present their interests in the budget process. In addition, government support of private research of a company in a particular state would benefit mostly that company and its hosting state, of which patent citations serve as evidence (Jeffe, Trajtenberg, and Henderson, 1992). On top of the sticky nature of knowledge spillovers, it takes time for knowledge to spillover to those who do not conduct R&D activities. Therefore, public support of industry R&D will be regarded as redistribution to organized interests for the analytical purposes in the section that follows.

Characterizing the nature of public R&D conducted by government and higher education is not as straightforward as in public R&D performed by industries. First, although R&D conducted by governmental personnel may be viewed as producing public goods due to its basic nature, it can also be regarded as serving bureaucratic interests of the research agencies and employed scientists therein. In the latter view, R&D activities by direct government may amount to an example of political rents or bureaucratic budget maximization. On the other hand, universities have served as a bastion of basic research, primarily pursuing answers to questions at the fundamental level without any specific aims of application. However, it has also been an increasingly significant player in applied research (Rosenberg and Nelson, 1994). Moreover, university research is more likely to benefit neighboring regions than others, as in the case of biotechnology research (Zucker, Darby, and Brewer 1998; Zucker and Darby, 1999). Another indication of the nature of distributive politics concerning university research is academic earmarking for which universities

intensively lobby Congress (Savage, 1999). Therefore, empirically, university research funded by the government may be identified as both a public good and redistribution.

As for controls, per capita GDP is used as a proxy for overall capacity to invest in R&D. The share of the population over 65 is used to take into account budgetary competitions posed by the need for welfare spending. Voter turnout is a control for public awareness of government spending and policies. Lastly, the models have a dummy for controlling European Union member countries to consider the fact that the EU member countries are taking joint measures to improve their competitive edges as an economic block. For example, the Lisbon strategy adopted in 2000 called for National Reform Programmes to take specific measures to improve the R&D capacity of its members. The dependent and independent variables and brief descriptions of them are provided in table 1.

[Table 1, about here]

Data Sources and Analytical Methods

Data for the analysis are obtained mainly from two sources. The R&D appropriations and gross R&D expenditures data are from the OECD, which is available from the database OECDSource. This data source makes private and public R&D expenditures available by sources of funds and performers for the period of 1981–2007. Data for the characteristics of democratic institutions is garnered from the Comparative Political Data Set 1960–2007, which is available from the Institut fūr Politikwissenschaft (Univeritāt Bern). This article's analysis covers 18 OECD countries. Five countries (Greece, Iceland, Luxembourg, Portugal and Spain), although their R&D expenditure data are available, are excluded from the analysis since the Political Comparative Data Set does not cover these countries on key variables of democratic institutions.

The analysis uses a Time Series Cross Section (TSCS) dataset with observations of

18 countries covering the period of 1981–2007. Observations in year per country are between 1 and 27 with an average of 21, and the total number of observations is between 240 and 371. Relying on Ordinary Least Squares (OLS) regression would be problematic because of its temporal and spatial properties (Beck and Katz, 1995): the typically observed phenomena of panel heteroskedasticity, contemporaneous correlation, and serial correlation. Against the possibility that the hypothesis tests may be misleading because of heteroskedasticity and serial correlation problems, Beck and Katz (1996) advise using OLS with panel-corrected standard errors (PCSEs) while controlling temporal dynamics of serial correlation. Most of the key independent variables of political institutions are constant across the study period and more than 89% of the variation in each of the dependent variables is jointly explained by the specified independent and control variables. Therefore, the models specified in this study include lagged dependent variables with panel-specific first-order autocorrelation structure, which is typical for removing serial correlation in OLS with PCSEs.

Descriptive Statistics

Table 2 provides the means for the dependent variables for each type of political institution. At first glance, it is clear that the R&D budget appropriations in the countries with presidential systems are higher than those with parliamentary systems across all dependent variables. In terms of total per capita expenditures, countries with presidential systems have spent on average almost $223 annually over the study period. This preliminary finding is obviously at odds with Hypothesis 1, as will be discussed in the analysis section. For four dependent variables excluding university research appropriations, the majoritarian countries spend more than those with proportional systems. In supporting academic research, the proportional system countries spend $90.41 per capita, while their majoritarian counterparts spend about $67.02 per capita per year. Appropriations differences both between federal and unitary system countries and between bicameral and unicameral countries are not as obvious

as in those countries with different types of government or electoral systems. The mean expenditures across the dimensions of different democratic institutions indicate that the majority of public R&D is performed by the government itself and by academic institutions including universities and colleges. Industrial firms perform less than a quarter of public R&D.

[Table 2, about here]

Complicated Effects from Democratic Institutions

Before conducting regression analysis, bivariate Pearson's correlation coefficients are obtained, whose significance is also reported in table 2. In terms of *total* public R&D expenditures, intramural research, and industrial research support, the countries with presidential systems and majoritarian electoral systems spend more. It seems that countries with majoritarian systems spend less on basic research and academic R&D. Federalism countries spend more on intramural research as well as research performed by industries. On the other hand, bicameral countries consistently spend less on basic and academic research. While not reported in the table, the effect of the number of effective political parties is rather mixed: it is positively related with basic and academic research, but it also lowers expenditures on research performed by the government and industries. The impression is that the relationships between political institutions and R&D expenditures in OECD countries seem to be more complicated than hypothesized, but the results reveal that democratic institutions do matter in the determination of public R&D funding levels.

At the second stage of the analysis, regression coefficients on these different democratic institutions are estimated using panel-corrected standard errors for each of the different types and performers of R&D; these results are summarized in table 3.

[Table 3, about here]

Presidential and Majoritarian Systems

Hypothesis 1 posits that government support of R&D activities in presidential system countries will be lower than in parliamentary system countries since the presidential system pits political leaders and voters against each other in tougher competition, thus limiting their capacity to provide public goods and transfers. However, table 3 shows the opposite. Controlling the effects from the other dimensions of democratic institutions and government size and debt, countries with presidential systems spend about $6.44 more on public R&D activities. Clearly, such countries as Unites States, Finland, France, and Switzerland spend more on R&D than the other countries in the sample. The relationship looks more interesting when considering types and performers of research. For example, while presidential system countries spend more on intramural research, they spend as much as $4.39 more on R&D performed by universities than their parliamentary counterparts. Obviously, presidential system countries' higher spending on public R&D is primarily driven by a higher commitment to governmental in-house research and industrial research.

This variegated relationship between public R&D expenditures and two different government types is not entirely consistent with the findings from previous studies. Using formal models for the relationship between the presidential/parliamentary systems and public goods and redistributional expenditures, Persson and Tabellini (1999) focused on the potential of the presidential system to provide politicians and voters with more incentives to compete. According to the authors, more competition among politicians and voters means less public good and less redistribution. Empirical evidence from this analysis indicates that the relationship is not as straightforward as Persson and Tabellini predicted. Regardless of how R&D is viewed, either as a public good or as redistribution, presidential countries seem to spend more on governmental intramural research and R&D performed by industries. The

hypothesized relationship is not found with basic research and research performed in the academic setting, either. This result may present an inconsistency with previous studies. It is critically problematic to make a distinction between a public good and redistribution (or transfer) as in the case of R&D expenditures. For example, although universities tend to conduct basic research more than industries do, they are still heavily engaged in lobbying efforts to secure more research funds. Therefore, empirically testing Persson and his colleagues' arguments (1997, 1999, 2000, 2001, and 2007) seems too sketchy unless operational measures for making a distinction between public goods and redistribution are utilized in the model.

As for the difference in R&D expenditures between countries with majoritarian systems and those with proportional systems, the results show that in terms of total public R&D expenditure, the majoritarian countries seem to spend about $4.22 more than their proportional counterparts. However, these majoritarian countries spend substantially less on basic research, whose outputs tend to be in the public domain. If the R&D activities are viewed as redistribution benefiting specifically defined groups (R&D performed by industries), then there is no difference in governmental support between the countries with majoritarian systems and those with proportional systems. These findings are not consistent with the theoretical argument by Persson and Tabellini (1999) and are at odds with the empirical findings by other authors (Milesi-Ferretti, 2002; Persson and Tabellini, 2001). In the case of appropriations for basic research, the majoritarian system countries spend less than their proportional system counterparts, as predicted by the aforementioned works. However, these studies argue that the majoritarian countries will spend less on both public goods and distributive programs. First, countries with a majoritarian rule spend *more* on R&D, and second, there is no difference in public spending on R&D performed by specified institutional actors—government, industries, and academia. These results indicate that the

effects of the electoral systems on R&D expenditures may be moderated by the nature of research supported and by its performers.

How the outputs/outcomes of R&D benefit the economy may be helpful in understanding the relationship between R&D activities and the electoral politics. Scientific and technological knowledge is sticky when benefiting the neighboring regions of the R&D performers more than the rest of the country (Jaffe et al., 1992). Thus, the ruling party in a majoritarian electoral system will have incentives to direct R&D monies of targeted beneficiaries to the closely contested districts. On the other hand, the proportional system countries spend more on R&D activities viewed as a public good and spend less on redistributive R&D activities than their majoritarian counterparts. Therefore, Hypothesis 2 is partially confirmed since majoritarian countries spend less, not more, on basic R&D.

However, these interpretations become even more complicated when considering the potential interactions of different political institutions. The expenditure effect from the presidential system may be moderated or mediated by other institutional factors such as bicameralism, federalism, and the effective number of political parties, which are controlled in the analysis. Such interactions seem to explain why Persson and Tabellini (1999) report very fragile empirical findings in their OLS model with regards to expenditures on order and safety, transport, and education. This point is emphasized by the coefficients on the interaction terms in the second set of models for basic research appropriations, whose result summary is also provided in table 3. When introducing the interaction terms, the positive impact of the presidential system on public intramural research get clearly emboldened in the proportional system countries. If the electoral system is proportional, countries with presidential systems appropriate almost $25 more per capita than countries with parliamentary systems, compared to only $7.43 in countries with majoritarian systems. The U.S., which has a presidential and majoritarian system, spends less on research performed by

governmental in-house laboratories in per capita terms than Finland, France, and Switzerland. This presidential-proportional advantage is also conspicuous with regard to R&D performed by industries such that these countries will spend about $15.27 more on industrial R&D than their majoritarian counterpart, the United States. On the other dependent variables, the interactions between presidential and majoritarian systems are not significant. The effect of the majoritarian system on national public expenditures on R&D as a public good is rather uniform across different types of governments. Still, the results from the interaction terms are more than enough to evidence that the expenditure effect of an institutional characteristic may be contingent upon other institutional dimensions.

Federalism versus Non-federalism

With fiscal decentralization, the size of the central government may get smaller since taxing powers and spending responsibilities are delegated to the sub-national governments. The dataset used in the analysis confirms this prediction, where the Pearson's correlation coefficient between the percentage of public expenditures out of GDP and federalism is –.42, ($p<.01$). The federalism countries also tend to have smaller public debt in terms of the percentage of GDP ($r = –.09$, $p<.10$). Moreover, the composition of central expenditures will not remain the same. For example, the share of defense and/or R&D expenditures, whose provision usually falls on the central government, may get bigger.

The result in table 3 shows that in terms of total public R&D expenditure, the federalism countries spend as much as $2.50 less than the unitary ones, but this is rather inconclusive ($p<.10$). No significant difference in public R&D expenditures has been found in the other dependent variables. The primary implication from the empirical evidence about the fiscal impacts of federalism is that the evidence is not conclusive, which is essentially the finding of the extant analysis. However, that does not mean that there will be no difference in

public R&D spending between federalism and non-federalism countries since 1) the federalism countries seem to spend less, though marginally, and 2) this does not take into account sub-national level public R&D expenditures. For example, when the U.S. federal government rejected supporting stem cell research during the George Bush administration, the state of California actively funded academic research on stem cells. While the empirical dust surrounding the academic debate on the effect of federalism on public expenditures has yet to settle, its impact on R&D activities may not be neutral, as suggested in Hypothesis 3. However, the analysis cannot find any meaningful difference in basic research expenditures, nor in research performed by the government, industries, or academia.

Interaction terms with bicameralism and the number of effective political parties add additional insight into the joint effect from differing political institutions. First, bicameral countries with federalism tend to spend even less than unicameral federal countries. Public R&D spending by Canada and Austria is higher than by countries such as Germany, the U.S., and Australia. Second, when making distinctions by the nature and performers of R&D, the findings from the models *without* interaction terms still hold true with the models *with* interaction terms. This means that the fiscal effect of federalism on public R&D is largely independent of other institutional dimensions.

Bicameralism versus Unicameralism

The findings regarding Hypotheses 4-1 through 4-3 are mixed. Democracies with bicameral systems tend to spend about $4.96 more on public R&D than those with unicameralism. As predicted in Hypothesis 4-1, bicameral countries spend less on basic research. There is no difference between bicameral and unicameral countries in governmental support of industrial, in-house, and academic R&D, which is at odds with Hypotheses 4-2 and 4-3. When it comes to overall appropriations for R&D activities, the bicameral legislatures seem to be more

conducive. However, bicameralism does not seem to do a particularly better job in supporting basic research. When it comes to R&D performed by specified groups, bicameralism countries are not substantially better. As discussed in the previous section, bicameralism's implication to government size is complicated by other political factors such as control of each house, the congruence of the political control of the legislature with the executive branch, and the homogeneity of voter preferences in the population. Although the models do not control such factors, the results offer a counterargument against the argument that bicameralism is biased toward distributive spending (Heller, 1997). However, obviously the bicameral legislature is still not favorable to programs of remote and diffuse benefits (Downs, 1960). That is, it may not be particularly vulnerable to organized groups, but clearly unfavorable to public goods with less visible benefits.

With interaction terms for joint effects among different institutions, the relationship gets more complicated, as is the case with the other dimensions of political institutions. First, non-federal bicameral countries tend to spend as much as $23.27 more on public R&D compared to unicameral ones, meaning that the bicameralism effect on R&D expenditures is much greater for non-federal system countries. At the same time, its negative impact on basic research is still greater for the unitary system countries. Second, the unitary bicameral countries tend to spend more, not less, on intramural research, consistent with Hypothesis 4-2. Third, with more political parties in bicameral countries, it seems more difficult to appropriate research funds except for pure basic research. These results are somewhat confusing, while suggesting a couple of key insights. In the bicameral system, with more competing actors in the budgetary process, a higher number of political parties aggravates the problem of veto points if the appropriations themselves are supposed to target better defined groups such as bureaucrat-researchers and well-organized industrial firms. In the bicameral system, as the effective number of political party increases, bureaucrats at research agencies

and industrial firms seem to have more difficulty developing closer relationships with members of legislative bodies than those in the unicameral system. With more decision-makers in the legislature and higher complexity in the process, it may be more difficult for them to get relevant information about the distribution of decisional influences in the budget process and to target their limited resources.

Effective Number of Political Parties (ENP)

It is expected that if R&D is a public good, a higher ENP will decrease R&D spending and that if not, it will raise the spending level. The analytic result shows that a higher ENP lowers overall public expenditures on R&D activities, as expected, but the effect size seems rather minor compared to the other dimensions of democratic institutions. As ENP increases by one, total R&D appropriations decrease about $1 in per capita terms. The findings from the other models indicate that more political parties in the legislature come with a significant dent in the public R&D expenditures for government laboratories and universities. With an additional political party in the expenditure game, research bureaucracies and universities suffer as much as $.73 in per capita terms. However, when considering interactions with the other institutional variables, the revelation is that ENP makes a substantial difference jointly with them across different types and performers of research. First, in the presidential system, a higher number of political parties is associated with higher expenditures on basic research but less on public R&D performed by the government and industries. When ENP interacts with the majoritarian electoral system, one additional political party lowers public R&D expenditure by as much as $6.25 and expenditure on industrial R&D by $2.35. Clearly, the negative impact of more political parties is most conspicuous in the bicameral system. In the bicameral system countries, additional political parties tend to lead to a lower total R&D expenditure as well as a lower support of in-house and industrial R&D. However, the effect

from ENP mitigates the negative effect of bicameralism on basic research. This is clearly the opposite of Hypotheses 5-1 through 5-3. The findings indicate that having more political parties in the system creates more difficulties to support R&D performed by the government and industrial firms and, on the other hand, a favorable condition for funding basic research. However, this is not the direct effect of ENP but an indirect one moderated by different dimensions of political institutions.

Overall, it seems that ENP is positively related with basic research expenditures but negatively with R&D performed by organized groups. For example, in a presidential country with a bicameral legislature, one additional political party increases basic research spending by as much as $6.50 but decreases appropriations on R&D performed by the government and industrial firms by $6.63 and $4.38, respectively. This is an exceptionally surprising result given the characteristics of R&D activities and their outputs as well as the dominant view from the literature (Mukherjee, 2003; Roubini and Sachs, 1989). The benefits of R&D activities, regardless of being a public good or redistribution, are realized in the longer term. Typically, at least seven years of time lag between scientific publication and citation of the publication by industry patents has been reported (Branstetter and Ogura, 2005; Gellman Associates, 1976; Mansfield, 1991, 1998). Others report that the time lag is as long as 20 years (Adams, 1990). With more parties in the legislature, parties may have more incentive to provide projects whose benefits are well-defined in terms of the beneficiaries and realized in a shorter term. In such a case, expenditures on R&D activities would not be a high priority. However, the analysis result tells a different story: depending upon the types of political institutions, the democratic process involving more effective parties can produce a policy result that benefits the general public as opposed to narrowly defined groups.

Discussions and Conclusion

The primary finding from the analysis is that political institutions do matter in governmental support of R&D activities. Even with relatively smaller R&D expenditures, compared to other expenditure categories such as defense and education, political institutions make a substantial difference in one way or another. However, they matter differently according to who performs the R&D and what types of research are supported. The distinction between the presidential versus parliamentary systems of government does have an effect on the overall levels of public R&D expenditure. As opposed to the argument from the literature, the presidential system is more effective in supporting investment in R&D programs whose benefits tend to be realized over a longer term and are not readily visible. The distinction between the majoritarian versus proportional electoral systems seems relevant in the determination of overall government R&D appropriations. Moreover, the electoral system does matter in terms of who performs the research. The majoritarian system, as opposed to the proportional system, does lower R&D activities that are conducted without any specific prospect of application. At the same time, the electoral system is largely irrelevant regarding public expenditures across different performers of R&D activities.

The federalism factor is not as dramatic as the government types or electoral systems, but it still shows a negative effect on the overall support of R&D. It appears that the federalism dimension of political institutions is largely neural in the appropriations for basic research or for different performers, which is consistent with the discussions in the literature. At the same time, federalism is relatively independent from the interactions with other political institutional dimensions, for example, with the number of political party. Countries with a bicameral legislature tend to support less basic research. Bicameralism is not necessarily beneficial to R&Ds performed by specific groups. In terms of overall level of R&D appropriation, its impact is found to be an additional $5 per capita beyond the levels in unicameral countries. The number of effective political parties seems to be no less important

a factor as the other institutional dimensions. While ENP lowers expenditures on R&D by the government and academia, it increases basic research appropriations. This factor's effect on public R&D spending is mediated or moderated by the other dimensions of political institutions. It turns out that the number of political party is either attenuating or emboldening the effect of the other political variables.

The relationship between political institutions and the degree to which government supports R&D is not as straightforward as predicted by the hypotheses. There may be multiple complicating reasons. First, the dependent variables that are specified in the models may not exactly measure what they are meant to be measuring. For example, R&D performed by universities may be either public goods or redistribution, depending upon the political characteristics of the process of supporting the research—a complicating reality that the specified models may not take into account. While producing knowledge with the nature of both spillover and appropriability, R&D activities pose a unique difficulty in being conceptualized as either a public good or a transfer of benefits to organized groups. Even in the output from publicly financed industrial R&D, there emerge spillovers, utilized by competing firms. Second, the effect of one dimension of political institutions is moderated by the other dimensions. Every political institution of the democratic process works jointly with the other institutions. On top of that, this extant research has yet to explore the different ways that the different political institutions are operated in different cultural and historical contexts, which leads our attention to political culture. These limitations point to a need for further research on how different political institutions and political cultures interact to affect different types and performers of R&D activities.

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Table 1: Descriptions of Dependent and Independent Variables

Variables	Descriptions
Total public R&D : Both public goods and redistribution	Per capita central government R&D appropriations 1981–2007
Public basic research : More public goods than redistribution	Per capita central government R&D appropriations for non-oriented research
R&D performed by the government : Both public goods and redistribution	Per capita R&D expenditure conducted and funded by the government
Public R&D performed by industries : More redistribution than public goods	Per capita R&D expenditure conducted by industries and funded by the government
Public R&D performed by academia : Both public goods and redistribution	Per capita R&D expenditure conducted by educational institutions and funded by the government
Presidential system	= 1 if presidential system and = 0 if parliamentary system
Majoritarian system	= 1 if majoritarian system and = 0 if proportional system
Federal system	= 1 if federal system and = 0 if unitary system
Bicameral system	= 1 if bicameral legislature and = 0 if unicameral legislature
Effective number of political parties	effective numbers of parties in parliament by Laakso and Taagepera (1979)
Voter turnout	voter turnout in election
Per capita GDP	per capita GDP
Population over 65	share of population 65+ in total population
Government expenditures	Percentage of public expenditures out of GDP
Public debt	Percentage of public debt out of GDP
EU member	= 1 if EU member and = 0 if not
Presidential*majoritarian	Interaction between presidential and majoritarian system
Federalism*bicameralism	Interaction between federalism and bicameralism
Presidential*party numbers	Interaction between presidential system and effective number of political parties
Majoritarian*party numbers	Interaction between majoritarian system and effective number of political parties
Federalism*party numbers	Interaction between federalism and effective number of political parties
Bicameralism*party numbers	Interaction between bicameralism and effective number of political parties

Table 2: Average Per Capita Government Support of R&D Activities by Democratic Institutions (Constant Dollars in 2000)

	Presidential	Parliamentary	Majoritarian	Proportional	Federalism	Non-Federalism	Bicameralism	Unicameralism
Total Public R&D Appropriations	222.97	156.57 [c] ***	186.44	167.98**	174.35	170.00	171.03	172.28
Public Basic Research	26.44 (.12)[a]	21.53***(.14)	14.25 (.08)	24.73***(.15)	21.05 (.12)	23.46*(.14)	20.56 (.12)	24.17***(.14)
Public R&D Performed by the Government[b]	81.20 (.36)	54.15***(.35)	74.04 (.40)	56.43***(.34)	65.74 (.38)	57.84***(.34)	61.53 (.36)	60.06 (.35)
Public R&D Performed by Industries	52.48 (.24)	21.44***(.14)	46.24 (.25)	22.87***(.14)	35.31 (.20)	24.36***(.14)	29.78 (.17)	27.20 (.16)
Public R&D Performed by Academia	89.85 (.40)	82.93 (.53)	67.02 (.36)	90.41***(.54)	86.62 (.50)	83.29 (.49)	78.88 (.46)	90.32***(.52)

a. Parentheses indicate the proportion in total public R&D appropriations. Since the proportions reported are the means among the countries whose data are available, they do not reveal relative distribution of public R&D monies in a specific country.
b. The R&D performed by the government, industries, and academia does not amount to the total governmental R&D expenditures since the dataset is not balanced. In some years, data on all of these three different performers are available, but in other years they are not.
c. Significance of Pearson's correlation coefficients is reported by *** p<.01, ** p<.05, and * p<.10.

Table 3: OLS Estimations with Panel-corrected Standard Errors

Independent Variables	Total Public R&D		Public Basic Research		R&D Performed by the Government		Public R&D Performed by Industries		Public R&D Performed by Academia	
Presidential	6.437**	25.424	-2.540	-20.799	4.765***	25.192***	4.390**	15.270**	.668	-5.029
Majoritarian	4.216*	27.349***	-5.890*	-5.538	-.584	8.975	1.402	7.229**	-2.590	-.224
Federalism	-2.50*	-.136	-1.281	-8.969**	.567	2.533	1.129	1.083	-.390	1.428
Bicameralism	4.963**	23.265***	-2.326*	-18.172**	1.092	16.545***	1.782	4.650	-2.306	1.425
Effective Number of Parties	-1.042*	2.240*	.710*	-2.053*	-.731***	2.137*	-.377	1.207*	-.657**	-.227
Per Capita GDP	.001***	.001***	.0003***	.0003***	-.0001**	-.0001***	-.000	-.0001	.0005***	.001***
Voter Turnout	.033	.074	-.151	-.222**	.078*	.051	-.017	-.021	.068	.066
Government Expenditure as % of GDP	.656***	.589***	-.038	.016	.058	.010	.005	-.004	.080	.099
Public Debt as % of GDP	-.037	-.066*	-.064**	-.026	-.009	-.026	.003	-.009	.023	.013
% of Population over 65	.325	.742	.397*	-.175	.472**	.666**	-.010	.039	-1.068***	-.990**
EU Member	-.378	-.128	-1.355	-2.232	-3.301***	-2.387*	2.524	2.772*	3.042	3.724*
Presidential * Majoritarian		-8.895		6.669		-17.760**		.046		2.212
Federalism * Bicameralism		-7.673*		8.849*		-3.027		-.596		-3.274
Presidential * Political Party Numbers		-3.871		3.729*		-3.765***		-2.904***		.969
Majoritarian * Political Party Numbers		-6.247***		-1.209		-1.588		-2.354***		-.707
Federalism * Political Party Numbers		.697		.818		.098		.185		.159
Bicameralism * Political Party Numbers		-3.652**		2.774*		-2.863**		-1.477*		-.586
One Year Lagged Dependent Variable	.915***	.910***	.697***	.633***	.920***	.898***	.881***	.843***	.932***	.921***
Model Summary										
Observations	370	370	369	369	249	249	271	271	240	240
R-squared	.98	.98	.90	.90	.97	.89	.95	.96	.98	.99
Wald Chi-squared	22975.5***	27872.3***	1319.9***	1076.9***	13076.3***	2753.9***	4379.5***	8198.2***	6361.4***	9109.6***

Significance Levels: *** p<.01, ** p<.05, and * p<.10