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Composition of Federal R&D Spending, and Regional Economy : The Case of the U.S.A*

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1. Introduction

In recent years, the composition and concentration of R&D spending have attracted increasing attention. For example, growing evidence indicates that aggregate R&D spending may have had only a negligible effect on recent U.S. productivity trends (Wolff, 1985 ; Griliches, 1988 ; Scherer, 1983). At the level of individual firms, market-driven industrial R&D, marked contrast with government-funded R&D, has consistently shown the clearer association with productivity gains and competitive product lines(Griliches, 1986 ; Leonard, 1971). Indeed, under certain circumstances not only may increases in federal R&D funding actually be counterproductive (Lichtenberg, 1984), but at the level of metropolitan-scale regional economies federal R&D flows may even be associated with the retardation of aggregate personal income growth (Malecki, 1982). Finally, the basic research share of total firm- or industry-level R&D expenditures has been shown to have a greater impact on productivity growth than does total R&D spending (Griliches, 1986).

This study seeks to extend this focus to the sectoral and spatial composition of federal R&D spending by first drawing attention to the distinct R&D missions of different federal funding sources -- particularly, defense vs. civilian-oriented R&D agendas. Next, attention shifts to differing funding destinations -- defined by both performer-type and geographic location -- that characterize federal R&D spending flows. The guiding assumption is that because federal R&D funding flows are highly concentrated in specific industries, industrial missions, and production/development locations, efforts to link them to subsequent economic impacts require the introduction of these compositional factors into impact analytic models. The working hypothesis is that, despite their having been missed before, federal contract R&D may well be associated with identifiable impacts. However, such impacts are better detected at the level of recipient region-scale economies, rather than for the nation at-large.

This study is defined by three distinct stages. First, it test the possibility that federal contract R&D funds supporting defense and nondefense projects are associated with differential regional employment and income effects. Subsequently, an sequence of models tests for differences between recipient/performer sectors categorized on several key dimensions. This sequence includes for -profit vs. not-for-profit performer orientation and industry/corporate vs.

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educational/research center vs. other research institutional type. An elaboration of Model Ⅲ disaggregates the industry/corporate(for-profit) sector into large and small businesses subsectors.

2. Sectoral and Spatial Composition of Federal R&D Spending

The net result of studies of the economic impacts of R&D expenditures has been to make the knowledge/technology factor less transparent in accounts of economic growth and productivity performances. Two distinct perspectives organize much of what is known to date. A sectoral perspective traces R&D spending impacts to distinctions involving research objectives, funding sources, and research-performing sectors. A far less well-developed spatial perspective organizes these effects by their locations in the nation's economic geography. Let us explore each briefly.

1) Sectoral Composition Perspective

The federal government accounts for slightly less than half (44 percent) of the more than $150 billion -- approximately 2.8 percent of the nation's GNP -- currently being spent on R&D in the nation. Government research support and subsequent procurement strategies are widely created with accelerating and steering technical advances in such domains as lasers, semiconductors, and high-speed computing, and even inspiring entirely new commercial industries (Flamm, 1988 ; Nelson, 1984). Nonetheless, sectoral analyses have also engendered a widespread concern that the net effect of much recent government R&D spending may be suboptimal or even counterproductive. The reasons for this relate both to the superior efficacy associated with firms spending their own R&D resources in response to market signals as well as to the various compositional factors -- or "tilts" -- characterizing government-funded R&D which tend to reduce the access and relevance of project results to commercial applications. The major tilts in federal R&D are :

A Tilt Away from University Research : A second compositional factor is related to basic research. Mansfield (1991), underscoring the critical contribution to industrial innovation made by university-sited -- and predominately basic -- research, has estimated that in selected industries as much as ten percent of new products and processes could not have been developed without the academic contributions to knowledge made during the previous fifteen years. This suggests that research universities and other nonprofit research organizations are important first-order sources of technological advances in industry (Crow and Emmert, 1984 ; Nelson, 1986 ; Howells, 1986 ; and Jaffe, 1989). Moreover, when university research is funded by industry directly, a momentum is evident that leads to subsequent increased industry R&D expenditures (Berman, 1990). Nonetheless, even though universities and other nonprofit organizations play important roles in technological spin-off and are widely regarded as being more flexible in transferring information and providing R&D personnel and other resources than are for-profit organizations, the bulk of federal contract R&D funding flows to major corporations instead.

A Tilt Away from Civilian/Commercial Applications : Finally, any concern that the bulk of government funded-R&D fails to lead to demonstrable economic benefits can be traced directly to the dominant compositional feature of recent federal R&D spending. Not only do defense goods and services account for an estimated three-quarters of all federal procurement (Wynne, 1991), but most federal R&D

funding flows to projects with a military orientation. As defense R&D spending doubled between 1980 and 1987, its share of total federal R&D rose from 50.2 percent to 69.2 percent. Actual real declines in nondefense-oriented federal R &D spending over the same period accompanied this trend (Carter, 1988). While there is little direct evidence that defense spending has either retarded or stimulated overall investment, productivity, or economic growth(Gold, 1990 ; Quinn, 1986), concern lingers that defense spending may well foreclose more economic options than it creates(Melman, 1983 ; Dumas, 1986).

There are several reasons for this concern. First, because defense demand account for only a modest share -- estimated at 6. 7 percent in 1990 (Koretz, 1991) -- of U.S. manufacturing output, the bulk of these funds are confined to development projects that are likely to benefit directly only a relatively narrow range of industrial applications. Second, because of the technical sophistication of much R&D-intensive defense work, the bulk of federal R&D funds tends to be concentrated in only a few firms (and locations) (Anton, et al., 1980 ; Malecki 1982). Even the spending surge in the early 1980s did little to lessen this industrial and/or geographical concentration (Markusen, et al., 1988). Nonetheless, despite these barriers to broader application, defense-oriented R&D may well exert powerful indirect effects on the civilian economy that are neither easily modeled nor detected (Carter, 1988 ; 13). The sectoral and spatial structure of the defense industrial base is such that it places powerful limitations on the range of beneficial impacts able to be leveraged by defense R&D spending.

It is far from clear that defense spending has played more than a marginal role in the continuing slow growth of U.S. productivity or the presumed decline of U. S. competitiveness in specific industries and technology domains(Gole, 1990 ; Browne, 1988 ; Sveikauskas, 1986). However, it is reasonable to suggest that despite the fact that recent defense spending accounts for only a modest share (5-6 percent) of the nation's GNP -- with rapid economic expansion during the 1980s making even that burden ever easier to bear -- the commitment to allocating such large shares of federal R& D resources to military projects casts a larger shadow than simple budget analyses suggest.

For example, procurement policies that govern defense spending have shifted more of the cost sharing for upgrading of technology/production bases to defense contractors. While this has not dampened, and may even have increased, aggregate U.S. corporate R&D spending, the more micro-level effect has often involved the dedication of significant private R&D resources to defense contract competition, and in so doing has effectively transformed these funds into defense R& D spending. Moreover, recent efforts to stimulate competition within the defense industrial base has had the effect of accelerating the turnover among defense prime and subcontractors at the very time when long-term stable supplier relationships have become a major competitive advantage and a critical ingredient in the implementation of "soft" technologies such as Just-In-Time throughout commercial industrial sectors(Nordwall, 1986 ; CSIS, 1989). For these reasons, among others, the question of the economic impacts of public funding of defense vs. precompetitive civilian-oriented R&D agendas merits continued investigation.

Small vs. Large Business : Yet another sectoral dimension relates to enterprise size. During the 1980s, there developed a special fasination with the contributions of the small business sector to the nation's aggregate economic performance, especially

as measured by employment creation (Birch, 1979) and technological innovation (Hansen, et al, 1984). Generally obscured by the employment-creation capacity of the small business sector, however, was the fact that the large business sector continued to account for a steadily rising share of total output, increasing from an estimated 48.7 percent in 1958 to 55.3 percent in 1985 with projections of a 59.0 percent share by 2001(Small Business Administration, 1986). While product innovations were more likely to be introduced by small firms than large ones, in many cases this, too, obscured the fact that their origins could often be traced original investments made by large industrial enterprises which, with the departure of entrepreneurial employees, were unable to capture the returns on those investments. Therfore, an idea originally spawned inside a large corporate entity was often brought to full commercial utility by a small, often new, enterprise. In this way the large vs. small business dichotomy can obscure the developmental sequencing of industrial innovation. Moreover, Florida and Kenney (1990) argue that the ease with which small-business startups occur in our economy has had the effect of cannibalizing the capacity of the large-business sector to compete with major global competitors by hindering their ability to appropriate the full range of benefits of their investment and development strategies and allocation market share to round after round of new firm entrants which often lack staying power.

Such scenarios notwithstanding, however, growing evidence suggests that the small business setor is making an increased contribution to the nation's R&D activity. During the 1960-1980 period, the R&D efforts of the small business sector accounted for approximately 6 percent of corporate R&D. By 1987, that share had doubled (Economist, 1990). However the same trend is not evident in the R&D efforts supported by federal funds. While as much as a quarter of prime defense contract spending is destined for small and/or minority-owned businesses(Small Business Administration, 1985), the greater access of large firms to complex and sophisticated technology bases means that the small business sector garners only an tiny share of major defense R&D contracts(Malecki, 1981). Moreover, the R&D work specified in such prime contracts is even less likely to be subcontracted to smaller firms than are contracts for defense supplies and equipment(Malecki, 1984).

2) Spatial Concentration

The dominant defense orientation of federal R&D spending imposes a powerful concentrative effect evident among technologies, firms, and geo-industrial production and R&D locations. Because federal R&D fund flows tend to be structured by the distribution of critical production capabilities and support infrastructures across the nation's economic landscape, a relatively small number of the nation's major metropolitan regions tend to capture the bulk of federal funds. In FY 1988, for example, although modest 51.8 percent of all federal contract obligations for supplies and equipment and 40.8 percent of all such obligations for federal service flowed to the nation's 39 largest metropolitan areas with populations exceeding one million, fully 77.3 percent of all federal contract obligations for R&D did so(Lee, 1991). Indeed, only six metro -- Boston, Nassau-Suffolk Conties, Washington, D.C., Los Angeles-Long Beach, Denver-Boulder, and San Jose -- received annual federal R&D obligations totalling more than $1 billion in FY 1988. Moreover, past analyses of federal R&D spending substantiate the fact that for decades federal R&D funds

have flowed to enduring concentrations defined both by corporate hierarchy among defense contractors and location in a relatively few major urban areas (Nalecki, 1984). These spatial patterns indicate a potentially powerful agglomerative effect at work. As a result, important industrial capacities are created and their quality confirmed by the abilities of only a few leading regions in the defense industrial base to attract and apply federal contract R&D funds.

3. Linking federal R&D Spending to Regional Economic Impacts

While most studies of economic impact of government R&D spending have sought evidence generalizable to the nation at-large, few studies have sought to identify explicitly subnational impacts. Yet, a political economic perspective on federal R&D spending would appear to beg a subnational framework for estimating economic impacts if only to acknowledge the great and enduring concentration of this funding. In one study, Mehay and Skolnick(1990), reported that aggregate defense spending stimulates personal income and manufacturing employment growth at the state level ; further work limited the stimulus to those portions of defense spending that performed an investment function. Malecki(1982), while reporting declines in regional per capita income during 1950-72 associated with federal R &D spending acknowledges that other positive effects may well be linked to the agglomeration and spin-off such spending concentration reinforces. Lee and Hicks (1991) have demonstrated that federal contract R&D funds flows are influenced by region size and have both employment and income stimulative effects measured at the level of metro-regions. Moreover, Hicks(1988) has argued for devising regional development strategies that leverage these metro-level federal spending concentrations against local civilian assets for greatest commercial effect.

4. Model Specification

This study seeks to extend the inquiry wherein federal contract R&D fund flows are traced to their sectoral and spatial economic impacts. The approach is guided by the realization that the composition and concentration of a region's federal R &D funds may be stimulative beyond what their levels alone may suggest. Accordingly, we disaggregate federal funding flows by selected dimensions of both funding sources and funding recipients and proceed to link specific patterns of R&D spending dedicated to specific objectives to specific outcomes at the level of metro-regional economies.

A first model exploits the distinction between federal R&D spending on military vs. civilian projects. A second model shifts emphasis to distinct categories of recipients defined by economic sector, principally the for-profit sector and the nonprofit sector. A third and fourth model disaggregates the nonprofit sector into educational/research institutions and other nonprofit research organizations such as research universities and nonuniversity research centers and the for-profit sector into large and small business subsectors.

The data used in this study are derived from records of individual contract "actions" developed by the Federal Procurement Data Center of the Office of Management and Buget(OMB). These actions refer to the portions of federal R &D contract obligations that actually flow to "places of performance" in a given fiscal year. Because R&D contracts are far less likely than prime contracts for production to be redistributed out of a

region through a subsequent round of subcontracts, they are relatively well suited to impact analyses using bounded metro-regions in which to detect spending effects. While the actual dispersal of funds may take place throughout the fiscal year and beyond, as funds are obligated annually by fiscal year, only those funds designated for dispersal in a given fiscal year are counted as contract actions. This corrects for biases associated with contract data which fails to distinguish single-from multi-year awards.

In the analysis that follows, we seek to identify the regional employment and income effects of federal contract R&D spending. The unit of analysis is the (Primary) Metropolitan Statistical Area (PMSA/MSA), and the models tested below draw on a population of all the nation's metro-scale regional economies. Two Principal dependent variables were used to build and test a variety of distinct models. Because regional employment and population levels are highly correlated, the employment variable was cast in the form of the share of the metro-regional labor force employed. The resulting measure therefore conveys information on the capacity of the region's economy to respond to external influences such as receipt of federal R&D contracts with employment rate shifts. The impact on a region's per capita personal income performance is measured by average annual regional wage, that is, total regional income divided by total regional employment. ERit is the annual average employment rate in the ith MSA and tth year ; AAWit is the real annual average wage in MSAi and tth year. The main independent variable, PFRit is the real ($1988) dollar value of per capita federal contract R&D funds in ith MSA and tth year. Federal contract R&D values were standardized by population to eliminate influences attributable variation in population size across metro-regions, and they were further adjusted both for general inflation using the GNP deflator and regional cost-of-living differences. The following simultaneous equations are build under the assumption of that regional income and employment performances exert a bi-directional influence on one another, and are common to the models tested :

$$ERit = f(AAWit, PFRit, POPit, POPit, PMEit, PSEit, DR1, \cdots, DR8) \cdots\cdots (1)$$

$$AAWit = f(ERit, PFRit, POPit, PMIit, PSIit, DR1, \cdots, DR8) \cdots\cdots (2)$$

POPit is the population size in thousands in MSAi and tth year and is included to capture any evidence of an independent agglomerative effect associated with a region's size and scale within the U.S. urban hierarchy. PMEit is the manufacturing share of total regional employment, PMIit is the manufacturing share of total regional income, PSEit is the producer services share of total employment, and PSIit is the producer services share of total income in MSAi and tth year. To control for multi-state and time-specific biases, the final models employ dummy variables for the major census divisions and years. DR1 through DR8 are the regional dummies designed to capture any residual influence of regional size differences ; they are defined as follows : [1]

DR1 = 1 if Middle Atlantic
DR2 = 1 if East North Central
DR3 = 1 if West North Central
DR4 = 1 if South Atantic
DR5 = 1 if East South Central
DR6 = 1 if West South Central
DR7 = 1 if Mountain
DR8 = 1 if Pacific

All models are tested using regression techniques. After preliminary cross-sectional models revealed evidence of heteroskedasticity, Models Ⅰ-Ⅳ were designed to incorporate both two-stage

least squares(2SLS) and weighted least squares(WLS) adjustments.[2)]

More efficient parameter estimates were obtained by pooling cross-sectional and time-series data over the three-year FY 1986-88 period.

5. Results

1) Model I : Effects by Funding Source/ Mission : Defense vs. Civilian Orientation

Is there a detectable stimulative effect at the metro-regional level associated with either defense or nondefense-oriented federal R&D funding? In Model I, PFRDOD refers to the real per capita value FY86-88 federal R&D contract outlays by the Department of Defense flowing to defense-related projects in the ith metro-region in the tth year. Although substantial portions of the R&D funds distributed by both the department of Energy and NASA also support military-related research, they were not included in this variable because the funds could not be traced to specific places of performance at the level of metro-regions. PFRCIV refers to the real per capita value of federal contract R &D funds allocated to the ith metro-region in the tty year by all other(nondefense) federal agencies. The effects associated with these funding flows are reported in Table 1.

While both federal R&D funding sources have statistically significant regional employment and income effects, those associated with nondefense missions are substantially larger than those associated with defense. In the employment(ER) equation, the coefficient for nondefense R &D (PFRCIV) is approximately thirteen times larger than that for defense R&D (PFRDOD). In the annual average wage (AAW) equation, the coefficient for PFRCIV is approximately ten times larger than that for PFRDOD.

Model I also offers evidence of a strong agglomeration effect associated with federal R&D spending. Stimulative effects on both dependent variables were stronger in larger metro-regions than smaller ones as evidenced by the significant POP coefficients. In addition, the industrial structure of the recipient regional economy emerged as an important contextual factor. The greater the manufacturing share of regional employment(PME), the stronger the employment effect of federal R&D spending. Similarly, the greater the manufacturing share of aggregate regional income(PMI), the greater the income effect of this spending. By contrast, not only does the producer services share of regional employment (PSE) and income (PSI) fall short of having similar independent effects, but the negative coefficient of PSI suggests that a regional industrial mix too heavily weighted toward producer services may actually be detrimental to a region's economic performance. Significant time dummy coefficients indicate that the 1986 -87 period was one of gradual economic recovery, while significant coefficients associated with the majority of regional dummies indicate that the West South Central, Mountain and Pacific division had lower economic performances than others during the period. The resulting consistent and significant negative coefficients associated with both ER and AAW confirm that regional income and employment performances exert a bi-directional influence on one another.

2) MODEL II : Effects by Performer Sector : For-Profit vs. Not-for-Profit

The core inquiry of "political economy" involves understanding the ways in which the private and public sectors influence one another. In this study, the former category is composed exclusively of for-profit firms ; the latter category is defined by a greater diversity of organizations, including public and nonprofit educational and research institutions. For purposes of

Table 1. Regression Results of Model I and Model II

	Model I		Model II	
VAR.	ER(EQ1) 2SLS and WLS	AAW(EQ2) ESTIMATES	ER(EQ3) 2SLS and WLS	AAW(EQ4) ESTIMATES
INT.	97.0233***	108154.82***	97.2119***	94766.5466***
	(79.95)	(12.05)	(101.94)	(12.17)
AAW	-0.00029***		-0.0003	
	(-4.88)		(-6.03)	
ER		-986.57229***		-848.7423***
		(-10.18)		(-10.12)
PFRDOD	0.00067***	1,4606663***		
	(2.78)	(7.96)		
PFRCIV	0.00776***	14.2850671***		
	(7.24)	(9.55)		
PFRP			0.0015***	3.4018***
			(6.36)	(12.08)
PFRNP			0.0086***	4.8371**
			(5.82)	(2.25)
POP	0.00041***	0.088217767***	0.0004***	0.8557***
	(7.11)	(15.28)	(5.96)	(15.47)
PME	0.0279***		0.0345***	
	(3.05)		(4.03)	
PSE	0.0434**		0.0306**	
	(2.80)		(2.58)	
PMI		40.3954847***		45.6484***
		(5.81)		(7.21)
PSI		-24.3899055		-21.9853*
		(1.64)		(-1.68)
DY86	-1.2849***	-1447.1360***	-1.3115***	-1302.2205***
	(-10.48)	(-8.11)	(-10.66)	(-7.55)
DY87	-1.2849***	-459.48230**	-0.5855***	-297.2820**
	(-5.47)	(-3.60)	(-5.01)	(-2.46)
DR1	2.7857***	2729.39273***	2.6397***	2344.7204***
	(10.78)	(7.24)	(9.75)	(6.87)
DR2	1.3637***	1642.23300***	1.4315***	1642.8229***
	(5.75)	(6.40)	(6.15)	(6.59)
DR3	0.6352*	2276.08787***	0.7290***	2400.8492***
	(2.46)	(11.75)	(3.34)	(13.09)
DR4	1.7039***	2302.66044***	1.8988***	2325.5989***
	(7.55)	(8.98)	(8.35)	(9.15)
DR5	1.2963***	1178.49722***	1.3306***	1174.3772***
	(6.46)	(5.47)	(6.78)	(5.97)
DR6	-0.5402*	-735.18521	-0.7703**	-196.9977
	(-1.84)	(-3.07)	(-2.96)	(-0.85)
DR7	-1.7611***	-1490.20408***	-1.5811***	-889.2410***
	(-6.12)	(-5.35)	(-5.66)	(-3.53)
DR8	-0.0700	91.83069	0.1079	515.7674**
	(-0.31)	(0.49)	(0.48)	(2.70)
F-VALUE	34.047	39.452	35.049	36.641
R-SQUARE	0.3710	0.4067	0.3782	0.3887
ADJ. RSQ	0.3608	0.3968	0.3674	0.3781
N=939				

Note : T-ratios in parentheses, $P^{*}<0.05$ $P^{**}<0.01$ $P^{***}<0.001$

this study, this classification mirrors closely to the industry-university sectoral distinction that in recent years has engendered considerable discussion concerning ways to use federal funding to stimulate technology transfer, encourage research collaboration, and promote dual-use technology development. Does federal R&D funding flowing to the for-profit and nonprofit sectors register differing regional economic impacts? Model Ⅱ exploits this most basic dimension organizing a modern mixed economy and is designed to isolate the effects of federal support for both sectors. As before, effects are measured at the level of the nation's metro-regions.

The results for Model Ⅱ are also reported in Table 1. Both categories of federal R&D performers are associated with significant regional econmic impacts. However, once again, the stimulative impacts across sectors are not equally strong. The employment equation indicates that the not-for-profit sector (PFRNP) generates an employment stimulus from federal R&D funds that is nearly six times greater than that for the for-profit sector. Similarly, the income effect of federal R&D spending received by a region's not-for-profit (PFRNP) sector is larger than that associated with R&D funding received by a region's for-profit (PFRP) sector. These findings are consistent with the view that as for-profit organizations are oriented to maximizing profits, they have strong incentives to achieve the highest possible productivity levels by restraining employment growth and associated labor costs.

As in Model Ⅰ, the strongest stimulative effects are again found in the largest metro-regions. Moreover, the same patterns of regional employment and income effects associated with regional industry mix, time and regional dummies in Model Ⅰ and also evident in Model Ⅱ.

3) Models Ⅲ and Ⅳ : Effects by Research Performer : Industry (Small vs. Large) vs. Educational/Research and Other Research Institutions

In recent year, the distinctions between science and technology and basic and applied research -- and the performer communities aligned with them -- have received considerable attention. The commercial(knowledge-using) goals of market-oriented firms are often contrasted with the academic(knowledge-creation) role of research universities. R&D-performing organizations such as state and local hospitals and other nonprofit research organizations consititute a residual third sector. The substantial differences in mission and orientation toward research in general have been widely used to substantiate the view that each sector makes fundamentally different contributions to overall economic performance and competitiveness. In addition, much has been made recently of the capacity of the small business sector to create employment, host rapid technology cycles, and to deploy R&D investments efficiently compared to larger business. Therefore, Models Ⅲ and Ⅳ are designed to illuminate in sequence any distinct stimulative effects associated with these separate sectors and subsectors.

Model Ⅲ isolates the separate stimulative effects of federal R&D funding flows to industry(PFRID), educational/research institutions such as research universities (PFREI), and other research-performing organizations(PFROI). The results, reported in Table 2, indicate that both industry and education/research organizations mediate significant regional employment and income effects through their receipt of federal R&D contracts. However, corresponding to the differences in the strength of these effects across sectors found in Model Ⅱ, the employment effect associated with education/

Table 2. Regression Results of Model Ⅲ and Ⅳ

	Model Ⅲ		Model Ⅳ	
VAR.	ER(EQ5) 2SLS and WLS	AAW(EQ6) ESTIMATES	ER(EQ7) 2SLS and WLS	AAW(EQ8) ESTIMATES
INT.	95.3539***	84119***	95.5806***	89150***
	(87.71)	(9.58)	(90.49)	(10.18)
AAW	-0.0003***		-0.0003	
	(-4.95)		(-5.40)	
ER		-741.1183***		-798.1164***
		(-7.78)		(-8.40)
PFRID	0.0012***	3.1692***		
	(5.03)	(13.72)		
PFRSB			0.0020***	1.4998*
			(3.45)	(1.70)
PFRLB			0.0012***	3.4543***
			(4.52)	(16.21)
PFREI	0.0133***	5.9957***	0.0134***	6.2333***
	(6.02)	(3.61)	(6.42)	(3.64)
PFROI	0.0052***	5.4512*	-0.0036	5.4828*
	(-1.49)	(1.92)	(-1.09)	(2.27)
POP	0.0004***	0.8059***	0.0004***	0.7629***
	(5.90)	(13.86)	(5.87)	(15.51)
PME	0.0482***		0.0472***	
	(6.12)		(6.14)	
PSE	0.0666***		0.0655***	
	(5.97)		(5.95)	
PMI		54.2757***		54.7219***
		(9.36)		(9.40)
PSI		-7.4489		9.4009
		(-0.72)		(1.02)
DY86	-1.3588***	-1074.9524***	-1.2973***	-1155.9626***
	(-11.13)	(-6.43)	(-11.39)	(-7.62)
DY87	-0.6696***	-290.7837**	-0.6588***	-460.7152***
	(-6.14)	(-2.45)	(-6.38)	(-4.23)
DR1	2.1652***	1960.8154***	2.2388***	2120.9868***
	(8.96)	(5.57)	(9.54)	(6.00)
DR2	1.0241***	1478.3201***	1.2314***	1671.1441***
	(4.53)	(5.69)	(5.58)	(6.64)
DR3	0.4242*	2282.0240***	0.6428**	2392.9108***
	(1.97)	(12.60)	(2.89)	(14.41)
DR4	1.9492***	2176.0395***	2.0140***	2146.6038***
	(9.29)	(8.17)	(9.92)	(8.24)
DR5	1.2596***	1181.6627***	1.4185***	1202.4304***
	(7.14)	(5.73)	(8.29)	(6.17)
DR6	-0.7047*	-160.8941	-0.4941*	-180.5940
	(-2.73)	(-0.70)	(-1.66)	(-0.80)
DR7	-1.6760***	-574.1300***	-1.4613***	-669.5141**
	(-6.34)	(-2.22)	(-5.92)	(-2.72)
DR8	-0.2333	603.5799***	-0.0104	491.6075***
	(-1.14)	(3.62)	(-1.05)	(3.55)
F-VALUE	34.024	36.889	32.050	32.884
R-SQUARE	0.3855	0.3903	0.3854	0.3915
ADJ. RSQ	0.3748	0.3797	0.3734	0.3796
N=939				

Note : T-ratios in parentheses, $P^{*}<0.05$ $P^{**}<0.01$ $P^{***}<0.001$

research sector is eleven times greater than that associated with the industrial sector, while the income effect is nearly twice as large. Other research recipients have significant income effects associated with the R&D funds, but the employment effects turn to negative and statistically insignificant.

Model Ⅳ (Table 2) disaggregates the industrial sector into large-and-small-firm recipients of federal contract R&D. While the regional employment effect is replicated in both business-size sectors, the small business employment effect is nearly twice as great as that for large business. However, while the regional income effect associated with the large business sector alone attains clear statistical significance, this sector's income effect in more than twice as large as that for the small business sector. The greatest effects, however, can be traced once again to the education/research sector. The regional employment stimulus mediated by this sector is nearly seven times greater than that for the small business sector, while its regional income stimulus is nearly twice that of the large business sector.

Models Ⅲ and Ⅳ demonstrate again a powerful agglomerative effect whereby larger regions derive relatively greater employment and income gains than smaller regions. Moreover, the same general patterns of regional employment and income effects associated with regional industry mix, time and regional dummies evident in Models Ⅰ and Ⅱ are also evident in Models Ⅲ and Ⅳ.

6. Summary

In this study, the significant and enduring concentration of federal R&D spending in metro-scale clusters across the nation is treated as evidence of the operation of a distinct industrial infrastructure defined by the ability of R&D performers to attract external funding and pursue the sophisticated project work demanded. It follows, then, that the agglomerative potential of these R&D concentrations -- performers and their support infrastructures -- requires a search for economic impacts guided by a different stimulative effects attributable to federal R&D spending may be that substantial subnational economic impacts are routinely obscured and diluted by research designs that seek to discover impacts either at the level of nation-scale economic aggregates or on firms or specific industries organized spatially. Therefore, this study proceeds by seeking to link the locational clustering of federal contract R&D spending to more localized economic impacts. It tests a series of models(Ⅰ-Ⅳ) designed to trace federal contract R&D spending flows to economic impacts registered at the level of metro-regional economies.

By shifting the focus from funding sources to recipient types and then to sector-specific impacts, the patterns of consistent results become increasingly compelling. In general, these results indicate that federal R&D spending does indeed nurture the development of an important nation-spanning advanced industrial production and R&D infrastructure anchored primarily by two dozen or so metro-regions. However, dominated as it is by a strong defense-industrial orientation, federal contract R&D spending would appear to constitute a relatively inefficient national economic development policy, at least as registered on conventional indicators. Federal contract R&D destined for the support of nondefense/civilian (Model Ⅰ), nonprofit (Model Ⅱ), and educational/research (Mode Ⅲ) R&D agendas is associated with substantially greater regional employment and income impacts than is R&D funding disbursed by the Department of Defense. While federal R&D support

from DOD (Model Ⅰ) and for-profit (Model Ⅱ) and industrial performer (Model Ⅲ) contract R&D agendas are associated with positive regional economic impacts, they are substantially smaller than those associated with performers operating outside the defense industrial base. Moreover, evidence that the large-business sector mediates a small business sector (Model Ⅵ) justifies closer scrutiny of the relative contribution to economic growth and development made by these two sectors, as well as of the primacy typically accorded employment change as a conventional economic performance indicator.

Ultimately, those regions receiving federal R&D spending have experienced measurable employment and income gains as a result. However, whether or not those gains could be improved by changing the composition -- and therefore the primary missions -- of federal R&D spending cannot be decided by merely citing eviedence of its economic impacts of the kind reported here. Rather, that decision turns on a prior public choice relating to the trade-offs deemed acceptable between conventional employment and income gains, the strength of a nation's industrial base not reflected in such indicators, and the reigning conception of what constitutes national security -- military might or a competitve civilian economy.

Note

1) For purpposes of the dummy variable analysis, the New England division is omitted.
2) See Vijverberg and Lee(1991) for 2SLS and WLS estimation technique for simultaneous equation systems.

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