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EMPIRICAL EVIDENCE ON THE GEOGRAPHIC AND INDUSTRIAL DISTRIBUTION OF AEROSPACE EXPENDITURES

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EMPIRICAL EVIDENCE ON THE GEOGRAPHIC AND INDUSTRIAL DISTRIBUTION OF AEROSPACE EXPENDITURES

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I Introduction

Little detailed information is currently available on the economic effects of the vast subcontracting expenditures generated by the United States aerospace program. One possible explanation for this state of affairs is surely the lack of reliable data on the geographic and especially the industrial distribution of such expenditures. In contrast to the fairly complete distributional data available for prime contract expenditures, only limited amounts of incomplete and highly aggregative geographic data are to be had with respect to subcontract expenditures. /2

It seems reasonable to expect that little of value can be said with regard to the income and employment effects of subcontract expenditures unless the industries and regions affected can be identified, for any hypothesis of predictive content in these former areas must invariably be based on either strong empirical evidence and/or assumptions about the latter. In addition,

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/1 The author wishes to acknowledge the continuing encouragement and guidance afforded him while writing this paper by his advisor, Dr. Murray L. Weidenbaum. Thanks are also in order for helpful suggestions to the staff of the Dept. of Economics, Washington University and in particular Dr. Werner Hochwald. Last, but by no means least, the assistance of Mr. John Bickers, McDonnell Aircraft Corporation; Mr. Albert Shapero, Stanford Research Institute; Mr. Michel Andrieu, Washington University is gratefully acknowledged.

/2 See for example, NASA Annual Procurement Report-Fiscal Year 1964, National Aeronautics and Space Administration, Washington, D. C., 1964, pp. 4-14, 4-15, 10-2, 10-3, 10-4, 10-5.

due to the large number of dollars typically involved in aerospace subcontracting, the influence of these expenditures on the prosperity of subcontracting industries and regions must be considered. Intelligent and efficient policy therefore, requires accurate knowledge of the industrial and geographic distributions of these expenditures.

This paper initially concentrates on specifying both the locational subcontracting pattern and the interindustry requirements of a single large aerospace project. The data obtained from this investigation have two important features not generally present in most statistics currently available on aerospace subcontract expenditures. First, only first tier subcontracts are included, thus isolating for study the primary subcontract demands of the project on the economy. Second, the data are free of any possible errors due to aggregation found in multiproject data.

The second major objective of this paper is to utilize the data developed in the first part to test several hypotheses. An important point of concentration in this section is the possibility of predicting subcontract location when the location of the prime contractor is known. Before turning to these matters, however, a brief discussion of the origin and method of refining the data on which this study is based will be useful.

II The Gemini Data

The data used in this paper are derived from the subcontract expenditures of the National Aeronautics and Space Administration's Gemini project. The prime contract for this space capsule program was awarded to the McDonnell Aircraft Corporation, St. Louis, Missouri late in December, 1961. /3 The data covers a period starting at that date and ending March 1, 1965. The period of analysis is therefore approximately thirty-nine months. It should be emphasized immediately that these data do not represent subcontract obligations or awards, but actual expenditures or payments by McDonnell to its first tier subcontractors. /4 Actual payments to a subcontractor typically lag somewhat behind the award in much the same manner as actual delivery of ordered material lags behind the obligation to deliver. The data are therefore a sample of the eventual subcontract distribution that will emerge only when payments to subcontractors catch up with procurement obligations.

Considerable refinement was necessary before the original expenditure data provided by McDonnell were usable for analysis. Each subcontractor has been carefully classified by state and industry. A plant rather than a firm approach was adopted in order to pinpoint actual geographic points of subcontract production (i.e. plants) rather than a multiplant firm's home office

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/3 McDonnell Aircraft Corporation-1964 Annual Report, McDonnell Aircraft Corporation, St. Louis, Missouri, June 1964, p. 7.

/4 A complete discussion of expenditure versus obligation impact is found in Murray L. Weidenbaum, "The Economic Impact of the Government Spending Process", Business Review, The University of Houston, Houston, Texas, Spring, 1961, pp. 1-47.

where no actual work was taking place. This procedure allows single firms to count as more than one observation in the final data if, for example, a firm's sub-contract calls for batteries produced at a Detroit plant and generators at a Texas plant.

The Standard Industrial Code was employed to group subcontractors by industry. Poors Register of Corporations and Fortune's Plant and Product Directory were used where possible; however, in many cases comparison of McDonnell procurement descriptions and Bureau of the Budget SIC definitions was the only method of classification open. This somewhat crude procedure made refinement to a degree greater than three digit industries unfeasible.

Subcontract expenditures for Gemini amounted to approximately eighty-two million dollars during the period under investigation. It should be noted, however, that this figure represents payments to major subcontractors which are defined as those receiving more than one thousand Gemini dollars during the time period. Subcontractors that received less than one thousand dollars were discarded as insignificant and payments to them were not included in the data. /5

Manufacturing and service industry subcontractors accounted for more than eighty percent of the eighty-two million total expenditure. The 305 observations in these categories were distributed among twenty-nine states and forty-two industries. /6 It is with these subcontracts that this paper is primarily concerned.

/5 The total dollar amount discarded was also insignificant.

/6 One subcontractor is located in Canada.

III The Impact of Gemini Expenditure on the Economy

The purpose of this section is mainly descriptive. In this respect the data are merely being allowed to speak for themselves before any more significant analysis is undertaken. Such an inductive procedure is justified, however, in order to clearly depict the more obvious implications of the demands the Gemini project makes on the economy.

a) The Interindustry Gemini Production Function

As already mentioned, the primary focus of this study is on the manufacturing and service industries receiving large Gemini subcontracts. It is necessary, therefore, to isolate the effect of Gemini expenditure on manufacturing and service industries from such factors as non-manufacturing subcontract expenditures and primary McDonnell inputs (i.e. value added) added to goods and services purchased from other firms. It is quite simple to eliminate primary inputs from consideration since they are not represented in subcontract data. Besides the fact that a discussion of McDonnell primary inputs requires additional data, however, consideration of these inputs necessitates, in addition, study of topics which are essentially beyond the scope of this paper. This latter point will become more evident below. Subcontracts of a non-manufacturing nature are not actually eliminated from this paper, but a discussion of their importance is postponed until later. [7] In dollar terms, the portion of Gemini expenditure remaining for discussion here is $66,675,614..

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[7] See section five below.

The techniques that are used to organize the data and describe the Gemini program's interindustry impact are those of elementary input-output analysis. /8 Table one is a conceptual illustration of a simple input-output transactions matrix. Row one, for example, shows the allocation of the output of industry one to industry one (x_{11}), industry two (x_{12}), industry j (x_{1j}), and final demands (Y_1). Row two is the same for industry two, etc. Columns on the other hand display the input structure of an industry. Inputs are either of an interindustry nature (x_{11}, x_{21}, ----, x_{i1}) or primary (value added) inputs (V_1, V_2, ----, V_j). The rows of the transactions matrix or input-output table sum to yield total output (X_1, X_2,----X_i). If the transactions matrix is expressed in dollars rather than physical units, adding interindustry and primary inputs again results in total product or output of the system (X_1, X_2,----X_j).

Outlined in table one is the so-called interindustry matrix. In this part of the input-output table every entry possesses a dual nature. Each x_{ij} expressed in dollars is as a row element a sales figure and as a column entry to cost figure. The interindustry matrix is therefore a complete

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/8 On input-output analysis see H. B. Chenery and P. G. Clark, et. al., Interindustry Economics, John Wiley and Sons, New York, 1959; R. Dorfman P. Samuelson and R. Solow, Linear Programming and Economic Analysis, McGraw Hill Book Co., New York, 1958, pp. 204-229; W. W. Leontief, "Input Output Economics", Scientific American, April, 1965, pp. 3-9; _____, "The Structure of the U.S. Economy", Scientific American, April, 1965, pp. 25-35; P. J. Bourque, Fundamentals of Input-Output Analysis, University of Washington, undated lecture notes.

Table 1

Sample Transactions Matrix

	Inputs Industry 1	Inputs Industry 2	Inputs Industry i	Final Demands	Total Output of Industries
Industry 1	x_{11}	x_{12}	x_{1j}	Y_1	X_1
Industry 2	x_{21}	x_{22}	x_{2j}	Y_2	X_2
Industry i	x_{i1}	x_{i2}	x_{ij}	Y_i	X_i
Primary Inputs	V_1	V_2	V_j		V
Total Product	X_1	X_2	X_j	Y	X

description of the interindustry relations of the entire system. Column and row totals of interindustry elements represent total cost and sales respectively exclusive of primary inputs or final demands. Into this framework the Gemini data may be easily fitted. Table two is the equivalent of all the rows of an interindustry matrix consisting of one column (i.e. a vector). Each entry is both a sales figure (of the subcontracting industry) and a cost figure (of the Gemini program). In this special case, however, the column represents an input breakdown of Gemini rather than an entire industry or sector. In other words, the column is highly disaggregated (i.e. to the project level). Rows, however, are disaggregated only to the three digit SIC level.

It is permissible to consider every entry in table two as a factor of production in the Gemini production function. This relation could be expressed Gemini = G (x_{281}, x_{282}, x_{283}----) with subscripts indicating the

Table 2

Gemini Interindustry Inputs:
A Partial Gemini Production Function

SIC	Description	Amount
19	Ordnance and Accessories	$ 99,687
229	Miscellaneous Textile Goods	4,538
281	Industrial Chemicals	56,992
282	Fibers, Plastics and Rubbers	562,542
283	Drugs, Medicinal Chemicals	7,692
285	Paints and Varnishes	2,751
289	Miscellaneous Chemicals	471,347
306	Fabricated Rubber Products	2,174
307	Miscellaneous Plastic Products	65,673
322	Glass and Glassware	2,080
323	Glass Products (made of Purchased Glass)	5,280
327	Concrete, Gypsum, Plaster	3,436
329	Miscellaneous Non-Metallic Minerals	11,750
331	Steel Mills	36,754
335	Nonferrous Rolling and Drawing	139,780
339	Miscellaneous Primary Metals	48,340
342	Hand Tools, Hardware	126,458
344	Fabricated Structual Metal Products	75,816
345	Screw Machine Products	86,979
346	Metal Stampings	11,707
348	Fabricated Wire Products	72,406
349	Miscellaneous Fabricated Metal Products	95,099
354	Metal Working Machinery	1,773
356	General Industrial Equipment	600,010
357	Computing Machines	17,681
358	Service Machinery	25,955
359	Miscellaneous Machinery, Machine Shops	6,703,020
361	Electrical Transmission & Distribution Equipment	14,833,975
362	Electrical Industrial Apparatus	492,850
364	Lighting & Wiring Equipment	5,384,203
365	Radio & T.V. Receiving Sets	3,407,162
366	Communication Equipment	1,773,143
367	Electronic Components & Accessories	2,647,771
369	Miscellaneous Electric Machinery & Supplies	41,609
371	Motor Vehicles & Equipment	147,657
372	Aircraft & Parts	11,891,808
381	Scientific & Laboratory Equipment	156,581
382	Measuring & Indicating Instruments	14,649,256
383	Optical Equipment & Lens	56,105
386	Photographic Equipment & Supplies	1,936
739	Business Services (R&D)	49,576
891	Engineering & Architectural Services	136,627
999	Unallocated Manufacturing & Service Subcontracts	1,667,635
500-600	Nonmanufacturing Subcontracts	15,374,755
TOTAL		$82,050,369

various component industries. However, since the primary inputs row is not included in the interindustry matrix nor in table two, this production function is not a complete but a partial one. Only interindustry requirements are shown.

In table three, non-manufacturing inputs are subtracted, and the remainder of the abbreviated transactions matrix converted into a percentage distribution. Table three is derived by dividing each manufacturing and service entry in table two by the total cost (expenditure) of manufacturing and service inputs on Gemini to March 1, 1965 (i.e. $66,675,614). These new figures tell us more about the relative weights of the manufacturing and service components of the production function which could now be written more explicitly as Gemini = G (.09 X_{281}, .84 X_{282}, .01 X_{285}....) where the coefficients are the percentages found in column one of table three. [19]

Table three provides a complete description of Gemini manufacturing and service inputs. Industries are ranked according to their share of Gemini expenditure dollars in order to clearly indicate those most essential to the space capsule program. It is immediately apparent from these figures that an extreme dependence on only a few types of suppliers exists. Eight industries have a greater than one percent share of total expenditure. These represent nearly ninety-two percent of that figure.

Although the severity of concentration may be unanticipated, the industries involved should come as no surprise to those familiar with aerospace projects of the Gemini type. Electronics (361, 362, 364, 365, 366, 367, 369),

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[19] These percentages are not to be confused with marginal input coefficients. See Chenery and Clark, op. cit. pp. 22-25. Input-Output techniques beyond the transactions matrix are not included in this paper.

Table 3

Gemini Inputs Ranked by Percentage of Manufacturing and Service Expenditure

SIC	Industry Descriptions	%	Cum. %	# of Observations
361	Electrical Transmission & Distribution Equipment	22.25	22.25	18
382	Instruments, Measuring Controling, Indicating	21.97	44.22	23
372	Aircraft and Parts	17.84	62.05	28
359	Miscellaneous Machinery, Machine Shops	10.05	72.11	10
364	Electric Lighting and Wiring Equipment	8.08	80.18	5
365	Radio and T.V. Receiving Sets	5.11	85.29	8
367	Electronic Components & Accessories	3.97	89.26	25
366	Communication Equipment	2.66	91.92	8
356	General Industrial Machinery & Equipment	.90	92.82	7
282	Fibers, Plastics & Rubbers	.84	93.67	2
362	Electrical Industrial Apparatus	.74	94.41	10
289	Miscellaneous Chemicals	.71	95.11	10
381	Scientific Laboratory Equipment	.23	95.35	4
371	Motor Vehicles & Motor Vehicle Equipment	.22	95.57	6
335	Non-Ferrous Rolling & Drawing	.21	95.79	10
891	Engineering & Architectural	.20	95.98	2
342	General Hardware, Hand Tools	.19	96.17	4
19	Ordnance & Accessories	.15	96.32	2
349	Miscellaneous Fabricated Metal Products	.14	96.47	6
345	Screw Machine Products	.13	96.60	11
344	Fabricated Structural Metal Products	.11	96.70	4
348	Fabricated Wire Products	.11	96.82	2
307	Miscellaneous Plastic Products	.10	96.92	7
281	Industrial Chemicals	.09	97.00	6
383	Optical Equipment	.08	97.09	1
739	Business Services (R&D)	.07	97.16	2
339	Miscellaneous Primary Metals	.07	97.23	6
369	Miscellaneous Electric Machinery, Equipment & Supplies	.06	97.30	1
331	Steel Mills	.06	97.35	6
358	Service Machinery	.04	97.39	3
357	Computing Machinery	.03	97.42	4
329	Miscellaneous Non-Metallic Mineral Products	.02	97.43	2
346	Metal Stampings	.02	97.45	1
283	Drugs, Medicinal Chemicals	.01	97.46	1
323	Glass Products Made of Purchased Glass	.01	97.47	1
229	Miscellaneous Textile Goods	.01	97.48-	1
327	Concrete Gypsum Plastics	.01	97.48+	1
285	Paints & Varnishes	*	97.48+	2
306	Fabricated Rubber Products	*	97.49-	1
322	Glassware & Glass	*	97.49+	1
386	Photo Equipment & Supplies	*	97.49+	1
354	Metal Working Machinery	*	97.50-	2
SUB TOTALS		97.49	97.50	255
999	UNALLOCATED	2.50	100.0	50
GRAND TOTAL		99.99	100.0	305

*Less than one-twentieth of one percent.

Aircraft and Parts (372), and Measuring Instruments (382) should be expected to be extremely important in the Gemini production function. /10 The relatively large share of inputs supplied by industry 359, Miscellaneous Machinery and Machine Shops (10.05%) may be initially perplexing, but a closer look will reveal that this figure too is entirely reasonable. Into this category fall establishments that do work on a job or order basis and those that turn out such seemingly unsophisticated products as values, couplings, and pistons. /11 In highly intricate aerospace projects, however, items of this nature generally call for exacting specification and design and such requirements should logically exclude mass production methods and result in high unit costs.

Further observation of table three, pertaining mainly to industries other than the top ten, points out the greater importance of non-ferrous metals in comparison to steel. Also, the rather intriguing grouping of four fabricated metal industries (349, 445, 344, 348) with nearly equal shares. Finally, note the relative unimportance of the non-metallic minerals and related industries (329, 323, 229, 327, 306, 322). /12

/10 See for example Murray L. Weidenbaum, Measures of the Impact of Defense and Space Programs, Department of Economics, Washington University, Working Paper 6514, St. Louis, Missouri, August, 1965, pp. 17-18.

/11 Standard Industrial Classification Manual, U.S. Bureau of the Budget, Office of Statistical Standards, Washington, D. C., 1957, p. 105.

/12 A comment with regard to the unallocated category (999) seems in order. Subcontracts classified 999 were those of so obscure a description that the probablity of a classification error was intolerably large. Rather than introduce undue error into the data, these subcontracts (usually to smaller firms not listed in one of the standard directories) were relegated to the special 999 category.

Table four aggregates the data of tables two and three into large industrial groups providing a clear summary of these descriptive paragraphs. The dependence of the Gemini program on the Electronics, Measuring Instruments, Machinery, and Aircraft Industries is again evident. /13 In addition, on the basis of the clear break in the number of observations column between Primary Metals and Other Instruments, it seems apparent that the Metals and Chemicals Industries, while unimportant dollarwize, have a comparatively large number of plants engaged in some form of Gemini production. This fact may be of extreme importance for aerospace studies concerned with local and regional income and employment multipliers.

b) A Geographic Distribution of the Gemini Production Function

The Gemini production function discussed above may be looked at as indicating either the production requirements of Gemini or the demands for various inputs Gemini production places on the economy. In the latter sense, it is clear that an ability to complement our industrial dimension with a geographic dimension would be extremely advantageous. This is especially so when it is recalled that all Gemini demands (i.e. subcontract expenditures) originate at a single location, St. Louis, Missouri. Disaggregating the production function by states and regions allows areas of industrial impact and concentration to be located geographically. The combination of these two separate

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/13 Note, however, that the machinery category is almost exclusively composed of industry 359 discussed above.

Table 4

Major Interindustry Groups' Percentage of Gemini Manufacturing & Service Expenditure

	%	$	# of Observations
Electronics	42.87	2,858,073	75
Measuring Instruments	21.97	14,649,256	23
Aircraft and Parts	17.84	11,891,808	28
Machinery, except electrical	11.02	7,346,666	26
Chemicals	1.65	1,101,324	21
Fabricated Metals	.70	468,465	28
Primary Metals	.34	224,874	22
Other Instruments	.31	214,622	6
Services	.27	186,203	4
Other Transportation Equipment	.22	147,667	6
Ordnance & Accessories	.15	99,687	2
Rubber & Plastics	.10	67,847	8
Non Metallic Minerals	.04	22,546	5
Miscellaneous Textile Goods	.01	4,538	1
SUB TOTAL	97.49	65,007,979	255
UNALLOCATED	2.50	1,667,635	50
GRAND TOTAL	99.99	66,675,614	305

dimensions should result in clear implications for the general impact of aerospace projects on the economy.

A state-by-state percentage distribution of the Gemini production function is presented in table five. This table is conceptually analogous to table three above and is derived in a similar manner. Each row represents a different state receiving Gemini dollars. Industries are segregated into columns. Each individual entry, therefore, indicates the percentage of Gemini subcontract expenditure going to the state and industry found at the head of its respective row and column.

The immediate impression received from table five is that Gemini expenditure impact is concentrated not only in a few industries, but in a very few geographic locations as well. California, the northeast, and the Florida area seem especially well represented in the more important industries. Florida turns out to be an especially important contributor of Electrical Transmission and Distribution Equipment. California contributes highly significant shares of major subcontracting industries 382, Measuring and Indicating Instruments; 372, Aircraft and Parts; 365, Radio and T.V. Receiving Sets; and 359, Miscellaneous Machinery and Machine Shops.

Other major contributions to Gemini are found in New Jersey industry 366, Communication Equipment; Michigan and Iowa industry 367, Electronic Components and Parts; and Minnesota and Florida industry 382, Measuring and Indicating Instruments. Note, however, that there are very few extremely large entries in table five. Special attention should be drawn to the fact that not a single industry located in the Gemini local area (i.e. Missouri or Illinois) received a one percent share of Gemini dollars even though a large number of industries in these two states received small shares.

Table 5

A Geographic Distribution of the

Gemini Production Function in Percentages

	19	229	281	282	283	285	289	306	307	322	323	327	329	331
Alabama														
Arizona														
California	.15						.02	*	.04					.03
Colorado														
Connecticut						*								*
Delaware							*							
Florida			*											
Georgia														
Illinois			.06				.09							
Indiana							*							
Iowa														
Kansas									.01			.01		
Louisiana							.01							
Maryland		.01		.84										
Massachusetts														
Michigan														
Minnesota									.03					
Missouri			.004				.58		.01					.03
New Hampshire														
New Jersey			.02							*				
New York									*					
North Carolina														
Ohio							.01						*	
Oklahoma														
Ontario														
Oregon														
Pennsylvania					.02						.01		.02	
Rhode Island														
Texas			*			*								
Washington														

* Less than one twentieth of one percent.

Table 5
(continued)
A Geographic Distribution of the

Gemini Production Function in Percentages

	335	339	342	344	345	346	348	349	354	356	357	358	359
Alabama													
Arizona													*
California	.02	.01	.01	*	.07	.02	.10	.09		.09	.01		9.91
Colorado													
Connecticut													
Delaware													
Florida													
Georgia													
Illinois	.14	*		.01	.02								
Indiana													
Iowa													
Kansas					*								
Louisiana													
Maryland													
Massachusetts										*			
Michigan		.06								.58			
Minnesota													
Missouri	.02	.01								*	.02	.01	.01
New Hampshire													
New Jersey								*		.05		.02	
New York	*							.06		.10	.01	.02	
North Carolina				*									
Ohio	.02				*				*				*
Oklahoma													
Ontario													
Oregon	.01												
Pennsylvania		*	.18		.04		.01		*				
Rhode Island													
Texas										.08			.13
Washington													

* Less than one twentieth of one percent.

Table 5
(continued)
A Geographic Distribution of the

Gemini Production Function in Percentages

	335	339	342	344	345	346	348	349	354	356	357	358	359
Alabama													
Arizona													*
California	.02	.01	.01	*	.07	.02	.10	.09		.09	.01		9.91
Colorado													
Connecticut													
Delaware													
Florida													
Georgia													
Illinois	.14	*		.01	.02								
Indiana													
Iowa													
Kansas					*								
Louisiana													
Maryland													
Massachusetts										*			
Michigan		.06								.58			
Minnesota													
Missouri	.02	.01								*	.02	.01	.01
New Hampshire													
New Jersey								*		.05		.02	
New York	*							.06		.10	.01	.02	
North Carolina				*									
Ohio	.02				*				*				*
Oklahoma													
Ontario													
Oregon	.01												
Pennsylvania		*	.18		.04		.01		*				
Rhode Island													
Texas										.08			.13
Washington													

* Less than one twentieth of one percent.

Table 5
(continued)
A Geographic Distribution of the

Gemini Production Function in Percentages

	361	362	364	365	366	367	369	371	372	381	382	383
Alabama									.07			
Arizona									.48			
California	.03	.20	.05	4.86	.13	.39	.06		15.01	*	5.41	
Colorado									.02		*	
Connecticut						.01			.61		.06	
Delaware												
Florida	21.12										11.47	
Georgia												
Illinois	.13			.07		.03				*		
Indiana				.03		.03						
Iowa						1.36			.21			
Kansas	*											
Louisiana												
Maryland			7.95							.09	.01	
Massachusetts					.01	.02					.09	
Michigan				.03		1.73		.01	.33			
Minnesota					.38						4.85	
Missouri	.55	.04	.02		.88				.29		*	
New Hampshire											*	
New Jersey	.11	.13		.20	1.26	.10			.132	.146	.012	
New York	.28	.32		.02		.28		*	.18		*	
North Carolina												
Ohio		.06							.21			
Oklahoma												
Ontario									.27			
Oregon												
Pennsylvania			.07			.03		.01	.02		.06	.08
Rhode Island								.01				
Texas						*		*				
Washington												

* Less than one-twentieth of one percent.

Table 5
(continued)

A Geographic Distribution of the

Gemini Production Function in Percentages

	386	739	890	999
Alabama				
Arizona				
California	*			.76
Colorado				
Connecticut				
Delaware				
Florida				
Georgia				.01
Illinois				.24
Indiana				
Iowa				.01
Kansas				
Louisiana				
Maryland				.08
Massachusetts		.07	.21	
Michigan				
Minnesota				
Missouri				.66
New Hampshire				
New Jersey				.03
New York				.13
North Carolina				
Ohio				.04
Oklahoma				.57
Ontario				
Oregon				
Pennsylvania				
Rhode Island				
Texas				*
Washington				

* Less than one-twentieth of one percent.

It is quite clear from the data presented in table five that a definite pattern of subcontract location is emerging. Major subcontracting industries are concentrated in coastal states. Interior regions are receiving comparatively few Gemini dollars with these dollars resulting from subcontracts to the less important industries in the Gemini production function.

c) Summary of Geographic Distribution of Gemini Expenditures

A step by step description of table five seems unnecessary since the data are reasonably self explanatory. However, just as the discussion of the Gemini production function above provided a summary of the industrial distribution of Gemini subcontracts, some brief summary comments on the geographic distribution of Gemini expenditure seems necessary.

In table six, states receiving Gemini dollars are ranked by their percentage share. This table, therefore, illustrates the geographic origin of the factors of the Gemini production function (i.e. it illustrates the geographic hierarchy of subcontracting markets). Conjectures about geographic concentration analogous to the industrial concentration found above are confirmed by the data presented in table six. Of the twenty-nine states directly touched by Gemini first tier subcontracting dollars, only nine received more than one percent of the total. These states are California, Florida, Maryland, Minnesota, Missouri, Michigan, New Jersey, Iowa, and New York. California and Florida dominate the list, accounting for over 65 percent of total Gemini expenditures to manufacturing and service industries between them. Minnesota and Maryland are a poor third and fourth by comparison (8.97 percent and 5.26 percent respectively). Due to the location

Table 6

Geographic Distribution of Gemini Subcontracts By State

	$	%	# of Observations
California	24,973,721	37.46	89
Florida	21,733,263	32.60	3
Maryland	5,983,720	8.97	7
Minnesota	3,505,868	5.26	4
Missouri	2,058,621	3.09	49
Michigan	1,851,605	2.78	9
New Jersey	1,397,747	2.10	21
Iowa	1,053,872	1.58	3
New York	939,086	1.41	24
Illinois	579,804	.87	19
Connecticut	467,004	.69	9
Oklahoma	376,572	.56	1
Pennsylvania	347,043	.52	16
Arizona	318,486	.48	3
Ohio	230,176	.58	12
Massachusetts	265,169	.40	9
Texas	229,893	.34	7
Ontario	178,693	.27	1
Washington	54,881	.08	1
Alabama	48,069	.07	1
Indiana	37,529	.06	3
Kansas	14,996	.02	5
Colorado	14,284	.02	2
Louisiana	7,665	.01	1
Georgia	4,472	.01	1
Oregon	4,032	.01	1
Rhode Island	3,290	*	1
North Carolina	1,478	*	1
Delaware	530	*	1
New Hampshire	5	*	1
TOTALS	66,675,614	100.14	305

* Less than one-twentieth of one percent.

of the Gemini prime contract in St. Louis, it would seem reasonable to expect a large amount of subcontracting in Missouri and/or Missouri and Illinois. This expectation, however, is not born out when confronted with the data. Missouri's share of Gemini subcontract expenditures is a low 3.09 percent. Combining Missouri and Illinois into a two state region only lifts this amount to 3.96 percent.

Table seven aggregates states into regions. The importance of the coastal regions is quite evident. Furthermore, their combined share of all inputs (84.3%) is divided almost equally between east and west (37.55% west, 46.7% east). Subcontracts to companies in the Rocky Mountains and South Central Regions are negligible as might be expected. The Midwest Region, which contains the Gemini home state, accounts for a comparatively low 14.14%.

Table 7

Geographic Distribution of Gemini Subcontracts By Region

Region	%	# of Observations
West Coast	37.55	91
Rocky Mountains	.50	5
Midwest	14.14	104
South Central	.98	10
Southeast	32.61	5
Northeast	14.09	89
Canada	.27	1

West Coast: California, Oregon, Washington.

Rocky Mountains: Nevada, Utah, Colorado, New Mexico, Arizona.

Midwest: Kansas, Minnesota, Iowa, Missouri, Wisconsin, Michigan, Illinois, Indiana, Ohio.

South Central: Oklahoma, Texas, Arkansas, Louisiana, Kentucky, Tennessee, Mississippi, Alabama.

South East: West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida.

North East: New York, New Jersey, Pennsylvania, Maine, New Hampshire, Vermont, Connecticut, Massachusetts, Rhode Island, Maryland, Delaware.

IV A Hypothetical Model of Subcontracting Location

With knowledge of the nature of Gemini inputs and their geographic distribution now in hand, the time has come to go beyond mere description. It is a major objective of this paper to develop a hypothesis of subcontract location that embodies predictive content and to make use of the Gemini data discussed in section three as a test case. The most significant contribution to date dealing with subcontract location is embodied in a recent study published by the Stanford Research Institute (SRI). /14 Since the findings of this study are highly suggestive and more important testable, a brief discussion of the SRI hypothesis will serve as introduction to the conceptual content of this section.

a) The Stanford Research Institute Hypothesis

The SRI study under discussion is an extensive investigation into many aspects of the R&D industry. It should be emphasized that only a single proposal of the SRI study is being discussed and tested in this paper, namely, their hypothesis of subcontract location. Negative results here are of course no discredit to other parts of what is a pioneering effort.

The essential features of the SRI Model of subcontract location are as follows:

> "Two regions, the west coast and the northeast,---account for two-thirds of the material procurement (i.e. subcontract) dollars spent.
>
> Though the percentage of material procurement dollars going to the combination of these two regions remains fairly constant, the relative portion that goes to each depends on the location of the prime contractor making the procurements, with the larger proportion going to the nearest of the two regions.

/14 A. Shapero, R. P. Howell, J. R. Tombough, An Exploratory Study of the Structure and Dynamics of the R&D Industry, Stanford Research Institute, Menlo Park, California, June, 1964, especially chapters II, VI.

> There is a considerable amount of substitutability of suppliers between these two regions.
>
> Five major defense R&D complexes--account for 45-60% of the materials procurement dollars spent by defense R&D prime contractors. These complexes include
>
> A Southern California Complex
> A San Francisco Bay Area Complex
> A New York City, North New Jersey Complex
> A Boston Centered Complex
> A Washington, D. C. Centered Complex
>
> Defense R&D prime contractors located outside the defense R&D complexes procure approximately one-fifth of their material from their home states."/15

This model is based on data collected from three DOD-NASA prime contract locations: Orlando, Florida; Denver, Colorado; and Phoenix, Arizona.

The existence and importance of the five major complexes and the substitutability of suppliers between them seems hardly in question. Examination of Gemini data corroborates all three of these proposals. For example, observe the geographic concentrations found in tables six and seven, and the geographic distribution of industries 366 and 367 in table five. The table found in Appendix A below provides clear evidence of the substitutability hypothesis. This table shows the geographic distribution of each industry's Gemini subcontracts. In addition, McDonnell procurement descriptions in the original data further support the substitutability hypothesis. In what follows, therefore, these three proposals will be taken as datum.

Given the existence and importance of the five complexes and the substitutability of suppliers between them, what remains of the SRI model quoted above is a hypothesis suggesting the existence of a predictable geographic

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/15 Shapero, Howell, Tombough, op. cit., p. 5.

distribution of subcontractors. The distribution that would be expected for Gemini subcontracts is estimated in table 8 and compared to the actual figures.[716]

Table 8

The SRI Hypothesis Tested With Gemini Data

Region	Expected Share (SRI)	Actual Share (Gemini)
California-Northeast	67%	42.6
California	30-40%	37.5
Northeast	30-40%	5.1
Home State		
Missouri only	20%	3.1
Missouri & Illinois		4.0

The comparison presented in table 8 does not lend a great deal of support to the SRI hypothesis. The mid-continent location of St. Louis would seem to imply nearly equal shares of Gemini subcontract dollars for California and the northeast if SRI is correct. Any east-west balance that exists, however, is due primarily to Florida (32.6%, see table 6), an area of subcontract concentration not anticipated by the SRI hypothesis. The northeast falls drastically below its predicted share, and although Maryland and Delaware are not included in the SRI northeast region, even the addition of these two states leaves the combined California-northeast percentage more than 15 points too low. Finally, the home state predictions are far from correct. Instead of the nearly 20% expected, the states of Missouri and Illinois received only 4% of Gemini subcontract dollars.

[716] The SRI northeast region does not include the states Maryland and Delaware as does the northeast region presented in table 7 above. The SRI region, therefore, excludes the Washington, D. C.. complex. As indicated in the text, however, even if these states are taken into account, the data still do not corroborate the SRI hypothesis.

b) A Model of Subcontract Location

Constructing a tenable model of subcontract location that has significant analytic and predictive content and in addition retains sufficient generality is a complex and frustrating undertaking. The importance of such a model, however, warrants a new attempt.

Returning to the SRI hypothesis for a moment, there seem to be two principle reasons for its failure to correctly anticipate the Gemini subcontract distribution. First, given the existence of the five complexes and the substitutability of suppliers between them, the subcontracting location results of the SRI study may well be a tautological interpretation of their data. For example, Phoenix certainly lies well within the sphere of influence of the California complexes. In addition, Denver would certainly favor the west coast over the east, and Orlando, even granting the possibility of a Florida complex, would certainly favor the northeast over California on any locational or distance criteria imaginable. The second point to be made is that the SRI study contained no explicit industrial specification of subcontractors. While it seems obvious that the major complexes must be responsible for the majority of the highly technical and specialty inputs in a project such as Gemini, the lack of an industrial specification makes the determination of the location of other inputs in relation to the prime contractor impossible.

The sum total of this brief critique of the SRI hypothesis is that it fails to present a sufficiently general case. This defect may be corrected by replacing the SRI hypothesis with one that takes the industrial character of aerospace subcontracts explicitly into account and makes subcontract location a direct function of this feature and the location of the prime contractor. The hypothetical relationship that emerges from this alteration is

that certain types of aerospace subcontractors should be expected to possess a locational advantage due to the nature of their goods. In particular, subcontracts of a bulky, heavy nature, unspecialized, low technology, low value to weight ratio should be largely located within the region immediately surrounding the prime contractor. /17 Any prime contractor located within the economic sphere of influence of a major complex, therefore, should generate a subcontract distribution which combines both 'specialized' and 'unspecialized' subcontracts in the surrounding geographic region. On the other hand, as one moves farther away from the major complexes, a locational pattern should appear with the specialty subcontracts concentrated in the centers and the other inputs concentrated in a region surrounding the prime contractor.

The Gemini data is, of course, the ideal test case for this hypothesis. All Gemini subcontract expenditures originate in St. Louis, Missouri, making Gemini one of the few large NASA or DOD prime aerospace contracts not located in one of the five centers. In addition, St. Louis is economically equidistant between the complexes all of which are located on the east and west coast. The Gemini data, therefore, should exhibit a clear subcontracting pattern that would be unattainable if the prime contract were located in Los Angeles, New York, or for example, the SRI Phoenix case. Also, while both St. Louis and Florida (i.e. SRI Orlando case) are about equal distances from the northeast complexes, clearly the locational preference of St. Louis for the east coast over the west coast would be expected to be geographically much weaker.

/17 This statement is merely an application of orthodox location theory to the aerospace industry. See for example, E. M. Hoover, The Location of Economic Activity, McGraw-Hill Book Co., New York, 1948; W. Isard, Location and Space Economy, John Wiley, New York, 1955.

To properly test the proposed hypothesis with the Gemini data, it is necessary to construct a region that arbitrarily (1) isolates a section of the country that seems most economically connected with St. Louis, and (2) excludes all five of the important aerospace centers and their attendant complexes. /18 A region with a radius extending five hundred miles from St. Louis accomplishes both objectives. It contains within its boundry eighteen states of which Missouri, Iowa, Minnesota, Michigan, Ohio, Illinois, Indiana, Alabama, Oklahoma, Texas, and Kansas contain Gemini subcontracting observations. If the hypothesis is valid, the Gemini subcontractors for unspecialized, low technology, bulky, heavy inputs should be predominately located within this region.

Relegated to the Appendix are two tables which organize the Gemini data derived in section three into a form suitable for the test. Appendix A, as indicated previously, contains each state's percentage share of each subcontracting industry. Since it is only necessary to know what percentage of each industry's total subcontract dollars are located within five hundred miles of St. Louis as opposed to the rest of the U.S., Appendix B aggregates states into regions on the basis of this criteria.

Absolute proof is neither expected nor sensible to expect; however, a concentration of sixty percent or greater of any industry within the five hundred mile region would seem substantial evidence of locational preference. It is on this basis that table 9 is constructed from Appendices A and B. Any

/18 A conceptually similar region has been constructed for other purposes by F. T. Moore and J. W. Peterson, "Regional Analysis: An Interindustry Study of Utah," Review of Economics and Statistics, November, 1955.

Gemini subcontracting industry whose subcontracts are concentrated within five hundred miles of St. Louis to a degree of sixty percent or more has been designated regional (R) in table 9. On the other hand, if an industry has sixty percent or more of its subcontracts located outside the five hundred mile region, it has been rated national (N). Industries with sixty percent in neither region have been relegated to a third category entitled unclassified (U).

Table 9

Regional and National Gemini Inputs

SIC	Description	%	Observations
1)	Industries with greater than 60% of subcontract dollars located regionally (R)		
281	Industrial Chemicals	70.4	6
289	Miscellaneous Chemicals	95.6	10
327	Concrete, Gypsum	100.0	1
335	Non-Ferrous Rolling and Drawing	85.0	10
339	Miscellaneous Primary Metals	92.8	6
344	Fabricated Structual Metal Products	86.4	4
354	Metal Working Machinery	88.6	2
356	General Industrial Equipment	65.0	7
367	Electronic Components	79.3	25
371	Motor Vehicle and Equipment	95.4	6
2)	Industries with greater than 60% of subcontract dollars located nationally (N)		
19	Ordnance and Accessories	100.0	2
229	Miscellaneous Textile Goods	100.0	1
282	Fibers, Plastics and Rubbers	100.0	2
283	Drugs, Medicinal Chemicals	100.0	1
306	Fabricated Rubber Products	100.0	1
322	Glass and Glassware	100.0	1
323	Glass Products (made of Purchased Glass)	100.0	1
329	Miscellaneous Non-Metallic Minerals	87.8	2
342	Hand Tools, Hardware	100.0	4
345	Screw Machine Products	83.2	11
346	Metal Stampings	100.0	1
348	Fabricated Wire Products	100.0	2

Table 9
(continued)

Regional and National Gemini Inputs

SIC	Description	%	Observations
349	Miscellaneous Fabricated Metal Products	100.0	6
358	Service Machinery	77.6	3
359	Miscellaneous Machinery, Machine Shop	98.6	10
361	Electrical Transmission & Distribution Equipment	96.8	18
362	Electrical Industrial Apparatus	87.1	10
364	Lighting & Wiring Equipment	99.8	5
365	Radio & T.V. Receiving Sets	97.5	8
369	Miscellaneous Electric Machinery & Supplies	100.0	1
372	Aircraft & Parts	93.8	28
381	Scientific & Laboratory Equipment	99.2	4
382	Measuring & Indicating Instruments	77.9	23
383	Optical Equipment and Lens	100.0	1
386	Photo Equipment & Supplies	100.0	1
739	Business Services (R&D)	100.0	2
891	Engineering & Architectural Services	100.0	2
3)	Unclassified Industries (U)		
285	Paints, Varnishes, Lacquers, Enamels & Allied Products	----	2
307	Miscellaneous Plastics Products	----	7
331	Blast Furnances, Steel Works, & Rolling & Finishing Mills	----	6
357	Office, Computing and Accounting Machines	----	4
366	Communication Equipment	----	8

Careful analyses of table 9 reveals that the industries designated regional (R) are generally of a ubiquitous (281, 289), bulky (327, 335, 339), unspecialized, low technology (356, 367) nature. All the highly technical, more refined Gemini inputs (359, 361, 382, 372, etc.) are primarily subcontracted for outside the five hundred mile region. As already indicated, the majority of the subcontracts in the 'national' category have gone to one of the five complexes (see table 5 and Appendix A).

Table 9 clearly implies the existence of some advantage to the prime contractor from awarding subcontracts in 'unspecialized' industries to firms of not to distant location. Some pattern is definitely present in the geographic distribution of Gemini subcontracting. Further evidence is provided by table 10. Since the Gemini expenditure data being used in this study were derived on a plant rather than firm basis, the mean value of each geographic point of production in each subcontracting industry may be calculated as a simple average. Ranking subcontracting industries on the basis of these figures and again designating each industry as regional, national or unclassified (from table 9), results in a comparison of location and value. /19

The proposed hypothesis would suggest that the low value subcontract would have a locational advantage and therefore tend to be located within the hypothetical five hundred mile region. High value on the other hand would tend to dilute the locational advantage and impart a more footloose character to the industry. /20 In the Gemini case, this implies that the opportunity cost to the prime contractor of subcontracting outside the five hundred mile region is less the more valuable the subcontract. /21 Table 10 supports this proposal. The industries with the highest average value per subcontract are all designated 'national' (N). The first industries designated regional are far down the list. They are Electronic Components and Parts (367) and General Industrial Machinery (356). As indicated above, these industries are not of a particularly specialized nature. A fan, transistor or blower are common items of manufacture in almost any large metropolitan area.

/19 In calculating mean values, subcontracting industries with less than two observations have been eliminated.

/20 See Hoover, op. cit.

/21 Note that the advantage lost may be positive, negative or zero.

Table 10

A Comparison of Subcontract Location and Value*

SIC		$ Mean	Concentration	# of Observations
364	Lighting and Wiring Devices	1,076,840	N	5
361	Electrical Transmission & Distribution Equipment	824,109	N	18
359	Miscellaneous Machinery, Machine Shops	670,302	N	10
382	Measuring & Indicating Instruments	636,924	N	23
365	Radio & T.V. Receiving Sets	424,895	N	8
372	Aircraft & Parts	424,707	N	28
282	Fibers, Plastics & Rubber	281,271	N	2
366	Communication Equipment	221,642	U	8
367	Electronic Components	105,910	R	25
356	General Industrial Equipment	85,715	R	7
891	Engineering & Architectural Services	68,313	N	2
319	Ordnance & Accessories	49,843	N	2
362	Electrical Industrial Appartus	49,285	N	10
289	Miscellaneous Chemicals	47,134	R	10
381	Scientific & Laboratory Equipment	39,145	N	4
348	Fabricated Wire Products	36,203	N	2
342	Hand Tools & Hardware	31,614	N	4
739	Business Service	24,788	N	2
371	Motor Vehicles & Equipment	24,609	R	6
344	Fabricated Structural Metal Products	18,954	R	4
349	Miscellaneous Structural Metal Products	15,849	N	6
335	Non Ferrous Rolling & Drawing	13,978	R	10
281	Industrial Chemicals	9,498	R	6
307	Miscellaneous Plastic Products	9,381	U	7
358	Service Machines	8,651	N	3
339	Miscellaneous	8,056	R	6
345	Screw Machine Products	7,907	N	11
331	Stell Mills	6,125	U	6
329	Miscellaneous Non-Metallic Mineral Products	5,875	N	2
357	Computing Machines	4,420	U	3
285	Paints & Varnishes	1,375	U	2
354	Metal Working Machines	866	R	2

N = National
R = Regional
U = Unclassified
* Two observations required

The general impression derived from tables 9 and 10 is that certain types of Gemini subcontracts are concentrated within what might be called the St. Louis economic region. These subcontracts tend to be of a low value, low technology, high weight and bulk nature. In other words, a geographic pattern is present. The Gemini data supports the hypothesis that certain types of industries possess a locational advantage in the letting of aerospace subcontracts. Furthermore, since the Gemini data also indicate that most high value, high technology inputs are subcontracted for within the five complexes, it seems a safe conjecture to assume that some form of trade-off exists between the locational advantage proposed here and whatever advantage may be derived from subcontracting within the complexes with the crucial determinant of which outweighs the other being the physical nature and value of the input.

It will be recalled that this hypothesis took as given the SRI findings of (1) the existence of five major R&D complexes, (2) the relative importance of these complexes with regard to aerospace subcontracting, and (3) the substitutability of suppliers between complexes. Together, these four proposals result in the foundations of a predictive model of the location of subcontract expenditures. To be operational, all that is required is knowledge of prime contract location. Caution, however, is advised for the Gemini data has provided only a single test of this model. Although the data fit the hypotheses, nothing has been proven conclusively and considerable further testing and refinement are necessary before this model can be established as a reliable theory. While this may prove difficult due to the lack of prime contract sights possessing St. Louis' quasi isolation from aerospace centers, the generality of the

results is implied by a recent study by Peterson and Tiebout whose findings on subcontract location are in agreement with those presented above but based on multi-project, multi-tier data collected in California. /22 In addition, the model must remain sufficiently flexible to allow for the special features of a particular project, and for the possible development of additional R&D, or more specifically, aerospace complexes. On this latter point, for example, the Gemini data suggest the possibility of such a development in Florida.

c) A Possible Qualification

One factor of great importance has been ignored thus far. The locational preferences discussed above are all based on tenets of orthodox location theory. These encouraging results may be qualified, however, by the primary locations of the industries involved in the overall industrial structure of the United States. This is particularly true of the industries designated 'regional' on essentially location theory grounds. The preference for subcontracting in these industries within the St. Louis region may simply be that the major proportion of these industries in existence in the United States is located within five hundred miles of St. Louis. To complete the model, therefore, this factor must be explicitly taken into account.

The strength of this critical point depends heavily on the location of the prime contractor. To determine its significance in the Gemini case,

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/22 R.S. Peterson and C. M. Tiebout, "Measuring the Impact of Regional Defense-Space Expenditures", Review of Economics and Statistics, November, 1964, pp. 426-27.

table 11 has been constructed with the aid of census data. /23 In this table, regionally concentrated Gemini industries are compared with the national industry distribution. Two especially clear cut cases emerge from the data. Column two in table 11 indicates that industry 371, Motor Vehicles and Equipment, is heavily concentrated within the St. Louis region. To the contrary, industry 367, Electronic Components, is represented negligibly by comparison. Both of these industries, however, are strong regionally in the Gemini case. The census data suggest that the Gemini concentration in the former may result from the predominance of the national industry in the same area. In the latter case, national concentration is not in evidence adding support to the power of the locational factors.

Table 11

Gemini Industrial Concentrations Compared To
National Industrial Concentrations

SIC	Description	Regional % Gemini	Regional % Census	National % Census	Census Total
281	Industrial Chemicals	70.4	47.7	44.3	92.0
289	Miscellaneous Chemicals	95.6	45.8	43.3	89.1
327	Concrete, Gypsum, Plaster	100.0			
335	Non-Ferrous Rolling & Drawing	85.0	29.0	43.7	72.7
339	Miscellaneous Primary Metals	92.8	62.3	35.9	98.2
344	Fabricated Structural Metal Products	86.4	46.0	53.2	99.2
354	Metal Working Machinery	88.6	59.0	35.8	94.8
356	General Industrial Equipment	65.0	49.0	49.4	98.4
367	Electronic Components & Parts	79.3	23.6	67.7	91.3
371	Motor Vehicles and Equipment	95.4	75.2	17.3	92.5

/23 United States Census of Manufacturers: 1958, United States Department of Commerce, Bureau of the Census, Washington, D. C., 1958, Vol. III.

Regional concentration of the national industry may also go a long way to explain the Gemini concentration of industries 339, Miscellaneous Primary Metals and 354, Metal Working Machinery, but these cases are not a obvious as 371. The remainder of the industries are only vaguely supported in either direction (or neither direction), and in many cases the census data seem somewhat unreliable (289, 335). The inconclusiveness of the majority of the evidence is not, however, grounds for dismissal of this qualification to the model. Its implications should be weighed carefully for it is capable of destroying the validity of the entire theoretical structure constructed earlier.

V Non-Manufacturing Subcontractors and Local Impacts

Throughout the course of this paper, the Gemini project has been treated more or less as an exogenous disturbance which has had significant impacts on the private sector of the economy. In particular, the Gemini data have permitted study of these impacts from a nationwide viewpoint. This same data, however, also provide extensive information on local impact (i.e. impact in the immediate geographic area surrounding the prime contractor), a subject which along with the actual placement of the prime contract itself is often rife with ulterior political and economic objectives (i.e. economic and industrial development, political prestige). /24

Specifically, the aspects of local impact that will be discussed here are (1) the effects on local firms and industries tied by interindustry sales to the firm or industry initially affected (i.e. McDonnell) and (2) the implications of the Gemini non-manufacturing subcontracts most of which are local in geographic character. No account will be taken of the effect of the prime Gemini contract on McDonnell's internal operations or of any ensuing income effects resulting from changes in activity either at McDonnell or its local subcontractors. /25 These latter two objectives are simply beyond the range of the data developed in this paper.

/24 On public purchasing see R. A. Musgrave, Public Finance, McGraw-Hill Book Co., New York, 1959, chapter 3.

/25 Various categories of local impact are discussed in W. Z. Hirsch, "A General Structure for Regional Economic Analysis," in W. Hochwald ed., Design of Regional Accounts, Johns Hopkins Press, Baltimore, Maryland, 1961, pp. 1-32.

Implicit in this postulated discussion is a rough test of the extent to which a project such as Gemini fosters the development of a supporting aerospace oriented industrial complex in the local area. Given that Gemini was preceded in time by Mercury plus the several large air force contracts awarded McDonnell in recent years (i.e. Voodoo, Phantom), it would seem plausibile to expect a complex of supporting aerospace industries to be emerging in the St. Louis area, and if such were the case, it would seem equally plausibile to expect some of the more technical Gemini subcontracts to be awarded to local firms.

As has already been indicated in sections three and four above, the Gemini impact on manufacturing and service industries has been slight in the home state region (i.e. Missouri and Illinois). If the local area is defined to be the St. Louis Standard Metropolitan Statistical Area (SMSA), an area of approximately 100 miles radius from St. Louis proper, local impact is necessarily even smaller. Quantitatively, Gemini demands on local manufacturing and service industries are approximately three percent of total subcontract expenditure in these industries. That such an amount does not indicate the presence of an aerospace complex seems clear from table 12. This table shows the local share of each industry's Gemini dollars. Except for industry 366, Communication Equipment, the major factors of the Gemini production function are not well represented in the local area (i.e. 361, 372, 382, 359, 364, 365). Instead, it is discovered that not only is the total local expenditure small, but that, in addition, the industries that are well represented locally are (1) of a nature suggested by the hypothesis developed in the preceding section and (2) not those that received major shares of

Table 12

Local Gemini Subcontract Expenditures

SIC	Description	Local Expenditure %
19	Ordnance and Accessories	----
229	Miscellaneous Textile Goods	----
281	Industrial Chemicals	70.3
282	Fibers, Plastics and Rubbers	----
283	Drugs, Medicinal Chemicals	----
285	Paints and Varnishes	----
289	Miscellaneous Chemcials	.3
306	Fabricated Rubber Products	----
307	Miscellaneous Plastic Products	13.6
322	Glass and Glassware	----
323	Glass Products (made of Purchased Glass)	----
327	Concrete, Gypsum Plaster	----
329	Miscellaneous Non-Metallic Minerals	----
331	Steel Mills	48.1
335	Non-ferrous Rolling and Drawing	7.9
339	Miscellaneous Primary Metals	7.7
342	Hand Tools, Hardware	----
344	Fabricated Structual Metal Products	----
345	Screw Machine Products	----
346	Metal Stampings	----
348	Fabricated Wire Products	----
349	Miscellaneous Fabricated Metal Products	----
354	Metal Working Machinery	----
356	General Industrial Equipment	.4
357	Computing Machines	----
359	Miscellaneous Machinery, Machine Shops	.1
361	Electrical Transmission & Distribution Equipment	2.7
362	Electrical Industrial Apparatus	.2
364	Lighting & Wiring Equipment	----
365	Radio & T.V. Receiving Sets	----
366	Communication Equipment	33.0
367	Electronic Components & Accessories	.2
369	Miscellaneous Electric Machinery & Supplies	----
371	Motor Vehicles & Equipment	----
372	Aircraft & Parts	1.6
381	Scientific & Laboratory Equipment	----
382	Measuring & Indicating Instruments	*
383	Optical Equipment & Lens	----
386	Photographic Equipment and Supplies	----
739	Business Services (R&D)	----
891	Engineering & Architectural Services	----

* Less than one-twentieth of one percent.

Gemini expenditure (i.e. they are minor elements in the Gemini production function). In particular, observe the local subcontract expenditure in industries 281, Industrial Chemicals and 331, 335, 339, Primary Metals.

In other words, the subcontracting interindustry ties of Gemini do not indicate the existence of a supporting aerospace complex in St. Louis. Furthermore, the observed lack of local specialized aerospace subcontracts, in spite of what seems ample incentive over recent years, seems to indicate that the prospects for future complex development are not bright. /26 The local industries affected significantly by Gemini are not in general the highly technical type but basic industries found in any major diversified industrial complex in the United States. To date, there is no clear conception of what constitutes the minimum stimulus necessary to spawn a new aerospace complex. Careful watch over future developments in the Florida and Houston area, however, may result in a major breakthrough in this regard.

Non-manufacturing subcontracts further color the local impact picture. These subcontracts are of two types. Either they represent McDonnell payments (1) to independent wholesale firms or (2) to local sales' offices, manufactures' representatives etc. of non-St. Louis firms. In table 13, the former group has code number 500 and the latter 600. Except for a single case, all such payments were local. /27

Ignoring the Florida case, code five hundred non-manufacturing subcontracts are legitimate local non-manufacturing firms. The six hundred group, however,

/26 Recall that income effects are not being considered. These may well be the most significant local effect of Gemini. Subcontracting data, however provides direct information only on interindustry effects. The relative importance of these effects can not be ascertained with soley this information.

/27 The Florida case was a wholesale firm not a sale's office, manufacture's representative, etc.

are not firms at all but merely St. Louis' offices of non-local firms processing local orders. The similarity between these two groups lies in the fact that they are both receiving payments from McDonnell for goods and services produced elsewhere. These subcontracts have not been classified with the others, not because the industry could not be identified as with unallocated 999 subcontracts, but because the place of actual manufacture could not be ascertained beyond the fact that it was not in St. Louis.

Note in table 13 that the distribution of non-manufacturing subcontracts generally follows closely the manufacturing and service distribution studied in section 3. It is concentrated in the highly technical industries. If these non-manufacturing subcontracts are misinterpreted and expenditures to such firms and quasi firms added to local (i.e. St. Louis SMSA) manufacturing and service subcontract expenditure, a striking but incorrect impression of local Gemini effects is attained. In fact, local expenditure approaches a figure close to 20%. /28 Given the industries affected, committing such an error results in quite a different conclusion with regard to aerospace complex development. In fact, it would seem legitimate to conclude that to some extent one exists or is developing in St. Louis. It has already been shown, however, that such is not the case. While it may be acceptable to count local wholesale firms in local impact, this is certainly not the case with sales' offices and manufactures' representatives, and this latter group dominate table 13. The implication is obvious. Major subcontracting firms in major

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/28 The similarity of this figure with the SRI home state prediction discussed earlier should be ignored. Although such an error as indicated would result in agreement between Gemini data and SRI, this error was not present in the SRI work.

Table 13a

Non-Manufacturing
Gemini Expenditure in Dollars

Code	Description	Missouri	Florida	Total
506	Electrical Goods	115,563	--------	115,563
508	Machinery, Instruments, Equipment and Supplies	42,041	30,640	72,681
509	Miscellaneous	11,503	--------	11,503
5091	Metals and Minerals (except petroleum products & scrap)	20,715	--------	20,715
5096	Paper and Paper Products	10,504	--------	10,504
601	Motor Vehicles and Automotive Equipment	35,907	--------	35,907
602	Chemicals and Allied Products	247,037	--------	247,037
606	Electrical Goods	12,959,265	--------	12,959,265
607	Hardware, Heating Equipment, and etc.	3,313	--------	3,313
608	Machinery, Instruments, Equipment and Supplies	64,776	--------	64,776
6091	Metals and Minerals (except petroleum products)	67,077	--------	67,077
6096	Paper and Paper Products	10,504	--------	10,504
6098	Construction Materials	1,774,340	--------	1,774,340
TOTALS		15,374,755	30,640	15,405,395

Table 13b

Non-Manufacturing
Gemini Expenditure in Percentages

Code	Description	Missouri	Florida	Total
506	Electrical Goods	.750	-------	.750
508	Machinery, Instruments, Equipment and Supplies	.273	.228	.471
509	Miscellaneous	.074	-------	.074
5091	Metals and Minerals (except petroleum products & scrap)	.134	-------	.134
5096	Paper and Paper Products	.068	-------	.068
601	Motor Vehicles and Automotive Equipment	.233	-------	.233
602	Chemicals and Allied Products	1.604	-------	1.604
606	Electrical Goods	84.122	--------	84.122
607	Hardware, Heating Equipment, and etc.	.022	-------	.022
608	Machinery, Instruments, Equipment and Supplies	.420	-------	.420
6091	Metals and Minerals (except petroleum products)	.435	-------	.435
6096	Paper and Paper Products	.147	-------	.147
6098	Construction Materials	11.518	-------	11.518
TOTALS		99.772	.228	100.0

subcontracting industries have seen fit to open business offices to expedite operations but not to extend actual production facilities to the St. Louis area. Sales' offices and manufactures' representatives certainly do not indicate development of a supporting aerospace complex in the local Gemini area.

VI Summary and Conclusions

The major objectives of this paper were (1) to describe the subcontracting expenditures of the Gemini project both industrially and geographically and enumerate the implication derived from the data and (2) develop and test a hypothesis of subcontract location. Both of these objectives have been substantially attained. Both supply important information that can be applied to future projects such as Gemini, and prerequisite data needed to properly predict employment and income effects. Major conclusions may be summarized as follows:

(1) Gemini subcontracts are concentrated in a small number of industries of which electronics, instruments, and aircraft predominate.

(2) Subcontracts are also highly concentrated geographically with California and Florida predominating and the home states of Missouri and Illinois being somewhat insignificant.

(3) There are grounds for belief that locational factors could be the basis for a predicative model of geographic interindustry impact for aerospace projects similar to Gemini. In particular, the opportunity costs of subcontracting outside the region most economically connected with the prime contractor seem prohibitive with regard to low technology, low value, high weight, and bulk subcontracts.

(4) The local Gemini interindustry effects have been small contributing to the belief that development of an aerospace complex in the St. Louis area is neither taking place now nor is iminent in the near future. Much additional work is necessary if the threshold of aerospace complex development is to be determined.

APPENDIX A

Geographic Distribution of Individual Industry Expenditure

	19	229	281	282	283	285	289	306	307	322
Alabama										
Arizona										
California	100.0						2.52	100.0	41.84	
Colorado										
Connecticut						46.64				
Delaware							.11			
Florida			5.05							
Illinois			65.72				12.69			
Indiana							.24			
Iowa										
Kansas									8.92	
Louisiana							1.63			
Maryland		100.0		100.0						
Massachusetts										
Michigan										
Minnesota									32.81	
Missouri			4.60				81.52		13.56	
New Hampshire										
New Jersey			24.56							
New York									2.88	100.0
North Carolina										
Pennsylvania					100.0					
Ohio							1.30			
Ontario										
Oregon										
Rhode Island										
Texas			.06			53.36				
Washington										
Georgia										
Oklahoma										

APPENDIX A

(continued)

Geographic Distribution of Individual Industry Expenditure

	323	327	329	331	335	339	342	344	345	346
Alabama										
Arizona										
California				46.97	11.29	6.93	.288	3.72	53.64	100.0
Colorado										
Connecticut				4.95				7.97		
Delaware										
Florida										
Illinois					68.11	4.41		86.36	11.04	
Indiana										
Iowa										
Kansas		100.0							3.60	
Louisiana										
Maryland										
Massachusetts										
Michigan						80.72				
Minnesota										
Missouri				48.08	7.85	7.67				
New Hampshire										
New Jersey										
New York					.83					
North Carolina								1.95		
Pennsylvania	100.0		87.77			.26	97.12		29.58	
Ohio			12.23		9.05				1.94	
Ontario										
Oregon					2.88					
Rhode Island										
Texas										
Washington										
Georgia										
Oklahoma										

APPENDIX A

(continued)

Geographic Distribution of Individual Industry Expenditure

	348	349	354	356	357	358	359	361	362	364
Alabama										
Arizona										
California	95.59	59.59		9.76	22.71		98.62	.15	26.44	.56
Colorado										
Connecticut										
Delaware										
Florida								94.92		
Illinois								.60		
Indiana										
Iowa										
Kansas								.02		
Louisiana										
Maryland										98.44
Massachusetts										
Michigan				64.63	58.66	22.50				
Minnesota										
Missouri				.38			.05	2.49	5.17	.18
New Hampshire										
New Jersey		1.94		4.96		38.61		.47	16.94	
New York		38.47		10.79	18.62	38.89		1.30	43.71	
North Carolina										
Pennsylvania	4.41		11.45							.82
Ohio			88.55				.04		7.73	
Ontario										
Oregon										
Rhode Island										
Texas							1.29	.04		
Washington				9.15						
Georgia										
Oklahoma										

APPENDIX A

(continued)

Geographic Distribution of Individual Industry Expenditure

	365	366	367	369	371	372	381	382	383	386
Alabama						.40				
Arizona						2.68				
California	95.09	4.97	9.72	100.0		84.14	.70	24.64		100.0
Colorado						.12				
Connecticut			.14			3.44		.27		
Delaware										
Florida								52.22		
Illinois	1.33		.62				.84			
Indiana	.52		.71							
Iowa			34.29			1.16				
Kansas										
Louisiana										
Maryland		.20					36.28	.06		
Massachusetts			.58					.40		
Michigan	.63		43.67		5.15	1.88				
Minnesota		14.26						22.06		
Missouri		33.01				1.64		.01		
New Hampshire										
New Jersey	2.13	47.54	2.47			.74	62.18	.05		
New York	.30		7.09		2.07	1.03		.01		
North Carolina										
Pennsylvania			.65		.26	.10		.28	100.0	
Ohio						1.17				
Ontario						1.50				
Oregon										
Rhode Island					2.23					
Texas			.07		90.29					
Washington										
Georgia										
Oklahoma										

APPENDIX A

(continued)

Geographic Distribution of Individual Industry Expenditure

	739	891	999
Alabama			
Arizona			
California			33.84
Colorado			
Connecticut			
Delaware			
Florida			
Illinois			9.43
Indiana			
Iowa			.46
Kansas			
Louisiana			
Maryland			3.06
Massachusetts	100.0	100.0	
Michigan			
Minnesota			
Missouri			26.28
New Hampshire			
New Jersey			.87
New York			5.17
North Carolina			
Pennsylvania			
Ohio			1.58
Ontario			
Oregon			
Rhode Island			
Texas			.06
Washington			
Georgia			.27
Oklahoma			22.58

APPENDIX B

Percentage of
Gemini Subcontracts Located Within
The St. Louis Economic Region

SIC	Description	Located Within 500 Miles of St. Louis	Located Outside St. Louis Region
19	Ordnance and Accessories	----	100.0
229	Miscellaneous Textile Goods	----	100.0
281	Industrial Chemicals	70.4	29.6
282	Fibers, Plastics and Rubbers	----	100.0
283	Drugs, Medicinal Chemicals	----	100.0
285	Paints and Varnishes	53.36	46.64
289	Miscellaneous Chemicals	95.6	4.3
306	Fabricated Rubber Products	----	100.0
307	Miscellaneous Plastic Products	55.2	44.72
322	Glass and Glassware	----	100.0
323	Glass Products (made of Purchased Glass)	----	100.0
327	Concrete, Gypsum, Plaster	100.0	----
329	Miscellaneous Non-Metallic Minerals	12.2	87.8
331	Steel Mills	48.1	51.9
335	Nonferrous Rolling and Drawing	85.0	15.0
339	Miscellaneous Primary Metals	92.8	7.2
342	Hand Tools, Hardware	----	100.0
344	Fabricated Structual Metal Products	86.4	13.6
345	Screw Machine Products	16.6	83.2
346	Metal Stampings	----	100.0
348	Fabricated Wire Products	----	100.0
349	Miscellaneous Fabricated Metal Products	----	100.0
354	Metal Working Machinery	88.6	11.5
356	General Industrial Equipment	65.0	34.7
357	Computing Machines	58.7	41.3
358	Service Machinery	22.5	77.6
359	Miscellaneous Machinery, Machine Shops	1.4	98.6
361	Electrical Transmission & Distribution Equipment	3.3	96.8
362	Electrical Industrial Apparatus	12.9	87.1
364	Lighting & Wiring Equipment	.2	99.8
365	Radio & T.V. Receiving Sets	2.5	97.5
366	Communication Equipment	47.3	52.7
367	Electronic Components & Accessories	79.3	20.7
369	Miscellaneous Electric Machinery & Supplies	----	100.0
371	Motor Vehicles & Equipment	95.4	4.6
372	Aircraft & Parts	6.2	93.8
381	Scientific & Laboratory Equipment	.8	99.2
382	Measuring & Indicating Instruments	22.1	77.9
383	Optical Equipment & Lens	----	100.0
386	Photographic Equipment & Supplies	----	100.0
739	Business Services (R&D)	----	100.0
891	Engineering & Architectural Services	----	100.0
999	Unallocated Manufacturing & Service Subcontracts	60.5	39.6

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