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Author(s): Scott E. Masten
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THE ORGANIZATION OF PRODUCTION: EVIDENCE FROM THE AEROSPACE INDUSTRY*

SCOTT E. MASTEN
University of Michigan

THE interface between successive stages of production is frequently governed by contractual agreements, and the efficiency of such arrangements has been the subject of considerable attention in the economic literature. But production is organized administratively within firms as well as contractually between them, and given the practical limitations of bureaucratic organization, the relevant question can be seen to be not merely whether contractual deficiencies exist but how severe such deficiencies may be relative to the alternative costs of organizing production internally. The important issue from an institutional choice perspective thus becomes how the particular details of a transaction affect the *differential* efficiency of alternative organizational forms.

Recent theoretical work has sought to identify such relationships.[1] In particular, the choice between internal and external organization and, in the event of the latter, the choice of contract terms have been related to several critical parameters of the transaction. This paper presents some

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[1] See, in particular, Benjamin Klein, Robert G. Crawford, & Armen A. Alchian, Vertical Integration, Appropriable Rents, and the Competitive Contracting Process, 21 J. Law & Econ. 297 (1978); and Oliver E. Williamson, Transaction-Cost Economics: The Governance of Contractual Relations, 22 J. Law & Econ. 233 (1979). A formal model treating the make-or-buy decision as part of a producer's overall optimization problem may be found in Scott E. Masten, Transaction Costs, Institutional Choice and the Theory of the Firm (1982) (unpublished Ph.D. dissertation, Univ. Pennsylvania); *id.*, Institutional Choice and the Organization of Production: the Make-or-Buy Decision (January 1984) (unpublished manuscript Univ. Virginia, Dept. Economics).

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evidence of the practical import of those relationships, based on a study of input procurement practices in the aerospace industry.

The administration of procurement in this industry is two tiered. On the first level, the government chooses a prime contractor who is assigned overall responsibility for a particular program; and on the second, the contractor manages the production of the system itself, including what is of particular interest here—the administration of subcontracts. This paper considers procurement practices at both levels. To begin, the essential elements of the theory will be briefly reviewed in Section I. Section II then presents the results of an examination of input procurement for an aerospace system containing nearly two thousand component specifications. Tests are based on a probit model of the dichotomous choice between internal and external procurement of supplies. The estimated coefficients provide indirect measures of the relative costs of internal and external procurement with respect to several qualitative variables. Following this, the procurement policies of the federal government are reviewed and interpreted in light of the theory, with particular emphasis on the form of the relationship between the government and the prime contractor. Conclusion and additional comments appear in the final section.

I. The Make-or-Buy Decision

Having selected an end-product line, a producer must decide which in the stream of intermediate products and processes successively combining to form his eventual output he will administer within the organization and which he will delegate to outside suppliers, along with the terms under which any external procurements would take place. In practice, this series of procurement decisions—sometimes referred to as a producer's make-or-buy program—involves a large number of considerations including design requirements; inventory needs; quality control; production, overhead, and transportation costs; and the capabilities, capacities, and negotiating strength of potential suppliers relative to those of the producer himself.[2]

Transaction cost economics has sought to place these concerns within an economic context and relate the outcome of individual make-or-buy decisions to details of the transaction. According to that view, the choice among alternative organizational arrangements is part of an agent's over-

[2] These concerns and many others are evident in E. Raymond Corey, Procurement Management: Strategy, Organization, and Decision-Making (1978), and were also present in internal memoranda and discussions with company representatives.

all optimization problem, and the net value of a transaction organized in a particular manner depends not only on the losses due to potential misallocations of resources but also on the costs of conducting the transaction itself. Hence, a manager choosing a procurement mode will consider, in addition to the value of the goods and services actually procured, both the opportunity costs of the additional demands that would be placed on his time and attention by internalizing a transaction and the various "organizational" expenses that would be involved in dealing with outside suppliers. The latter include the costs of negotiating the terms under which exchange is to take place and, oftentimes, the various expenses associated with adopting and upholding formal contractual agreements.

In general, the organizational costs associated with market exchange increase, the more specialized, profitable, and durable are the investments associated with a given transaction. Idiosyncratic assets, because of their specialized and durable nature, imply that parties to a transaction face only imperfect exchange alternatives for an extended period. The more specialized those assets, the larger will be the quasi-rents at stake over that period and hence the greater the incentive for agents to attempt to influence the terms of trade through bargaining or other rent-seeking activities once the investments are in place.

The role of contracts is to prevent such activities from dissipating too large a portion of the gains from trade by stipulating acceptable behavior at the outset of a transaction-specific relationship. But contracts incur expenses in both specification and enforcement that limit their usefulness. First, because contingent performance is costly to stipulate and even more difficult for courts to administer, contracts typically contain few provisions and, as a result, tend to be inflexible mechanisms for governing exchange. The greater the complexity of the transaction and the level of uncertainty associated with it, the greater the likelihood of being bound to an inappropriate action, and hence the greater the implicit costs of contractual organization. This inflexibility, in turn, tends to constrict the time span of contractual agreements. Because confidence that any given state of the world will obtain decreases the more distant the relevant horizon, committing yourself to a particular activity becomes less desirable the more remote the specified date of performance. A trade-off therefore exists between the opportunity costs of being bound to an inflexible agreement and the hazards of negotiating follow-on procurements in a condition of bilateral monopoly. In sum, the more idiosyncratic are the investments associated with a particular transaction, the greater are the incentives to incur the costs of writing more detailed and longer term contracts. Greater uncertainty or complexity of a transaction, however,

implies, on the one hand, an incentive to write more detailed agreements and, on the other, a disincentive to commit to long term contractual relationships.[3]

Greater complexity would also, of course, put additional strain on decision makers under internal organization, which is intended to eliminate rent seeking by internalizing the quasi-rents that are the object of that behavior.[4] But the possibility of rendering decisions in an adaptive, sequential fashion under internal organization reduces the need relative to contracting of exploring and enumerating the full contingency tree ex ante.[5] Nevertheless, the expediency of internalizing successive transactions is limited by the bureaucratic inefficiencies that inevitably develop as organizations get large.

II. Input Procurement in the Aerospace Industry

There is an abundance of supportive, if informal, evidence illustrating the relationships discussed above. A recent article on the semiconductor industry, for example, revealed the existence of a correlation between design specificity and the internal procurement of supplies in the production of electronic components: "Most major chip buyers, after trying but failing to get the big producers to serve their needs for low volumes of custom circuits, have launched chip-production lines of their own and today turn out almost all of the custom chips made as well as two-thirds of such semi-custom products as gate arrays."[6]

In addition, the article contended that the reason that downstream producers found it necessary to develop in-house production capabilities for these products, despite the expertise of the established chip manufacturers and "the high cost of maintaining internal production," was to avoid the "frictions between vendors and customers" encountered in a market where specialized designs are highly profitable and increasingly complex.[7]

Although accounts of this type can be illuminating, they lack the au-

[3] The trade-offs involved here are discussed at greater length in Masten, Transaction Costs, Institutional Choice and the Theory of the Firm, *supra* note 1.

[4] In the case of specialized human capital, quasi-rents cannot be eliminated by internalization in the same way that they can with physical capital. Rather, hierarchical organization seeks to substitute internal for third-party adjudication of conflicting interests. Thus, from this perspective, the firm becomes a quasi-judicial body entrusted by its members to resolve disputes and enforce cooperative behavior.

[5] Oliver E. Williamson, Markets and Hierarchies: Analysis and Antitrust Implications 25 (1975).

[6] The 80's Look in Chips: Custom, Not Standard, Business Week, January 18, 1982, at 36H.

[7] *Id.* at 36D-L.

thority often accorded formal tests of hypotheses. Unfortunately, the level of detail at which the theory operates has made rigorous applications difficult. One way in which the information requirements can be moderated, however, is to restrict attention to a single industry. This reduces the need for absolute measures for such variables as design specificity and complexity and permits qualitative tests based on ordinal rankings of inputs by their characteristics. Recently, this strategy has been employed by Kirk Monteverde and David Teece to analyze vertical integration in the automobile industry and by Thomas Palay in a study of railroads.[8] The present paper examines related issues in the context of defense-related production, an area in which specialized designs are common and the alternative values of investments often limited.

The model I wish to test is the following: Let G_i be the institution chosen by the producer to govern the acquisition of product or process i, and let G_i^* represent internal organization of that activity and $\tilde{G}_i$ external or "market" procurement. Then the outcome of the producer's make-or-buy decision can be summarized as

$$G_i = G_i^* \quad \text{if } L_i^*(\omega_i) < \tilde{L}(\lambda_i, \omega_i),$$

and

$$G_i = \tilde{G}_i \quad \text{if } L_i^*(\omega_i) \geq \tilde{L}(\lambda_i, \omega_i),$$

where L_i^* is the cost of maintaining production internally and $\tilde{L}_i$ is the cost of market-mediated exchange, depicted as a function of the specificity (λ) and complexity (ω) of the transaction.

The aerospace system studied contained 1,887 component specifications, each of which was identified as either a "make" or "buy" item by a team of company representatives made up of the managers of the material systems and manufacturing engineering departments and members of their staffs. The disposition of the entire make-or-buy program is summarized by generic category in Table 1.

The procurement team was asked to complete questionnaires designed to elicit information about the attributes of the items and associated investments. Each of the items within several of the cells in Table 1 shared similar characteristics, permitting completion of a single questionnaire for the entire cell. The remaining cells were randomly sampled in approximate proportion to the ratio between the size of the cell and the total

[8] Kirk Monteverde & David J. Teece, Supplier Switching Costs and Vertical Integration in the Automobile Industry, 13 Bell J. Econ. 206 (1982); Thomas Palay, Comparative Institutional Economics: The Governance of Rail-Freight Contracting, 13 J. Legal Stud. 265 (1984).

TABLE 1
THE MAKE-OR-BUY PROGRAM

Category	Quantity	Make	Buy
Top and major subassemblies	17	17	...
Components assembly	185	114	71
Structure machining	11	5	6
Structure forgings	8	...	8
Mechanical detail parts	138	53	85
Connectors	180	...	180
Printed wire board assembly	80	80	...
Flexible/hard printed wire boards	151	147	4
Electrical piece parts	971	11	960
Heat shields	4	...	4
Insulating materials	62	10	52
Harness/coax	80	80	...

number of components in the system. The result was thirty-four individual observations, which can be statistically weighted to reflect their actual distribution in the program.[9]

From this information, two measures of specificity were developed. The first, corresponding to design specificity, was based on whether an item was identified as used exclusively by this company (highly specialized), used or easily adaptable for use by other aerospace firms (somewhat specialized), or used in other industries (relatively standard). "Electrical piece parts" such as transistors and resistors, for example, would be standard items, while hybrid circuits designed to individual specifications would be considered highly specialized.[10]

A second variable was created to reflect site specificity based on whether colocation or grouping of facilities or processes was considered to be an important factor in production. Various economies may arise from positioning successive operations side by side. But if associated assets are costly to reposition, their alternative use value may be low. Such was the case in this system with the computerized lathes and other machinery used to bore and mill nose cones. The machinery itself has a

[9] Since the data for this study were generated from a choice based sample, weighted exogenous sampling maximum likelihood estimation was employed. For a discussion of the properties of these estimators see Charles F. Manski & Steven R. Lerman, Estimation of Choice Probabilities from Choice Based Samples, 45 Econometrica 1977 (1977).

[10] Although *asset* design would be preferable to *input* design as a measure of specificity, it is difficult, even at this level of disaggregation, to separate the specialized from standard assets used in the manufacture of a given input. The fact that specialized inputs may at times be produced using standardized assets, however, merely implies that input design measures will have lower *t*-statistics than would asset design; hence, information on the latter would only improve the explanatory power of the model. See *infra*.

number of uses. However, because of transfer and control costs between operations, the configuration and geographical location of the equipment is important. Meanwhile, installation and removal costs make relocation impractical. Consequently, once the assets have been positioned, they are more or less committed to a particular use.

Since this study focused on a single system, it was not possible to test the effects of demand uncertainty on the internalization decision using these data alone. Complexity, however, may be used as a proxy for the degree of uncertainty on the production side; the more complex a component, the more details to be accounted for and the more dimensions in which something can go wrong. To determine the relative complexity of the components, a ranking system used internally by the company was adopted. In that three-way classification scheme, "A-items" were the most and "C-items" the least complex.

For estimation purposes, the following specification of the model was employed:

$$L_i^* = \bar{B} + b \cdot \omega_i + u_i,$$

and

$$\tilde{L}_i = a \cdot \lambda_i + c \cdot \omega_i + v_i,$$

where u_i and v_i are random errors assumed to have independent normal distributions, and a, b, and c are coefficients. $\bar{B}$ represents the "administrative burden" of internalizing a transaction and would be expected to be positive. Since complexity increases the costs associated with organizing production both administratively within firms and contractually between them, both b and c should be positive. But because flexibility in contracting demands prior anticipation of potential problems while internal organization permits adaptation to changing circumstances in a sequential fashion, the differential effect of complexity on the costs of alternative organizational arrangements favors internal organization over contractual exchange.[11] Hence, we would expect $c - b > 0$. Finally, the coefficient on item specificity, a, is also expected to be positive reflecting the greater potential for opportunistic behavior in idiosyncratic transactions.

Since L^* and $\tilde{L}$ are not actually observed, the estimation is based on the disposition of the dichotomous make-or-buy choice. The probability that input j will be produced inside the firm is

$$\begin{aligned} \text{pr}(L_j^* < \tilde{L}_j) &= \text{pr}(u_j - v_j < a\lambda_j + (c - b)\omega_j - \bar{B}) \\ &= F(a\lambda_j + (c - b)\omega_j - \bar{B}), \end{aligned}$$

[11] See Williamson, *supra* note 5.

TABLE 2
ESTIMATED COEFFICIENTS FOR THE MAKE-OR-BUY DECISION

Variable	Coefficient	t-Ratio	Mean of Variable
CONSTANT	−3.8657	−6.8064	1.00000
COMPLEX	1.8865	5.4444	.84208
SPECI	3.3696	6.5486	.34605
STANDARD	−2.7775	−.1724	.50874
COLOC	5.1120	.1269	.09433
χ^2: 32.0788, 4 *df**			
Pseudo R^2: .610734†			
Proportion of observations for which $y = 1$: .2729.			

*Indicates that the equation is significant beyond the .001 level.
†This measure is analogous to standard R^2s. Its properties are discussed in Takeshi Amemiya, Qualitative Response Models: A Survey, 19 J. Econ. Literature 1483 (1981).

where $F(\cdot)$ is the normal distribution. The likelihood function of the model is

$$\Lambda = \prod_{i=1}^{n} F(a\lambda_i + (c - b)\omega_i - \bar{B})^{y_i} [1 - F(a\lambda_i + (c - b)\omega_i - \bar{B})]^{(1 - y_i)},$$

where $y_i = 1$ if item i is produced internally and zero if acquired outside the firm. The actual explanatory variables used in the estimations were

$\text{COMPLEX}_i = 1$ if the item is rated as complex (A- and B-items),[12]
$= 0$ otherwise (C-items);
$\text{SPECI}_i = 1$ if the item is highly specialized,
$= 0$ otherwise;
$\text{STANDARD}_i = 1$ if the item is relatively standard,
$= 0$ otherwise;[13]
$\text{COLOC}_i = 1$ if colocation of assets or processes is considered important,
$= 0$ otherwise.

Maximum likelihood estimates for the weighted observations and corresponding statistics are presented in Table 2. The column on the far

[12] No significant difference was found in the coefficients on A- and B-items in any of the various specifications of the model experimented with.

[13] The variables SPECI_i and STANDARD_i were derived from the same ordinally measured construct; see text at note 10 *supra*. "Somewhat specialized" items are the omitted category.

COMPLEX \ SPECI	0	1
0	< .01	.31
1	.02	.92

FIGURE 1

right-hand side of the table, "mean of variable," indicates the proportion of inputs possessing that characteristic.

The coefficients on both COMPLEX and SPECI are highly significant and positive as expected, indicating that the probability of internalization is higher for complex and highly specialized inputs. But although the coefficients for COLOC and STANDARD have the expected signs, statistical confidence in these estimates is low.[14]

Note also that the constant term in this equation has a large effect on the probability of internalization. This coefficient reflects the predisposition of management toward external procurement and, given the specification of the model, can be interpreted as an indirect measure of the administrative burden incurred by internalizing an additional transaction. Each of the remaining coefficients provides an estimate of the implicit costs of contracting *relative* to this burden for transactions possessing the corresponding characteristic.

The matrix in Figure 1 presents the estimated probabilities that components possessing the corresponding characteristics will be produced internally.[15] As is apparent from these estimates, the degree of specialization is by far the most important determinant of organizational form in this system. The lack of alternative uses for a component increases the probability that it will be procured internally from less than 1 percent to 31 percent for relatively uncomplex items and from 2 percent to 92 percent for more complex components. Since the omitted category includes those inputs

[14] The insignificant coefficient on STANDARD implies that there is no significant difference between the effects of "standard" items and the omitted category, "somewhat specialized" items, on the internalization decision. In other words, "standard" items are at least as likely to be procured externally as are "somewhat specialized" components.

[15] Specifically, the probability that component i will be procured internally is $F(-3.8657 + 1.8865\text{COMPLEX}_i + 3.3696\text{SPECI}_i)$ where F is the cumulative normal distribution.

used only in other aerospace applications, these estimates suggest that the existence of alternative uses for a component, even in a fairly highly concentrated industry such as this, warrants reliance on external procurement.

The complexity of an item also increases the probability that it will be "sourced in-house." Moreover, as expected, the hazards of incomplete contracts in complex environments appear to be much greater when specialized designs are involved, increasing the likelihood of internalization from 31 percent to 92 percent (as compared with less than 1 percent to only about 2 percent for items which are only "somewhat specialized"). Thus, as predicted by the theory, the need to employ specialized designs appears to be a necessary condition for the breakdown of market-mediated exchange and the subsequent internalization of production, especially where fairly complex products are involved.

Additional detail missed in the surveys but obtainable case by case further supports the hypothesized relationships. For instance, the system design called for both rigid and flexible printed wire boards. Although both types involved specialized designs, the flexible boards could be produced using standard equipment and were procured externally. The hard boards, on the other hand, were unique items that could not be produced using existing facilities. Not having an expertise in this area, the company sought to establish outside sources but found that manufacturers were "unwilling" to take on the business. The fact that the company was obliged to develop its own production capability suggests that the "organizational savings" from sourcing outside the company were not adequate to compensate potential suppliers for the hazards to which they would be exposed by incurring such specialized costs. However, the components that, although specially designed, could be produced with standard assets were not subject to those hazards. Such evidence supports the contention that asset design is a more powerful predictor of organization form than is input design.

The survey also indicated other factors of concern to procurement managers in deciding whether to internalize production. Among the more important were the existence of preexisting production capability or capacity and the perception of a need for "control" over the production process. But each of these concerns is itself explained in large part by the degree of complexity and specificity of the item: the company was more likely to have previously developed a capability or capacity for the production of more specialized and complex components, and the perception of a need for control arose primarily in those cases in which the market or the courts were least likely to regulate transactions effectively, again when production was highly specialized and complex.

III. Government Procurement Policies

Although data sufficiently detailed to permit evaluation of all the hypotheses of the transaction-cost paradigm are not yet available, it is possible at least to compare the concerns identified in these theories with the procedures adopted by procurement managers. This section selectively examines several of the federal government's procurement policies to see how well they conform to the theory presented in Section I.

A. Make-or-Buy Policies

Although in defense-related production the basic responsibility for procurement decisions, as with all management functions, remains with the firm, the government reserves the right to review a prospective contractor's make-or-buy program.[16] Of particular interest from the standpoint of the present analysis is that proposed make-or-buy programs need only be submitted for review "where the work is complex, the dollar value substantial, and there is not adequate price competition."[17] More specifically, information on a prospective contractor's make-or-buy program is *not* required by the government:

i) when a proposed contract has total estimated value of less than $1,000,000 . . . ;
ii) in research and development contracts, unless the contract is for prototypes or hardware and it can reasonably be anticipated that significant follow-up quantitites of the product will be procured;
iii) when the contracting officer determines that the price is based on adequate price competition, or established catalog or market prices of commercial items sold in substantial quantities to the general public . . . ; or
iv) when the contracting officer determines that the work is not complex.[18]

What is notable about this passage is that each of the stipulations contained in it has a direct correlate in transaction-cost theory: special attention or precautions are unnecessary for transactions which (i) are low in value, (ii) are not likely to generate first-mover advantages in follow-on production, (iii) are accompanied by price competition or involve standard products, or (iv) are not complex. If the value of the contract is

[16] The government defines a contractor's make-or-buy program as "that part of a contractor's written plan which identifies the major subsystems, assemblies, subassemblies, and components to be manufactured, developed, or assembled in his own facilities, and those which will be obtained elsewhere by subcontract." Defense Acquisition Regulations, Gov't Cont. Rep. (CCH) ¶ 32,888. The objective of such reviews is to assure that the contractor has applied "sound business and technical judgement" and that his decisions will not "adversely affect the government's interests," *id.* ¶ 32,888.15.

[17] *Id.* ¶ 32,887.

[18] *Id.* ¶ 32,888.

small, the potential losses to an inappropriate make-or-buy program will also be small and therefore will not generally justify the cost of review. Where large amounts are at stake, however, an improper make-or-buy decision can have more serious consequences. Review is also desirable where research and development activities will bestow extended advantages on the agent; a contractor's decision to subcontract some part of this work to another firm may leave both the prime contractor and the government open to extortion in subsequent dealings. In contrast, items which are generally available pose relatively few such hazards. Finally, when work is not complex, an agent has fewer opportunities to deceive the government about his costs and is therefore less likely to be successful in obtaining unwarranted price adjustments.

B. Procurement Hazards and Remedies

The government's policies for administering its own acquisitions further reveal its awareness of the potential for opportunistic behavior on the part of contractors and of the conditions under which such behavior is most likely to emerge. "Buying in" is one manifestation explicitly recognized as a potential hazard. " 'Buying in' refers to the practice of attempting to obtain a contract award by knowingly offering a price or cost estimate less than anticipated costs with the expectation of either (i) increasing contract price or estimated cost during the period of performance through change orders or other means, or (ii) receiving future 'follow-on' contracts at prices high enough to recover any losses on the original 'buy-in' contract."[19]

Contracting officers are advised to be particularly alert to this possibility when performance of the contract involves substantial "preproduction engineering, special tooling, special plant rearrangement, training programs and such nonrecurring costs as initial rework, initial spoilage, and pilot runs,"[20] all of which represent specialized investments in the transaction. Where such investments are at stake, the government provides several policy options directed at preventing the incidence of buying in at the outset of the relationship.

1. *Acquisition of Special Tooling.* One option, applicable at least in cases where first-mover advantages are embedded in specialized physical capital, is for the government to take title to specialized assets.[21] Oppor-

[19] *Id.* ¶ 32,069.

[20] *Id.* ¶ 32,866.

[21] This alternative is referred to as quasi-vertical integration by Kirk Monteverde & David J. Teece, Appropriable Rents and Quasi-Vertical Integration, 25 J. Law & Econ. 321 (1982).

tunism by the original contractor can then be countered by transferring the assets to more cooperative suppliers. The government's policies covering the acquisition of special tooling and special test equipment address this alternative in detail, clearly indicating a sensitivity to the trade-offs between the hazards of leaving title to specialized tooling with contractors and the costs of internal administration.

Policy. It is the policy of the Department of Defense that contractors provide and retain title to special tooling required for the performance of defense contracts to the maximum extent consistent with sound procurement objectives. Government acquisition of title or the right to title in special tooling creates substantial administrative burden, encumbers the competitive procurement process and frequently results in the retention of special tooling without advantage commensurate with such burden. In certain instances, however, the acquisition of special tooling or rights thereto may help the Government obtain fair prices, recover the residual value of special tooling paid for by the Government, and increase competition in subsequent procurements by increasing the number of sources, where tooling is susceptible of use by more than one contractor, considering its adaptability and all costs of movement.[22]

The instances in which acquisition is likely to be beneficial are precisely those in which buying in is apt to be a problem, namely, where because of "start-up costs or other nonrecurring costs, . . . the successful offeror is likely to become, in effect, a sole source for follow-on procurements."[23]

The data accumulated on the aerospace system discussed in the preceding section indicates that the government frequently employs the option to acquire special tooling. Of the fifty-four investments in special tooling or test equipment covered by the surveys, the government retained title in all but seven instances. Moreover, with one exception involving proprietary technology, each of the latter either was ranked as having a high alternative use value or had a shorter use life than the average for the forty-seven to which the government acquired title.

The expediency of this policy toward special tooling depends heavily on the mobility and adaptability of the assets in question; rents will still accrue to equipment unless it can be removed and reassigned to other uses or users at low cost. In addition, the policy cannot eliminate advantages that arise from specialized know-how acquired through performance of the contract.

[22] Defense Acquisition Regulations, supra note 16, ¶ 34,705. See also the criteria in *id.* ¶ 34,705.10. "*Special tooling* means all jigs, dies, fixtures, molds, patterns, taps, gauges, other equipment and manufacturing aids . . . which are of such a specialized nature that, without substantial modification, their use is limited to the development or production of particular supplies or parts thereof, or the performance of particular services." *Id.* ¶ 34,657. A similar definition applies to special test equipment, ¶ 34,657.35.

[23] *Id.* ¶ 32,866.

2. *Extended Contracting.* Because the latter policy option applies only where specialized investments are easily transferable, the government provides other methods to attempt to forestall buying in. In particular, where specialized investments cannot be internalized for adaptability or administrative reasons, government policy calls for the use of more extensive contracting: "To avoid or minimize the opportunity for 'buying in' on a procurement which is likely to be succeeded by one or more 'follow-on' procurements, the Government should obtain from the contractor a binding price commitment covering as much of the entire program as is practicable. Such a commitment may be secured through employment of one of the following procurement techniques: (i) multi-year procurement . . . ; or (ii) price options for additional quantities. . . ."[24]

Quantity options are intended for use in contracts where "additional requirements are foreseeable but not known and . . . realistic competition for the option is impracticable once the initial contract is awarded."[25] Similarly, multiyear contracting and subcontracting are encouraged where "the item is expected to be obtained only from a sole source during the entire multi-year period."[26] But because of the rigidity of contracting in general, multiyear agreements should only be adopted if "(i) the contract or service is of stable design and specification [and] (ii) the quantity required is reasonably firm and continuing,"[27] that is, where the degree of uncertainty is moderate. Thus, the terms and conditions under which extended contracting is to be employed indicate a perception of the benefits and hazards of the institution that coincide with the arguments outlined in Section I.

IV. Conclusions

Evidence from both stages of the defense procurement process indicates a general reluctance on the part of administrators to internalize transactions: government procurement policies refer explicitly to the "substantial administrative burden" incurred in acquiring and managing equipment and facilities, and estimations of actual contractor procurement practices indicate a strong "predisposition" toward external sourcing. But it is a reluctance that can be overcome by exposure to the hazards of market exchange when components are specialized and complex, as the evidence also attests.

[24] *Id.* ¶ 32,069.

[25] *Id.* ¶ 32,423; also see Use of Options, *id.* ¶ 32,081.

[26] *Id.* ¶ 32,082.

[27] *Id.* ¶ 32,081.

Overall, the data on the aerospace system support the contention that design specificity and complexity are necessary, if not sufficient, conditions for the breakdown of cooperation in market-mediated exchanges and the subsequent integration of production within the firm. In addition, the procurement policies professed by the government provide supportive detail not yet available in the formal analysis, such as the effects of uncertainty on the scope of contractual agreements and the relevance of the absolute value of investments on the need for specialized governance structures. How one views this evidence depends on one's prior assumptions. In a descriptive sense, these excerpts suggest that agents engaged in procurement activities are concerned with the sorts of issues addressed in the transaction-cost paradigm. From a prescriptive standpoint, the model indicates that the government's policies in this regard are appropriate and sensible. Whether or not these policies are actually carried out is, of course, another matter.[28]

Finally, the estimations reported here provide an indication of the relative efficiency of contractual and hierarchical organizational forms. While at a rudimentary level at present, this sort of analysis may eventually permit economists to assess the value of particular contractual arrangements to the parties involved and, subsequently, to evaluate the desirability of adopting alternative legal conventions or of government interference in contractual relationships.

[28] See, for example, Oliver E. Williamson, The Economics of Defense Contracting: Incentives and Performance, in Issues in Defense Economics 229–32 (Roland N. McKean ed. 1979).