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Evaluating the Performance of Incentive Contracts without Individual Transaction Data: Japan's Procurement of Defense Equipment

Questions (A Guide to Reading This Material)

1. Evaluate the performance of Japan's procurement for defense equipment, referring to the summary of results listed in Tables 1, 2, and 3.

2. Read the description on incentive contracts for defense equipment. Try to evaluate the features of incentive schemes, referring to the numerical values shown in Tables 4 and 5.

3. Confirm that those contracts are precisely expressed in mathematical form that is noted in the Appendix. How can we evaluate the performance of those incentive schemes without individual transaction data? State your own idea, referring to notes written in the Appendix.

This case was written by Naoki Watanabe (Graduate School of Business Administration, Keio University) for facilitating classroom discussions at Keio Business School. The contents are partly based on the MBA thesis of Mr. Motohiko Kasai submitted to the Graduate School of Business Administration at Keio University. Inquiries about reproducing the case should be referred to Keio Business School (4-1-1 Hiyoshi Kohoku, Yokohama, Kanagawa 223-8526; Phone: +81-45-564-2444; E-mail:case@kbs.keio.ac.jp). To order the copies of the case, go to the website (http://www.kbs.keio.ac.jp).

The aim of this case

This material aims to provide readers who have learned contract theory with an opportunity in which they should explore their own evaluation of the performance of a system few data on which are available. Incentive contracts in procurement of defense equipment are taken as a typical example. The detail data on transactions of defense equipment are basically undisclosed for security reasons. Unlike other public goods, therefore, it is impossible to empirically evaluate incentive contracts for defense equipment. This material depicts the system of incentive contracts and the limited summary of transactions described in the official documents issued by the Japan Ministry of Defense. How can we evaluate the performance of those incentive schemes without individual transaction data?

1 Introduction

The Japan Ministry of Defense (MOD, formerly, the Defense Agency) introduced a system of incentive contracts in its procurement of defense equipment in 1999, having intended to induce suppliers to exert effort toward reducing their production costs. But, major changes in the incentive schemes were made in 2008 and 2013 for improving the unsatisfactory performance. In many cases, a large amount of defense equipment is procured through private contracts with designated suppliers, because it is difficult to procure defense equipment through competitive bidding due to the specifications, technologies, and confidentiality concerns required for it. The MOD is faced with another difficulty in obtaining precise information on production costs suppliers actually pay even through cost auditing and quotation scrutiny. Accordingly, the supplier commits to an amount of cost reduction in advance, and payment is made based on the committed amount of cost reduction. There is no opportunity for renegotiating the amount of payment, except some special cases.

This material aims to provide readers with an opportunity in which they explore their own evaluation of a system the data on which are not sufficiently available. Did improvements that have been made to the system of incentive contracts actually work as intended? Did those improvements induce suppliers to exert more effort toward reducing their production costs? The MOD discloses simple statistics, but because of the feature, there is no transaction data detail enough for empirical evaluation of those incentive schemes. Then, how can we evaluate this system of incentive contracts? What should the MOD maximize or minimize in your idea?

The remainder of this material is organized as follows. Section 2 summarizes the methods of the procurement and Section 3 describes the system of incentive contracts, according to the official documents issued by the MOD. The Appendix briefly notes the mathematical expressions of the system of incentive schemes simplified for the analysis.

2 Japan's Procurement of Defense Equipment

Defense-related expenditures have been increasing in recent years, and the fiscal year budget exceeds 5 trillion JPY, according to the Ministry of Defense (2020). There is a strong call for restraint on spending. This section explains methods of the procurement and summarizes the results of the procurement conducted in 2019 (fiscal year).

Methods of the Procurement

In the MOD, the Acquisition, Technology & Logistics Agency (ATLA) is the office that handles the procurement of major items (firearms, guided weapons, ships, aircraft, etc.) in a centralized manner, in accordance with the “Instructions for Procurement of Equipment and Services (Soubihin Tou oyobi Yakumu no Chotatsu Jisshi ni Kansuru Kunrei, in Japanese).” This procurement accounts for about one-third of all defenserelated spending in each fiscal year. Contract suppliers are categorized as follows.

- open competitive bidding: Contract details and bidding conditions are announced publicly and the number of qualified parties that may participate in the bidding is not specified before the bidding.
- closed competitive bidding: A limited number of parties are invited for bids if they meet specific contract conditions and qualified as the bidders. The contract details and bidding conditions are directly notified to them; otherwise not.
- private contracts: The government may conclude a contract with a suitable party designated according to specified conditions that agreed upon through the negotiations, when it is stipulated by law and regulations, or the nature or purpose of a contract does not permit competitive bidding, or when it is impossible to conduct competitive bidding due to an urgent need or a disadvantageous situation.

The Accounting Law stipulates that, in principle, procurement should be subject to competition, but substantial amounts of defense equipment are, in practice, procured through private contracts. Procurement of defense equipment does not lend itself to competitive bidding due to the requirements for special specifications and advanced technologies as well as due to applicable legal and regulatory restrictions.

For each procurement, the expected contract value is calculated in advance as a price estimate by the ATLA officers who are in charge of contracting, for use as a reference in contract negotiations. The expected contract values serve as a kind of yardstick, or upper limit price, for anticipating the approximate successful bid price, as well as to calculate an appropriate and reasonable figure to ensure

the most economical procurement within a given budget. There are two methods of calculation for this: the **market price method** and the **cost accounting method**.

The market price method is based on the idea that the market value of an item is represented by the price agreed upon by a seller and a buyer in a competitive market. The cost accounting method is used when the market price cannot be estimated; it calculates production cost by adding up expenses for each component of production and then adds an appropriate profit margin on top of the cost.

In principle, the contract price should be fixed at the time of contract conclusion, but in some cases, depending on the nature of the contract, it may not be possible to finalize the contract value when the contract is initiated, or it may be inappropriate to do so. Three types of contract methods are used in accordance with some conditions.

- fixed contract: The amount to be paid to the counter party is fixed, as per the contract value.
- semi-fixed contract: The amount to be paid is fixed within a range of contract values, in accordance with predefined criteria.
- approximate contract: The amount to be paid is to be determined at a later date, according to predefined criteria. It is used when it is deemed inappropriate to use either of the preceding two contract types.

Summary of the Results in FY2019

The defense equipment procurement conducted in 2019 (fiscal year) are summarized in the following tables. (The values after the second decimal point are rounded down.) Except for Foreign Military Sales (FMS), private contracts were used for the highest valued procurements, with a value of 900 million JPY per contract (Table 1).[1] Contracts exceeding 200 million JPY in value account for about 92% of total contract value (Table 2), and, excluding FMS, contracts priced using the cost accounting method account for about 70% of total procurement by value (Table 3). The exchange rate in 2019 (fiscal year) was approximately 109 JPY per U.S. dollar.

[1] FMS is a procurement method for purchasing equipment and services from the U.S. government based on the Mutual Defense Assistance Agreement between Japan and the U.S.

Table 1: Procurement results by contract type in FY2019 (in JPY)

	open competitive bidding	closed competitive bidding	private contract	FMS	total
no. of contracts	4,663 82.5%	6 0.1%	766 13.6%	214 3.8%	5,649
Total value (× 100 million)	4,819 26.4%	9 < 0.1%	6,546 35.9%	6,869 37.7%	18,243

Note: no. of contracts means the number of contracts.

Table 2: Procurement results by contract value in FY2019 (in JPY)

	10 million or less	10-30 million	30-100 million	100-200 million	more than 200 million	total
no. of contracts	2,425 42.9%	1,005 17.8%	1004 17.8%	457 8.1%	758 13.4%	5,649
total value (× 100 million)	86 0.4%	180 1.0%	575 3.2%	640 3.5%	16,763 91.9%	18,243

Note: no. of contracts means the number of contracts.

Table 3: Procurement results by calculation method in FY2019 (in JPY)

		general equipment	guided weapons	navy ships	aircrafts	general imports	FMS	total
market price method	no. cont.	4,054	0	55	62	97	214	4,482
	value × 10 million	2,484	0	80	19	836	6,869	10,288
cost accounting method	no. cont.	793	81	63	229	1	0	1,167
	value × 10 million	3,226	1,629	1,280	1,818	1	0	7,954
total	no. cont.	4,847	81	118	291	98	214	5,649
	value × 10 million	5,710	1,629	1,360	1,837	837	6,869	18,243

Note: no. cont. means the number of contracts.

3 Incentive Contracts for Defense Equipment

The Defense Agency was reorganized to become the Ministry of Defense (MOD) in January 2007. In the following description, we refer to the Defense Agency also as the MOD in order to avoid confusion due to the different names. The Equipment Procurement and Construction Office (EPCO) of the MOD is currently in charge of designing and improving the system of incentive contracts for defense equipment. This section briefly explains when and how those incentive contracts were introduced and have been revised.

In 1999, the MOD established the **Cost Improvement Proposal Scheme**, aimed at reducing prices of defense equipment in procurement. It was described as "a scheme for realizing reduced procurement prices by increasing suppliers' motive to lower costs by offering to pay them a portion of any cost-savings they achieve when they reduce their costs by their efforts" (EPCO, 2008). This scheme required the supplier company to make a commitment to the method and amount of cost reduction in its production before commencing cost-saving measures.

In 2002, this scheme was redesigned and renamed the **Incentive Contract Scheme**. Under the new scheme, "private companies that took advantage of their technological invention or manufacturing expertise would receive 50% of the cost reduction they achieved through proposals that were able to cut procurement costs as a technology proposal fee paid over 5 years." But actually, in the first 9 years of the scheme being used, only two cost reduction proposals were submitted, which were worth only a total of approximately 27 million JPY in savings.

In 2008, the scope of the scheme was thus expanded in order to encourage greater use by suppliers, by adding "various kinds of cost reduction efforts, such as capital investment and production management improvements" to the existing proposal requirements (EPCO, 2008). Losses in profits due to the reduced production costs would be compensated by separate payments.

In addition, for procurement over 5 years of the scheme, it became possible to make weighted allocations of the cost improvement proposal fee, if within the range of 50% of the amount of price reduction within the applicable period (e.g., for the same volume each year, 90%, 80%, 50%, 20%, 10%, respectively). As under the previous scheme, suppliers were required to commit to the method and amount of cost reduction in its production before commencing their cost-saving efforts. According to the Ministry of Defense (2010), however, the scheme was utilized only twice in the first 2 years following the introduction of the scheme.

In 2013, the scheme was again modified in order to to further encourage its active use by suppliers. According to the EPCO (2013), "To motivate companies to try and reduce costs, when a company proposes a cost reduction measure based on a technology that was not considered at the time the contract was concluded and the proposal is adopted, a portion of the cost-savings is added to the contract price after cost reduction as an incentive fee." With this modification, the supplier was asked to commit to the method and amount of cost reduction in its production before commencing

the costsaving task; the supplier first demonstrated the method of reducing its production cost before commencing the cost-saving task, and then after the event must verify the actual cost-savings or report on the actual cost reduction achieved.

Furthermore, as shown in Table 4, the incentive fee rate was increased (e.g., average of 80% over 5 years for a company pledging to cut production costs by up to 5%, as opposed to 50% previously), and the application period for the scheme was extended by 1 year for each year that the amount of cost reduction exceeds 10% of the original production cost. It was also noticed that even when production cost was reduced, no reductions in large-scale production cost necessitating large initial investments were made by suppliers under the previous scheme, since there was no promise of a contract after the fact. It was therefore decided that for a commitment to a production cost reduction exceeding 20% during the scheme application period, a private contract would be awarded to the supplier. According to ATLA of the MOD (2020), the number of applications under the current scheme is increasing, as can be seen in Table 5.

Table 4: Incentive fee rates for each method (%)

method applied		1 year or less	1-2 years	2-3 years	3-4 years	4-5 years	more than 5 years
cost improvement proposal method (pledge type)	up to 5% of reduction	90	85	80	75	70	55
	over 5% of reduction	100	95	90	85	80	
cost improvement proposal method (verification type)		80	75	70	65	60	55
cost improvement proposal method		55	55	55	55	55	55

Note: Decimal points are rounded off.

Table 5: Results of the incentive contract

	FY2015	FY2016	FY2017	FY2018	FY2019
Cases	13	22	26	33	35

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Appendix

The utility of the ministry of Defense (MOD) is not directly measured, and it is also impossible to estimate it without the accounting data. Once it is defined in some way, however, we can evaluate its incentive contracts from the viewpoint of incentives. In this Appendix, we propose the utility function of the MOD according to the standard way in the literature of contract theory.[2] In the definition, we assume that there are no possible competitions among suppliers. Thus, there should be possible definitions made suitably for the situation that incorporates the entry of plural suppliers.

Consider a situation where the MOD concludes an exclusive contract with a supplier in order to procure certain defense equipment for T periods (fiscal years). There is no entry of the other suppliers during the contract period, as noted above. In period $t = 1, \ldots, T$, the MOD purchases Q_t units of the equipment from the supplier. The total quantity for T periods is denoted by $Q = \sum_{t=1}^{T} Q_t$. The MOD knows the supplier's initial unit cost of production C_B ($0 < C_B < \infty$). In the contract, the supplier commits to a cost reduction. The committed amount of cost reduction per unit is denoted by c_p ($0 \leq c_p \leq C_B$). In what follows, it is assumed that there is no change in the social and economic environment, and thus there is no opportunity for renegotiating the procurement volume, production cost, cost reduction, and other contract terms during the entire contract period.

The supplier exerts effort e ($0 \leq e < \infty$) for reducing the unit cost of production only once at the beginning of period $t = 1$, paying some amount cost of effort $\psi(e)$ ($0 \leq \psi(e)$ for any e). Assume that $\psi(0) = \psi'(0) = 0$ and that $\psi'(e) > 0$ and $\psi''(e) > 0$ for any $e > 0$. The MOD can observe neither the level of effort nor the cost of effort. Accordingly, the contract cannot be written based on e and $\psi(e)$. If the supplier exerts effort, then the amount of cost reduction per unit, x ($0 \leq x \leq C_B$), is realized before the production in period $t = 1$ according to the probability density function $f(x, e)$. If the supplier does not exert effort, then there is no cost reduction, i.e., $x = 0$ when $e = 0$. Assume that the domain of x is independent of e.

Denote the MOD's total transfer (payment) to the supplier over the entire contract period by T_T and the supplier's gross profit by $\Pi_T = T_T - (C_B - x)Q$ (without deducting the cost of effort for cost reduction, $\psi(e)$). To simplify the model, we assume that the transaction conducted between the MOD and the supplier will not be implemented when the realized amount of cost reduction per unit (value of x) does not reach the committed amount of cost reduction per unit c_p. In that case, $T_T = 0$ and the supplier.

The utility of the supplier is expressed as $U_a(\Pi_T - \psi(e))$, where $U_a' > 0$ and $U_a'' \leq 0$. Given T_T, C_B, and Q, the supplier maximizes its expected utility, i.e.,

$$\int_{c_p}^{C_B} U_a(\Pi_T) f(x, e)\, dx - \psi(e). \tag{1}$$

[2] See, e.g., Laffont and Tirole (1993).

Note that when the supplier exerts no effort, there is no possibility of cost reduction, as noted above. In that case, the supplier receives the utility $\bar{U}_a$.

Let $S(Q)$ denote the benefit that the general public in Japan gains from defense services with a quantity Q of defense equipment over T periods. Assume that $S(0) = 0$ and that $S'(Q) > 0$ and $S''(Q) < 0$ for all Q. The opportunity cost of spending the transfer T_T is expressed by $(1 + \lambda)T_T$, where λ is the rate of unit cost of transfer. The utility of the MOD is expressed as $U_p(S(Q) - (1 + \lambda)T_T)$, where $U_p' > 0$ and $U_p'' \leq 0$.

The MOD maximizes its expected utility, i.e.,

$$\int_{c_p}^{C_B} U_p(S(Q) - (1+\lambda)T_T) f(x, e)dx, \tag{2}$$

taking into account the supplier's effort level and its participation to the contract.

Three Incentive Schemes

Three incentive schemes are expressed below in mathematical form.[3] The first one was introduced in 1999 and was revised as the second one in 2008, and the third one has been used since 2013. For simplification in a unified treatment of those schemes, we rename them to (1) the **technology proposal fee**, (2) the **cost improvement proposal fee**, and (3) the **incentive fee (commitment type)**, respectively, with the rate of cost reduction, c_p/C_B, being 5% or less. Each incentive scheme is applied for the first k periods ($0 < k <$ T).

Under the incentive contract with the incentive fee (commitment type), over the entire period, the MOD's transfer (total payment) T_T^3 to the supplier and the supplier's gross profit Π_T^3 are determined as follows.

$$T_T^3 = (1 + \alpha)(C_B - c_p)Q + \sum_{t=1}^{k} (\alpha + \beta_t)c_pQ_t \tag{3}$$

$$\Pi_T^3 = T_T^3 - (C_B - x)Q = \alpha C_B Q + \sum_{t=1}^{k} (\alpha + \beta_t)c_pQ_t - (1 + \alpha)c_pQ + xQ, \tag{4}$$

[3] Kasai and Watanabe (2021) provides an idea to analyze the performance of those schemes.

where α ($0 < \alpha < 1$) denotes the reward rate applied to the committed cost of production $(C_B - c_p)Q_t$ and β_t ($0 < \beta_t < 1$ for all $t = 1, \ldots, k$) represents the incentive rate applied to the committed amount of cost reduction per unit c_p in period t in addition to α.

In the case of an incentive contract with the cost improvement proposal fee, the incentive rate β_t is fixed at 0.5 over all application periods in the contract. Under this scheme, over the entire contract period, the MOD's transfer T_T^2 to the supplier and the supplier's gross profit Π_T^2 are determined as follows.

$$T_T^2 = (1 + \alpha)(C_B - c_p)Q + \sum_{t=1}^{k} (\alpha + 0.5)c_p Q_t \tag{5}$$

$$\Pi_T^2 = T_T^2 - (C_B - x) = \alpha C_B Q + \sum_{t=1}^{k} (\alpha + 0.5)c_p Q_t - (1 + \alpha)c_p Q + xQ. \tag{6}$$

In the case of incentive contract with the technology proposal fee, the reward rate α in the second term on the right-hand side is zero and the incentive rate $\beta_t = 0.5$ is fixed in every application period. Under this contract, over the entire contract period, the MOD's transfer T_T^1 to the supplier and the supplier's gross profit Π_T^1 are determined as follows.

$$T_T^1 = (1 + \alpha)(C_B - c_p)Q + 0.5 \sum_{t=1}^{k} c_p Q_t \tag{7}$$

$$\Pi_T^1 = T_T^1 - (C_B - x)Q = 0.5 \sum_{t=1}^{k} c_p Q_t - c_p Q + xQ. \tag{8}$$

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