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Rules of Evidence and Liability in Contract Litigation: The Efficiency of the General Dynamics Rule

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We examine rules of evidence and liability in contract litigation. When a contractor fails to perform, it has a legal defense that the buyer withheld private information relevant to the performance of the contract. Suppose the buyer claims that admitting evidence for the defense would compromise a valuable secret, e.g., a state secret, what should the legal rule be? We show that the evidentiary rules introduced by the Supreme Court in General Dynamics v. U.S. lead to a more efficient outcome than either a strict liability rule or an evidentiary rule requiring the disclosure of the buyer's private information.

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Keywords: Procurement auctions; state-secrets privilege; superior knowledge; private information

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1 Introduction

In 1988, the U.S. Navy awarded through a procurement auction a $4.8 billion fixed-price contract to General Dynamics Corporation and McDonnell Douglas Corporation for the design and production of an advanced, carrier-based stealth aircraft called the A-12 Avenger. The government agreed to share certain classified information with the contractors since the project relied on state-of-the-art stealth technology already being used in other government programs, and such technology would have been prohibitively costly and time-consuming to reproduce (Schwinn, 2011). The project soon encountered a series of delays, and after failing to meet various benchmarks, the contractors formally requested a restructuring of the contract from a fixed-price to a cost-reimbursement agreement, arguing that the cost was much higher than originally anticipated. Failing to reach an agreement and dissatisfied with the lack of progress, the Navy terminated the contract for default in 1991 and sought repayment of $1.3 billion plus $2.5 billion in accumulated interest.

The contractors counter-sued the U.S. claiming that their inability to complete the project was excusable due to the government's failure to share its superior knowledge regarding stealth technology. As a general principle in contract law, either the impossibility to perform or the withholding of key private information by the principal is an admissible legal defense (Posner and Rosenfield 1977, Posner 2005). In response, the government invoked the state-secrets privilege to prevent the classified information from being used as evidence. Thus, the contractors were caught in a Catch-22: they claimed that they failed to perform because the government did not provide critical information on stealth technology, but the contractors could not use that information as evidence in prosecuting their case because the government deemed the technology a state secret. (See Appendix A for a detailed history of the litigation.)

After twenty years of litigation, the case was resolved in 2011 by the U.S. Supreme Court in *General Dynamics v. United States.* The Supreme Court concluded that both parties must have been aware that the state-secrets privilege would prevent a resolution of such a contractual dispute, and both parties accepted this risk when they signed the contract. The court's decision was to let both parties remain where they were before the case was litigated. Thus, the contractors did not have to pay back any of the $2.7 billion they had received from the Navy, and the government did not have to make any additional payments to the contractors, which had spent $3.9 billion on the project. As Justice Scalia summarized: "It's the 'go away' principle of our jurisprudence, right?" (*General Dynamics v. U.S.*, 2011, Oral Argument.)

While the Supreme Court's decision was primarily the result of the matter being non-justiciable due to the inability of the contractors to build a proper defense given the state-secrets privilege invoked by the government, the case raises broader economic issues. Virtually all contracts have some form of private information and such information can distort outcomes and lead to inefficiencies. Legal rules of evidence and liability strongly influence economic outcomes, since sophisticated contracting parties are aware of information asymmetries, anticipate future conflicts, base their conflict-resolution expectations on these rules, and contract accordingly. Moreover, in recent years there has been a dramatic increase in the government's asserting of the state secrets privilege in litigation (Frost 2007).

Thus, *General Dynamics v. U.S.* raises several interesting questions. First, which liability rule is more efficient: (1) forcing the contractors to be strictly liable for their failure to perform or (2) the *General Dynamics* rule? Second, what are the optimal bidding functions under strict liability and the *General Dynamics* rule? Third, how does the game change if the evidentiary rules require a buyer's private information to be admitted in court and used by the contractor in its defense?

A vast literature exists on the law and economics of contracts (see Hermalin, Katz, and Craswell (2007) for a recent literature review), which includes theories of contract efficiency and efficient default rules (Schwartz and Scott, 2003). A substantial literature also exists that examines the tradeoff in first-price auctions between price and contractual performance, see, e.g., Spulber (1990), Waehrer (1995), and Zheng (2001). Directly relevant to this research are theories of contract breach and enforcement, limits of the bargaining principle, exceptions from full contract enforcement, and contract interpretation, see, e.g., Eisenberg (1982) and (1995), Posner (2005), and Shavell (2005). Several papers within this literature study optimal mechanism design when bidders can default, see, e.g., Bruguet et al. (2009) and Chillermi and Mezzetti (2009). There is also a significant literature on optimal contract design by an informed principal, (e.g., Maskin and Tirole 1990) However, we are not aware of any research that studies either the risk of bidder default in a litigation context or the efficiency effects of differing rules of evidence and liability in such litigation.

We study a contracting auction environment where the buyer possesses private information regarding the true cost of the project. This holds in defense contracting with secret technologies, but also holds more generally, whenever the buyer has private cost information. We study the bidding process, the arrival and resolution of conflicts, and the economic efficiency implications of different rules of evidence and liability. In addition to the *General Dynamics* rule, we consider a strict liability rule where the contractor is held liable and forced to complete the project regardless of cost. We also consider an evidentiary rule requiring the buyer's private information to be admitted in court for use by the contractor in its defense.

In our model, contractors are aware at the time of bidding that the buyer might have private information and that the true cost of the project might include an additional random cost component. Contractors anticipate future conflicts and default situations and, depending on the evidentiary and liability rules, bid accordingly. We find that the rules of evidence and liability strongly affect the incentives of both the contractors and the buyer. Our basic finding is that the evidentiary and liability rules in *General Dynamics* lead to a more efficient outcome than a strict liability rule or an evidentiary rule requiring disclosure of the buyer's private information.

2 The Model

There are $N \geq 2$ contractors who bid to undertake a government project. The government's valuation of a completed share $q_t \in [0,1]$ of the project is $q_t V$ (implying that the government's valuation of the completed project is V). Bidder i's total cost of completing the project, C_i, equals $c_i + X$, where c_i denotes bidder i's private cost (i.e., c_i is known only by bidder i) and X denotes an ex ante unknown, common cost associated with a technological secret possessed by the government. Bidders' private costs are independently and identically distributed according to a cumulative distribution function (cdf) known to all bidders and the government: c_i is distributed according to the cdf $F(\cdot)$ on the support $[0,V]$.

Each bidder's total cost of completing the project includes the common cost X because construction of the project involves classified technology possessed only by the government and to which no bidder has access. Bidders only know their individual costs and the presence of a random cost x, assumed to be uniformly distributed on the interval $[0,V]$. We assume a first-price, sealed-bid auction as the rule for awarding the contract. During execution of the project, the winning bidder finds out the true value of the random cost X and completes a part of the project q_t. In order to avoid complications associated with moral hazard, we assume close monitoring or "fair play" on the contractor's part such that the fraction of the project completed is a quantity proportional to her individual cost[1]. Specifically, we assume $q_t = \frac{c_i}{c_i+X}$. The cost for the winning bidder to complete q_t is c_i. The timing of the game is the following:

Step 1. Bidders bid for contracts.

Step 2. The contract is awarded to the lowest bidder.

Step 3. The government pays the contractor the value of her bid and the contractor begins work on the project.

Step 4. The contractor finds out X (the true value of the random cost), produces and delivers a part of the final project $q_t = \frac{c_i}{c_i+X}$, from which the government infers the true value of the winning bidder's cost c_i.

[1]This might seem like a strong assumption, but in situations such as the one we describe, when the buyer is a monopsonist, contractors are bound by dynamic incentives to play nicely. Moral hazard is a serious issue, and in a one shot game the contractor will indeed have incentives to shirk, especially if he expects that the court will not award damages. However, in repeat interactions with a monopsonist, a firm that tries to shy away from due work will surely jeopardize their position and chance of landing future contracts. In fact, one only needs to look at the shape of the contract to realize that. A fixed price contract is never optimal under such conditions and the government would have never offered such contract if they had suspected shirking on the contractor's side. Future contracts will not be jeopardized however, if the contractor could show that he made all possible efforts of completing the project, which is what this assumption ensures.

Step 5. The government decides whether to sue the contractor for damages or support the cost over-runs and finish the project without legal intervention[2].

We study and compare the outcomes for different rules of evidence and liability. We assume these rules to be common knowledge at the time of the bidding process. We consider three different rules of evidence and liability:

- *General Dynamics*: the court (1) does not allow the contractor to use the buyer's private information regarding the cost of the secret technology in litigation; (2) voids the contract so that the project is not completed; and (3) allows the contractor to keep any compensation received, but does not require the buyer to make any additional payments.
- *Strict Liability* (SL): the court (1) does not allow the contractor to use the buyer's private information regarding the cost of the secret technology in litigation; (2) enforces the contract so the project is completed; and (3) requires the buyer to make all payments specified in the contract.
- *Disclosure of Private Information* (DPI): the court (1) allows the contractor to use the buyer's private information regarding the cost of the secret technology in litigation; and (2) the court rules for or against the contractor depending on the cost of the secret technology. Specifically, if the cost associated with the technological secret is higher than some threshold, then the *General Dynamics* rules apply. If, however, the cost of the secret technology falls bellow the threshold, the SL rules apply.

[2] Although we do not formally model renegotiation, this step somehow mimics it. Before entering litigation, the government has the option to pay any cost over-runs to the contractor and finish the project. Under a strict liability rule, the government will surely never pay, but under such a rule any renegotiation will also fail since there will be no incentive for the government to pay anything. Furthermore, renegotiation often fails in real life even when it would be optimal for both parties to do so, or else we would never have litigation. We are primarily motivated by such a case, and want to see what the effects of the legal rules are in situations where renegotiation fails.

3 Characterization of outcomes under *General Dynamics*

If the court's rule is to void the contract and let both parties keep what they already received, the government's decision to sue or support the cost overruns and complete the project is equivalent to an efficiency condition. To see this, consider the government's profits in the two possible scenarios:

$$\begin{cases} \pi_G^{Sue} = q_t V - b_i, \text{ if the government sues} \\ \pi_G^{Pay} = V - b_i - X, \text{ if the government pays the cost overruns and finishes the project} \end{cases}$$

where b_i is the winning bid, V is government valuation for the completed project, X is the secret cost, and $q_t = \frac{c_i}{c_i+X}$ is the completed part of the project delivered by the contractor[3].

The government knows precisely the value of both X and c_i at the time of deciding whether to sue or not and therefore compares the two possible profits π_G^{Sue} and π_G^{Pay}. The decision to sue or not is given by the following rule:

$$\begin{cases} \text{Pay if } V > c_i + X \\ \text{Sue if } V < c_i + X. \end{cases}$$

This condition ensures that from an efficiency standpoint, when the valuation of the project exceeds the total cost and hence the project should be finished, it actually will be finished and the government will support the cost overruns. On the other hand, when the valuation of the project is less than the total cost and hence the project should not be finished, the government will sue, the project will not be finished, and the government will be at a

[3]The linear shape of the government's valuation of partially completed projects can be relaxed without changing the qualitative conclusions of the model. In particular, if one assumes a convex shaped valuation (where a completed project is worth much more than a partially completed one), some inefficient projects will be finished under the *General Dynamics* rules, but so would they under the SL rules. The overall economic efficiency will be the same, with the only difference being who pays the cost of these inefficiencies. We can argue again, that from a fairness perspective it should be the government that pays these costs since they are the direct result of its own secret information.

loss. This can be considered fair since the government is the source of the information asymmetry, and the government will not allow the technological secret to be used by the contractor in litigation. In the inefficient case, when the cost exceeds the valuation, it is impossible to decide ex ante whether the project should be undertaken or not due to the information asymmetry. The government has to pay a price in order to give proper incentives to the bidders to reveal their costs truthfully and bid accordingly and at the same time keep its secret technology classified. If the cost of the secret technology were public information, there would be self selection on bidders' side and no bidder with a total cost above V would bid, hence ensuring efficiency.

We now analyze the bidders' optimal bidding strategy. We assume each bidder follows a bidding strategy increasing in its individual cost. Each bidder submits a bid $b_i(c_i)$, and the bidder with the lowest bid is awarded the contract. Since bids are increasing in costs, this ensures that the winning bidder is actually the bidder with the lowest individual cost. Regardless of whether the government decides to sue or cover the cost overrun, the contractor will always earn $b_i - c_i$. Hence, bidders maximize their expected profits

$$\max_{b_i} \pi_i = [P(winning)](b_i - c_i)$$

which yields the optimal bidding strategy (see Appendix B):

$$b_i(c_i) = c_i + \frac{\int_{c_i}^{V} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}}.$$

This is identical to the optimal bidding for a contracting auction with no secret cost. If both c_i and X are assumed to be uniformly distributed on the interval $[0,V]$, then the bidding function becomes

$$b_i = c_i + \frac{V - c_i}{N}.$$

Under uniformly distributed costs, the ex post profits for the contractor and the government are:

$$\begin{cases} \pi^C = \frac{V-c}{N} \\ \\ \pi^G = \begin{cases} V-\underline{c}-X-\frac{V-c}{N} & \text{when } V > \underline{c}+X \\ q_t V-\underline{c}-\frac{V-c}{N} & \text{when } V < \underline{c}+X \end{cases} \end{cases}$$

where $\underline{c}$ is the lowest individual cost (i.e., the individual cost of the winning bidder).

4 Characterization of outcomes under strict liability

If the court's rule is strict liability, then in equilibrium the government will always sue and demand that the contractor fulfill her obligations. Therefore the government will always earn

$$\pi^G = V - b_i$$

while the winning bidder's profit will be

$$\pi^C = b_i - c_i - X.$$

Since bidders do not know the true value of X at the time of bidding, they consider the expected value of X instead. Following the same bidding strategy (increasing in cost), they maximize their expected profits

$$\max_{b_i} \pi_i = [P(winning)](b_i - c_i - E(x)).$$

Since X is uniformly distributed on $[0,V]$, $E(x) = \frac{V}{2}$ and the optimal bidding function is (see Appendix B):

$$b_i(c_i) = c_i + \frac{\int_{c_i}^{\frac{V}{2}} [1-F(x)]^{N-1} dx}{[1-F(c_i)]^{N-1}} + \frac{V}{2}.$$

The optimal bidding function in the SL case is similar to the bidding function in the *General Dynamics* case, but with the addition of the last term ($\frac{V}{2}$) and the different limit of integration. Since bidders know they will be held liable for the entire contract, they insure themselves against future losses by bidding more. Also since they increase their bids by the expected value of the random cost X, some contractors will not bid. Specifically, only bidders with individual costs lower than $V - E(X) = \frac{V}{2}$ will bid. If all costs are assumed to be uniformly distributed on $[0,V]$, then the optimal bidding function becomes

$$b_i(c_i) = c_i + \frac{V - c_i}{N} + \frac{V}{2} - \frac{V^N}{N2^N(V - c_i)^{N-1}}, \text{ if } c_i < \frac{V}{2}$$

and the ex post profits for the winning contractor (if the minimum cost is below $\frac{V}{2}$) and the government are

$$\begin{cases} \pi^C = \frac{V-\underline{c}}{N} + \frac{V}{2} - \frac{V^N}{N2^N(V-\underline{c})^{N-1}} - X \\ \\ \pi^G = \frac{V}{2} - \underline{c} - \frac{V-\underline{c}}{N} + \frac{V^N}{N2^N(V-\underline{c})^{N-1}} \end{cases}$$

where $\underline{c}$ is the lowest individual cost (i.e., the individual cost of the winning bidder). When there is no bidder with individual cost below $\frac{V}{2}$, no contractor bids and therefore both profits equal zero.

5 Strict liability or not? Discussion

From an ex post perspective, which court rule, *General Dynamics* or SL, would be preferable from a social perspective? For simplicity we continue to assume both individual costs and the secret government cost to be ex ante uniformly distributed on $[0,V]$. Ex post, let X be the true value of the secret government cost and $\underline{c}$ the smallest individual (winning) cost. We define total welfare as the sum of the government's and contractor's profits. That is

$$W = \pi^G + \pi^C.$$

If at least one bidder has individual costs below the $\frac{V}{2}$ threshold, there will be a winning bid, a contract, and total welfare under SL will equal

$$W^{SL} = V - \underline{c} - X.$$

Under *General Dynamics* however, we will always have a winning bid and a contract. Total welfare under *General Dynamics* equals

$$\begin{cases} W_E^{GD} = V - \underline{c} - X & \text{if } V > \underline{c} + X \\ W_{NE}^{GD} = q_t V - \underline{c} & \text{if } V < \underline{c} + X \end{cases}$$

where "GD" indicates *General Dynamics*, "E" indicates it is efficient to complete the project, and "NE" indicates it is not efficient to complete the project.

Thus, in the efficient case, when the valuation exceeds the true cost of production, total welfare is the same under both rules. However in the inefficient case, when the valuation is smaller than the cost of production, there are higher losses under SL. From a social perspective, *General Dynamics* yields strictly better outcomes than SL if either there are bids under both rules or the project is efficient to complete. The only case when SL yields higher welfare than *General Dynamics* is when no individual cost is below $\frac{V}{2}$ and $V - \underline{c} - X < 0$. In such a case *General Dynamics* yields small losses while SL eliminates these losses. However, the probability of this case is very small if the number of bidders is large.

6 Disclosure of Buyer's Private Cost Information

Suppose the court allows the winning bidder to use in its defense the government's delay in providing the secret technology and the cost of that technology. This is the disclosure of private information (DPI) rule. The court uses a threshold cost criterion to decide for or against the contractor. Specifically, if the cost associated with the technological secret is higher than some threshold, $X > \overline{X}$, then the *General Dynamics* rules apply. If, however, the secret cost falls below the threshold, $X < \overline{X}$, then the SL rules apply. The game under the DPI rule follows exactly as before: bidders bid, the contract is awarded to the lowest bidder, the government pays the amount of the bid, the project gets underway, the contractor delivers $q_t = \frac{c_i}{c_i+X}$, and then the government decides whether to sue or cover the cost overruns. The government will always sue when $X < \overline{X}$, in which case the profits will equal

$$\pi^G = V - b_i \text{ and } \pi^C = b_i - c_i - X.$$

On the other hand, if $X > \overline{X}$ the government will sue and terminate the contract in the inefficient case (when $V - b_i - X < 0$). The government will support the cost overruns in the efficient case (when $V - b_i - X > 0$). In both these cases the profit for the contractor equals

$$\pi^C = b_i - c_i$$

while the government's profit equals

$$\begin{cases} \pi^G_{Sue} = q_t V - b_i \\ \pi^G_{Pay} = V - b_i - X. \end{cases}$$

Therefore, each bidder chooses her optimal bidding function to maximize expected profits:

$$\max_{b_i} \pi_i = [P(winning)][P(x > \overline{X})(b_i - c_i) + P(x < \overline{X})(b_i - c_i - E(x|x < \overline{X})].$$

Since x is uniformly distributed on $[0,V]$, $E(x|x < \overline{X}) = \frac{X}{2}$ and the optimal bidding function is (see Appendix B):

$$b_i(c_i) = c_i + \frac{\int_{c_i}^{V - \frac{\overline{X}^2}{2V}} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} + \frac{\overline{X}^2}{2V}.$$

The bidding function with the DPI rule is similar to the previous cases: bidders bid their individual cost plus an adjustment factor to insure against potential future losses if the government terminates the contract for default and sues to recover its costs. The adjustment factor equals $\frac{\overline{X}^2}{2V}$, which is the expected value of the secret cost conditional on the secret cost being below the court threshold times the probability of the secret cost being below that threshold. Again, as in the SL case, because of this additional term, contractors with individual costs $c_i > V - \frac{\overline{X}^2}{2V}$ will not bid and hence the integration limit differs. If all costs are assumed to be uniformly distributed on $[0,V]$, then the bidding function becomes

$$b_i(c_i) = c_i + \frac{V - c_i}{N} + \frac{\overline{X}^2}{2V} - \frac{\overline{X}^{2N}}{N 2^N V^N (V - c_i)^{N-1}}, \text{ if } c_i < V - \frac{\overline{X}^2}{2V}.$$

In terms of aggregate welfare, if at least one bidder has a cost below $V - \frac{\overline{X}^2}{2V}$, then the sum of the profits will be

$$\pi^G + \pi^C = \begin{cases} V - \underline{c} - X, \text{ if } X < \overline{X} \text{ (no matter if efficient or not)} \\ V - \underline{c} - X, \text{ if } X > \overline{X} \text{ and } V - \underline{c} - X > 0 \\ q_t V - \underline{c}, \text{ if } X > \overline{X} \text{ and } V - \underline{c} - X < 0. \end{cases}$$

Thus, if there is at least one bid, the DPI rule is inferior to *General Dynamics* from a social perspective. Admitting the secret as a defense yields the same welfare as *General Dynamics* under most circumstances, but it is strictly worse whenever the secret cost falls below the court's threshold and it is inefficient to build. As with SL, the only case when admitting the secret as a defense yields higher total welfare than *General Dynamics* is when we are in the inefficient case and no bidder has low enough costs to bid. In this case, admitting the secret as a defense yields zero aggregate profits, while *General Dynamics* yields losses. Again, the probability of this happening is very small with a large enough number of bidders.

7 An Alternative Continuous Production Model

In this section, we present an alternative way to model the production decision after the bids have been submitted. In the previous sections, we assumed the winning contractor produced a portion of the project, proportional to the individual cost/total cost ratio. We now consider a model in which the winning contractor, unaware of the true cost of the project, starts executing and keeps producing until she either finishes the project or reaches a point where the true cost would outweigh the winning bid. If this stopping point is reached, litigation occurs as before.

To formalize, let there be N contractors bidding for a government project with valuation V. Contractors have individual marginal costs c_i identically and independently distributed on a commonly known cdf $F(\cdot)$. The project difficulty is ex ante unknown to the bidders. Let the true difficulty of the project be $D = D_1 + X$, where D_1 is the known component and X is the random component that only the government knows ex ante. From a bidder's perspective, X is a random variable uniformly distributed on the interval $[0,V]$. Bidders bid for the project, and the bidder with the lowest bid is selected as the winning contractor. The government pays the entire amount of the bid and the contractor begins working on the project. Initially, the expected difficulty of the project is $E(D) = D_1 + \frac{V}{2}$ and the cost of finalizing the project is $E(C) = c_i E(D)$. The contractor builds more and more difficult parts of the project with each difficulty increment coming at the marginal cost of c_i. As the lower difficulty threshold D_1 is reached and passed, the contractor starts updating her expectations regarding the random difficulty component and hence the expected total cost of the project. There is no updating before reaching D_1 since this is the known difficulty component, and we assume strict liability for this portion of the project in order to avoid "weird bidding." Not imposing strict liability for at least a small portion of the project would lead to "weird bidding" behavior where bidders with high costs would bid zero and produce nothing in equilibrium. After passing the D_1 difficulty level, the contractor keeps producing and updating her expected cost until either the project is completed or the contractor reaches a stopping point D_{stop} where the expected costs exceed the winning bid. If this stopping point is reached, the government has the option to pay for the cost overruns and complete the project or sue for damages. Under *General Dynamics*, suing means nothing more than accepting the completed portion of the project and severing all contractual ties between the parties. We assume the government derives a value from an incomplete project proportional to the amount of the project that is finalized. More formally, for any stopping point D_{stop}, the government's valuation is $V \cdot \frac{D_{stop}}{D}$. If the stopping point is the completion point, then the government extracts its full valuation V.

For any winning bid b_i, the winning bidder can calculate her stopping point D_{stop} where the expected cost for completing the project would exceed the bid b_i. If this stopping point is reached without completing the project, the random difficulty component X is now distributed uniformly between D_{stop} and $D_1 + X$. Hence, the expected cost of completing the project will be $E(C) = c_i \cdot \frac{D_{stop}+D_1+V}{2}$. By setting the expected cost equal to b_i, we can calculate the stopping point $D_{stop} = \frac{2b_i}{c_i} - (D_1 + V)$. Since we assume strict liability for the D_1 portion of the project, D_{stop} has to be greater or equal to D_1, so for any bid $b_i \leq \frac{c_i(2D_1+V)}{2}$ the stopping point will be D_1. Summarizing:

$$D_{stop} = \begin{cases} D_1, \text{if } b_i \leq \frac{c_i(2D_1+V)}{2} \\ \frac{2b_i}{c_i} - (D_1+V), \text{if } b_i > \frac{c_i(2D_1+V)}{2}. \end{cases}$$

If a stopping point is reached, the government has the option under *General Dynamics* to pay for the extra costs and complete the project or litigate and dissolve all contractual ties with the contractor. The government knows the extra effort required to complete the project and hence the cost to do this. We denote this difference by $\Delta = D - D_{stop}$. If this portion is completed, it would bring additional benefits to the government equal to $V \cdot \frac{\Delta}{D}$, with a cost equal to $c_i\Delta$. The government will decide to pay for the cost over-runs if the extra benefits are greater than the extra costs, and will sue otherwise. We write the pay and complete the project condition as

$$V\frac{\Delta}{D} \geq c_i\Delta \Longleftrightarrow V \geq c_iD$$

which is equivalent to an efficiency condition. In other words, the government will pay the cost over-runs and complete the project when the project is efficient to build.

We can now express the profits for the government and for the contractor, and calculate total welfare depending on whether building the project is efficient or not. Since the government suing does not impose any additional costs on the contractor (if the government sues, the contract is simply terminated under *General Dynamics* without any further penalties), and the government paying for the cost over-runs does not bring additional benefits to the contractor (the government pays exactly the additional completion costs and nothing more), the profit for the contractor will be the same regardless of whether the government decides to sue or not: $\pi^C = b_i - c_i D_{stop}$. On the other hand, the government's profit depends on whether the project is stopped or completed. If the project is efficient, $\pi^G = V - b_i - c_i\Delta$, where Δ is the extra difficulty required to complete the project. In the inefficient case, $\pi^G = V\frac{D_{stop}}{D} - b_i$. By adding up the contractor's profit and the government's profit, we calculate total welfare under *General Dynamics*:

$$W^{GD} = \pi^C + \pi^G = \begin{cases} V - c_i D_{stop} - c_i\Delta = V - c_i D, \text{ if } V \geq c_i D \\ V\frac{D_{stop}}{D} - c_i D_{stop} = (V - c_i D)\frac{D_{stop}}{D}, \text{ if } V < c_i D. \end{cases}$$

Thus, as long as there exists at least one bid, SL is inferior to *General Dynamics* from a total welfare perspective. SL requires finishing the project at all costs, whether it is efficient or not. Therefore $W^{SL} = V - c_i D$, which is the same with W^{GD} in the efficient case, but strictly lower in the inefficient case. Again, SL would be preferred only in the improbable case when it is inefficient to build and there is no winning bidder. We only focus on the case when the project is not completed by the contractor. The case where the contractor completes the project before reaching its stopping point does not involve litigation and, therefore, yields the same welfare under either SL or *General Dynamics*. However, we show below that the bids are such that there is no project completion in equilibrium.

To study the optimal bidding strategy under *General Dynamics* we need to consider the stopping points and expected profits for different bids. We have already seen that any winning bid $b_i \leq c_i(D_1 + \frac{V}{2})$ implies $D_{stop} = D_1$ and hence the contractor's expected profit if she wins the auction equals $\pi^C = b_i - c_i D_1$. On the other hand, if the winning bid $b_i > c_i(D_1 + \frac{V}{2})$, then the building continues past difficulty point D_1, until the project is either completed, or the stopping point $D_{stop} = \frac{2b_i}{c_i} - (D_1 + V)$ is reached. Therefore, project completion is only possible if the bids exceed the level $c_i(D_1 + \frac{V}{2})$.

But is this possible in equilibrium? To see that it is not, consider the expected contractor profits under this scenario. For any such bid that exceeds the threshold, there is a stopping point, D_{stop}. With probability $\frac{D_{stop}-D_1}{V}$ the completion point will be reached before reaching the stoppage point, in which case the contractor will earn $b_i - c_i E(D|D_1 < D < D_{stop})$. On the other hand, if the true difficulty is greater than D_{stop}, which occurs with probability $\frac{V-D_{stop}+D_1}{V}$, the contractor will earn $b_i - c_i D_{stop}$. Therefore, each contractor will choose a bid to maximize her expected profit:

$$\max_{b_i} \pi_i = P(winning) \cdot [(\frac{D_{stop}-D_1}{V})(b_i - c_i E(D|D_1 < D < D_{stop})+$$

$$+(\frac{V-D_{stop}+D_1}{V})(b_i - c_i D_{stop})].$$

Since $D_{stop} = \frac{2b_i}{c_i} - (D_1+V)$, the expected profit from winning the auction can be rewritten as:

$$E(\pi) = (\frac{D_{stop}-D_1}{V})(\frac{c_i V}{2}) + (\frac{V-D_{stop}+D_1}{V})[c_i(D_1+V)-b_i] =$$

$$= (\frac{2b_i}{c_i V} - \frac{2D_1}{V} - 1)(\frac{c_i V}{2}) + (2 + \frac{2D_1}{V} - \frac{2b_i}{c_i V})[c_i(D_1+V)-b_i].$$

This expression is a quadratic convex function of b_i and, hence, by lowering her bid, each bidder can increase her expected profit and at the same time increase the probability of winning the auction. Very high bids, on the increasing portion of the quadratic function, that could in principle yield higher expected profits, cannot be equilibria since bidders with higher costs can deviate to a lower bid where they could win the auction. Therefore, there cannot be any equilibrium in bidding with bids $b_i > c_i(D_1 + \frac{V}{2})$. Thus, equilibrium bidding implies no production past the D_1 difficulty level and bids that maximize the following:

$$\max_{b_i} \pi^C = P(winning) \cdot (b_i - c_i D_1).$$

This is almost identical to the result in the base model, with the only difference being that instead of having a total cost c_i for the common knowledge part of the project, we now have a marginal cost c_i and a total cost $c_i D_1$ for the common knowledge difficulty level. Following the same procedure, we obtain the optimal bidding function:

$$B_i(c_i) = D_1[c_i + \frac{\int_{c_i}^{\frac{V}{D_1}} [1-F(x)]^{N-1} dx}{[1-F(c_i)]^{N-1}}].$$

In the base model, we assumed the contractor will produce a fraction proportional to the ratio of individual (ex ante known) cost to total (ex ante unknown) cost. In the alternative model with continuous production, we have shown that the winning contractor will bid such that she will produce a fraction of the total project equal to the ratio of the known difficulty component and the unknown true difficulty of the project. Thus, our results are robust to these two winning bidder production models.

8 Conclusions

We have analyzed the welfare implications of three different sets of evidentiary and liability rules in contractual disputes with private information. Information asymmetries distort incentives and create inefficiencies. When contracts are affected by asymmetric information, conflicts develop between parties and litigation is often the only way to resolve such contractual disputes. Therefore, when contracting parties are aware of the presence of private information, they anticipate future conflicts and litigation, and contracting terms are directly influenced by the applicable legal rules. In a contracting auction setting, we studied the effects of a strict liability (SL) rule; an evidentiary rule that allows the contractor to build a case around the withholding of private cost information by the buyer (the DPI rule); and the *General Dynamics* rule. We showed that, as long as there is at least one bid, *General Dynamics* yields higher efficiency than both the SL and DPI rules. We found this result to be robust to two different ways of modeling the winning bidder's production process.

In addition, *General Dynamics* creates efficient incentives for both the buyer and the contractor. It gives the buyer the incentive to reveal his private information to contractors before the bidding starts, and it gives contractors the incentive to lower their bids considerably. In contrast, SL gives the buyer the incentive to hide his private information and deceive the contractors. In return, contractors severely overbid in order to insure themselves against future losses, which results in large efficiency losses.

Our model's main qualitative implications could be extended to other types of auctions affected by asymmetric information. Intuitively, a SL rule would incentivize individuals who possess private information to hide it and free ride on their contracting counterparts who in turn will seek to avoid future losses by adjusting their bids accordingly. *General Dynamics*, on the other hand, induces individuals who possess private information to make it public and, hence, corrects the inefficiency problem. Exactly how the courts will rule is not known at the time of contracting. However, legal precedents are extremely important in determining agents' expectations with regard to future litigation, and our model shows that the Supreme Court's ruling in *General Dynamics* set an economically efficient precedent for similar future contractual disputes.

Appendix A: A Brief History of *General Dynamics v. U.S.*

Within weeks of terminating the contract for default, the Navy concluded that it had provided progress payments for work that was never performed. The Navy then sent the contractors a letter demanding that the contractors repay the Government approximately $1.35 billion. Both parties then entered into a deferred payment agreement for this amount. However, the contractors later filed suit in the Court of Federal Claims (CFC) in order to challenge the termination decision under the Contract Disputes Act of 1978. The contractors claimed that their failure to complete the project, resulting in contract default, was excusable due to the fact that the Government failed to present the contractors with its "superior knowledge" about how to design and manufacture stealth aircraft, which the Government had agreed to provide. Pursuant to *GAF Corp. v. United States* (1991), the Federal Circuit has recognized that the government has an obligation "not to mislead contractors about, or silently withhold, its 'superior knowledge' of difficult-to-discover information 'vital' to contractual performance."[4] Furthermore, the contractors requested that the termination for default be converted to a termination for convenience, a much less attractive outcome for the Government (Schwinn, 2011).

Major problems began to arise when the difficulty of determining the extent to which the Government had prior experience with stealth technology became apparent, as all information pertaining to the design, materials, and manufacturing process of previously developed B-2 and F-117A stealth aircraft are closely guarded military secrets. Despite this, the Government allowed ten members of the contractor's litigation team "access to the Secret/Special Access level of the B-2 and F-117A programs," four of which were also given access to the most sensitive details of the programs.[5] But in

[4]General Dynamics Corp. v. United States, 563 U.S. 2 (2011).

[5]General Dynamics Corp. v. United States, 563 U.S. 3 (2011).

March of 1993, the Acting Secretary of the Air Force asserted the state-secrets privilege in order to prevent discovery into certain details of stealth technology that were not considered part of the contractor's "need-to-know" authorizations. There were two depositions of military officials in which military secrets were revealed during questioning that neither side's litigation team was authorized to know, and copies of one unclassified deposition were widely distributed in unsealed court filings. Such actions led the Acting Secretary of the Air Force to file a declaration with the CFC alleging that any further discovery into the breadth of the Government's superior knowledge would present a serious risk of the divulgence of military and state secrets, and that even presumably harmless questions would create unacceptable risks of disclosure of classified and special access information.[6]

The state secrets doctrine provides that the United States Government can withhold certain information in a judicial proceeding given that disclosing such information would pose a "reasonable danger to national security" (Capra, 2011). Prominent cases regarding state secrets are *United States v. Reynolds*, *Totten v. United States*, and *Tenet v. Doe*.

The CFC terminated discovery with regards to superior knowledge and later determined that the extent of the Government's superior knowledge was a non-justiciable question. Although the CFC found that both sides had adequate evidence to argue their case effectively, the CFC was concerned that "with numerous layers of potentially dispositive facts," convoluted by the superior-knowledge privilege, any ruling would be a sham, and a potential threat to national security.[7]

In 1996, the CFC converted the termination for default to one of convenience, much to the despair of the Government, and awarded petitioners $1.2 billion. This decision was then reversed by the Federal Circuit, leaving the CFC to revisit, on remand, the decision of whether discovery into the superior-knowledge issue was precluded by the necessity of guarding military secrets. The CFC sustained the default termination, once again confirming

[6]General Dynamics Corp. v. United States, 563 U.S. 3 (2011).

[7]General Dynamics Corp. v. United States, 563 U.S. 4 (2011).

that the issue of whether the Government's superior knowledge excused the petitioners' default could not be safely litigated. The Court of Appeals then reversed the default termination, but confirmed that the state-secrets privilege precluded the courts from deciding whether the Government's superior knowledge exonerated the petitioners from default. However the Court of Appeals, pursuant to *United States v. Reynolds*, rejected the petitioner's argument that the Government should not be allowed to issue a claim against a party if it is going to use the state-secrets privilege to trump any defenses to that claim. The CFC then, once again on remand, found that the petitioners had defaulted. The Court of Appeals affirmed and finally, the Supreme Court granted certiorari to evaluate the state-secrets holding.[8]

The Supreme Court held that the terminology of the A-12 agreement restricted the Court from converting the termination to one for convenience and reinstating the CFC's $1.2 billion dollar damages award. Pursuant to the agreement, the Court could only convert a termination for default into one for convenience if it "determine[d] that the Contractor was not in default, or that the default was excusable," and the Court found these issues to be non-justiciable.[9] Further, a termination for convenience generally allows the contractor the right to recover its incurred costs of performance, reasonable termination expenses, and a reasonable profit for the work performed. Such damages would be impossible to calculate without establishing how much of the petitioner's cost overruns were contributable to the failure of the Government to share its superior knowledge. Without evidence of the existence and extent of the superior knowledge, the $1.2 billion award might be an unwarranted consequence.[10]

The Government had requested that the $1.35 billion that it had paid the petitioners in progress payments be returned, as it stated those payments were for work that had never been performed. The Supreme Court held that due to the assertion of the state-secrets privilege, it was impossible to rule

[8] General Dynamics Corp. v. United States, 563 U.S. 4 (2011).

[9] General Dynamics Corp. v. United States, 563 U.S. 11 (2011).

[10] General Dynamics Corp. v. United States, 563 U.S. 11 (2011).

on whether or not the petitioners had indeed been compensated for work that was not performed and subsequently defaulted on the contract. The issue was non-justiciable.[11]

The Supreme Court ultimately decided to leave both parties where they were, that is to let the petitioners keep the $1.35 billion they had received in progress payments and to forgo the $1.2 billion award requested by the petitioners. The Court held that both parties must have been aware of the fact that state secrets would prevent the resolution of many contractual disputes in court, and that this was a risk both parties understood when they entered into the contract. It was the opinion of the Court that the greatest impact of this ruling would be to clarify the law with regard to like matters, leaving future contractors better fit to predict and accommodate outcomes and make more informed contractual decisions.[12]

[11] General Dynamics Corp. v. United States, 563 U.S. 11 (2011).

[12] General Dynamics Corp. v. United States, 563 U.S. 12 (2011).

Appendix B

Derivation of the optimal bid under *General Dynamics*

Under *General Dynamics*, bidder i maximizes his expected profit:

$$\max_{b_i} \pi_i = [P(winning)](b_i - c_i).$$

Probability of winning for bidder i is the probability that his bid $b_i = B(c_i)$ is smaller than all other bids. Since there are N-1 other bidders and all bids are increasing in cost, then

$$P(winning) = \prod_{c_j \neq c_i} P(c_j > c_i) = [1 - F(c_i)]^{N-1} = [1 - F(B^{-1}(b_i)]^{N-1}$$

where $B^{-1}(b_i)$ is the inverse bid function and F is the cdf from which individual costs are drawn. Given that in equilibrium all bids are symmetric we obtain the necessary condition for bids to be optimal:

$$[1 - F(c_i)]^{N-1} + (N-1)[1 - F(c_i)]^{N-2}(-f(c_i))\frac{1}{B'(c_i)}(b_i - c_i) = 0 \Rightarrow$$

$$\Rightarrow B'(c_i)[1-F(c_i)]^{N-1} + B(c_i)(N-1)[1-F(c_i)]^{N-2}(-f(c_i)) = c_i(N-1)[1-F(c_i)]^{N-2}(-f(c_i)).$$

Let $G(c_i) = [1 - F(c_i)]^{N-1}$. Then we can rewrite the necessary condition as:

$$B'(c_i)G(c_i) + B(c_i)G'(c_i) = c_i G'(c_i).$$

We can now solve for the optimal bidding function $B(c_i)$ by integrating the above equation with the boundary condition $B(V) = V$. That means that a bidder with individual cost equal to V makes zero profit. By integrating we obtain:

$$B_i(c_i) = c_i + \frac{\int_{c_i}^{V} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} + \frac{K}{[1 - F(c_i)]^{N-1}}.$$

The boundary condition $B(V) = V$ implies $K = 0$ and hence we get the optimal bidding function:

$$B_i(c_i) = c_i + \frac{\int_{c_i}^{V} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}}.$$

The boundary condition makes sense since for a bidder with individual cost $c_i = V$, bidding $b_i = V$ and making zero profits weakly dominates any other bid. Bidding higher than V will result in the bid being rejected by the government since it is more expensive than the valuation for the project and bidding less than V will result in negative profits.

Derivation of the optimal bid under strict liability

Under SL, bidder i maximizes his expected profit:

$$\max_{b_i} \pi_i = [P(winning)](b_i - c_i - E(x)) = [P(winning)](b_i - c_i - \frac{V}{2})$$

since x is uniformly distributed on the interval $[0, V]$.

Using the same expression for the probability of winning and the result that in equilibrium bids are symmetric we can again write the necessary condition for an optimal bid:

$$B'(c_i)[1-F(c_i)]^{N-1} + B(c_i)(N-1)[1-F(c_i)]^{N-2}(-f(c_i)) = (c_i + \frac{V}{2})(N-1)[1-F(c_i)]^{N-2}(-f(c_i))$$

which by using the same notation $G(c_i) = [1 - F(c_i)]^{N-1}$ we can rewrite as:

$$B'(c_i)G(c_i) + B(c_i)G'(c_i) = (c_i + \frac{V}{2})G'(c_i).$$

We solve for $B(c_i)$ by integrating which yields:

$$B(c_i) = c_i + \frac{V}{2} + \frac{\int_{c_i}^{V} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} + \frac{K}{[1 - F(c_i)]^{N-1}}.$$

To find K we use a different boundary condition this time, $B(\frac{V}{2}) = V$. Since bidders have to insure themselves for potential losses they increase their bid by the expected value of the random cost. Bidders with individual costs higher than $\frac{V}{2}$ won't participate since their bids will exceed the government valuation and hence the highest cost bidder able to participate is the bidder with cost $\frac{V}{2}$. His profit will be zero by the same argument made before. Using this boundary condition gives:

$$B(\frac{V}{2}) = \frac{V}{2} + \frac{V}{2} + \frac{\int_{\frac{V}{2}}^{V}[1-F(x)]^{N-1}dx}{[1-F(c_i)]^{N-1}} + \frac{K}{[1-F(c_i)]^{N-1}} = V \Rightarrow$$

$$\Rightarrow K = -\int_{\frac{V}{2}}^{V}[1-F(x)]^{N-1}dx.$$

Plugging back into the bidding function we get:

$$B(c_i) = c_i + \frac{V}{2} + \frac{\int_{c_i}^{\frac{V}{2}}[1-F(x)]^{N-1}dx}{[1-F(c_i)]^{N-1}}.$$

Derivation of the optimal bid under disclosure of buyer's private cost information

Bidder i chooses his bidding strategy to maximize his expected profit:

$$\max_{b_i} \pi_i = [P(winning)][P(x > \overline{X})(b_i - c_i) + P(x < \overline{X})(b_i - c_i - E(x|x < \overline{X})].$$

As before, we look for a symmetric equilibrium. The probability of winning is just like before and we use the properties of the uniform distribution to write expressions for the other probabilities in the profit function and for the conditional expectation. We obtain the following necessary condition for the bids to be optimal:

$$[1-F(c_i)]^{N-1} + (N-1)[1-F(c_i)]^{N-2}(-f(c_i))\frac{1}{B'(c_i)}[B(c_i) - c_i - \frac{\overline{X}^2}{2V}] = 0.$$

Again we use the notation $G(c_i) = [1-F(c_i)]^{N-1}$ and by rearranging we can rewrite the necessary condition as:

$$G(c_i)B'(c_i) + G'(c_i)B(c_i) = G'(c_i)(c_i + \frac{\overline{X}^2}{2V}).$$

We solve the differential equation by integrating which results in:

$$B(c_i) = c_i + \frac{\overline{X}^2}{2V} + \frac{\int_{c_i}^{V} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} + \frac{K}{[1 - F(c_i)]^{N-1}}.$$

Observe that compared to the strict liability case, this is somehow similar only the size of the overbid "insurance" is different since bidders only need to insure themselves for a particular situation and not for every possible situation. Hence we use a similar argument to determine the boundary condition $B(V - \frac{\overline{X}^2}{2V}) = V$. A bidder with such an individual cost has no incentive to bid higher since that would make his bid higher than the government valuation and hence not accepted and he would also not be able to bid less than V since that would result in negative expected payoffs. Using this boundary condition implies $K = -\int_{V-\frac{\overline{X}^2}{2V}}^{V} [1 - F(x)]^{N-1} dx$ which results in the optimal bidding function:

$$B(c_i) = c_i + + \frac{\overline{X}^2}{2V} + \frac{\int_{c_i}^{V-\frac{\overline{X}^2}{2V}} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}}.$$

References

[1] Bruguet R., Ganuza, J., and Hauk, E. (2009), "Limited Liability and Mechanism Design in Procurement," available at http://handle.digital.csic.es/bitstream/10261/14421/1/76709.pdf.

[2] Capra, Daniel J. (2011), "The Philip D. Reed Lecture Series: Panel Discussion: The State Secrets Privilege and Access to Justice: What is the Proper Balance?" Fordham Law Review, Vol. 80, pp. 1-27.

[3] Chillemi, O. and Mezzetti, C. (2009), "Procurement Under Default Risk: Auctions or Lotteries?," available at https://agenda.unibocconi.it/eventi/attach/abstract20110725125429.pdf.

[4] Eisenberg, M. (1982), "The Bargain Principle and its Limits," Harvard Law Review, Vol. 95, No. 4, pp. 741-801.

[5] Eisenberg, M. (1995), "The Limits of Cognition and the Limits of Contract," Stanford Law Review, Vol. 47, No. 2, pp. 211-259.

[6] Frost, A. (2007), "The State Secrets Privilege and Separation of Powers." Fordham Law Review, Vol. 75, pp. 1931-1964.

[7] General Dynamics Corp. v. United States, 563 U.S. 2 (2011).

[8] General Dynamics Corp. v. United States, 563 U.S. 2 (2011), Oral Argument.

[9] Hermalin, B., Katz, A., Craswell, R. (2007), "Contract Law," in Handbook of Law and Economics, Amsterdam, The Netherlands, Elsevier B.V.

[10] Maskin, E and Tirole, J, (1990) "The Principal-Agent Relationship with an Informed Principal: The Case of Private Values." Econometrica Vol. 58, pp. 379-409.

[11] Posner, R. (2005), "The Law and Economics of Contract Interpretation," University of Texas Law Review, pp. 1581-1614.

[12] Posner, R. and Rosenfield, A, (1977) "Impossibility and Related Doctrines in Contract law: An Economic Analysis," Journal of Legal Studies, Vol. 6, No. 1, pp. 83-118.

[13] Schwartz, A. and Scott, R. (2003), "Contract Theory and the Limits of Contract Law," Yale Law Journal, Vol. 113, pp. 541-619.

[14] Schwinn, Steven D. (2011), "Can the Government Prevail on a Claim That a Contractor Defaulted on a Government Contract Even When the Government Invokes the State Secrets Privilege to Protect Material Needed by the Contractor to Rebut That Claim?," Preview of United States Supreme Court Cases, pp. 152-155.

[15] Shavell, S. (2005), "Specific Performance versus Damages for Breach of Contract," Harvard Law School Discussion Paper, 2005.

[16] Spulber, D. (1990), "Auctions and Contract Enforcement," Journal of Law, Economics and Organization, vol. 6, pp. 325-344.

[17] Waehrer, K. (1995), "A Model of Auction Contracts with Liquidated Damages," Journal of Economic Theory, vol. 67, pp. 531-555.

[18] Zheng, C. (2001), "High Bids and Broke Winners," Journal Economic Theory, vol. 100, pp. 129-171.