Received: 7 August 2017 | Accepted: 8 October 2017
DOI: 10.1111/jpet.12279

WILEY JOURNAL OF PUBLIC ECONOMIC THEORY

ARTICLE

Rules of evidence and liability in contract litigation: The efficiency of the *General Dynamics* rule

Vlad Radoias[1] | **Simon J. Wilkie**[2] | **Michael A. Williams**[3]

[1]Sam Houston State University
[2]University of Southern California and Microsoft
[3]Competition Economics LLC

Vlad Radoias, Department of Economics and International Business, Sam Houston State University, Box 2118, Huntsville, TX 77341, USA (radoias@shsu.edu).

Simon J. Wilkie, Department of Economics, University of Southern California, 3620 South Vermont Avenue, KAP300, Los Angeles, CA 90089, USA (swilkie@usc.edu).

Michael A. Williams, Competition Economics LLC, 2000 Powell Street, Suite 510, Emeryville, CA 94608, USA (mwilliams@c-econ.com).

We thank Brijesh Pinto, three anonymous referees, and the editors for helpful comments. We also thank William Havens, David Park, and Lara Yang for research assistance.

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, for example, 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.

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 because 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 countersued the United States 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, 2005; Posner & Rosenfield, 1977). 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 online Appendix A for a detailed history of the litigation.)

After 20 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).

Although the Supreme Court's decision was primarily the result of the matter being nonjusticiable 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 (SL) 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, & Craswell, 2007, for a recent literature review), which includes theories of contract efficiency and efficient default rules (Schwartz & Scott, 2003). A substantial literature also exists that examines the trade-off in first-price auctions between price and contractual performance; see, for example, 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, for example, Eisenberg (1982, 1995), Posner (2005), and Shavell (2005). Several papers within this literature study optimal mechanism design when bidders can default; see, for example, Bruguet, Ganuza, and Hauk (2012) and Chillemi and Mezzetti (2014). There is also a significant literature on optimal contract design by an informed principal (e.g., Maskin & 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 SL 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 SL rule or an evidentiary rule requiring disclosure of the buyer's private information. In a somewhat related paper dealing with tort law, Chakravarty and Kelsey (2016) also find SL to be inefficient in situations that involve ambiguous risks.

2 | THE MODEL

There are $N \geq 2$ contractors who bid to undertake a government project. The government's valuation of a completed share $q \in [0, 1]$ of the project is qV (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 the execution of the project, the winning bidder finds out the true value of the random cost X (denoted by x) and completes a part of the project, q. 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 $q = \frac{c_i}{c_i+x}$. The cost for the winning bidder to deliver this fraction q of the project is therefore 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 X), produces and delivers a part of the final project, $q = \frac{c_i}{c_i+x}$, from which the government infers the true value of the winning bidder's cost c_i.

Step 5. The government decides whether to sue the contractor for damages or to 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

[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 a 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 to complete the project, which is what this assumption ensures. Menezes and Ryan (2015) model situations where bidders can use the threat of default to extort the government, but their model is more applicable to situations where the contractors have outside contract options. This is usually not the case with military contractors.

[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 an SL 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.

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.

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 to 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:

$$\begin{cases} \pi_G^{Sue} = qV - b_i, & \text{if the government sues} \\ \pi_G^{Pay} = V - b_i - x, & \text{if the government pays the cost overruns and the project is completed,} \end{cases}$$

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

The government knows 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:

$$\begin{cases} \text{Pay} & \text{if } V \geq c_i + x \\ \text{Sue} & \text{if } V < c_i + x. \end{cases}$$

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 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 $b_i = B(c_i)$, and the bidder with the lowest bid is awarded the contract. Because 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 online Appendix B):

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

[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* rule, 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 because they are the direct result of its own secret information.

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

$$B(c_i) = c_i + \frac{V - c_i}{N}. \tag{2}$$

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

$$\begin{cases} \pi_C = \frac{V-\underline{c}}{N} \\ \pi_G = \begin{cases} V - \underline{c} - x - \frac{V-\underline{c}}{N} & \text{when } V \geq \underline{c} + x \\ qV - \underline{c} - \frac{V-\underline{c}}{N} & \text{when } V < \underline{c} + x, \end{cases} \end{cases} \tag{3}$$

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

$$\pi_G = V - b_i, \tag{4}$$

while the winning bidder's expected profit will be

$$\pi_C = b_i - c_i - E(X). \tag{5}$$

Because 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

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

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

$$B(c_i) = c_i + \frac{\int_{c_i}^{\frac{V}{2}} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} + \frac{V}{2}. \tag{6}$$

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. Because 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

$$B(c_i) = c_i + \frac{V - c_i}{N} + \frac{V}{2} - \frac{V^N}{N2^N(V - c_i)^{N-1}}, \quad \text{if } c_i < \frac{V}{2}, \tag{7}$$

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

$$\begin{cases} \pi_C = \frac{V-\underline{c}}{N} + \frac{V}{2} - \frac{V^N}{N2^N(V-\underline{c})^{N-1}} - x \\ \pi_G = \frac{V}{2} - \underline{c} - \frac{V-\underline{c}}{N} + \frac{V^N}{N2^N(V-\underline{c})^{N-1}}, \end{cases} \tag{8}$$

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, W, as the sum of the government's and contractor's profits. That is,

$$W = \pi_G + \pi_C. \tag{9}$$

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

$$W^{SL} = V - \underline{c} - x. \tag{10}$$

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

$$\begin{cases} W_E^{GD} = V - \underline{c} - x & \text{if } V \geq \underline{c} + x \\ W_{NE}^{GD} = qV - \underline{c} & \text{if } V < \underline{c} + x, \end{cases} \tag{11}$$

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. More precisely, for N bidders with uniformly distributed costs, the probability that no cost falls below $\frac{V}{2}$ is $\frac{1}{2^N}$, which gets very small when the number of bidders increases.

We ran simulations for the case of the uniform distribution to test the efficiency superiority of the GD rule. For the case with 10 bidders ($N = 10$), we only found 6 out of 10,000 draws where SL performed better, and 901 draws where GD performed better. The remainder of the draws yielded equal welfare under both rules. For the case with five bidders ($N = 5$), SL performed better in 180 draws out of 10,000, while GD performed better in 1,615 draws. Finally, even with only two bidders, SL performed better in only 1,640 draws, while GD performed better in 2,476 draws. For all cases, the expected value of the welfare gains under GD was positive.

6 | ROBUSTNESS TO ALTERNATIVE SPECIFICATIONS

In this section, we analyze the implications of certain alternative specifications regarding progress payments and early stopping rules that could change the outcomes of the *General Dynamics* rule. We will then compare with SL to see if the efficiency implications still hold.

First, suppose that the contractor uses a "less than fair-play" stopping rule. That is, instead of stopping after producing $q = \frac{c_i}{c_i + x}$, the contractor stops at some αq, with $0 \leq \alpha \leq 1$. Note that it is never optimal under GD for the contractor to spend more than its cost. In fact, optimally, the contractor should stop working immediately after discovering the presence of extra costs, which at the latest will occur once the contractor spends c_i without finishing the project. Hence, α cannot be higher than 1. Also note that stopping earlier (and incurring a cost lower than c_i) implies that the optimal bid will decrease, but because bids are transfer payments they do not affect the efficiency discussion. Under early stopping, the government's profits are

$$\begin{cases} \pi_G^{Sue} = \alpha qV - b_i, & \text{if the government sues} \\ \pi_G^{Pay} = V - b_i - x, & \text{if the government pays the cost overruns and finishes the project.} \end{cases}$$

Therefore, the government will sue and effectively stop the project when $V + \frac{c_i V(1-\alpha)}{x} < c_i + x$, which compared to the "fair-play" stopping when $\alpha = 1$ implies that the government stops less often and some inefficient projects are actually completed. This does not mean however, that GD is less efficient than SL. GD and SL result in the same amount of welfare as long as the projects are completed. When the project is stopped under GD, the resulting welfare will be $W^{GD} = \alpha(qV - \underline{c})$, which represents a smaller loss than either $W^{SL} = V - \underline{c} - x$ or the loss under the fair-play stopping when $\alpha = 1$. Hence, the conclusion that GD is more efficient than SL as long as there is at least one bid under SL still holds under early stopping assumptions.

Regarding the possibility of progress payment, assume the government only pays a portion of the winning bid up front after which the contractor executes a portion of the project before stopping. Formally, let αb_i be the progress payment paid by the government and βq be the finished portion of the project executed by the contractor before stopping. It is never optimal for the contractor to spend more than the progress payments before litigating so $0 \le \alpha \le 1$ and $0 \le \beta \le \frac{\alpha b_i}{c_i}$. Under these assumptions, the government's profits are:

$$\begin{cases} \pi_G^{Sue} = \beta qV - \alpha b_i, & \text{if the government sues} \\ \pi_G^{Pay} = V - b_i - x, & \text{if the government pays the cost overruns and finishes the project.} \end{cases}$$

The government will sue and effectively stop the project if $\beta qV - \alpha b_i \ge V - b_i - x$, which occurs less frequently than stopping with full bid payment and "fair-play" stopping. Note that compared to the base case, bids are smaller here (the contractor only pays its full cost if the project is completed), and so it results in a stronger constraint. (The right-hand side increases by Δb_i, while the left-hand side increases by only $\alpha \Delta b_i$ and decreases by $(1 - \beta)qV$.) Efficiency-wise, this means that some inefficient project will be completed, in which case GD and SL result in the same welfare. For the inefficient projects that are stopped short, however, GD results in $W^{GD} = \beta(qV - \underline{c})$, which is a smaller loss than under both SL and the base scenario with full payment.

Therefore, the base result that the *General Dynamics* ruling ensures more efficient outcomes than the SL ruling is robust to both (1) the presence or absence of progress payments and (2) different stopping rules. These alternative payment and stopping scenarios improve overall efficiency in some cases by limiting the losses of inefficient projects to only a fraction of what full payment and production would create. On the other hand, they also allow some inefficient projects to be finished (thus increasing the loss) by sinking too much of the government payments relative to whatever is being delivered by the contractor before litigation.

7 | 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 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, $x \ge \bar{x}$, then the *General Dynamics* rules apply. If, however, the secret cost falls below the threshold, $x < \bar{x}$, 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 under way, the contractor delivers $q = \frac{c_i}{c_i + x}$, and then the government decides whether to sue or cover the cost overruns. The government will always sue when $x < \bar{x}$, in which case the profits will equal $\pi_G = V - b_i$ and $\pi_C = b_i - c_i - x$.

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

$$\pi_C = b_i - c_i \tag{12}$$

whereas the government's profit equals

$$\begin{cases} \pi_G^{Sue} = qV - b_i \\ \pi_G^{Pay} = V - b_i - x. \end{cases} \tag{13}$$

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

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

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

$$B(c_i) = c_i + \frac{\int_{c_i}^{V - \frac{\bar{x}^2}{2V}} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} + \frac{\bar{x}^2}{2V}. \tag{14}$$

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 $\frac{\bar{x}^2}{2V}$, 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 $c_i > V - \frac{\bar{x}^2}{2V}$ 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

$$B(c_i) = c_i + \frac{V - c_i}{N} + \frac{\bar{x}^2}{2V} - \frac{\bar{x}^{2N}}{N 2^N V^N (V - c_i)^{N-1}}, \quad \text{if } c_i < V - \frac{\bar{x}^2}{2V}. \tag{15}$$

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

$$\pi_G + \pi_C = \begin{cases} V - \underline{c} - x, & \text{if } x < \bar{x} \text{ (no matter if efficient or not)} \\ V - \underline{c} - x, & \text{if } x \geq \bar{x} \text{ and } V - \underline{c} - x \geq 0 \\ qV - \underline{c}, & \text{if } x \geq \bar{x} \text{ and } V - \underline{c} - x < 0. \end{cases} \tag{16}$$

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. However, admitting the secret as a defense yields lower welfare than the *General Dynamics* rule when (1) the secret cost falls below the court's threshold and (2) the project is inefficient to complete. 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 costs low enough 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.

8 | 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 SL for this portion of the project in order to avoid "weird bidding." Not imposing SL 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 $D_{stop} = \frac{2b_i}{c_i} - (D_1 + V)$. Because we assume SL for the D_1 portion of the project, D_{stop} has to be greater or equal to D_1. Thus, for any bid $b_i \le \frac{c_i(2D_1+V)}{2}$ the stopping point will be D_1. Summarizing,

$$D_{stop} = \begin{cases} D_1, & \text{if } b_i \le \frac{c_i(2D_1+V)}{2} \\ \frac{2b_i}{c_i} - (D_1 + V), & \text{if } b_i > \frac{c_i(2D_1+V)}{2}. \end{cases} \tag{17}$$

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. Thus, the condition under which the government will pay the contractor to complete the project is as follows:

$$V\frac{\Delta}{D} \ge c_i\Delta \iff V \ge c_i D, \tag{18}$$

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. Because 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*:

$$W^{GD} = \pi_C + \pi_G = \begin{cases} V - c_i D_{stop} - c_i\Delta = V - c_i D, & \text{if } V \geq c_i D \\ V\frac{D_{stop}}{D} - c_i D_{stop} = (V - c_i D)\frac{D_{stop}}{D}, & \text{if } V < c_i D. \end{cases} \tag{19}$$

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*. 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:

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

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

$$\begin{aligned} E(\pi) &= \left(\frac{D_{stop} - D_1}{V}\right)\left(\frac{c_i V}{2}\right) + \left(\frac{V - D_{stop} + D_1}{V}\right)[c_i(D_1 + V) - b_i] \\ &= \left(\frac{2b_i}{c_i V} - \frac{2D_1}{V} - 1\right)\left(\frac{c_i V}{2}\right) + \left(2 + \frac{2D_1}{V} - \frac{2b_i}{c_i V}\right)[c_i(D_1 + V) - b_i]. \end{aligned} \tag{20}$$

This expression is a quadratic convex function of b_i that is decreasing for $b_i < c_i(D_1 + \frac{3V}{4})$ and increasing for $b_i > c_i(D_1 + \frac{3V}{4})$. On the decreasing region of this profit function, bidders can always reduce their bids to achieve both higher profits and higher probabilities of winning the auction. Furthermore, for any bid on the increasing region such that $c_i(D_1 + \frac{3V}{4}) < b_i < c_i(D_1 + V)$, the bidder could achieve the same profit but a higher probability of winning by lowering his bid to the symmetric but decreasing region of the profit function, which again reduces the bids. Finally, very high bids on the increasing portion of the quadratic function, which correspond to higher profits, imply a stopping point larger than the highest possible difficulty of the project. Formally, if $b_i > c_i(D_1 + V)$, then $D_{stop} > D_1 + V$, which can never lead to litigation and any comparison between legal rules would not be applicable. Therefore, in order for litigation to be a possibility, there cannot be any equilibrium in bidding with bids $b_i > c_i(D_1 + \frac{V}{2})$, which 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

$$B(c_i) = D_1 \left[c_i + \frac{\int_{c_i}^{\frac{V}{D_1}} [1 - F(x)]^{N-1} dx}{[1 - F(c_i)]^{N-1}} \right]. \tag{21}$$

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 (1) the known difficulty component to (2) the unknown true difficulty of the project. Thus, our results are robust to these two winning bidder production models.

9 | 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, an 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.

ORCID

Vlad Radoias http://orcid.org/0000-0002-9099-9449

REFERENCES

Bruguet, R., Ganuza, J., & Hauk, E. (2012). Limited liability and mechanism design in procurement. *Games and Economic Behavior*, *76*, 15–25.

Capra, D. 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*, *80*, 1–27.

Chakravarty, S., & Kelsey, D. (2016). Ambiguity and accident law. *Journal of Public Economic Theory*, *19*, 97–120.

Chillemi, O., & Mezzetti, C. (2014). Optimal procurement mechanisms: Bidding on price and damages for breach. *Economic Theory*, *55*, 335–355.

Eisenberg, M. (1982). The bargain principle and its limits. *Harvard Law Review*, *95*, 741–801.

Eisenberg, M. (1995). The limits of cognition and the limits of contract. *Stanford Law Review*, *47*, 211–259.

Frost, A. (2007). The state secrets privilege and separation of powers. *Fordham Law Review*, *75*, 1931–1964.

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

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

Hermalin, B., Katz, A., & Craswell, R. (2007). Contract law. In A. M. Polinsky & S. Shavell (Eds.), *Handbook of law and economics* (pp. 3–138). Amsterdam, The Netherlands: Elsevier.

Maskin, E., & Tirole, J. (1990). The principal–agent relationship with an informed principal: The case of private values. *Econometrica*, *58*, 379–409.

Menezes, F., & Ryan, M. (2015). Default and renegotiation in public–private partnership auctions. *Journal of Public Economic Theory*, *17*, 49–77.

Posner, R. (2005). The law and economics of contract interpretation. *University of Texas Law Review*, *83*, 1581–1614.

Posner, R., & Rosenfield, A. (1977). Impossibility and related doctrines in contract law: An economic analysis. *Journal of Legal Studies*, *6*(1), 83–118.

Schwartz, A., & Scott, R. (2003). Contract theory and the limits of contract law. *Yale Law Journal*, *113*, 541–619.

Schwinn, S. 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*, *38*(4), 152–155.

Shavell, S. (2005). Specific performance versus damages for breach of contract. Harvard Law School Discussion Paper, 2005.

Spulber, D. (1990). Auctions and contract enforcement. *Journal of Law, Economics and Organization*, *6*, 325–344.

Waehrer, K. (1995). A model of auction contracts with liquidated damages. *Journal of Economic Theory*, *67*, 531–555.

Zheng, C. (2001). High bids and broke winners. *Journal of Economic Theory*, *100*, 129–171.

SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

How to cite this article: Radoias V, Wilkie SJ, Williams MA. Rules of evidence and liability in contract litigation: The efficiency of the *General Dynamics* rule. *J Public Econ Theory*. 2017;00:1–12. https://doi.org/10.1111/jpet.12279