

Specific investments, holdup, and the outside option principle *

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ABSTRACT. According to the outside option principle the holdup problem can be solved when the non-investor has a binding outside option. The investor then becomes residual claimant, creating efficient investment incentives. This paper reports about an experiment designed to test this. We find that when the outside option is binding investment levels fall short of the efficient level, but holdup is less of a problem than predicted when the outside option is non-binding.

JEL Codes: J41, J31, C91

Keywords: holdup problem, contractual solutions, outside option principle, experiments

* *Date*: This version October 2002. Helpful comments by Ken Binmore, Laurent Denant-Boemont, Edwin Leuven, Theo Offerman, Arno Riedl, two anonymous referees and the editor Klaus Schmidt are gratefully acknowledged. The usual disclaimer applies.

The authors are affiliated with the University of Amsterdam, Department of Economics, and the Tinbergen Institute. Sloof and Oosterbeek are also affiliated with NWO Priority Program "Scholar", and Sonnemans with CREED.

1. Introduction

When relationship-specific investments are non-contractible underinvestment may occur because of holdup (cf. Williamson, 1985). The theoretical literature proposes several contractual solutions to overcome this problem. A general theme underlying many of these solutions is the effective restructuring of the bargaining process under which future renegotiations of the original contract take place (cf. Aghion et al., 1990, 1994). The essence of this restructuring is that one party is made residual claimant of the surplus created by the investment. This party then has the proper incentives to invest.

A simple mechanism to make the investing party residual claimant is by structuring the post-investment bargaining situation such that the non-investing party has a binding outside option. In such cases the so-called *outside option principle* applies (cf. Binmore et al., 1989). According to this principle the outside option of the non-investor only acts as a *constraint* on the equilibrium division. The surplus up for renegotiation is divided equally,¹ unless this yields the non-investor less than his outside option. In the latter case he simply obtains the value of his binding outside option and the investor becomes residual claimant of the remaining surplus. Theory therefore predicts that the level of investment will increase when the outside option of the non-investor increases from a non-binding low level to a binding high level. Moreover, in the latter case the level of investment equals the efficient level. This paper reports about an experiment designed to test these predictions.²

Subjects in our experiment play an alternating-offer bargaining game that is preceded by an initial investment stage in which one of the two parties makes an investment. Only the non-investor has an outside option, which can either be low or high. Our experiment basically adds an investment stage to a bargaining game with outside options. Predictions regarding investment behavior are based on the premise that the bargaining stage results in the equilibrium outcomes. Experiments by Binmore et al. (1989, 1991) yield support that actual bargaining outcomes are by and large in line with the outside option principle. In particular, they observe that a player indeed obtains a significantly larger share when his outside option is binding than when it is not. Yet an increase in a non-binding outside option does not lead to a larger share. Given these results it is reasonable to expect that also the theoretical relationship between investment behavior and the outside option principle will appear in the lab. On the other hand, Hackett (1993) and Ellingsen and Johannesson (2000) find that sunk investment costs may have significant influence on bargaining behavior. This could interfere with the outside option principle.

The remainder of this paper is organized as follows. Section 2 presents the two-stage game that we study and derives the equilibrium predictions and hypotheses. Section 3 describes the experimental design. Results are discussed in Section 4. The final section summarizes our main findings.

¹ The equal split follows under the standard assumption that players have equal bargaining power.

² In this paper we analyze a game where only the non-investor has an outside option. In Sonnemans et al. (2001), we consider the case where only the investor has one. There the focus is on whether, in the context of the property rights theory of the firm, asset ownership strengthens investment incentives.

2. Theory

2.1 Basic setup of the model

We focus on a bilateral trade relationship between a (female) buyer and a (male) seller. Trade is restricted to one unit. Production costs are assumed to be fixed and are normalized at zero. Besides trading with the buyer, the seller has the outside option to trade his single unit outside the relationship at a competitive fixed price b . Before trade occurs the buyer can make an investment, thereby increasing her valuation of the product. The two-stage game we consider has the following setup:

1. *Investment stage.* The buyer makes a specific investment $I \in \{0, 1, 2, \dots, 80\}$. Investment costs equal $C(I) = I^2$ and are immediately borne by the buyer.
2. *Bargaining stage.* The buyer and the seller bargain over the division of the gross surplus $R(I) = V + v \cdot I = 10,000 + 100 \cdot I$ created by the investment. The parties have equal bargaining power. The outside option of the seller equals $b \in \{b_{\text{low}}, b_{\text{high}}\} = \{3000, 9000\}$.

Parameter $V = 10,000$ represents the buyer's basic valuation when trading with the seller, and $v = 100$ is the constant increment in the buyer's valuation of this trade with each unit of investment. The buyer's investment only affects the gross surplus $R(I)$ within the relationship and does not affect the seller's outside option b . This reflects that the investment is completely relationship-specific. The assumptions that $b < V \leq R(I)$ and that the outside option is competitively priced ensure that trade between the buyer and the seller is always efficient, irrespective of the level of investment. It immediately follows that the efficient level of investment equals $I^* = 50$.

2.2 Equilibrium behavior and hypotheses

Equilibrium predictions based on subgame perfection are summarized in Table 1. In the bargaining stage the buyer and the seller alternate in making offers about how to distribute the joint surplus $R(I)$. If one party makes an offer the other party can react in three different ways: accept the offer, disagree and formulate a counter-offer in the next round, or quit the bargaining by opting out. If an offer is accepted the parties receive payoffs according to the proposal. In case of disagreement both parties receive nothing during the round of disagreement. If one of the parties opts out, the buyer receives nothing and the seller obtains the outside option payoff. Parties then cannot return to the bargaining table.

In equilibrium agreement is reached immediately. For the equilibrium division the outside option principle applies. The gross surplus $R(I)$ is split evenly, unless such a division yields the seller less than his outside option. In the latter case he just obtains a share of the surplus equal to b , while the buyer gets the residual $R(I) - b$. In the words of Binmore et al. (1989), the equilibrium division equals the 'deal-me-out' solution (DMO).

Table 1. *Equilibrium predictions*

		b = 3000	b = 9000
Stage I	Investment	25	50
Stage II	Share buyer	$5,000+50 \times I$	$1,000+100 \times I$

Turning to investment incentives, we distinguish two relevant ranges for the outside option value b . First, b can be so low that it does not put a constraint on the equilibrium division. In that case the buyer only gets half of the marginal return on the investment made, and will therefore choose $I=25$. Second, b can be that high such that the outside option constraint is strictly binding and fully determines the equilibrium division. Then the buyer gets the full marginal return on her investment and thus is predicted to invest efficiently ($I=50$).³ When b equals 3000 the outside option is always non-binding. When b equals 9000 the outside option is always binding given the admissible range of investment levels. From the equilibrium predictions we derive three main hypotheses:

- H1 (Comparative statics) Investment levels are *increasing* in the seller's outside option b .
- H2 (Holdup) Holdup occurs when the seller's outside option is non-binding ($b=3000$), while there is no holdup when the outside option is binding ($b=9000$).
- H3 (Return on investment) The buyer receives the full return on her investment when the seller's outside option is binding ($b=9000$), and half of the return when this outside option is non-binding ($b=3000$).

3. Experimental design

We ran four sessions with 80 participants in total. These were held in September 2002. The two values of the outside option were considered within each session. The subject pool was the undergraduate student population of the University of Amsterdam. Most of them were students in economics. They earned on average Euro 28.68 in about two hours.⁴ In this section we briefly discuss the experimental setup.

Subjects played the two-stage game 20 times (periods). We employed a block structure of periods to control for learning effects and for order effects. The 20 periods were divided into 4 blocks of 5 periods each. Within each block the value of sellers' outside option were kept fixed. In two sessions we used a "low-high" ordering of blocks (3000-9000-3000-9000). In the other two sessions we employed a "high-low" ordering (9000-3000-9000-3000). Subjects were informed about the exact order of b 's they would face. By comparing different blocks with the same value of sellers' outside option, we can test for learning effects. By comparing the different orderings we can check for order effects.

³ There is also an in-between situation in which b is on the verge of becoming binding and constraining the equilibrium division. Here it holds for the equilibrium level of investment that the division of the surplus when the outside option is absent exactly matches this outside option ($\frac{1}{2}R(I)=b$). We do not consider this in-between case in the experiment.

⁴ The conversion rate was 1 Euro for 5000 experimental points.

Half of the subjects performed the role of buyer, the remaining half were assigned the role of seller. Each participant kept the same role during the whole session. To rule out reputational considerations buyers were in each period anonymously paired to a different seller, using a rotating scheme per block of 5 periods. Subjects were explicitly told that within a block, they could meet a specific other subject only once. Within a session we divided the subjects into two separate groups of 10 subjects. Matching of pairs only took place within these groups. We did this to generate two independent aggregate (group-level) observations per session. The experiment was computerized. Both the instructions and the experiment were phrased neutrally.⁵

We provided the subjects with an initial endowment. Buyers received 70,000 points (14 Euro) and sellers got 10,000 points (2 Euro). Endowments were used to provide buyers with some initial funds to invest in the first few periods. Moreover, asymmetric endowments were needed to equalize at least somewhat the unequal payoffs buyers and sellers obtain in the game. Initial endowments were chosen such that buyers and sellers theoretically would earn about the same.

The bargaining stage was framed as a multiple-pie alternating offer game in which one pie vanishes in each round of disagreement. The buyer always made the first offer, and thus could formulate the proposal in all odd rounds. Bargaining lasted for 10 rounds. The gross surplus $R(I)$ and the outside option b were spread evenly over these 10 rounds. Hence in each round a pie of size $R(I)/10$ was to be divided between the parties. As soon as agreement was reached all remaining pies, including the one of the current round, were divided according to the proposal agreed upon and the period ended. In case of disagreement both parties received nothing during the round of disagreement. If one of the parties opted out in round t , the buyer received nothing while the seller obtained a payoff of $(11-t)/10$ times his outside option. Opting out ended the bargaining stage (and thus the period).⁶

At the start of each period, the computer screens informed subjects about the value of seller's outside option pertaining to that period. Then the buyer was asked how much she wanted to add to the base round pie of 1000 ($=V/10$) points. Effectively, buyers chose the amount $10 \cdot I$ ($=v \cdot I/10$) at costs I^2 . The size of the actual round pies was then set at the sum of the base round pie and the amount added. Subsequently, the subjects bargained over the division of the 10 actual round pies as described above.

4. Results

We present the findings of the experiment as 5 results. The presentation is divided into a part on investment levels and a part on bargaining outcomes.⁷

⁵ A summary of the instructions is available at the first author's website: <http://www1.fee.uva.nl/scholar/mdw/sloof/>.

⁶ In Sloof (2000) it is shown that the subgame perfect equilibrium predictions for the multiple pie bargaining game employed here are equal to the equilibrium shares spelled out in Table 1.

⁷ We tested for order effects by comparing investment levels between the sessions in which outside options are ordered low-high (3000-9000-3000-9000) and the sessions in which outside options are ordered high-low (9000-3000-9000-3000). Tests were performed separately for the first and second time subjects were confronted with a particular outside option. Based on individual level data p -values are never below 0.05. Based on group level data p -values are never below 0.10. From this we conclude that there are no significant order effects. Consequently we pooled the data from the low-high and high-low sessions.

4.1 Investment levels

The first result concerns the comparative statics relationship between buyers' investment levels and the value of the sellers' outside option (Hypothesis 1).

RESULT 1. *Overall average investment levels are constant over different values of the sellers' outside option. When subjects are inexperienced investment levels decrease with the value of the outside option.*

Evidence for this result is obtained from Table 2. Each buyer makes 20 investment decisions, equally divided over the low and high values of b . For each value of b we thus can calculate individual mean investment levels based on 10 investment decisions. The overall observed mean over all investors is reported in the top panel (in the row denoted observed; the row "optimum" will be explained in Subsection 4.2). Statistical tests are based on the individual mean values of the buyers and on mean values within a matching group. (Recall that each session gives means for two independent groups, resulting in 8 independent group level observations in total.) Within a row we compare average investment levels from the same (groups of) buyers for different values of the outside option. When we consider all periods together (the top panel) we find that Wilcoxon signrank tests do not reject equality of the investment levels for different values of the outside option. This is true both at the individual level and at the group level.

Table 2. *Mean and "optimum" investment levels by level of outside option and part of session*

		Outside option=3000 (Predicted: 25)	Outside option=9000 (Predicted: 50)	p -values H_0 : invest($b=3000$) =invest($b=9000$)
All rounds	Observed	40.04	38.27	0.4006
	"optimum"	28.71 (5.48)	37.67 (2.30)	<i>0.4401</i>
Rounds 1-10	Observed	43.11	37.08	0.0308
	"optimum"	24.15 (13.07)	33.72 (2.50)	<i>0.0687</i>
Rounds 11-20	Observed	36.96	39.46	0.2735
	"optimum"	29.60 (5.11)	44.13 (2.92)	<i>0.2626</i>
p -values				
H_0 : Invest(rounds 1-10)= Invest(rounds 11-20)		0.0051	0.1750	
		<i>0.0117</i>	<i>0.3250</i>	

Remarks. p -values are based on signrank tests for matched pairs. The first p -value in a cell is based on individual level data, the second (in italics) on group level data.

To assess the importance of experience, the middle and bottom panels of Table 2 report the same statistics as the top panel, but now only for data from respectively the first half and second half of the experiment. For both outside option values, individual mean investment levels are then based on 5 investment decisions. These results indicate that during the first part of the experiment (when subjects

are inexperienced), mean investment levels are higher when the outside option is non-binding (3000) than when the outside option is binding (9000). For the individual level data we reject equality at the 5%-level; for the group level data we reject equality at the 10%-level. Once subjects have gained experience with the situation, this difference disappears. This is due to subjects lowering their investment levels when the outside option is low (compare the p -values in the lower left cell). For the high value of the outside option, gaining experience seems to play no role.

Our second result concerns the occurrence of holdup (Hypothesis 2). It follows from comparing the realized mean investment levels in Table 2 with the predicted levels.

RESULT 2. In all treatments there is holdup: average investment levels are always below the efficient level of 50. Holdup is more severe than predicted when the seller's outside option is binding, and less severe when the seller's outside option is non-binding.

Our results provide no support for the theoretical relationship between investment incentives and the outside option principle. Experienced subjects invest the same for both levels of the outside option. Inexperienced buyers even invest less (rather than more) when the seller's outside option is binding instead of non-binding (Result 1). On the one hand, underinvestment still occurs when the seller's outside option is binding and efficient investment decisions are predicted. On the other hand, underinvestment is less severe than theory predicts in case the outside option is non-binding (Result 2). The latter finding that holdup is less of a problem than theory predicts is in line with the experimental results of Ellingsen and Johannesson (2000) and Hackett (1993).

4.2 Bargaining outcomes

The private return the buyer obtains on her investment is determined by the division finally agreed upon and the number of rounds required to reach agreement. The main interest in this subsection lies in whether the investment levels observed can be considered optimal (from the selfish point of view of the buyer) given actual bargaining behavior.

An important reason why actual offers may differ from the deal-me-out prediction (DMO) is given by considerations of fairness. One of the main regularities obtained from a vast number of bargaining experiments is that first offers and final agreements are typically biased towards an equal split of the surplus (cf. Roth, 1995). In our setup with advance investments there are several candidates for the relevant surplus. We consider two of these. The first is an equal split of the gross surplus (ESG), the second an equal split of the net surplus (ESN). ESG gives the buyer a share of $R(I)/2$, ESN a share of $C(I)+\frac{1}{2}(R(I)-C(I))$. ESN is inspired by the experimental evidence of Ellingsen and Johannesson (2000) and Hackett (1993) that bargainers care about sunk investment costs and usually take an equal split of the net surplus as the fair outcome.⁸ Result 3 summarizes our findings. In this result the term "offer" refers to the amount for the buyer.

RESULT 3. If the outside option is binding ($b=9000$), buyers' first offers and the finally accepted offers are very similar and somewhat below the DMO prediction. When the outside option is non-binding

⁸ A third possibility would be to give the buyer $C(I)+\frac{1}{2}(R(I)-C(I)-b)$. In that case not only sunk costs but also opportunity costs are taken into account.

($b=3000$) first offers exceed the DMO prediction (=ESG in this case) as well as the ESN-outcome. Finally agreed offers are also often above the DMO prediction.

Evidence for this result is provided in Table 3. This table presents the means and the frequency distributions of the buyers' first and the finally agreed offers, and relates these to (the mean values of) the three relevant benchmarks. In case of a binding outside option it necessarily holds that $DMO < ESG < ESN$, while in the non-binding situation $DMO = ESG < ESN$.

In the binding case 85% of the first offers are below the DMO-division. Buyers are thus typically prepared to give sellers somewhat more than their outside option. This can be interpreted as some minimum amount needed to make the seller prefer the buyer's first offer to his outside option. When this required markup increases with the size of the surplus, it leads to a somewhat lower return on investment for the buyer. This may explain that buyers invest below the optimal level even when the seller's outside option is binding. Yet the mean first offer is close to the mean DMO-solution. The finally agreed offers are somewhat below the first offers. Of the 330 cases in which agreement is reached, it is reached immediately in 268 cases. Accepted offers then equal first offers. In all but 4 of the remaining 62 cases the finally agreed offer is below the buyer's first offer. From the similarity between the buyers' first and the finally agreed offers we conclude that in the binding situation offers somewhat below the DMO-prediction are the typical bargaining behavior.

Table 3. Mean of first and finally accepted offers, together with frequency distribution

Situation		Offer	DMO	ESG	ESN	Offer/ R(I)	Benchmarks					n		
							DMO	ESG	ESN					
b=3000 (non-binding)	First	890	700	700	797	0.63	21	32	33	0	314	400		
	Accepted	789	700	700	798	0.56	48	67	69	0	191	375		
b=9000 (binding)	First	458	482	691	781	0.32	340	23	9	10	1	0	17	400
	Accepted	432	498	699	792	0.30	319	5	1	1	0	0	4	330

Remarks: ESG (ESN) stands for equal split of gross (net) surplus. Theoretical predictions are bold faced. In the frequency distributions numbers straight below the benchmarks represent the number of observations that exactly equal this benchmark. The numbers between them report the number of observations that fall in between these benchmarks. n gives the number of observations.

In the non-binding situation the DMO-prediction coincides with ESG. In a majority of the cases (87%) buyers ask for more than this in their first offer. They actually do obtain more in 65% of the cases. When the outside option is non-binding first and finally agreed offers are much further apart. The mean accepted offer is substantially below the mean first offer. Finally agreed offers are on average almost equal to the ESN-outcome.

The finding that accepted offers are on average lower than first offers is not surprising. In our setup the buyer always makes the first offer and offers are expressed as the amount the buyer obtains. If the seller accepts immediately the finally agreed offer equals the first offer. If not, it is likely that the seller does so in anticipation of a higher total or relative payoff. In both cases the finally agreed

offer must be lower than the first offer. The relatively large difference between first and accepted offers observed for the non-binding case suggests that especially here subjects had different expectations about the terms of agreement (cf. Roth, 1995, p. 307). Our next result that addresses Hypothesis 3 relates to this.

RESULT 4. *In the binding situation offers are less responsive to the investment level than predicted. In the non-binding case offers are too responsive to the investment level. Only in the non-binding situation first offers and finally agreed offers differ in buyers' return on investment.*

Evidence for Result 4 is given in Table 4 that contains for both bargaining situations results from regressing buyers' first offers and the finally agreed offers on the level of investment. The interactions in which sellers opted out were deleted from the regressions of finally agreed offers. To correct the estimates for possible learning effects the estimated equations also included the period in which the bargaining took place as a regressor. For both outside option values, first offers decrease significantly during the course of the experiment. The coefficients for the other regressors remain, however, almost identical when the period trends are removed. The regressions are based on multiple observations of each player. We employed the Huber-White estimator of the covariance matrix to take this into account (White 1980).⁹

When the outside option is binding "deal-me-out" predicts that the buyer becomes residual claimant and receives the full return on her investment. The estimation results show that on average buyers' first offers and finally agreed offers are somewhat lower than this prediction. These offers give the buyer a return of around 90%. These returns are not significantly different from each other.

Table 4. *Buyers' return on investment*

	Predicted	First offers	Finally agreed offers
b = 3000 (non binding)	50	87.5 (7.3)	73.8 (6.1)
b = 9000 (binding)	100	90.0 (2.9)	88.8 (3.1)

Remarks: Estimates are from regressions in which first offers and finally agreed offers are regressed on the level of investment and a time variable. Robust standard errors take account of correlated disturbance terms of multiple observations per subject. Number of buyers equals 40.

Also when the outside option is non-binding, buyers claim a return on investment of almost 90% in their first offer. The finally agreed amounts give buyers a return on investment of 74%. This is significantly (at the 5%-level) below the 87½% return originally demanded, but is still well above the theoretical prediction of a 50% return.

The results suggest that in their first offers buyers do not fully recognize the difference between a binding and a non-binding outside option for their return on investment. They ask for a 90% return, irrespective of whether the seller's outside option is binding or not. They indeed get so if the outside option is binding, but they get substantially less when it is not. In our setup the strong and credible threat of the seller to opt out under a binding outside option gives the buyer little leeway to disagree with him, and thus induces her to make a reasonable offer right from the start. This is not the

⁹ In all four cases incorporating I^2 as an additional explanatory variable does not yield a significant coefficient at the 5% level.

case when the outside option is low and non-binding. Then there seems to be a conflict between the two parties about the division of the return on the investment. Indeed, the average duration of the bargaining stage is significantly longer when the outside option is non-binding (2.3 rounds) than when it is binding (1.3 rounds). Also opting out is more likely when the outside option is high than when it is low. When b equals 9000, opting out occurs in 17½% of the cases, whereas for b equal to 3000 it occurs in 6¼% of the cases. An explanation for why buyers ask for the full return on investment when the outside option is non-binding is that they have a self-serving bias (cf. Babcock and Loewenstein, 1997). When they enlarged the amount up for division by making an investment they feel entitled to a substantial return of what they created, even if the strategic situation does not sustain that.

Our final result concerns the question whether observed investment levels can be considered optimal (for a selfish buyer) given actual bargaining behavior.

RESULT 5. When the outside option is high (binding) observed average investment levels are very similar to the “optimum” levels given actual bargaining outcomes. When the outside option is low (non-binding) buyers overinvest from a selfish point of view.

We estimated regression equations with the buyer’s net payoff as dependent variable, and the level of investment and investment squared as independent variables.¹⁰ The “optimum” levels of investment can be directly obtained from the estimated coefficients. Table 2 reports these “optimum” investment levels along with their standard errors. Comparing the estimated “optimum” levels with the actual mean investment levels yields Result 5.

A possible explanation for overinvestment when the outside option is non-binding is that the buyer does not anticipate the outcome of the bargaining correctly. In Result 4 we already concluded that only in this treatment, first and finally agreed offers differ in their private return on investment. Here buyers’ first offers indicate that they ask for almost the full return on the investment, despite the fact that the outside option is non-binding. Surely the buyer’s first offer will typically be somewhat larger than what she sincerely expects to get out of the bargaining, because it also has a strategic component. But these strategic considerations are not likely to vary much over the different treatments. It thus seems that buyers are not able to fully grasp the difference between the outside option being binding or not when making their investment decision. They expect the same high return on investment for both values of the outside option. This expectation turns out to be incorrect when it is non-binding.

¹⁰ To control for potential learning effects we again included the time that the buyer was confronted with this particular outside option. These time trends were never significant (at the 5% level). We also used the Huber-White covariance matrix estimator to correct for multiple observations per subject.

5. Conclusion

According to the outside option principle holdup can be avoided by structuring the post-investment bargaining stage in such a way that the non-investor has a binding outside option. The investor then becomes residual claimant and has the appropriate incentives to invest. Theory predicts that investments increase when non-investors' outside options increase from a non-binding low value to a binding high value and equal the efficient level in the latter case. The fact that under the outside option principle the investor may end up being residual claimant is the driving force behind recently proposed contractual solutions to holdup.

We find no support for the theoretical relationship between investment incentives and the outside option principle. After subjects have gained experience investment levels are independent of the non-investor's outside option being binding or not. A plausible explanation for this is that investors (who make the first offer in our setup) do not fully recognize the difference between these two situations when formulating their first offer in the post-investment bargaining stage. They always ask for about 90% of the return on investment. When the outside option is actually binding this claim is typically honoured, otherwise it is not. Therefore, in case investors base their investment decision on their own first offer, they will overinvest from a selfish point of view (only) when the outside option is low. This is exactly what we observe. A common sense explanation for the investors' incorrect anticipation of the bargaining outcome is given by the self-serving bias. We also find that holdup still occurs when the outside option is binding, yet is typically less of a problem than theory predicts when the outside option is non-binding. Taken together our results suggest that contractual solutions that rely on the outside option principle are unlikely to solve holdup.

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