

A Numerical Example for “Lies, Defection, and the Pattern of International Cooperation”

To illustrate the arguments in the paper, I present a numerical example.

Consider a cooperation setting where the benefits from cooperation of government i in the state (j, k) are

$$b_i(a_1^{jk}, a_2^{jk}) = -a_i^{jk} + 2a_{\sim i}^{jk},$$

as in the traditional PD. The cooperation surplus of government i in the state (j, k) is then

$$-a_i^{jk} + 2a_{\sim i}^{jk} - a_i^{jk} c_i.$$

Furthermore assume that the low costs $c^L = 0.5$, the high costs $c^H = 2$, and the probability of a low costs realization $p = 0.6$. The game matrix in Figure 1 summarizes the stage-game payoffs.

Figure 1: A cooperation game with varying costs of cooperation

		Government 2	
		$a_2^{jk} = 1$	$a_2^{jk} = 0$
Government 1	$a_1^{jk} = 1$	1 - c_1 , 1 - c_2	-1 - c_1 , 2
	$a_1^{jk} = 0$	2, -1 - c_2	0, 0

Consider implementing the best joint payoff in the stage-game. Then in the state (L, L) , we shall choose the action profile $(a_1^{LL} = 1, a_2^{LL} = 1)$ which achieves the joint cooperation surplus of $0.5 + 0.5 = 1$. In the state (H, H) , we shall choose the action profile $(0, 0)$ which achieves the joint surplus of 0. In the state (H, L) , we shall choose the action profile $(0, 1)$

which achieves the joint surplus of 0.5. And finally, in the state (L, H) , we shall choose the action profile $(1, 0)$ which also achieves the joint surplus of 0.5. This is the cooperation rule I call *domestic conditionality*.

Under domestic conditionality, the joint expected cooperation surplus in the stage-game will be

$$1p^2 + 0(1-p)^2 + 0.5(1-p)p + 0.5p(1-p) = 0.6.$$

Set the common discount factor $\delta = 0.8$. Denote the joint discounted expected cooperation surplus in the infinitely repeated game under domestic conditionality by \bar{V}^{DC} . We have

$$\bar{V}^{DC} = \frac{0.6}{1-\delta} = 3.$$

Compare this “flexible” cooperation rule to a “rigid” cooperation rule where governments cooperate each period irrespective of the actual cost realizations. In that case, the joint expected cooperation surplus in one period will be

$$(0.5 + 0.5)p^2 + (-1 - 1)(1-p)^2 + (-1 + 0.5)(1-p)p + (0.5 - 1)p(1-p) = -0.2.$$

And the joint discounted expected cooperation surplus, \bar{V}^R , is

$$\bar{V}^R = \frac{-0.2}{1-\delta} = -1.$$

If the cooperating governments divide the cooperation surplus evenly and implement domes-

tic conditionality, the enforcement constraint of each government in the state (L, L) is

$$0.5 + \delta \frac{0.3}{1 - \delta} \geq 2 + \delta V^{Aut} \quad \text{where} \quad V^{Aut} = 0.$$

Cooperation can then be sustained when $\delta \geq 0.84$.¹ On the other hand, when governments use the “rigid” cooperation rule, the enforcement constraint in the state (L, L) can not be satisfied for $\delta < 1$! Thus domestic conditionality enables cooperation at discount factors at which cooperation would fail under the “rigid” rule. A general argument concerning the efficiency of flexible cooperation rules is presented in Section 5 of the paper.

Now consider what happens when governments have private information about their costs of cooperation and attempt to implement domestic conditionality. In the states (H, L) and (L, H) , this rule instructs the government facing high costs to stay out while the government facing low costs fully participates. Then in the state (L, L) , the governments facing low costs will benefit from lying and may announce high costs in order to avoid participating.

Anticipating this, governments can devise the following cooperation rule called *rotation*: If Government 1 announces high costs in the state (H, L) , it does not participate in that period. However, afterwards it participates fully irrespective of its costs realizations until Government 2 announces high costs. Then the same rule applies to government 2. Less formally, rotation says, “Do not ask for another favor until you get a chance to return the last one!”

At the beginning of the game, the expected discounted cooperation surplus of govern-

¹It can be easily checked that the enforcement constraint in the state (L, L) binds most severely.

ment 1 from rotation, V_1 , is

$$V_1 = p^2(0.5 + \delta V_1^{LL}) + (1-p)^2(0 + \delta V_1^{HH}) + (1-p)p(2 + \delta V_1^{HL}) + p(1-p)(-1.5 + \delta V_1^{LH}),$$

where V_1^{HL} is the continuation payoff of Government 1 after it announced high costs in the state (H, L) . We can set $V_1 = V_1^{LL} = V_1^{HH}$ since the continuation payoffs after the states (L, L) and (H, H) are the same as in the beginning of the game. Rotation implies

$$\begin{aligned} V_1^{HL} &= \underbrace{p^2(0.5 + \delta V_1^{HL}) + (1-p)^2(-3 + \delta V_1^{HL}) + (1-p)p(-1 + \delta V_1^{HL})}_{\text{"Waiting to return a favor while in the states } (L, L), (H, L), \text{ and } (H, H)\text{"}} \\ &+ \underbrace{p(1-p)(-1.5 + \delta V_1^{LH})}_{\text{"Favor returned in the state } (L, H)\text{"}}. \end{aligned}$$

On the other hand, after Government 2 announced high costs in the state (L, H) , Government 1 receives the continuation payoff V_1^{LH} ,

$$\begin{aligned} V_1^{LH} &= \underbrace{p^2(0.5 + \delta V_1^{LH}) + (1-p)^2(2 + \delta V_1^{LH}) + p(1-p)(0.5 + \delta V_1^{LH})}_{\text{"Waiting to receive a favor while in the states } (L, L), (L, H), \text{ and } (H, H)\text{"}} \\ &+ \underbrace{(1-p)p(2 + \delta V_1^{HL})}_{\text{"Favor received in the state } (H, L)\text{"}}. \end{aligned}$$

Clearly, $V_1^{LH} > V_1^{HL}$, and announcing high cost implies lower future benefits from cooperation.

Is rotation sufficient to discourage governments from misreporting low costs as high costs?

Government 1 will not benefit from lying if in the states (L, L) and (L, H) if

$$\begin{aligned} 0.5 + \delta V_1 &\geq 2 + \delta V_1^{HL} \Rightarrow V_1 - V_1^{HL} \geq \frac{1.5}{\delta}, \\ -1.5 + \delta V_1^{LH} &\geq 0 + \delta V_1 \Rightarrow V_1^{LH} - V_1 \geq \frac{1.5}{\delta}. \end{aligned}$$

These inequalities are satisfied for $\delta \geq 0.92$.

However, we also need to verify that the continuation payoffs V_1 , V_1^{HL} , and V_1^{LH} are self-enforcing. It can be checked that the enforcement constraints bind government 1 most severely when the low continuation payoff V_1^{HL} is being implemented in the states (H, L) and (H, H) ,

$$\begin{aligned} -1 + \delta V_1^{HL} &\geq 2 + \delta V^{Aut} \Rightarrow \delta \geq \frac{3}{V_1^{HL}}, \\ -3 + \delta V_1^{HL} &\geq 0 + \delta V^{Aut} \Rightarrow \delta \geq \frac{3}{V_1^{HL}}. \end{aligned}$$

These inequalities are satisfied for $\delta \geq 0.99$. Setting $\delta = 0.99$ and solving for V_1 , V_1^{LH} , and V_1^{HL} we see that $V_1 = 10.41$, $V_1^{LH} = 12.06$, and $V_1^{HL} = 7.94$.

Thus when the governments implement rotation and are patient enough, government 1 will not find it profitable to lie about its cost realizations. Similar argument applies to government 2.

Note that inducing truth-telling comes at a cost. First, greater patience is required than under complete information. Thus for some discount factors cooperation will be possible under complete information but not under asymmetries of information. Second, in the periods when government 1 is waiting to “return the favor”, the cooperating governments

are not implementing actions that would be most efficient under complete information. In turn, efficiency is wasted due to asymmetries of information. A more general argument about the implications of private information for cooperation is presented in Sections 6 and 7 of the paper.