By Rob Lindgren and Bill Nelson

The past decade has seen an increased focus on the resilience of subsidiaries of international banks within jurisdictions. Ensuring that each such subsidiary can withstand losses or episodes of illiquidity using its own resources makes it less likely that creditors in that jurisdiction will experience losses from problems at subsidiaries in others. However, such “ex ante ringfencing” or “pre-positioning” leaves international banks less able to diversify losses or illiquidity, so the likelihood of failure of the global entity could increase. Because the price of such failure is high in terms of bankruptcy costs and lost franchise value, creditors can be made worse off overall when resources in individual jurisdictions are ringfenced. As a result, there is scope for cooperation between the financial authorities in different jurisdictions to make everyone better off and no one worse off.

Unfortunately, as we discuss in this note, this cooperation can be difficult to sustain. Faced with a situation where the subsidiary in the foreign jurisdiction has experienced a loss, domestic officials have an incentive to ringfence to protect domestic creditors. The situation is akin to the classic Prisoner’s Dilemma, and game theory offers some insights into the scope and limits of cooperation. In particular, when such games are repeated, cooperation can be sustained.

The note proceeds in three sections. First, we develop and draw inferences from a one-shot game intended to model the situations faced by authorities regulating an international bank with subsidiaries in each of their jurisdictions that are each subject to losses that can lead to failure of the global institution. Second, we consider the scope for cooperation between the authorities when the game is repeated. Third, we review the history of cooperation between U.S. and European authorities before, during, and after the financial crisis as developments in a repeated game subject to misunderstandings.

INTUITION

Before formally describing the game that we consider, we will attempt to provide the basic intuition in nontechnical terms.

Each jurisdiction must decide whether and how much to require international banking organizations to preposition liquidity and capital resources within their jurisdiction. While those resources protect the local operations of the organization, they are not available to support the global organization. Consequently, when each jurisdiction makes a decision in their own best interest to ex ante ringfence resources, the combined actions increase the likelihood the global institution will fail, making all jurisdictions worse off than if they allowed the resources to be deployed where needed.

Thus, the one-off situation facing the authorities resembles the prisoner’s dilemma game where each prisoner must decide whether to stay mute or rat on the other prisoner. If both prisoners stay mute, they each get a modest sentence. If either rats on the other, the rat gets off and the other gets the longest possible sentence. If both rat on each other, they both go to jail for long (but not the longest possible)

1 We are grateful to David Pearce for several helpful discussions.
sentences. Faced with this problem, the prisoners always rat on each other, each getting the second-worst outcome, rather than both staying silent. The prisoners don't cooperate.

The prisoners might cooperate, though, when the game is repeated. If the prisoners are likely to find themselves in the same situation in the future, then they might be able to agree credibly not to betray each other.

The regulatory authorities in the major jurisdictions are in just such a situation. The international banks they host, or for which they are home, will occasionally face difficulties, and that likely repetition could promote cooperation. Cooperation requires a strategy for dealing with cheating, however. One such strategy is “if either party cheats, we will never cooperate again.” While that draconian punishment can make cooperation attractive, it is so draconian that it won't work. Each jurisdiction would agree to renegotiate the terms of the punishment, and because they each know the punishment would be renegotiated, the cooperation can't be sustained.

What's needed is a strategy with a renegotiation-proof punishment regime. One such strategy is called “tit-for-tat.” Each jurisdiction mimics the most recent action of the other; if a jurisdiction cheats, the other will cheat in the next round and if a jurisdiction cooperates, the other will cooperate in the next round. A problem with the tit-for-tat strategy, though, is that it can't handle a situation where both jurisdictions simultaneously think the other cheated (in this case, two players using tit-for-tat will cheat forever). Game theorists have shown that the problem can be overcome if each player is contrite and forgiving, allowing occasional instances where the other player appears to have cheated to go unpunished.

The nontechnical reader can skip to “Ringfencing before, during, and after the crisis” where we argue that the intuitions provided by the game theory can help illuminate cooperation, and breakdowns in cooperation, between the United States and Europe.

**THE ONE-SHOT GAME**

Consider a situation with two players, $R_A$ and $R_B$, each the regulator of a jurisdiction. Imagine there is also an international bank with subsidiaries of equal size in each jurisdiction. Because the regulators are concerned with what happens to the subsidiary in their jurisdiction, we will treat each subsidiary's payoffs as the payoffs of their host regulators.

First, regulators $R_A$ and $R_B$ each decide whether or not to ex ante ringfence. Second, each, neither, or both subsidiaries experience a loss. Finally, depending on the regulators' choices and the distribution of losses, the institution fails or avoids failure.

Each subsidiary has net worth (equity) $E$ and is subject to loss $L$, as well as their share of bankruptcy cost $B / 2$. If one subsidiary experiences loss $L$ and that loss is not shared because their host regulator has ringfenced, then the global entity goes bankrupt. In this case, both subsidiaries are subject to their share of the nonzero expected bankruptcy cost $B / 2$. If the loss is shared, each subsidiary only experiences half the loss, $L / 2$, and the entity does not go bankrupt, so there are no bankruptcy costs to share.

Note that in the states where (1) both subsidiaries fail or (2) neither fails, player actions have no bearing on the payoffs. We can therefore set these aside and focus on the cases where only one subsidiary fails. Taking these cases to be equally likely, the expected value to each player is the average of payoffs in these cases, given a particular pair of player actions.
THE PAYOFF MATRIX

This gives us the following payoff matrix (in which “R” means “ringfence” and “N” means “no ringfencing”):

\[
\begin{array}{c|cc}
 & N & R \\
\hline
N & E - \frac{1}{2}L & E - \frac{1}{4}L - \frac{1}{4}B \\
R_A & E - \frac{1}{2}L & E - \frac{1}{4}L - \frac{1}{4}B \\
R & E - \frac{1}{4}L - \frac{1}{4}B & E - \frac{1}{2}L - \frac{1}{2}B \\
\end{array}
\]

If we simplify and normalize so that the payoff to the cooperative strategy is zero, we get:

\[
\begin{array}{c|cc}
 & N & R \\
\hline
N & 0, 0 & -L - B, L - B \\
R_A & L - B, -L - B & -2B, -2B \\
R & & \\
\end{array}
\]

When \( L > B \), this payoff matrix gives the same preference ordering as a Prisoner’s Dilemma. The Nash equilibrium for the Prisoner’s Dilemma is \( \{R, R\} \), the worst of the two symmetric strategy profiles.

IMPLICATIONS OF THE ONE-SHOT GAME

There are two conclusions we can draw from the one-shot game.

First, international efforts to reduce bankruptcy costs may have reduced the incentive to cooperate. If \( B \) is greater than \( L \), then \( \{N, N\} \) is the Nash equilibrium, and the two jurisdictions always cooperate even though the game is not repeated.

As a corollary, if the creation of intermediate holding companies (IHCs) cuts the bankruptcy cost to the domestic institution to zero, the domestic authorities will always ringfence.

Second, higher capital requirements may reduce the incentive to cooperate. If capital requirements are higher, then the loss necessary to result in failure of a subsidiary is higher relative to bankruptcy costs.

As discussed in the Appendix, if we do not require loss sharing to be 50-50, then it may be possible to sustain cooperation even in a one-shot game. In that case, higher equity increases the scope for cooperation, because it expands the range over which loss-sharing is both effective and compatible with incentives.
THE REPEATED GAME

However, ringfencing policy is not a situation that just happens once. Regulators make decisions within the context of history, aware of what they and other regulators have done in the past and what outcomes resulted. This gives us hope for cooperation, even when the incentives in a one-off situation lead regulators to ringfence (that is, if $L > B$).

An obvious strategy for a repeated version of the game described above is “grim trigger”: each regulator agrees not to ringfence their respective jurisdiction so long as the other does the same. But as soon as one of them cheats on this agreement, the other punishes the cheater by ringfencing forever.

The threat implicit in this strategy is extraordinary. Once a player deviates from their agreement, both players find themselves back in the one-shot Nash equilibrium that cooperation was meant to avoid. On further examination, the threat is not only extraordinary, but incredible. Once stuck in the Nash equilibrium, why not renegotiate their cooperative agreement? It’s in no one’s best interest to blindly stick to a commitment to punish the other player indefinitely, especially when that punishment is costly to oneself. And if both players know it would be irrational to stick to the grim-trigger punishment regime, why not cheat? Eventually the other player will agree to renegotiate anyway. After all, it’s in their best interest.

TIT-FOR-TAT STRATEGY

Because of this, we should seek a renegotiation-proof equilibrium, which Abreu and Pearse (1991) describe as one supported by a punishment that grants a better payoff than the Nash equilibrium to the punishing player and for which there is no other supportable continuation value that is even better. Conveniently, van Damme (1990) has proven for us that the Tit-for-Tat strategy already meets this criterion in the case of a Prisoner’s Dilemma.

The Tit-for-Tat strategy is simple. First, a player commits to the cooperative agreement, refraining from ringfencing. If the other player cheats on the agreement, the first player then demands that the second player allow them to cheat as well before returning to cooperation. If the players are patient enough (i.e., if they have a discount factor $\delta$ close enough to 1), this equilibrium is renegotiation-proof. In the international banking situation we are considering, “cooperating” is not ex ante ringfencing and “cheating” is ex ante ringfencing (i.e., pre-positioning).

Consider the payoffs to Player A when A 1) plays grim-trigger with no renegotiation, 2) plays grim-trigger but then renegotiates, and 3) plays tit-for-tat. In all cases, Player B cheats in the first round. Let $U_A$ be the sum of all payoffs to Player A.

Case 1 (Grim-trigger with no renegotiation):

\[
U_A = (-L - B) + \delta (-2B) + \delta^2 (-2B) + \delta^3 (-2B) + \cdots
\]

After Player B cheats in the first round, Player A responds by cheating as well in the second. At this point, B approaches A with an offer: if I cooperate from now on, will you? A rejects the offer, sticking to their grim-trigger strategy and trapping both players in the Nash equilibrium.

Case 2 (Grim-trigger with renegotiation):

\[
U_A = (-L - B) + \delta (-2B) + \delta^2 0 + \delta^3 0 + \cdots
\]

In this case, Player A accepts the offer to renegotiate, leading to cooperation after round 2. It should be clear that Player A is better off in Case 2 than Case 1, which is exactly why the grim-trigger strategy is not renegotiation-proof.

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2 A player that is sufficiently impatient will always opt for the immediate return from cheating irrespective of the future rewards or penalties.
Case 3 (Tit-for-tat):

\[ U_A = (-L - B) + \delta(L - B) + \delta^2 0 + \delta^3 0 + \cdots \]

Here, when Player B offers to renegotiate, Player A refuses, demanding the attractive payoff \( L - B \) (earned when Player A cheats and Player B cooperates) before returning to cooperation. Renegotiation does not make Player A better off, so tit-for-tat is renegotiation-proof. This remains true even when we imagine that the players remain in the Nash equilibrium for several rounds before Player B agrees to A’s demand for the best possible payoff.

In the Axelrod Tournaments of 1980, in which Robert Axelrod invited game theorists to submit strategies for the purpose of staging tournaments, Tit-for-Tat was found to be successful against a wide variety of strategies (Axelrod 1980a, 1980b).

**NOISE IN THE GAME**

A problem with modeling ringfencing behavior with the game we’ve described and that will be important in our discussion is that it does not capture the empirically plausible situation where players make mistakes. Player A may privately see their action as cooperating, but publicly, to Player B, it may appear to be cheating.

This misunderstanding leads to a problem for pure Tit-for-Tat: the strategy does not account for this discrepancy in how the players view the game’s history. Let’s say that Player A takes an action that he intend as cooperation but that Player B perceives as defection. Player B responds by defecting, as Tit-for-Tat prescribes. Player A’s response depends on what strategy he plays, but in the specific case where A plays Tit-for-Tat as well—defecting in response to Player B’s defection—the players find themselves trapped in the ringfencing equilibrium. In fact, two players using the Tit-for-Tat strategy will, on average, receive the same long-run payoffs as two strictly randomizing players at any level of noise (Molander 1985). Compare this with the outcome of a noiseless game with two Tit-for-Tat players, which results in mutual cooperation forever. The discrepancy is remarkable, and a better strategy is needed.

**VARIATIONS ON TIT-FOR-TAT**

Thankfully, there are intuitive variations on Tit-for-Tat that do well in the face of mistakes and misunderstanding: strategies known as generous and contrite (Wu and Axelrod 1995). The generous strategy is probabilistic, sometimes allowing the opponent’s defections to go unpunished and at other times punishing them. In a sense, it corrects the other player’s mistake. The contrite strategy, on the other hand, depends on recognizing one’s own error and correcting it. A contrite player will use Tit-for-Tat unless they mistakenly cheat: in this case, they willingly submit to their own punishment and cooperate thereafter.

These two strategies work best in different environments. Generosity outperforms contrition when the other player does not recognize the possibility of their own mistakes. Contrition is essentially the same thing as Tit-for-Tat unless the contrite player makes a mistake, so it fares no better than Tit-for-Tat in that case. Contrition, however, does exceptionally well when a player is faced with another contrite player: together they return to mutual cooperation almost immediately after a defection.

**RINGFENCING BEFORE, DURING, AND AFTER THE FINANCIAL CRISIS**

We can read the history of ringfencing in the U.S. and Europe as a repeated game in which the players would prefer mutual cooperation but have made some mistakes or misunderstood one another along the way. The game shows no ringfencing in the pre-crisis period, some ringfencing during the crisis, and then a slow transition back to the cooperative regime.

As discussed in Nelson (2019), before the crisis there was an informal international understanding about how lender-of-last-resort (LOLR) responsibilities would be divided between home and host jurisdictions. In particular, while the host jurisdiction may have to make the initial LOLR loan, the lending was ultimately the responsibility of the home jurisdiction.
During the crisis and its aftermath, however, both the United States and the European authorities had experiences that strained the informal understanding and may have been perceived as cheating. In Europe, the ECB posted book losses on a loan to a Lehman subsidiary. This was probably particularly galling because the Federal Reserve experienced no losses on its lending during the crisis. The ECB ultimately recovered its loan amount by selling the collateral.

In the United States, two European banks that borrowed from the Fed continued their borrowing for many months after the Fed reverted to its peacetime stance of only offering very short-term loans. Just speculating, it is possible that the European authorities were reluctant to step in with the necessary funds to the weak banks in part because of resentment over the handling of the ECB loan to the Lehman subsidiary.

In February 2014, the United States required large foreign banking organizations to organize all their U.S. entities except for branches under a single entity called an “intermediate holding company” or IHC. The IHC would be separately capitalized and maintain its own liquidity buffers. At the same time, liquidity requirements and “net due to” requirements were applied to branches of FBOs. All of these developments were designed to ringfence the U.S. assets of the FBO.

Subsequently, Europe passed CRD 5 in 2019 that requires non-EU banking groups with large EU operations to establish an EU intermediate parent undertaking (IPU). The new rules are similar to U.S. Federal Reserve requirements for certain non-U.S. banking organizations to establish an IHC. Each EU IPU will be subject to capital, liquidity, leverage, and other prudential standards on a consolidated basis. According to the Commission, the EU IPU rule is intended to ensure that the EU operations of non-EU groups are sufficiently capitalized so, if the group fails, there is enough capital locally to absorb the losses of the group’s European operations. It also fills a gap by giving the Single Resolution Board the requisite resolution supervisory tools for those firms established in the Eurozone. However, it is widely regarded as retaliation for the Federal Reserve’s requirement for non-U.S. banking organizations above a certain asset threshold to establish a U.S. IHC.

It is not hard to see how unforeseen and challenging circumstances, combined with ambiguous expectations, could have left both Europe and the United States thinking that the other had cheated on the agreement and therefore waiting on one another to start cooperating, leading to fits and starts in cooperation.

Such appears to be the case. For example, the Financial Stability Board established benchmarks that permitted—and even encouraged—local jurisdictions to allow local subsidiaries of foreign entities to be required to maintain total loss absorbing capacity (TLAC), or capital and loss-absorbing debt at only a fraction of the amount required of the parent institution. In particular, the FSB concluded that subsidiaries should maintain TLAC equal to 75 to 90 percent of the requirement for the parent institution.³

Unfortunately, after initial indications that jurisdictions would set such capital requirements at the low end of the suggested range, first Europe, then the United States, and then the United Kingdom set the requirements at the range’s upper end. Subsequent comments by the Bank of England and the Federal Reserve suggest that parties were searching for compromise. For example, in October 2017, when describing their internal TLAC calibration, the Bank of England stated:

Where other resolution authorities set requirements at the upper end of the 75% to 90% range, this may reduce the availability of extra resources that would be available to UK entities and may signal concerns about the credibility of the resolution strategy and cross-border co-operation. The Bank would need to take this into account in setting its own internal MREL and it may lead to the Bank scaling at the upper end of the range for specific UK firms.⁴

Subsequently, in May 2018, Fed Vice Chair Randal Quarles noted:

We continue to believe that the IHC and attendant requirements are appropriate for foreign banks with large U.S. operations. However, in light of our experience with these structures, I believe we should consider whether the internal TLAC calibration for IHCs could be adjusted to reflect the practice of other regulators without adversely affecting resolvability and U.S. financial stability. The current calibration is at the top end of the scale set forth by the FSB, and willingness by the United States to reconsider its calibration may prompt other jurisdictions to do the same, which could better the prospects of successful resolution for both foreign G-SIBs operating in the United States, and for U.S. G-SIBs operating abroad.\(^5\)

To date, neither party has moved off the high end of the FSB range, perhaps in part because the Euro area also chose the high end and established its choice as a matter of law, making adjustment difficult.

CONCLUSION

When a subsidiary of an international bank becomes insolvent, self-interest may encourage the authorities in other jurisdictions to prevent the resources of subsidiaries in their jurisdictions from being used to prevent a failure of the global entity. However, cooperation can be sustained, because the situation could be repeated: each jurisdiction understands that it may find itself with the troubled subsidiary in the future. Our analysis suggests that international bank regulatory agencies may have fallen into a noncooperative equilibrium because of a misunderstanding over the terms of cooperation and may currently be struggling to return to cooperation.

A return to cooperation can increase financial stability significantly. For example, in our simple game, when each jurisdiction ringfences, the probability that each international bank will fail nearly doubles. In a model with four subsidiaries calibrated to historical experience, Ervin (2018) finds that ex ante ringfencing can increase the risk of failure by a factor of between 5 and 15, depending on the correlation between the subsidiaries. Given the potential that all sides can be made better off and none worse off, we hope all jurisdictions can follow a contrite strategy and find their way back to greater cooperation.

APPENDIX: A POSSIBLE ONE-SHOT SOLUTION

Returning to the one-shot game, another way the problem could be solved is by imposing only partial loss sharing. Again consider the situation where subsidiary in country B makes a loss and regulator \(R_A\) has to decide whether to ex post ringfence. As a reminder, if \(R_A\) ringfences, the global entity fails and country A gets \(E - B/2\). If \(R_A\) does not ringfence, bankruptcy is avoided but the loss is shared, so the payoff is \(E - L/2\). Clearly, \(R_A\) will ringfence if \(L > B\).

If country B requests a payment from country A that leaves country A better off if it doesn't ringfence than if it does, then country A will choose not to ringfence. If the payment is sufficient to prevent bankruptcy, then country B will prefer receiving the lower payment to receiving no payment at all and incurring bankruptcy. Because the total available payoff is bigger when the countries do not ringfence and bankruptcy is avoided (as long as \(L > B\)), such a solution should always exist.

Specifically, regulator A will agree to pay any sum \(X\) as long as \(X < B/2\). Regulator B will be able to avoid bankruptcy as long as it receives a sum \(X\) that prevents the subsidiary in country B that experienced loss \(L\) from having negative equity, so \(X > L - E\). If \(L - E < B/2\), then such a mutually beneficial payment will exist.

That is, the capital hole needing to be filled has to be less than the bankruptcy cost the domestic institution would otherwise incur. The greater the capital, the less the potential loss; the higher the bankruptcy costs, the more likely a mutually agreeable loss-sharing exists.

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\(^5\) Quarles (2018).
The result is reminiscent of partial pre-positioning. It is not necessary that losses be shared equally to avoid the anarchic equilibrium with unnecessary bankruptcies. Some resources can be held back by each jurisdiction.
REFERENCES


