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Short-run vs. long-run cooperation among the G-20 countries

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Abstract

In a model of repeated games, we determine the conditions under which cooperation is an equilibrium outcome among the G-20 countries. We consider first, that members are uncertain about the lifespan of the G-20. Second, the nature of member countries and their interrelations can change because of shifts in government regimes. Monitoring and peer pressure to comply with the agreements made are necessary if the goals are to achieve cooperation and thereby attain desirable common goals. If member countries are prone to shifting government regimes and governments are not concerned about their countries' reputations, continuous cooperation becomes more difficult.

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Non-Technical Summary

The G-20, as never before, has now the best opportunity to advance policy cooperation between emerged and developed world to address important unsustainable global imbalances we are confronting in order to attain a higher worldwide growth. Dealing with the global imbalances implies the identification and examination of the policies that have created such imbalances. Among these well-known policies, one finds the unilateral decisions of certain countries to maintain a depreciated nominal exchange rate, or to simply carry out uncoordinated central bank interventions in the foreign exchange market. Even though, such a policy has been essential for export-led countries to achieve economic growth. Another policy of concern is the too expansive monetary and fiscal policy followed by certain countries to stimulate their economies which might lead to instability in other countries. One could also mention, the lack of harmonization regarding financial market regulation which can cause market participants to move to markets that allow them to maximize their risk-taking behavior. Such policies may, in some cases, have been good for individual countries, but often not for the rest of the global community. An additional distortion can be created by multinational corporations if they can play off host governments to lessen their carbon taxes (or other types of penalty due to environmental harm) in the absence of coordinated climate policy between the affected governments.

The recent discussions (February 2011) between the G-20 finance ministers on ways to measure economic “imbalances” and even laying out a list of indicators to monitor and judge the progress made by member countries in reducing imbalances, should be taken as a big achievement toward cooperation. By the time the G-20 meets again (in April 2011), it is expected that the country members agree on the adequate indicators. Among the possible candidates, it has been mentioned: current account balance, government fiscal balance, real exchange rate, reserves, capital flow volatility, and private finance positions (savings and debt) among others.

A failure to agreeing on how to tackle the unsustainable imbalances, and engaging in a long lasting and stable cooperation to pursue the corrective actions, could be detrimental for the credibility of the objectives of G-20 and the commitments made in Seoul in 2010 to strong, sustainable, and balanced economic world growth.

Agreements among countries to cooperate for achieving common shares objectives, whether they are short-, medium- and long-term, should be made looking into a long time horizon in order to allow for frequent country interactions and evaluations.

More often than not, countries have the tendency to make policy decisions *unilaterally* based on a concern for the *short run* in order to appear effective to its countrymen, but ignoring the implications of their policies for other countries. Such type of strategy has not been very useful for the world, as we can tell from the different policies implemented unilaterally by countries around the world over the years. Such policies (e.g. currencies misalignments, inappropriate regulations, large fiscal deficits, etc.) have resulted in a number of currency and financial crises with detrimental effects on world economic growth and poverty (see Global Monitoring Report 2010). The overall outcome has always been a lower welfare for everybody.

Many potential collective gains can vanish if countries follow *non-cooperative strategies* whether they are aimed to achieve short-, medium-, or long-run goals. Even policies

implemented to achieve short term goals can give better collective results when there is cooperation among countries to avoid that these policies create one-sided effects which are negative for the rest of the world. But an effective cooperation to acquire a common good is only possible when countries *interact frequently* and for a *long period of time*.

To accomplish cooperation, it is imperative that countries are held accountable for their actions and transparent in their decision making, continuously and for a long period of time. As a result, the establishment of social and economic norms that call for responsibility to support a cooperative outcome should arise spontaneously.

It could clearly be *challenging* to create *incentives* in individual countries to cooperate at the worldwide level or even within an organization such as the G-20. Some reasons for that could be that countries feel uncertain about the life span of the agreements made, and more importantly how the nature of the member countries, and consequently their interrelations, can be altered as a result of changes in government regimes (e.g. a new political party comes to power). Such uncertainties can make cooperation more difficult to attain.

Nevertheless, cooperation can be accomplished under uncertainty if countries are held *accountable* for their actions, and are *transparent* in their decision making, continuously and for a *long period of time*. In this regard, the *Mutual Assessment Process (MAP)* should play a very important role in evaluating not only the progress made by each country member, but also the policies they implement toward meeting the common shared objectives. This course of action will help both to establish social and economic norms that call for responsibility when agreements are or need to be violated, and to support a cooperative outcome to attain the common shared objectives that benefits everybody. A consolidation of these norms should also serve other emerging economies (middle and lower income countries) for discussing the externalities they face while being outside the G-20 and seeking agreements and cooperation with the G-20 countries.

There is a view that unilateral actions by countries willing to show they are effective to their countrymen unavoidably yield a zero-sum game for the world. We should perhaps move away from such a belief, and look for the opportunities for cooperation that instead lead to mutually rewarding activities between countries, and positive-sum game outcomes.

1. Introduction

The G-20, as never before, has now the best opportunity to advance cooperation between the emerging and developed world to solve some of the most important problems we are currently confronting and to attain greater worldwide welfare. The G-20 reflects the new world in which emerging countries are playing an increasingly influential role in the world economy. A failure to attain long-term, stable cooperation could be detrimental for the credibility of the G-20's objectives and the commitments made in Seoul in 2010 to strong, sustainable and balanced economic world growth. The main challenge its member countries face is the creation of incentives to encourage individual countries to consider the collective gains that can be obtained only by implementing policies over a long-term horizon. A consolidation of the G-20 in these terms should also serve to assist other emerging economies (middle- and lower-income countries) in discussing the externalities they face while being outside the G-20 and seeking agreements and cooperation with them.

Typically, countries' economic policy decisions are based on a concern for the short term that maximizes only their individual welfare and ignores the implications of their policies for other countries. When many interacting countries behave in such a way, the overall outcome will be inefficient because countries will attain a lower welfare in the long term. A well-known example of such uncoordinated policies is certain countries' current unilateral decisions to maintain a depreciated nominal exchange rate or to avoid appreciation using uncoordinated central bank interventions in the foreign exchange market. This policy has been essential for achieving economic growth in export-led countries. Additionally, certain countries have enacted excessively expansive monetary and fiscal policies to stimulate their economies; unfortunately, these policies might lead to instability in other countries. Furthermore, the lack of harmonization

in financial market regulation across countries causes market participants to move to markets that allow them to maximize their risk-taking behavior.

Olson (1965) has discussed the motivations that countries (or groups) may have for engaging in multilateral arrangements and mutual cooperation with other countries. However, in the context of his arguments, countries often behave in a self-interested manner that interferes with the desire to promote a collective interest. Olson has found that multilateralism, in which countries' policies are primarily directed toward promoting the common welfare of all countries, can be difficult to achieve when the number of countries that must cooperate is significantly large. He has also argued that powerful countries may opt to offer neither the effort nor the costs necessary to secure an agreement from which they would gain regardless of their effort (i.e., in which they are essentially free riders). Olson's arguments are absolutely correct, but these arguments only hold true when the time period for cooperating is limited and there is lack of incentive mechanisms to promote cooperation. Individual countries will then determine that cooperation is not the best course, regardless of others' actions. Hence, we should expect that if an organization functions for only a short period of time, in the absence of a central authority that governs the organization and enforces cooperation, no country will cooperate because there is no future to influence and countries with which to interact. This outcome is the well-known Prisoners' Dilemma, which has been recognized as inefficient.

The G-20's member countries ought to realize that to resolve current imbalances and avoid future imbalances, their economic policy decisions cannot continue to be based on short-term concerns that only maximize their individual welfare and ignore the implications of their policies for other countries, including those outside the G-20. The G-20 finance ministers' recent discussions on the methods for measuring economic "imbalances" at the Paris meeting on

February 19, 2011, are evidence that these countries are recognizing the disadvantages of implementing short-sighted policies and noncooperative solutions. One of the outcomes of such discussions has been the presentation of a list of indicators to monitor the progress of member countries in reducing imbalances to avoid another global financial crisis and recession. It is now widely recognized that these imbalances are the large external surpluses in countries such as China and Germany and the large deficits in the U.S. China must stimulate domestic demand and become less dependent on exports, while the U.S. must increase its savings rates and become less dependent on debt-driven consumption. Thus, they have suggested considering indicators such as: current account balance, government fiscal balance, real exchange rate, reserves, capital flow volatility, and private finance positions (savings and debt) among others. Putting forward this list of indicators is a significant achievement in terms of compromise and the commitment to move ahead, but continuous monitoring and peer pressure will be required to enforce the agreements. By the time the G-20 meets again in April 2011, they are expected to agree on the most adequate indicators.

Let us refer to the “life” of the G-20 as it pertains to the subsistence of the institution and to the institution’s stable rules or agreements, implicit or explicit, strictly followed by its member countries over time. If the life of the G-20 is expected to consist of a certain and finite number of periods with the same set of agents participating in each period and with no rule enforcement, the outcome will be a lack of cooperation among members. The main reason for this outcome is that there is no future in which members can interact with each other. During the penultimate periods, countries also have no incentive to cooperate because they can anticipate mutual defection on the last move. This line of reasoning implies that the game will find an answer based on the mutual defection in the first move of the sequence of plays that are known to have finite length (Luce

and Raiffa (1957)). This result has become well known in the theory of repeated games (see Fudenberg and Tirole (1991)). On the other hand, Hirshleifer and Rasmusen (1989) have demonstrated that if noncooperative countries are sanctioned and if the life of the organization is expected to be finite with certainty, cooperation will be possible up to the last period before the end of the organization's life. However, if the organization is expected to have an infinite life with certainty, again with the same set of countries, then cooperation with the same group of countries is possible (see, for instance, Aumann (1981) and Friedman (1977)). In this case, there is always a subsequent period in which noncooperative agents can be sanctioned. In another work, Cramer (1986) has shown that even when the organization has infinite life, if the players have fixed, predetermined lifetimes, they will never cooperate in the last period of the game.

The assumption of an infinite life for an organization such as the G-20 (with stable and self-enforcing rules), with long-term relationships between a fixed group of countries, is debatable. In reality, the character and interrelations of the member countries can be altered because of government regime changes (e.g., when a new political party assumes power). In addition, member countries might be uncertain about how long the organization itself would subsist. Neyman (1999) has supported this idea by arguing that the result that all equilibria of the finitely repeated Prisoners' Dilemma lead to the noncooperative outcome relies heavily on assumptions that players must know the number of repetitions and that each player might not know what the other players know. Neyman has argued against these assumptions and has alternatively considered incomplete information about the finite duration of the repeated game or the number of repetitions. In the context of this paper, his assumption implies that the lifespan of the institution is not common knowledge to all players. Neyman has found that cooperation is possible if each player makes strategic decisions based on uncertainty regarding the number of

repetitions of the Prisoners' Dilemma. He has modeled uncertainty by considering the expectation of the number of repetitions as equal to the exponential function of the number of players. Thus, there is an exponential departure from the common knowledge.

In this paper, we consider a more pragmatic case in which the lifespan of the organization is uncertain (as in Neyman), but we also account for the possibility that member countries' political preferences may change drastically as their government regimes shift (as in Cramer (1986)). Such shifts may lead to problems in enforcing a cooperative solution among members and thus increase the difficulty of achieving the organization's goals. In particular, governments in power may choose not to cooperate in the last period of their government regimes because radical changes in their country policies may be expected after that time and/or because a given administration in power may have less interest in cooperating beyond its own incumbency period. Our model shows that, in contrast to Cramer (1986), if governments are concerned about their legacies and their (and their countries') reputations over the long-term, cooperation is not only possible but also permanently stable. Moreover, this paper demonstrates the necessity of sanctioning countries that do not cooperate in order to achieve cooperation over the long horizon. This result opposes that of Hirshleifer and Rasmusen (1989) who assumed that the duration of the organization's lifespan is common knowledge and finite, and found that countries will never cooperate in the last period of the organization's lifespan even when there is a continuous threat of being sanctioned for not cooperating and being expelled from the organization. Note that we, in contrast, show that if governments care about their countries' reputation, given a sufficiently large discount factor and a credible sanction policy, cooperation is feasible in every period.

The present study considers the following environment: i) countries are sanctioned by being excluded from the organization if they do not cooperate, but they can reenter the

organization in a later period if they begin to cooperate again; ii) there is uncertainty about how long the organization itself will endure; iii) the countries' governments have finite lives and the duration of their government regimes are common knowledge; v) if a government does not cooperate in the last period of its regime, its country will be expelled from the organization for life; and v) individual governments may or may not be concerned about their reputations and their legacies even after their regimes end.

In this paper, we find the repeated game methodology useful because it is a good approximation of long-term relationships in which "trust" and "social pressure" are important and because formal agreements are used to enforce mutually beneficial trades in the absence of legally enforced contracts and a central authority to govern the organization. We will assume that each member country of the organization can observe the type of action of its "opponent". Thus, each member country can determine whether another country has shirked by observing its own utility. The consideration of asymmetric information about a country's utility functions should be the topic of future research.

The paper is organized as follows. Section 2 presents the basic model of a cooperative solution without externalities. Section 3 contains the solution to the repeated game when members are uncertain about the lifespan of the organization but more certain about the continuity of the countries' governmental policies and commitments. In Section 4, members of the organization are uncertain about whether policies will shift in accordance with the countries' change of governments (e.g., presidents, prime ministers). Section 5 concludes.

2. The cooperative solutions without externalities

Assume that when each of n countries decides to cooperate to increase the worldwide welfare, the country must exert certain effort denoted by α_i . We state that country i cooperates if it exerts effort α_i , but if it does not cooperate, it exerts effort α_i^D . The value of α 's characterizes the type of effort a country exerts. Thus, the worldwide welfare derived from having n countries that cooperate and each exert an effort equal to α_i is denoted by $\Omega(\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n)$. Ω will thus depend on the number of countries that contribute to the worldwide welfare, the countries' types of effort, and their decisions on whether to cooperate.

The n th country's marginal contribution to worldwide welfare due to its cooperation will then depend on its effort and can be expressed as the following:

$$p_n(\alpha_n) = \Omega(\alpha_1, \alpha_2, \dots, \alpha_n) - \Omega(\alpha_1, \alpha_2, \dots, \alpha_{n-1}); \quad (1a)$$

However, if it does not cooperate, the n th country's marginal contribution to worldwide welfare will be the following:

$$p_n(\alpha_n^D) = \Omega(\alpha_1, \alpha_2, \dots, \alpha_n^D) - \Omega(\alpha_1, \alpha_2, \dots, \alpha_{n-1}). \quad (1b)$$

p_i ($\forall i = 1, \dots, n$) may then be positive or negative, depending on whether this additional country n cooperates. When p_i is negative, the world's welfare decreases because country n chooses not to cooperate. Thus, country n may in principle *create (substantial) negative externalities for other countries by not cooperating and not choosing a Pareto optimal α_n* . However, country n has no incentive to consider these externalities when behaving selfishly.

If a larger number of countries choose a sub-optimal effort, α_i^D , and a smaller number of countries cooperate by making a positive contribution (i.e., shirking), fewer worldwide economic benefits will result.

The welfare for country i will be a function of the sum of the marginal contributions of all of the n countries when cooperating and country i 's cost of exerting the effort:

$$u_i = u \left[\sum_{i=1}^n p_i(\alpha_i) \right] - C(\alpha_i). \quad (2)$$

Each country i must choose its type of contribution or its type of effort α_i . If countries cooperate, the solution to this game would require a solution to the following problem:

$$\text{Max } \pi(\alpha_1, \alpha_2, \dots, \alpha_n) = \text{Max} \sum_{i=1}^n \left[u \left(\sum_{j=1}^n p_j(\alpha_j) \right) - C(\alpha_i) \right]. \quad (3)$$

π are the net aggregate marginal contributions from all countries when they cooperate and consequently choose α_i . $C(\alpha_i)$ is the cost of exerting effort when choosing α_i for country i . A country will incur no costs to exert the effort α_i^D if it decides not to cooperate.¹ The functions u and C in (3) are differentiable and monotonically increasing; the α 's exist and are strictly positive, while $C(\alpha_i)$ is convex. u in (3) is strictly concave in p_i (and consequently also in α_i).

The solution to the above problem will satisfy $p_1 = p_2 = \dots = p_n = p$, which consequently implies that $\alpha_1 = \alpha_2 = \dots = \alpha_n = \alpha$. If we denote Γ^n as the optimal level of $p(\alpha)$ common to all countries, Γ^n will be the solution to the following maximization problem:

$$\text{Max } \pi_i(n\Gamma^n) = \text{Max} \left[u(n\Gamma^n) - C(\Gamma^n) \right]. \quad (4)$$

¹ One can think of α_i^D as being very small.

More specifically, Γ^n can be solved from the following function:

$$u \pi'(n\Gamma^n) = C'(\Gamma^n) \quad (5)$$

However, we shall realize that no cooperation is the natural outcome in this organization. Accordingly, no cooperation is the dominant strategy of a game in which each agent chooses a level of effort equal to α_i^D . If defecting ought to be a dominant strategy, the following condition should be satisfied:

$$u \left(\sum_{i=1}^n p_i(\alpha_i^D) \right) > u \left(\sum_{i=1}^n p_i(\alpha_i) \right) - C(\alpha_i) \quad (6)$$

When condition (6) is met, we encounter a Prisoners' Dilemma, which illustrates the negative externality that each country can cause to each other when they do not cooperate. That is, a country will consider the adverse effect of its own participation on the welfare change but will not consider the effect on the total welfare in the organization. Hence, each country will choose not to cooperate, and suboptimal participation will result ($p(\alpha_i^D) \neq \Gamma^n$).

Players could achieve results that are better than the Prisoners' Dilemma outcome by merely considering the long-term consequences of their decisions. When these consequences are considered, an efficient collusion of players (i.e., countries) could aim to reach certain binding agreements that are not necessarily legally enforceable but bring mutual benefits to all member countries. In the best-case scenario, incentives to monitor each other would be created to ensure that each country's period-by-period decisions are in line with the agreements. Thus, cooperation could be sustained by self-interest and self-enforcing to promote the establishment of stable habits and rules.

Nonetheless, there are some caveats that could weaken the above argument. These caveats are as follows: i) deviations from any agreement will yield some gains today; ii) losses from retribution for deviating will occur in the future; iii) the size of the discount factor to determine whether the discounted losses are sufficiently large to offset the gains from deviating today; iv) the type of mechanisms for imposing the retribution; v) the length of time for which the country that deviates can continue deviating before the retribution begins; and v) the lifespan of the organization and whether this lifespan is common knowledge. This paper will next consider all of these factors and determine the mechanism under which cooperation is possible over the long term.

3. Uncertainty about the life duration of the organization, punishments and the prospects for cooperation as a repeated game

3.1 Main assumptions

Our modeling attempts to answer a central question regarding the conditions under which countries can improve upon the Prisoner's Dilemma outcome (i.e., moving a group of agents from noncooperative to cooperative equilibrium in the absence of a central authority). To answer this question, we must determine the nature of the equilibrium and establish the conditions for achieving such equilibrium.

At the beginning of the game, countries (e.g., members of the G-20) agree to cooperate and exert effort α_i to achieve certain goals. By cooperating, all countries will obtain higher welfare than they would obtain by defecting. As explained in Section 2, defection implies that countries do not exert sufficient effort to achieve the cooperative solution.

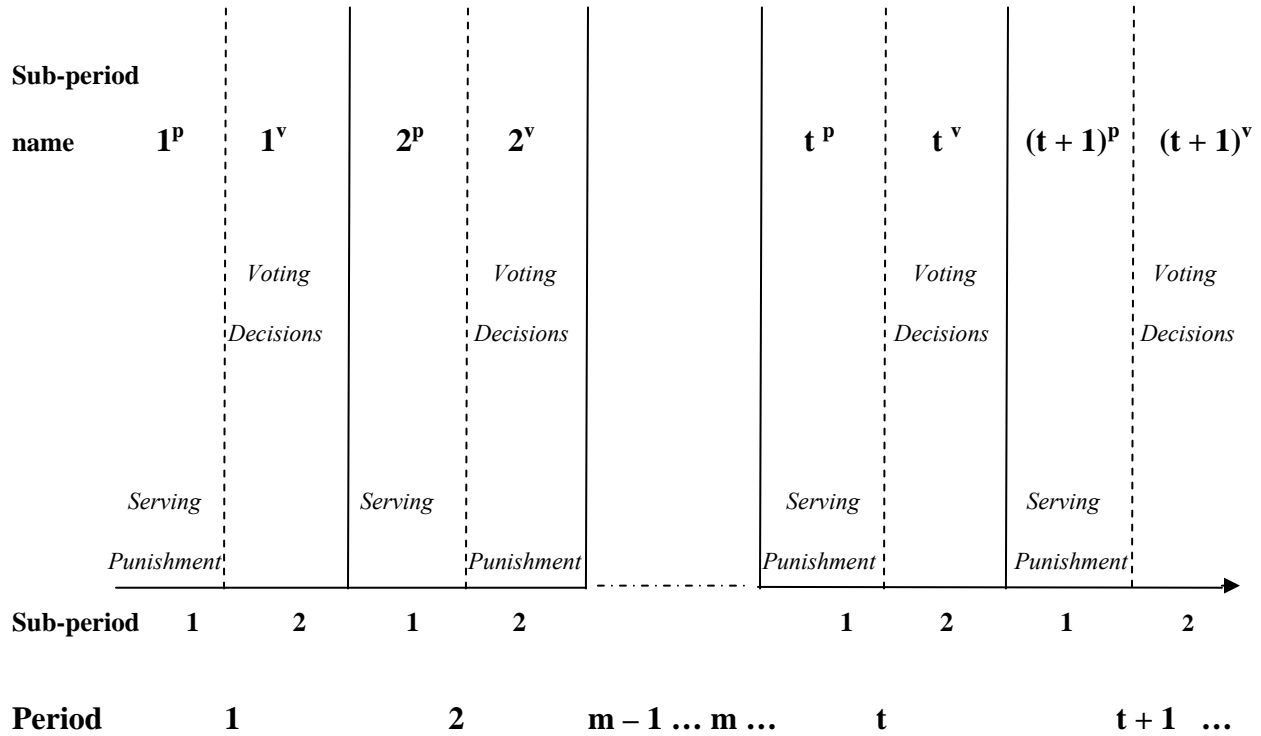
The following main assumptions are considered:

- The game begins with n countries, and there is uncertainty about the duration/longevity of the organization.
- Each period t has two phases. In the first phase, a member carry out its sanction; this phase is denoted as t^p . In the second phase, member countries evaluate and vote to sanction countries that have deviated. This phase is denoted by t^v . One vote is sufficient for punishing a defecting member.
- A country is considered a deviator/shirker if it does not exert the effort that is necessary for cooperation and if it does not successfully detect peer countries that are defecting.
- The sanction for defecting is the exclusion from the group for one period.
- Each player receives a base level of welfare because of its membership in the organization (G-20 group); we normalize this level as being equal to zero.
- Each player receives higher welfare (greater than zero) if all members cooperate. Payoffs per member country are an increasing function of the number of members who cooperate.
- When a member country is sanctioned for defecting, its welfare will fall below zero and be equal to $-Y$. Even if no one cooperates, a defector will be always sanctioned when it defects, and its loss in welfare is larger than its loss when it does not deviate.
- Voting entails no direct cost or benefit to those members who engage in it.

3.2 The basic dynamics of the model

We denote as n_t the number of members who play in the Prisoners' Dilemma at the end of every round t . The member countries in the first phase of t are those that have *not* been sanctioned (not excluded from the group). The number of these countries is referred to as n_t^p and should be equal to n_{t-1} .

Figure 1. The structure of the game when the lifespan of the organization is uncertain



- A member country that has been excluded (sanctioned) from the group during sub-period t^P in period t will not enter the Prisoners' Dilemma game at t^V in round t and will consequently not be evaluated at $(t+1)^P$ to determine whether it has defected.
- A defector that remains sanctioned at t^P receives payoffs for the entire period equal to $-Y$, which is the cost of not being part of the group. The defector can rejoin the group at $(t+1)^V$ and re-enter the organization and participate in the Prisoners' Dilemma game.
- A member country that deviates at t^P (given that it has not already deviated in $(t-1)^V$) will be sanctioned within the same period at t^V and will immediately face the costs of not being part of the organization, $-Y$. In addition, the country will continue to be expelled from the organization during the following period, $t+1$.

Because the sequence of the game has been described, we can now explain the basics of the game without appealing to time periods. Thus, n is the number of members and each of them evaluates who is defecting, determines which members should be punished, and decides whether to cooperate. The members of the organization equally share the total welfare that is bred by the members in the group at each t , including those that do not cooperate. Thus, they equally share the welfare that was determined above in equation (3):

$$\sum_{i=1}^n \left[u \left(\sum_{j=1}^n p_j(\alpha_j) \right) - C(\alpha_i) \right].$$

The average welfare per member country, π^{pc} , when every member cooperates is defined as follows:

$$\pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n, n). \quad (7)$$

Thus, the notation (n, n) in (7) indicates that all n members of the organization are cooperating each with effort α_i . In contrast, if one member country does not cooperate, the notation will be $(n-1, n)$. Thus, the average welfare per member country when one member does not cooperate is as follows:

$$\pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n^D; n-1, n). \quad (8)$$

We can now reinstitute our condition for the game to be a Prisoners' Dilemma, but this time the game will be in terms of per-individual welfare, in which defecting must be a dominant strategy, such as the following:

$$\pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n^D; n-1, n) > \pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n, n) - C(\alpha_i). \quad (9)$$

The assumption that welfare increases with the number of cooperating members is embodied in the following notation:

$$\pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_{n-1}; n-1, n-1) < \pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n, n), \quad (10)$$

This notation leads us to the definition that the per-capita welfare when no member cooperates is equal to the following:

$$\pi^{pc}(\alpha_1^D, \alpha_2^D, \dots, \alpha_n^D; 0, n) = 0, \quad (11)$$

Additionally, if we define n^C as the number of cooperators, a reduction in the number of members due to the loss of some members who have defected does not result in a reduction of welfare:

$$\pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n^C, n-1) \geq \pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n^C, n), \quad (12)$$

where $n^C \leq n-1$.

Thus, the payoffs for an individual member country i of the G-20 in any round t are as follows:

$$\begin{cases} \pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n, n) - C(\alpha_i) & \text{if } i \text{ cooperates} \\ \pi^{pc}(\alpha_1, \alpha_2, \dots, \alpha_n; n, n) & \text{if } i \text{ does not cooperate} \\ \pi^{pc}(\alpha_1^D, \alpha_2^D, \dots, \alpha_n^D; 0, n) & \text{if all members defect} \\ -Y & \text{if } i \text{ gets punished.} \end{cases} \quad (13)$$

Given that the lifespan of the organization is uncertain, we assume that there is a time-invariant probability q that the organization will end at any time t .

We simplify our notation as follows:

$$\pi(\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n); n, n) = w(n, n); \text{ and}$$

$$\pi(\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_n^D); n - 1, n) = w(n - 1, n)$$

3.2 Equilibrium

First, note that any member can vote to punish other members who defected at any phase in any period t . In addition, a member country that fails in its vote by sanctioning a member unfairly or not sanctioning a member that deserves sanctioning, if discovered, will be also sanctioned.

We must substantiate when one can support an equilibrium with cooperation in every round bearing in mind that member countries (and we, the authors) are uncertain regarding when the organization will end. To characterize the equilibrium, we must specify the conditions under which a deviation will occur at t^v and at t^p .

To facilitate the exposition, we have the following definitions.

Definition 1. The number of members that cooperate entering phase t^v is n_t^* .

Definition 2. n^d is the number of members that do not cooperate at time t^p , while the number of members that do deviate is n^{nd} . We identify the equilibrium level of members, \bar{n} , as the equilibrium in which all member countries remaining in the organization have not deviated at t^p and t^v .

a) *No-deviation subgame equilibrium in phase t^v*

Proposition 1. *A member country will never deviate at t^v if it has not deviated in t^p and if there is a positive probability that the organization will continue to exist.*

Proof. If a member country deviates at t^v , its immediate payoffs at t^v will be $[\pi(n_t^* - I, n_t)]$ rather than $[n_t^*, n_t] - C(\alpha_i)$. Because the country will be sanctioned and asked to leave the organization in phase or sub-period $(t+I)^p$, considering that there is a positive probability q that the organization may continue to exist, its discounted payoffs will be $-\delta q Y$ rather than $\delta q [n_{t+1}^*, n_{t+1}] - C(\alpha_i)$ during that period $(t+I)$. Therefore, countries will fare better if they cooperate.

If the following condition is satisfied, a country *will prefer to cooperate* at t^v , given that it did not deviate in t^p :

$$w(n_t^* - 1, n_t) - \delta q Y + \delta(1 - q)[0] \leq w(n_t^*, n_t) - C(\alpha_i) + \delta q [w(n_{t+1}, n_{t+1}) - C(\alpha_i)] + \delta(1 - q)[0] \quad (14)$$

According to (14), each member country will attach a probability $(1 - q)$ that the game will end at time $(I+t)^v$ ($\forall t$) so that if it does not cooperate, its payoffs will be zero. Thus, if the organization is expected to cease its existence at $(t+1)$, no member will cooperate, and there will be zero benefits for the member countries (see equation (11)). As in all repeated game models, cooperation will not occur if the discount factor is close to zero.

b) *Deviation sub-game equilibrium in phase t^v*

Proposition 2. *A member country will always deviate at t^v if it has already deviated in t^p independent of its expectations regarding the lifespan of the organization.*

Proof. If a member country has already shirked at t^p , it knows that it will remain out of the group between t^v and $(t+I)^p$. This knowledge holds even if the country thinks that the

probability q that the organization will continue to exist is equal to one and the discount factor is large. The country cannot lose by deviating in t^v because if it deviates, its payoffs are $[w(n_i^* - 1, n_i)]$ at t^v , but if it does not deviate, its payoffs are $[w(n_i^*, n_i) - C(\alpha_i)]$ at t^v . Obviously, the country obtains a lower welfare by cooperating.

c) *No deviation sub-game equilibrium in t^p*

Proposition 3. *As long as there is a positive probability that the organization will not cease to exist, a member country will be better off by cooperating in t^p .*

Proof. If a member country deviates at t^p , it will not be in the group at t^v (but it will still receive payoffs equal to $[w(n_i - 1, n_i)]$). However, its payoffs in $(t+1)^p$ will be $-\delta q Y + \delta(1 - q)[0]$ rather than $q\delta[w(\bar{n}, \bar{n}) - C(\alpha_i)] + \delta(1 - q)[0]$; these payoffs could be obtained in $(t+1)^v$ by being part of the group and cooperating at both t^v and $(t+1)^v$. Thus, as long as the probability that the organization will continue existing is nonnegative and the discount factor is not sufficiently small, a member country's welfare will be higher if it does not deviate at t^p .

d) *Deviation sub-game equilibrium in t^p*

Proposition 4. *Independent of the probabilities that the organization will exist in the long term, the decision of whether to deviate in t^p depends on whether a member country X's defection can be detected.*

Proof. If country X votes to sanction every other country in sub-period t^v , there will not be any remaining country in the organization to vote to sanction this country X. Country X's welfare will be zero (see equation (11)) rather than $[w(n^{nd}, n^{nd}) - C(\alpha_i)]$; this welfare can be

obtained in t^v by cooperating. Recall that if a member country makes an unwarranted vote to expel other members, the group size and the potential number of cooperators will decrease; thus, the welfare of the remaining countries will decrease. Furthermore, if no country participates and cooperates in the organization, the welfare that each country obtains will equal zero. Consequently, country X will be worse off if it decides to sanction every member to avoid cooperating.

Therefore, if a member country has not been excluded from the group at t^p (because it has not deviated at $(t - 1)^p$), the condition under which a member country will not find deviation profitable at t^p is the following:

$$w(n_i^d - 1, n_i^d) - \delta q Y + \delta(1 - q)[0] \leq w(n_i^{nd}, n_i^{nd}) - C(\alpha_i) + q\delta[w(\bar{n}, \bar{n}) - C(\alpha_i)] + \delta(1 - q)[0] \quad (15)$$

Equation (15) will hold for positive values of q and under the assumption that the discount factor is sufficiently large.

In conclusion, because we allow the realistic assumption of uncertainty about the life duration of the organization (or the number of repetitions of the game), our results differ from the results obtained by Hirshleifer and Rasmusen (1989). First, if the probability that the organization will not end is positive, cooperation is possible over an infinite number of periods. Second, even when sanctions can be implemented, member countries will not cooperate in any period t if they expect that the organization will cease to exist at period $t+1$ ($\forall t$). Thus, the organization's and expectations for its long life are necessary to ensure cooperation as an equilibrium outcome.

4. Cooperation when country membership depends on the political party in government

The member countries may decide to abide by the rules and any informal arrangements of the organization, but in reality, countries change their governments when new presidents are elected; thus, the continuity of their commitments to cooperate cannot necessarily be warranted. We will consider that presidents are elected only for a certain period of time and that cooperation cannot be warranted across the different governments in a single country. We will compare the results with those results obtained in Section 3.

Our model will incorporate the likelihood that some presidents might not have incentives to cooperate in the last period of their regimes because any sanction applied in this last period might not affect them. This tendency may be true even if the country knows that a lack of cooperation in the last period of its regime will result in being expelled from the organization and replaced by another new country for life. The final outcome will depend on whether the country is concerned about its own reputation and/or its country's reputation. In other words, a president may or may not be concerned about his and his country's legacy after finishing his term in the government. For this concern to be of interest and relevance, a president must internalize the reputation loss of his country in his own welfare/utility. We here say that a country loses its reputation if it cannot credibly convince the other members of the organization that a new government will cooperate. Moreover, when a country is expelled from the organization for life, the country loses its negotiation power and credibility inside and outside of the organization. We suggest future research on the endogenization of reputations. In this paper, a country's reputation is treated as an exogenous variable.

First, we will consider the case in which the government authority might be concerned about the possibility of its country's loss of reputation only in the last period of its government.

A country loses its reputation when it does not cooperate in the last period of its regime because it deviates in the last period of its regime or it is already expelled from the organization for not cooperating in the previous period. Second, we analyze the case in which a government is concerned about the reputation and credibility of its country at the ends of its regime and in the future.

a. Assumptions

We continue assuming uncertainty about whether the organization will have an infinite life. In addition, each government of the n countries (i.e., the 20 countries of the G-20) knows that it will be in power for a specific number of years; this length of time may be either shorter or longer than the expected life of the organization. The length of each government regime is common knowledge to every country. Each regime can be 1, 2, 3, ..., m number of years in government.² A shift in government occurs at the end of period $t + m - 1$. If the government of a country does not cooperate in its last period of its regime, it will be expelled from the organization for life and will be substituted by a new country that is qualified to enter the organization. Thus, a country will choose to shirk or cooperate depending on which alternative will offer the largest lifetime utility.

4.2 A government is concerned only about its reputation in the last period of its regime

a) Sub-game equilibrium at t^v

² For the sake of simplicity, we assume that presidents/prime ministers from all countries remain in office for the same number of years (e.g. m).

Proposition 5. *There will be cooperation in all periods except in the last period of the government's regime unless the organization's existence is expected to end.*

Proof. Following the reasoning above, one can establish the optimal conditions for deciding whether to cooperate. The decision of whether a particular country's government will cooperate during its regime and during the last period of its regime depends on whether the following inequalities are satisfied:

$$\begin{aligned}
 \text{(i)} \quad w(n_t^* - 1, n_t) - \delta q Y &\leq \begin{cases} w(n_t^*, n_t) - C(\alpha_i) + q\delta[w(n_{t+1}, n_{t+1}) - C(\alpha_i)] & \text{if } t < m-1 \\ w(n_t^*, n_t) - C(\alpha_i) + q\delta[w(n_{t+1}, n_{t+1}) + reputation - C(\alpha_i)] & \text{if } t = m-1 \end{cases} \\
 \text{(ii)} \quad w(n_t^* - 1, n_t) &\leq (w(n_t^*, n_t) - C(\alpha_i)) & \text{if } t = m
 \end{aligned} \tag{16}$$

In contrast with (14), (16) indicates that it is relevant for a country's government to verify its optimal decisions in previous periods before $m - 1$, at $m - 1$, and at m . By noticing (ii), we conclude that no government will be ready to cooperate in the last year of its regime because there is no reputation to lose after its regime has ended at m .

However, (i) suggests that governments may have no incentives to deviate before $m - 1$. In contrast, at $m - 1$, a government will consider that its cooperation will result in immediate payoffs $w(n_{m-1}, n_{m-1})$ at $(m - 1)^v$ in addition to the discounted expected payoffs and reputation $\delta q(w(n_m, n_m) - C(\alpha_i) + reputation)$ to be received at m . If the government decides not to cooperate, its payoffs will be $w(n_{m-1}, n_{m-1})$ at $(m - 1)^v$ in addition to a loss of $-\delta q Y$ due to its

expulsion at m (i.e., the costs of not being a member)³. The payoffs consider the probability of whether the organization will exist by the end of the government's regime. Thus, if reputation is important for a government, the case for cooperation up to period $m - 1$ is strengthened, particularly when there is even a small positive probability that the organization will not end.

As in Section 3, if within any period t , a government *has already deviated during the phase when punishments are served* (t^p), it will never cooperate within the same period in the phase or sub-period when voting takes place (t^v). This result will be true for all t , including the period in which its regime ends at m . This result holds true regardless of the value of the probability q .

b) Sub-game equilibrium at t^p

Proposition 6. *The decision of whether to deviate at t^p , given that the member has not deviated previously and that the organization is expected to exist, will depend on the length of time that remains until the end of its regime.*

Proof. We rewrite condition (15) to describe a government's optimal decision about whether to cooperate in phase t^p :

$$\begin{aligned}
 \text{(i)} \quad w(n_t^d - 1, n_t^d) - \delta q Y &\leq \begin{cases} w(n_t^{nd}, n_t^{nd}) - C(\alpha_i) + q\delta[w(\bar{n}, \bar{n}) - C(\alpha_i)] & \text{if } t < m - 1 \\ w(n_t^{nd}, n_t^{nd}) - C(\alpha_i) + q\delta[w(\bar{n}, \bar{n}) - C(\alpha_i) + \text{reputation}] & \text{if } t = m - 1 \end{cases} \\
 \text{(ii)} \quad w(n_t^d - 1, n_t^d) &\leq w(n_t^{nd}, n_t^{nd}) - C(\alpha_i) & \text{if } t = m
 \end{aligned} \tag{17}$$

³ If the government does not cooperate, it will not be eligible to vote and gain any payoff and reputation at m .

In addition to the role that the probability distribution regarding the life duration of the organization and the discount factor serve in determining the equilibrium outcome, reputational factors are very important in the decision making regarding whether to cooperate and the timing for such cooperation. For example, even if q and δ are very small, governments who value their reputations will always prefer to cooperate up to the penultimate period of its regime. Nevertheless, one cannot guarantee cooperation beyond $m - 1$. Governments will never cooperate at m because reputational effects beyond m do not affect the welfare of the governments in power. Finally, even governments who value reputation may cease cooperating at any time and as soon as they begin to expect that the organization will not continue to exist.

Our results differ from the results obtained by Cramer (1986) when we introduce uncertainty about the lifespan of the organization. The most drastic difference is that countries can cease cooperating as soon as they do not believe the organization will continue existing. Cramer has concluded that there will be cooperation until the penultimate period of the government regime. Another important result of our study that was not obtained by Cramer is that if reputation has a crucial role in governments' decisions, cooperation can be achieved even if the discount factor and q are small.

4.3 A government is concerned about its legacy and the future reputation of its country beyond the end of its regime

We are interested in determining the possibilities for cooperation in cases in which country governments aim to continuously protect their reputations while still considering the probability distribution of the organization's lifespan. To continuously protect their reputations, each government must cooperate until the end of its regime, m , to avoid being expelled from the

organization for life. Once this cooperation is attained, the government can ensure the possibilities for continuity in its country's cooperation. Because considering the future implies contemplating all of the possible payoffs and reputational effects that future governments will generate by cooperating, we assume without sacrificing generality that beyond m the payoffs and reputation are constant over time. This assumption will avoid unnecessary complications. Other formations of expectations will most likely not affect our qualitative conclusions. We establish the conditions for cooperation in t^v and t^p below.

a) *No deviation sub-game equilibrium at t^v*

Proposition 7. *Governments will always cooperate as long as they are concerned about their countries' reputations and there is a positive probability that the organization will not cease to exist.*

Proof. The conditions for determining participation up to $m - 1$ are the same as the conditions presented in Proposition 6. The main difference is the condition for determining the optimum equilibrium in the last period of the government regime at m . Such conditions are as follows:

$$\text{i) } w(n_t^* - 1, n_t) - \delta q Y \leq \begin{cases} w(n_t^*, n_t) - C(\alpha_i) + q\delta[w(n_{t+1}, n_{t+1}) - C(\alpha_i)] & \text{if } t < m - 1 \\ w(n_t^*, n_t) - C(\alpha_i) + q\delta[w(n_{t+1}, n_{t+1}) + reputation - C(\alpha_i)] & \text{if } t = m - 1 \end{cases}$$

$$\text{ii) } w(n_m^* - 1, n_m) \leq (w(n_m^*, n_m) + \sum_{\tau=m+1}^{\infty} \delta^\tau q^\tau (w(n_\tau, n_\tau) - C(\alpha_i) + reputation)) = (w(n_m^*, n_m) + \delta q \cdot \frac{1}{1 - \delta q} (w(n, n) - C(\alpha_i) + reputation)) \quad \text{if } t = m$$

(18)

(ii) indicates that if a government is concerned about its legacy in terms of its willingness to maintain its country's reputation, it will cooperate even in the last period of its government at m . Nonetheless, if the discount factor and the probability that the organization will subsist are very small, there will be no cooperation before m and beyond m .

b) *Sub-game equilibrium at t^p*

Proposition 8. *Governments will always cooperate in all sub-periods in which governments are sanctioned unless there are expectations that the organization will no longer exist.*

Proof. The number of member countries that have not deviated in t^v and t^p and will not consequently be punished in $(t+1)^p$ is denoted as \bar{n} . In this case of stability, a constant stream of payoffs can be expected to result from cooperating and reputational effects during the lifespan of the organization. Thus, cooperation will occur if the following conditions are satisfied:

$$\text{i) } w(n_t^* - 1, n_t) - \delta p Y \leq \begin{cases} w(n_t^*, n_t) - C(\alpha_i) + q\delta[w(\bar{n}, \bar{n}) - C(\alpha_i)] & \text{if } t < m - 1 \\ w(n_t^*, n_t) - C(\alpha_i) + q\delta[w(\bar{n}, \bar{n}) + reputation] - C(\alpha_i) & \text{if } t = m - 1 \end{cases}$$

$$\text{ii) } w(n_m^{nd} - 1, n_m^{nd}) \leq w(n_m^{nd}, n_m^{nd}) + \sum_{\tau=m+1}^{\infty} \delta^\tau p^\tau (w(\bar{n}, \bar{n}) - C(\alpha_i) + reputation) = w(n_m^{nd}, n_m^{nd}) + \delta p \cdot \frac{1}{1 - \delta p} (w(\bar{n}, \bar{n}) - C(\alpha_i) + reputation) \quad \text{if } t = m$$

(19)

As previously noted, if the probability that the organization will end, $(1 - q)$, equals one and the discount factor is relatively small, obtaining cooperation as an equilibrium outcome will not

be possible in m or in $(1 - m)$. In this case, we will experience a repeated Prisoners' Dilemma during the life of the organization.

5. Conclusions

The problems with and conditions for establishing and enforcing cooperation as presented above can be useful as a guide and prediction of what is required for the main countries in the international community to agree on issues that allow them to achieve strong sustainable and balanced growth both in their own countries and globally. In the example that was used extensively for the analysis above, the leading advanced and emerging economies of the G-20 face at least five challenges, as stated by Lipsky (2011), which require cooperation to attain certain objectives. These challenges include securing recovery; protecting the poor from the impact of the crisis; reforming the financial sector; restructuring and reforming international financial institutions; and reassessing the theoretical underpinnings of prevailing economic and financial policies.

The above challenges are significant, and the attempt to deal with these challenges is an ambitious undertaking. Several concrete examples suggest the prevalence of specific uncoordinated policies that can be damaging if cooperation is not stressed and enforced. One example refers to the unilateral decisions of certain countries to maintain a depreciated nominal exchange rate or to conduct uncoordinated central bank interventions in the foreign exchange market. This policy has been essential for export-led countries in achieving economic growth. In another example, the excessively expansive monetary and fiscal policies followed by certain countries to stimulate their economies may lead to instability to other countries. Additionally, the lack of harmonization regarding financial market regulation can cause market participants to

move to markets that allow them to maximize their risk-taking behavior. In some cases, such policies may have benefited these countries but often do not benefit the global community. In other cases, multinational corporations can take advantage of host governments to lessen their carbon taxes (or other types of penalties due to environmental harm) in the absence of coordinated climate policies between the affected governments. Each country has the incentive to appear effective to its citizens even at the expense of conflict with other countries and albeit such conflicts may adversely affect its citizens. However, countries are constantly in an iterated Prisoner's Dilemma with each other (see Laver (1977) for a similar argument); thus, they are faced with the temptations to behave uncooperatively. Economists have long since recognized the nature of the Prisoner's Dilemma problem, which captures an important part of the strategic interaction between countries and indicates that effective cooperation is possible only when countries interact frequently and for a long period of time. The approach followed in this paper elaborates on the continuous interaction issue; we believe that the theoretical game analysis of such interaction is a very powerful tool for understanding the process and outcomes of any attempts to promote cooperation.

There is this view that unilateral actions by countries that attempt to demonstrate effectiveness to their citizens yield zero-sum game outcomes, but nonetheless, one should look for the opportunities for cooperation that instead lead to mutually rewarding activities between countries, and positive-sum game outcomes.

On the basis of this study, we reach the following conclusions. We find, *first*, that it is possible to avoid the iterated Prisoner's Dilemma continuously and for an unspecified number of periods if the member countries of an organization, such as the G-20, engage in accountable and transparent decision making for a long period of time. When countries fail to engage in this

behavior, effective cooperation requires that sanctions are implemented for those parties (or countries) that violate social and economic norms. This paper demonstrates that establishing social norms that call for sanctioning when agreements are violated will result in self-fulfilling and self-reinforcing behavior that may support a cooperative outcome. This outcome results from the value of ensuring cooperation among all members and sanctioning both those that deviate or shirk and those who fail to sanction wrongdoing. In this situation, it becomes indispensable that the organization in question (we have here focused on the G-20) is expected to continue indefinitely. However, any existing expectations that the organization will not survive in the foreseeable future will result in countries defecting in the expected last period of the organization's life and possibly before this period. Otherwise, only sanctions will ensure cooperation among countries until the period before the organization is expected to cease to exist. Thus, it is crucial that the organization has the credibility associated with a long life and responsible members. Our *second* result arises from the realistic consideration that countries may wish to continuously abide by the rules and arrangements agreed within an organization (e.g., the G-20), but such initial concessions may depend on their particular elected governments, which may change during the life of the organization. We show that countries' governments might not cooperate in the last period of their regimes even if this lack of cooperation is sanctioned drastically by expulsion from the organization. They will cooperate only until the penultimate period of their regimes if i) they can be sanctioned for not cooperating at any period before the end of their regimes, ii) they show minimal concern for the loss of reputation that may result from expulsion from the organization, and iii) they do not expect that the organization's existence will end before their governments' regimes are about to end. Conversely, the outcome will be very different if, as part of its welfare function, every government internalizes its own

legacy and its country's reputation for avoiding expulsion from the organization. In this case, we find that equilibrium strategies that involve cooperation will exist during all rounds for as long as the organization is expected to endure. This final conclusion means that these reputational effects, combined with an enduring and credible organization to which the countries belong and create agreements to achieve key goals, can be very important when the objective is to achieve sustained and continuous cooperation between nations.

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