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Why Does Multilateral Cooperation Vary Across Issue Areas? Trade Versus Foreign Direct Investment

Imran Khan
Old Dominion University, ikhan004@odu.edu

WHY DOES MULTILATERAL COOPERATION VARY ACROSS ISSUE AREAS?

TRADE VERSUS FOREIGN DIRECT INVESTMENT

by

Imran Khan
B.S. May 2007, UET Lahore, Pakistan
M.P.P. May 2015, National University of Singapore, Singapore

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Approved by:

Jesse T. Richman (Director)

David Earnest (Member)

Erika Frydenlund (Member)

ABSTRACT

WHY DOES MULTILATERAL COOPERATION VARY ACROSS ISSUE AREAS?
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Imran Khan
Old Dominion University, 2024
Director: Dr. Jesse T. Richman

Why does multilateral cooperation sometimes fail to emerge, even in contexts where multilateral cooperation would be more beneficial for all parties than bilateral cooperation? To explore this puzzle, a generalization of the stag-hunt game is developed. The key finding from the analysis of this "stag-elephant" hunt game is that because pursuing multilateral cooperation is a riskier strategy due to the need for a larger number of players to cooperate to achieve it, multilateral cooperation can fail to emerge even when the payoffs from multilateral cooperation substantially exceed those of bilateral cooperation. To instantiate the central argument, I have selected the issue areas of international trade and FDI. The dominant pattern of cooperation in international trade is "multilateralism" while the dominant pattern of cooperation in FDI is "bilateralism". The dissertation specifically explores how and why different patterns of cooperation emerge in international trade and FDI. The central argument of the research is that cooperation can evolve to a particular pattern of cooperation through a combination of the effects of initial distribution of strategies (initial conditions) and the net payoff ratios. The net payoff ratio measures the relative benefit of multilateralism over bilateralism in an issue area. Multilateralism emerged in international trade due to favorable initial conditions (distribution of strategies) and because multilateralism is *much more* beneficial than bilateralism. On the other hand, bilateralism emerged in FDI due to favorable initial conditions and because multilateralism is *comparatively less* beneficial than bilateralism in FDI.

The simulation of the stag-elephant hunt game theoretic model using replicator dynamics shows that multilateralism is an Evolutionarily Stable Strategy (ESS) in international trade for a large set of initial distribution of strategies, while bilateralism is an ESS in FDI for large set of initial distribution of strategies. In other words, multilateralism is more likely in international trade while bilateralism is more likely in FDI.

I also found strong quantitative support for the three testable implications, which provides strong evidence regarding the usefulness of the model to understand how and why countries decide in a strategic situation whether to cooperate bilaterally or multilaterally.

I dedicate this dissertation to the idea of peace and cooperation between India and Pakistan. I hope that Kashmir, the bone of contention, will become the very instrument of deeper cooperation between the two countries.

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Of all the assets in my possession, knowledge is probably the most valuable. I value the people, relationships, and places in my life that has helped me acquire more knowledge.

The core idea of this dissertation is based on the coordination game, which originated from the exchange of ideas I had with Professor Jesse Richman, my dissertation supervisor and Professor David Earnest, external committee member. The game was subsequently named stag-elephant hunt game by Professor Jesse Richman. I met Professor Erika Frydenlund in the first semester of my PhD journey. She was always very encouraging and reinforced my desire to major in modeling and simulation. I deeply appreciate the patience, guidance, and persistent support of my dissertation committee to develop the research project. I must also acknowledge the generous support provided by GPIS professors to pursue a PhD degree. I truly appreciate the interdisciplinary nature of the program that has helped me to acquire knowledge from so many different fields. Again, this was not possible without the support of my dissertation supervisor.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE RESEARCH TOPIC

Multilateral cooperation varies across time and issue areas. Variation in multilateral cooperation across time: multilateral cooperation was virtually non-existent before WWII. However, in the postwar period, we saw a very high degree of multilateral cooperation on a wide range of international issues. The scope of multilateral cooperation is continuously expanding over time in most of the issue areas. Variation in multilateral cooperation across issue-areas: we see deeper multilateral cooperation in economic issue-areas while shallower multilateral cooperation in security issue-areas (Lipson 1984).

To explain the variation in multilateral cooperation, one strand of international relations (IR) literature emphasizes relative gains versus absolute gains (Jervis 1982; Powell 1991; Grieco, Powell et al. 1993; Hasenclever, Mayer et al. 2000). We see shallower cooperation in the security issue areas because the countries are more concerned about the relative gains in security issue areas than economic issue areas. The consideration of relative gains makes cooperation more difficult in any issue area (Milner 1992). The gains of cooperation are not uniformly distributed across the countries in any issue area. On the other hand, we see more cooperation in the economic issue area because the countries are more concerned about the absolute gains rather than relative gains.

Another explanation forwarded for the variation in multilateral cooperation across economic and security issue areas is based on the repetitive nature of the relationships. We see deeper multilateral cooperation in economic issue areas because the economic relations between the states are more repetitive than the security relations. The repetitive nature of the relationship

means that the same countries interact with each other over a longer period. This repetitive nature of relationships enables the countries to reciprocate the good or bad behavior over time. In the security realm, for example, when the country is attacked by a nuclear weapon, it may not be possible for the country under nuclear invasion to retaliate against the attacking country the next time. On the other hand, the same economic partners (trading, investment, monetary, etc.) interact with each other continuously over the period. The same economic partners have a long history as well as a future of interaction. All countries are more willing to cooperate with other countries when they know that they must meet other countries in the future. The length of the shadow of the future is an important explanatory variable for explaining the variation in multilateral cooperation across the security and economic issue areas.

However, when we move beyond this level of generality we see wide variation in multilateral cooperation within the economic issue-area. Length of the shadow of future or distribution of gains argument (alone or in combination) cannot fully explain variation in multilateral cooperation within the economic issue-area (international trade versus FDI (Foreign Direct Investment)). We see wide variation in multilateral cooperation across international trade and FDI despite having a similar length of the shadow of the future. There is no reason to believe that the countries are more concerned about relative gains in FDI than in international trade. Therefore, variation in multilateral cooperation across international trade and FDI is a puzzle that needs explanation.

1.2 RESEARCH QUESTION

We see deep multilateral cooperation in international trade and far less multilateral cooperation in FDI. What could be the possible explanation for the variation in multilateral

cooperation across international trade and FDI in the postwar period? The central question of my dissertation topic is: why is multilateral cooperation weaker in FDI than in international trade? We have multilateral agreements on different aspects of international trade, but we do not have a single multilateral agreement on FDI. Therefore, the "variation in multilateral cooperation" in the two issue areas could be understood as the absence of multilateral agreement in FDI and the presence of multilateral agreement in different aspects of international trade.[1] There is only a patchwork of FDI rules incorporated into different multilateral trade agreements. We have FDI provisions incorporated into existing multilateral trade agreements viz. Trade-Related Investment Measures (TRIMs), Trade-Related Aspects of Intellectual Property Rights (TRIPs), and General Agreement on Trade in Services (GATS). However, the existing International Relations (IR) literature has stressed having a single multilateral agreement on FDI covering investment liberalization commitments, investment protection, and investor-state dispute resolution mechanism (Vocke 1997).

The absence of multilateral cooperation does not mean the complete absence of cooperation in investment. Instead, bilateral cooperation is the dominant pattern of cooperation in investment. Similarly, we do not have multilateralism in international taxation. Instead, the most prevalent mode of cooperation in international taxation is bilateralism. The explanation regarding the shallower multilateral cooperation will be incomplete if we do not explain the dominant pattern of cooperation prevailing in these issue areas. The dominant pattern of cooperation in international trade is multilateralism while it is bilateralism in FDI (Thompson and Verdier 2014).

[1] Is multilateral cooperation really weaker in FDI than in international trade? How to explore this question more objectively? IR scholarship has made limited progress toward the measurement of multilateral cooperation. We do not have any quantitative indicator that could compare multilateral cooperation across different issue areas. It is beyond the scope of this dissertation to come up with operationalization of multilateral cooperation. The variation in multilateral cooperation is sharp across the two issue areas. There is no single comprehensive multilateral investment agreement. However, there are multilateral trade agreements covering different aspects of international trade.

The emergence of a pattern of cooperation in any issue area is a dynamic process. Countries do not establish the pattern of cooperation in one giant leap. They gradually adopted multilateralism in international trade and bilateralism in FDI. Countries interact strategically in each period to decide whether to cooperate bilaterally or multilaterally. It is not enough to explain why different patterns of cooperation emerge in two domains, but we must also try to understand how different patterns of cooperation emerge in the two domains from the initial conditions. We must open the black box to understand the process through which different patterns of cooperation emerge in the two domains. Therefore, in this research, I am trying to understand *how* and *why* different patterns of cooperation (bilateralism vs. multilateralism) emerge in international trade and FDI.

Multinational corporations are principal actors in the global economy. They are major drivers of international trade, foreign investment, and global GDP. The trade between states is primarily the trade between the different affiliates of a multinational corporation or between the multinational corporation and its affiliates established in different countries. Similarly, multinational corporations account for the major share of stocks and flows of global FDI. Despite the prominent position of the transnational actors in the global economy, international cooperation is intergovernmental in nature with transnational actors having limited or no direct control over international cooperation. In most cases, membership of international organizations is reserved for sovereign states only. For instance, membership is reserved for sovereign states in the United Nations, World Trade Organization, and International Monetary Fund. The decision regarding the different pattern of cooperation is related to the states rather than the transnational actors in the international system. Therefore, the research will focus on understanding how and why *states* decide to choose either to cooperate bilaterally or multilaterally.

There have been multiple attempts made on different platforms to reach a multilateral agreement on investment (MAI). However, the negotiations on MAI failed on all occasions. In the postwar period, the first attempt to reach MAI was made in the Havana Charter in 1947. However, MAI could not be concluded. Owing to the opposition of the developing countries, the talks on MAI could not be initiated from the platform of the World Trade Organization (WTO) (Tieleman 2000). The latest attempt to negotiate MAI was in the 1990s among the advanced economies from the platform of the Organization of Economic Cooperation and Development (OECD). However, the negotiations stalled in 1998 after a protracted negotiation of two years.

The International Center for Settlement of Investment Disputes (ICSID) and the United Nations Commission on International Trade Law (UNCITRAL) are the two main multilateral conventions for resolving the investment disputes that may arise between the host economies and foreign investors of home countries. However, these two conventions do not make the investment dispute settlement mechanism multilateral. This is because the two conventions only make the investment dispute settlement mechanism multilateral procedurally, not substantively. ICSID and UNCITRAL are not multilateral in a substantive sense. The substantive provisions related to the rights and obligations of parties, the definition and the protection of foreign investment vary from one bilateral investment treaty (or investment chapter of regional trade agreement) to another. The resolution of investment disputes by ICSID and UNCITRAL is done in accordance with the substantive provisions related to the rights and obligation of the parties under the investment agreement. Therefore, the investment dispute settlement mechanism is not multilateral in nature. This contrasts with the trade domain, where the dispute settlement mechanism is both substantively and procedurally multilateral. Consequently, we do not have a single comprehensive agreement covering investment protection, investment liberalization and dispute resolution mechanism.

We cannot deny the importance of a multilateral investment agreement given the rising investment flows in the global economy. Global FDI flows stood at US$ 1.6 trillion while the global FDI stocks stood at US$ 45 trillion in 2021, which is equivalent to half of global Gross Domestic Product (GDP) (United Nations Conference on Trade and Development (UNCTAD) 2022). The UNCTAD investment report also highlights that FDI stocks in the developing countries stood at US$ 12.3 trillion while FDI stocks in the developed countries stood at US$ 33.1 trillion. There is a growing complementarity between international trade and FDI in an era of Global Value Chains (Baldwin and Freeman 2022). FDI complements trade rather than replacing trade between the host and home economy. It is surprising that we do not have a single comprehensive MAI.

It has been often argued that a multilateral agreement on investment is desirable but not possible because of the opposition of developing countries. However, the attitude of developing countries towards Foreign Direct Investment has also changed over time. After decolonization, almost all the developing countries were hostile towards foreign ownership of their domestic assets. They raised various barriers to restrict the inflow of foreign investment from the colonial powers. Now many developing countries offer a wide range of generous fiscal incentives to attract FDI.

It is interesting to note that FDI is now a much bigger source of external capital for developing countries surpassing other forms of external financing such as portfolio, foreign aid, and debt flows (Milner 2014). The developing countries that consistently receive large FDI flows have grown faster than other developing countries that have failed to receive any sizable FDI flows. Notably, the large developing countries are not only the major recipient of FDI, but they are also the major investors abroad. FDI inflows to developing countries increased by 30 percent over the previous year reaching US$ 837 billion in 2021; more than half of the total global FDI flow

(UNCTAD 2022). FDI statistics indicate that the developing world is now the major recipient of FDI inflows. The UNCTAD investment report also highlights that FDI outflows from the developing countries increased from US$ 372 to US$ 438 billion between 2020 and 2021, suggesting that developing countries are also becoming active players in the investment arena. Global FDI statistics clearly indicate that the investment regime is no longer the sole concern of the developed world. The distinction between host and home economy is less clear in investment debates nowadays because many major economies are the recipient of FDI as well as major investors abroad. There is a growing convergence of interests between the FDI home and host countries.

1.3 LITERATURE REVIEW

I will present a more focused review of the literature, specifically examining explanations for multilateralism and bilateralism in trade versus foreign direct investment in the literature review chapter. Within the mainstream IR literature, three approaches are commonly used to explain multilateral cooperation in different issue areas (Hasenclever, Mayer et al. 1996). These approaches are as follows:

1. Interest-based explanation (neoliberal approach)
2. Power-based explanation (neorealist approach)
3. Knowledge-based explanation (constructivist).

These theoretical paradigms in international relations make important contributions to explaining different aspects of multilateral cooperation. Both the neoliberal approach and power-based approaches share the following common assumptions: they consider states as principal actors within an anarchic international system, and they assume the states are utility maximizers.

However, there is a difference in these approaches regarding their focus on gains: neoliberal approaches are concerned about absolute gains rather than relative gains. Therefore, power-based approaches also focus on the distribution of gains (relative gains) in addition to absolute gains.

Of all the three IR approaches mentioned above, the neoliberal scholarship (interest-based explanation) is the most popular approach for explaining multilateral cooperation (Hasenclever, Mayer et al. 1996). Neoliberal scholars explain multilateral cooperation based on the convergence of the interests of the states in an issue-area. Neoliberal scholars do not pay attention to the configuration of powers in an issue-area to explain multilateral cooperation. The identities and interests of states are exogenous in the interest-based explanations. Knowledge-based explanation (constructivist approach) pays particular attention to the formation of interests and identities of states. In the neoliberal literature, states are principal actors (rational) with the ability to decide whether to cooperate or not. Some degree of commonality of interests is necessary but not a sufficient condition for achieving multilateral cooperation. Game-theoretic models are developed in this tradition to explain interest-based multilateral cooperation. The prisoner's dilemma is an example where cooperation, rather than mutual defection, is in the interest of both states in a repetitive game.

Power-based (realism) approaches explain multilateral cooperation based on the global configuration of power. Multilateral cooperation is only possible if it serves the interest of the most powerful state in the international system. The interest of the most powerful state takes precedence over the interest of less powerful states (Kindleberger 1981). Multilateral cooperation is unstable because it often cannot survive the change in the global configuration of power. Multilateral cooperation is difficult to achieve because the states are concerned about relative gains rather than absolute gains. Power-based approaches predict too little multilateral cooperation in any issue-

area. International institutions (embodying multilateral cooperation) cannot reign in the most powerful state (Mearsheimer 1994). The most powerful state dictates the rules of the game by controlling the agenda and decision-making. In the euphemism of IR, the most powerful state has high "bargaining leverage" in the issue area. Power does not mean military power. The understanding of power varies from one issue-area to another issue-area. In the issue-area of international trade, the most powerful state means the largest trading nation. Similarly in the issue area of FDI, the most powerful state means the largest investing nation. The power may be hidden in international institutions. The exercise of power may be subtle. However, the exercise of power becomes visible in international institutions when we zoom in on the distribution of gains, agenda setting, and decision-making rules (Barnett and Duvall 2005). Hegemonic stability theory attributes the emergence of multilateral cooperation to the unipolar configuration of power in any issue area.

The constructivist approach (knowledge-based explanation) criticizes the neoliberal cooperation theory as incomplete because it assumes the exogeneity of the interests of states (Hopf 1998). However, the constructivist approach shares the neoliberal conclusion that multilateral cooperation is possible under anarchy. Constructivist scholars argue that the states derive their identities and interests in the international relations system through the process of social learning. The identities and interests of the states are not static. The identities of states have important implications for multilateral cooperation. Cooperating with allies is not the same as cooperating with adversaries.

These three mainstream approaches in international relations do not explain the variation in multilateral cooperation across the issue-area of international trade and FDI. There is no specific research available using these three traditional IR approaches that could explain variation in

multilateral cooperation across issue areas of international trade and FDI. Undoubtedly, the literature gap does exist that needs a concrete explanation. Neoliberal scholarship would predict higher multilateral cooperation in international trade and FDI while neorealist scholarship would predict lower multilateral cooperation in the two domains. However, traditional IR literature deals with the variation of multilateral cooperation at a higher level of generality. The variation in multilateral cooperation across international trade and FDI is indeed a puzzle for the mainstream IR approaches. The full justification of the literature gap will be provided in the literature review chapter.

I will develop an evolutionary game theory model to explain how and why different patterns of cooperation emerge in international trade versus FDI. However, the model development process is guided by the existing literature on cooperation, including three mainstream approaches. In the evolutionary game theory model, the players are states, which are considered principal actors according to both neoliberal and power-based approaches. The evolutionary game theory model, developed in the later chapter, is based on the maximization of absolute utility rather than relative utility. This aspect of the model is derived from the neoliberal scholarship. However, the model does not assume the perfect rationality of players, as is often assumed in neoliberal scholarship on international cooperation. Additionally, evolutionary game theory addresses the criticism of constructivism regarding the exogeneity of players' interests and identities in neoliberalism. The identity (multilateralism, bilateralism, or unilateralism) of players is not static; they can and do change their identities over the period through the process of social learning. This learning happens through adoption (imitation) of the identity (strategy) of the most successful player in the previous round.

1.4 CONTRIBUTION TO COOPERATION LITERATURE

Multilateral cooperation is an active area of research in international relations. However, there is no existing research that explains how and why different patterns of cooperation emerge in international trade and FDI. Therefore, this research contributes to cooperation literature by helping us understand how and why countries choose to cooperate either bilaterally or multilaterally in international trade and FDI. The two issue areas have remarkable similarities yet are dominated by different patterns of cooperation. Generally, the process through which countries reach a specific pattern of cooperation is put into the black box with no explanation provided. Using evolutionary game theory, the research explains how different patterns of cooperation emerges from initial conditions. It is nothing less than a puzzle why bilateralism emerges when multilateralism is more beneficial than bilateralism in all issue areas. International trade and FDI have been only used to instantiate the central argument. The application of the central argument is not limited to these two domains.

1.5 METHODOLOGY

I will use the formal game-theoretic model for the construction of theory. Formal models have a comparative advantage over other methods when it comes to studying international cooperation. They are clearer about the definition of actors, strategies available to actors, information structure and assumptions. Formal models incorporate the most fundamental elements of the research problem under investigation.[2] We can study the interrelationship of these fundamental elements in detail in formal models. In this regard, they help us understand the real

[2] Formal models always leaves out the unnecessary details to focus on fewer factors causing the phenomenon. For instance, a map is a model but leaves out a lot of unnecessary detail. Leaving out unnecessary information is important to make the model useful. A model as complex as the real world is not very useful. The purpose of the model is to simplify the reality so that we can draw useful insights from the model.

causal mechanism by isolating the unnecessary detail. One of the limitations of other methods is that we cannot explore the counterfactuals. If X is causing Y, then the absence of X also means absence of Y. Formal models become even more interesting and useful when we simulate formal models to explore counterfactuals (Pepinsky 2005). The usefulness of a formal model also comes out at the cost. They are more difficult to set up. But once they are set up, we can analyze the research question in a precise mathematical language. The formal model gets complex (mathematically) quickly with the inclusion of additional explanatory variables. Parsimony is advocated by international relations scholars coming from different methodological traditions. However, there is even a stronger case for parsimony in formal modeling to keep the mathematics simple.

Game theory is an appropriate tool to understand the variation in multilateral cooperation because multilateral cooperation in any issue-area is highly "strategic". We use game theory to model situations where the interaction among the players is highly strategic. The decision of one country to cooperate with another country is not independent of the cooperative stance of another country. Expansion of multilateral cooperation in international trade is a result of the reciprocal (rather than unilateral) reduction of the trade barriers by the participating countries in multilateral trade negotiations. Game theory has made an important contribution to explaining the emergence of multilateral cooperation amongst the self-interested countries in an anarchic international system.

Evolutionary game theory provides the theoretical framework to understand how and why different patterns of cooperation evolve in different issue areas. Countries don't make decisions whether to choose bilaterally or multilaterally in isolation. They decide whether to engage in bilateralism or multilateralism based on what other countries are doing at the same time in the

international system. Therefore, a country's decision is strategic in nature. Countries interact strategically over time to engage in multilateral cooperation or bilateral cooperation. The expected payoff of the same action (strategy) is different under different prevailing distributions of strategies.[3] Whether a multilateral (bilateralism) cooperation is successfully concluded or not depends on the proportion of countries willing to adopt and adhere to the multilateralism[4] (bilateralism). The success of a strategy is frequency-dependent: if the initial proportion of countries willing to adopt a multilateralism (bilateralism) is low, then the multilateralism (bilateralism) may fail to be established.

The central argument of the research is that cooperation can evolve to a particular pattern of cooperation through a combination of the effects of initial distribution of strategies (initial conditions) and the net payoff ratios. Net payoff ratio measures the relative benefit of multilateralism over bilateralism in an issue area. Multilateralism emerged in international trade due to favorable initial conditions and because multilateralism is much more beneficial than bilateralism. On the other hand, bilateralism emerged in FDI due to favorable initial conditions

[3] Countries decide whether to engage in multilateralism or bilateralism based on the expected payoffs. The expected payoff is the most appropriate indicator because countries do not know in advance what proportion of FDI will originate from the countries with whom they are having a multilateral or bilateral or no agreement at all. The expected payoff is the average payoff a country would expect to receive FDI over the long run. The expected payoff is based on the payoffs of the strategies and probabilities of different strategies (actions) being played in the population. Countries can protect and promote FDI multilaterally, bilaterally, or unilaterally. If a higher proportion of countries are willing to adopt and adhere to multilateral investment agreement, then the multilateral investment agreement has higher probability of being played. The higher the proportion of countries willing to adopt and adhere to multilateral investment agreement, the higher the expected payoff for the multilateral investment agreement. In evolutionary game theory, the expected payoff plays a significant role in determining which strategy will be replicated though the international system.

[4] In the hawk-dove game, neither a hawk nor a dove strategy is the "universally" best strategy. If the proportion of the hawks in the population is too high, then they will end up fighting with each other. Therefore, the expected payoff of the hawk strategy is less if the proportion of the hawks in the population is very high. If the proportion of doves in the population is too high, then the hawks can exploit them. Therefore, the expected payoff of the dove strategy is low if the proportion of the doves in the population is very high. The success of hawk or dove strategy depends on the prevailing distribution of the strategies in the population.

and because multilateralism is comparatively less beneficial than bilateralism in FDI. I will explain the central argument in detail in the game theory chapter.

1.6 PLAN OF THE DISSERTATION

My dissertation will comprise seven chapters. Following the introductory chapter will be a literature review chapter in which I explain the definitions of different patterns of cooperation (multilateralism and bilateralism) and review the literature on bilateralism versus multilateralism. The chapter also focusses on the game theoretic literature to understand the variation in multilateral cooperation. The literature review chapter also explains how and why coordination games can model different patterns of cooperation.

Following the literature review chapter will be a method chapter which provides justification for why game theory (specifically evolutionary game theory) is an appropriate methodology to model different patterns of cooperation in issue areas. The chapter explains how and why the three-players three-strategies stag-elephant hunt game captures the strategic situation that countries encounter in the international system when deciding whether to cooperate bilaterally or multilaterally. A discussion of the limitations of game-theoretic models is included. Subsequently, the chapter discusses how replicator dynamics are used for simulating the model in the context of *three strategies* to crowd out the unsuccessful strategies. the methodological approach known as “analytic narratives”, which serves as the foundation for the history chapter is introduced. The chapter elucidates the necessity and value of employing an analytic narratives approach to narrate the history of patterns of cooperation, utilizing the structured and coherent approach inherent in analytic narratives. Analytic narratives do not validate the formal game

theoretic model. Before concluding, a section on survival analysis that will be used to empirically validate the insights generated by the formal model.

The fourth chapter on game theory will discuss the results of simulations of the game theoretic model using modified replicator dynamics for three strategies. The initial set of conditions (distribution of strategies) from which different patterns of cooperation will emerge in two different issue areas are specified. The chapter will show that the dominant pattern of cooperation in international trade (multilateralism) is evolutionarily stable for a large set of initial distribution of strategies (larger basin of attraction), while the dominant pattern of cooperation in FDI (bilateralism) is evolutionarily stable for large set of initial distribution of strategies (larger basin of attraction). In simpler terms, the game theory chapter will show that multilateralism is more likely in international trade, while the bilateralism is more likely in FDI. Multilateralism is stable to mutations in international trade while bilateralism is stable to mutations in FDI. Additionally, the chapter will also include the testable implications of the game theoretic model in the last section.

Chapter five will provide historical context, it will focus on the historical evolution of different patterns of cooperation within investment and trade during the postwar period. The simulation of the game theoretic model shows that the emergence of both patterns of cooperation is possible in both domains, depending on the initial distribution of strategies (initial conditions). While it was less likely for multilateralism (bilateralism) to emerge in the investment (trade) domain, there was still a possibility depending on the initial distribution of strategies. Therefore, the history chapter also focuses on the role of initial distribution of strategies (initial conditions) in the emergence of multilateralism in trade and bilateralism in investment. I will employ the structured paired “analytics approach” in the history chapter to explain the evolution of specific

pattern of cooperation in both the trade and investment domain according to the corresponding model developed for that specific domain in the fourth chapter. The purpose of this chapter is not to empirically validate the stag-elephant hunt game theoretic model but rather to narrate the actual history of the evolution of different patterns of cooperation in the two domains. While utilizing the model as a useful guide, the chapter also explains why the multilateral cooperation failed to emerge in the investment domain despite the repeated attempts.

The sixth chapter will focus on the empirical validation of the testable implications of the model. I will employ survival analysis on a bilateral investment treaties dataset spanning from 1958 to 2023 to evaluate the testable implications of the model introduced at the end of the game theory chapter. In this chapter, I evaluated the three testable implications of the stag-elephant hunt model using Cox proportional hazard model. The reasons for using survival analysis for evaluating the testable implications of the model are discussed. This chapter builds on and extends the survival analysis approach used by (Elkins, Guzman et al. 2006) to test some of the implications of my model. I found strong quantitative evidence in the support of the hypothesis that episodes of failed multilateralism in investment increases the odds of signing (adoption) a bilateral investment treaty (alternative strategy). Furthermore, I found support for the hypothesis that an increase in the cumulative number of BITs globally signed also increases the odds of signing BITs. I also found quantitative support for the learning mechanism inherent in the evolutionary stag-elephant hunt game. The fifth chapter also provided qualitative support for the notion of a learning mechanism.

The last chapter will discuss the larger significance and implications of the model, its generalizability to other issue areas, as well as the limitation of the approach. I recommend three modifications/extensions that future researchers can make to enrich the model further.

CHAPTER 2

LITERATURE REVIEW

The purpose of the literature review is to address two main aspects: 1. Why do we observe variations in multilateral cooperation across different issue areas? and 2. How and why do different patterns of cooperation emerge in different issue areas? The literature review chapter is structured into the following sections. Section 2.1 examines the definitions of multilateralism and bilateralism, as well as identifies the specific definition of multilateralism that will be used for building the game-theoretic model in chapters 3 and 4. Section 2.2 compares the current state of multilateral cooperation in international trade and FDI, investigating whether there is a variation in multilateral cooperation across the two domains. Section 2.3 reviews various explanations for *variation in multilateral cooperation* across different issue areas, with a focus on the traditional game theory literature. However, while traditional game theory literature explains *why* cooperation arises, it does not explain *how* cooperation emerges in different issue areas. This section also makes the case for the use of Evolutionary Game Theory (EGT) to investigate the choice of countries between bilateralism and multilateralism. Section 2.4 investigates the existing literature to understand why countries choose to cooperate either bilaterally or multilaterally. Game theoretic literature has made extensive contributions to understand various aspects of international cooperation. This section notes that the game theoretic literature is notably missing when it comes to the debate about why countries choose to cooperate either bilaterally or multilaterally. Finally, in Section 2.5, the chapter concludes with a review of EGT. I explain how the theoretical framework of EGT offers a valuable perspective on understanding the long-term stability and adaptation of different patterns of cooperation. By structuring the literature review in this manner,

the chapter aims to provide a comprehensive understanding of the factors influencing countries' choices between bilateral and multilateral cooperation, the variation in multilateral cooperation across different issue areas, and the insights offered by EGT in analyzing cooperative dynamics.

2.1 DEFINITIONS OF MULTILATERALISM AND BILATERALISM

Keohane (1990) has defined multilateralism as "the practice of coordinating national policies in groups of three or more states, through ad hoc arrangements or by means of institutions." The membership size of the multilateral episode could be anywhere between three members and universal membership (Caporaso 1992). There are many multilateral organizations with almost universal membership for instance United Nations, International Monetary Fund, and World Trade Organization. In common parlance, the term multilateralism is reserved for an institutional arrangement with universal membership (Van Oudenaren 2003). John Ruggie made significant improvements in the definition of multilateral cooperation. Ruggie (1992) defined it as "an institutional form which coordinates relations among three or more states on the basis of generalized principles of conduct-that is, principles which specify appropriate conduct for a class of actions, without regard to the particularistic interests of the parties or the strategic exigencies that may exist in any specific occurrence." Caporaso (1992) has distinguished multilateral cooperation from other patterns of cooperation based on three attributes: indivisibility, a generalized principle of conduct, and diffuse reciprocity. Indivisibility refers to the spillover effects the one country has over other countries. If we cannot limit the consequences of actions of a country to a specific set of countries, it becomes difficult to compartmentalize relationships into smaller groups. For instance, even though Singapore is a small country, its trade liberalization or environmental pollution can have consequences for distant countries. The generalized principle of

conduct requires all members to follow a principle of nondiscrimination. The most favored nation (MFN) principle is a general treaty obligation included in all multilateral trade agreements, with only limited exceptions allowed to signatories. The MFN principle means that no country is allowed to impose different tariffs on the same goods imported from different foreign countries. Any trade concession granted to one country must be immediately and unconditionally accorded to all the countries engaged in multilateral cooperation. Diffuse reciprocity, as defined by Ruggie, means that the parties involved in a cooperation episode "yield a rough equivalence of benefits in the aggregate and over time." (Ruggie 1992). Many developing countries did not exchange equal value of tariff concessions with developed countries in the first few rounds of multilateral trade negotiations. However, the developed countries in General Agreement on Tariffs and Trade (GATT) did not insist on benefitting from every trade issue in every period. This research project develops the model based on Keohane's definition of multilateralism requiring initial coordination of only three states. However, the model developed in the game theory chapter allows the participation to multilateralism by more states when states dynamically adjust their strategies from bilateralism or unilateralism to multilateralism.

Two definitions of multilateralism, one based on numbers and other based on norms, does create some confusion[5] whether the multilateralism is about the norms or membership size (numbers) of the multilateral episode. However, there is no confusion regarding the bilateralism. The bilateral episodes, by definition, are discriminatory and includes only two players. One important difference between the bilateralism and multilateralism is that former is based on

[5] The regional episodes such as NAFTA, ASEAN, and the EU having three or more members will be considered multilateral episodes according to the Keohane's definition of multilateralism. These episodes of economic integration coordinate the policies of three or more countries in various domains. However, these episodes are discriminatory in nature because membership is not open for accession on global basis. Therefore, these episodes of economic integration violate the Ruggie's definition of multilateralism.

specific reciprocity while the latter is based on diffuse reciprocity. The specific reciprocity is when the two parties engaged in cooperation episode exchange comparable benefits directly and immediately. The diffuse reciprocity also incorporates the notion of indirect reciprocity. The example of bilateralism in international trade is a Free Trade Agreement (FTA) signed between two countries that includes the bilateral exchange of tariff concessions. And the example of bilateralism in the investment domain is a Bilateral Investment Treaty (BIT) signed between the two countries that accords protection to each other's foreign investment in the treaty partner countries. It is interesting to note that we have much more bilateral investment treaties than bilateral trade agreements (FTAs/Preferential Trade Agreements (PTAs)). BITs also differ in one important aspect from bilateral trade agreements. Almost all BITs contain some multilateralizing elements i.e., MFN principle. If the more favorable investment concession is granted to any third country by either of the treaty partners, then it must be granted unconditionally and immediately to the other treaty partner. In this regard, BITs are less discriminatory than the traditional bilateral trade agreements with no MFN principle.

2.2 IS THERE VARIATION IN MULTILATERAL COOPERATION ACROSS INTERNATIONAL TRADE AND FDI?

The purpose of the dissertation is to explain the variation in multilateral cooperation across the domains of international trade and FDI. Therefore, it is crucial to establish, through a comprehensive review of the existing literature, that indeed there exists a variation in multilateral cooperation across the two issue areas.

We see deeper multilateral cooperation in international trade but shallower multilateral cooperation in investment. One pattern of cooperation is not mutually exclusive to other patterns

of cooperation in an issue area. It is possible for the same set of countries to cooperate multilaterally, regionally, and bilaterally simultaneously in an issue area. However, the *dominant* pattern of cooperation in international trade is multilateralism while the *dominant* pattern of cooperation in investment is bilateralism (Shenkin 1993; Thompson and Verdier 2014). We have multilateral agreements on different aspects of international trade, but we do not have a single comprehensive multilateral agreement on FDI. Therefore, the "variation in multilateral cooperation" in the two issue areas could be understood as the absence of multilateral agreement in FDI and the presence of multilateral agreement in different aspects of international trade. Only a patchwork of FDI rules are incorporated into different multilateral trade agreements. There are FDI provisions incorporated into existing multilateral trade agreements, namely; TRIMs, TRIP, and GATS (Canner 1998). Only those aspects of investment are regulated in multilateral trade agreements which are directly or indirectly related to trade. Mode 3 of service supply deals with the commercial presence of a service supplier from the home country in the host economy. The commercial presence of a service supplier of one country into another country is regulated through a GATS agreement. The commercial presence of a service supplier is only possible through FDI. Many foreign services cannot be supplied (tradeable) in the host country without commercial presence, for example, banking, insurance, transportation, restaurants etc. GATS increase the tradability of services through commercial presence (FDI). GATS also allows the host economies to put various restrictions on foreign service suppliers. Therefore, GATS do not comprehensively liberalize all services sectors for foreign investment. TRIMs agreements deal with restrictions on investment (both domestic and foreign investment) that host economies are prohibited from applying. Host economies are not allowed to impose local content requirements, exchange balancing, trade balancing etc. on local and foreign investment. TRIP regimes do not directly

contain investment provisions. However, foreign investment is the main source of technology acquisition for developing countries. The level of protection of intellectual property rights is an important factor for the host economy when it receives foreign direct investment in knowledge-intensive sectors (Maskus 1998). There are no multilateral rules that give uniform protection to foreign investment across the globe. Different countries have signed BITs to protect and promote foreign direct investment. Some countries have even signed regional trade agreements with elaborate investment chapters to protect and promote FDI. For example, North American Free Trade Agreement (NAFTA), Association of Southeast Asian Nations (ASEAN), and the European Union (EU) have stronger rules to regulate different aspects of foreign investment in their respective regions. The FDI regime is fragmented across multilateral, regional, and bilateral networks. Bilateral and regional trade agreements are embedded within the multilateral trade framework. Enabling clause, Article 24 in GATT, and Article V in GATS allow the members of the WTO to enter into preferential trading arrangements (bilateral or regional) provided that they do not increase barriers for non-members. According to the WTO database, there are 628 preferential trade episodes signed between the members of WTO.[6] However, it should be noted that the principal mode of trade liberalization is multilateral, rather than bilateral or regional. The dominant pattern of international cooperation in the investment domain is bilateralism while the dominant pattern of cooperation in trade is multilateralism. The existing IR literature has stressed having a single multilateral agreement on FDI covering investment liberalization commitments, investment protection, and an investor-state dispute resolution mechanism (Vocke 1997; Åslund 2013).

[6] The data on preferential trade arrangements notified to the WTO was retrieved on July 02, 2023, using the following weblink https://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

Multiple attempts were made in the postwar period to conclude a multilateral investment agreement, but they all ended up in failure (Young and Tavares 2004). We do need a comprehensive MAI despite the rising number of BITs. BITs are important tools for protecting and promoting foreign investment, but they cannot fully fulfill the need for a MAI. There is no single template for BITs that all countries follow, and the investment issues covered in one BIT can significantly differs from those that are covered in another. The variation in BITs is a result of different interests and bargaining powers of the country-pairs engaged in bilateral investment negotiations. BITs can vary significantly in terms of the level of protection they provide to foreign investors, as well as in the coverage of their issues such as sectoral liberalization, performance requirements, fiscal incentives, and dispute resolution mechanisms. On the other hand, MAIs can provide a more standardized and predictable environment for the investment flows. The varying level of investment protection provided to different investors across BITs creates the problem of treaty shopping[7], which can only be resolved by signing a single comprehensive multilateral agreement on investment with uniform investment protection (Baumgartner 2016).

There numerous authors who have argued that *investment multilateralism* is happening through proliferation of BITs (Chalamish 2008; Schill 2009; Nikièma 2017). This argument implies that we do not need a multilateral framework for investment because a dense web of BITs is akin to investment multilateralism. For instance, Kim (2015) has argued that an increase in homogeneity (structure, scope, and content) and density (actual dyadic investment ties to possible dyadic investment ties) of the bilateral investment network in Asia is leading to a de facto multilateral investment governance in Asia. The author has referred to this phenomenon as the

[7] The problem of treaty shopping arises due to two reasons: first, the difficulty of determining the home country for multinational corporations having many subsidiaries in different parts of the world, and second, the varying levels of investment protection to foreign investment in different BITs. Treaty shopping is a big issue for all host economies.

Multilateralization-Through-Bilateralism (MTB) thesis. However, the homogeneity and density of bilateral investment network has not reached that point at the global level where we could think of the bilateral investment network as something analogous to a multilateral investment regime. There are 193 member countries in the United Nations. Bilateral (dyadic) relationship represents a binary relation between the two countries. The total number of *possible dyadic relationship* in a world with 193 countries is a combinatorial problem. Therefore, the total number of possible bilateral relationships is 18,528.

$$\boldsymbol{nCr} = \mathbf{193}\boldsymbol{C}\mathbf{2} = 18{,}528$$

According to the UN investment policy hub, there are only 2827 BITs signed between countries, just 15 percent of the total possible BITs. The density of the bilateral investment network at the global level stands at $\frac{2827}{18528} = 0.15$. This calculation shows that multilateralism in the investment domain is not present, even though many of BITs contains multilateralizing elements. Even if all countries sign BITs dyadically, there will remain an important difference between bilateralism and multilateralism that goes to the core of the nature of different patterns of cooperation. It is possible for a country dyad to renegotiate or terminate the bilateral investment relationship without affecting a third country. However, this is not possible for any country dyad in a truly multilateral arrangement.

The purpose of this section was to compare the state of multilateral cooperation in the domains of international trade and FDI. Currently, there is no quantitative study that measures the level of multilateral cooperation across international trade and FDI on a continuous scale. However, the presence of multilateral agreements in the trade domain, coupled with the absence of a multilateral investment agreement, clearly indicates a variation in multilateral cooperation

across the two issue areas. To effectively protect and promote cross-border investment stocks and flows, there is a need for single comprehensive multilateral investment agreement.

2.3 VARIOUS EXPLANATIONS FOR VARIATION IN MULTILATERAL COOPERATION

This section is further divided into two subsections. The first subsection will explore various non-game theoretic explanations for variation in multilateral cooperation. In this subsection, I have examined the role of transnational actors, the number of players and the power dynamics on variation in multilateral cooperation. The second subsection will delve into game theoretic explanations for variation in multilateral cooperation with a specific focus on coordination games. This focus is because the stag-elephant hunt game (the game developed to model the strategic situation countries face when they decide whether to cooperate bilaterally or multilaterally) is a modification of the stag-hunt game which is a coordination game. The subsection also makes a case for the combination of the coordination game with evolutionary game theory, an idea which will be developed more fully in Chapter 3.

2.3.1 Subsection I

The transnational literature explains variation in multilateral cooperation across different issue domains based on role/preference/strength of transnational actors (Gilpin 1971). Multilateral cooperation is intergovernmental in nature.[8] However, the preferences of states in multilateral negotiations reflect the interests of multinational corporations (MNCs) headquartered in those

[8] MNCs do not have seat on WTO trade negotiations. But not having a seat in the WTO does not mean that they do not have influence on the trade negotiating process.

states. MNCs are the most dominant actors in the international economic system.[9] MNCs can even bring strategic rivals closer to each other. For example, US MNCs brought the US and China closer to each other on various international economic policy issues, while Japanese MNCs created the strong economic linkages between China and Japan. Higher levels of economic interdependence in the international system are the result of MNCs. The transnational literature attributes the success or failure of the multilateral cooperation in different sub-economic domain to the strengths and interests of MNCs. In the Global Value Chain era, MNCs prefer deeper cooperation between states in the domains of trade, services, investment, and intellectual property rights. (Baldwin 2016). However, the transnational literature does not provide an answer to why we observe deeper multilateral cooperation in international trade and shallower multilateral cooperation in FDI.

Different strands of realist approaches explain multilateral cooperation based on the global configuration of power. Multilateral cooperation is only possible in an issue area if it serves the interests of the most powerful state in the international system. The interest of the most powerful state takes precedence over the interests of less powerful states (Kindleberger 1981). Multilateral cooperation is unstable because it cannot survive the changes in the global configuration of power. Additionally, multilateral cooperation is difficult to achieve because states are concerned about relative gains rather than absolute gains (Grieco, Powell et al. 1993) . Power-based approaches predict too little multilateral cooperation in all issue-areas. International institutions cannot rein in the most powerful state (Mearsheimer 1994). The most powerful state dictates the rules of the game by controlling the agenda and decision-making. Power does not mean military power as the

[9] MNCs operate with considerable independence from the state's control (Thiel and Maslanik 2010). Sometimes, MNCs are even more powerful and resourceful than the states in which they are headquartered (Kim and Milner 2019). There are many MNCs whose annual sales revenue is higher than the Gross Domestic Product of the countries hosting them.

understanding of power varies from one issue-area to another. In the issue-area of international trade, the most powerful state refers to the largest trading nation. Similarly in the issue area of FDI, the most powerful state refers to the largest investing nation. Power may also be hidden in international institutions, and its exercise of power may be subtle. However, the exercise of power becomes visible in international institutions when we examine the distribution of gains, agenda setting, and decision-making rules (Barnett and Duvall 2005). Hegemonic stability theory attributes the emergence of multilateral cooperation to the unipolar configuration of power in any issue area. The United States has been by far the most dominant player in the international trade and FDI for a very long period. Therefore, it is implausible that the United States does not have an interest and/or capability to lead multilateral cooperation in the investment domain, while it does have an interest and/or capability to lead multilateral cooperation in the trade domain.

How does the number of players affect the likelihood of cooperation in an issue area? Cooperation becomes more beneficial as the number of players in the issue area increases (Chamberlin 1974). A multilateral episode with more players is more beneficial than the one with a smaller number of players. Several scholars have highlighted the different obstacles to achieving cooperation in large groups within an issue area. Olson (1989) highlighted the difficulty of collective action for generating public good within larger groups. Oye (1985) attributed the difficulty of achieving cooperation in a large group to the increased difficulty of monitoring and sanctioning individual violations of the agreement. Earnest (2008), using Agent-based modeling simulation, demonstrated that a large numbers of players in the issue area actually facilitate the cooperation rather than hinder it. Each offer is more likely to get a match as the number and heterogeneity of players increase in multilateral negotiations. There is no definitive answer

regarding the impact of the number of players on achieving international cooperation in different issue areas.

The question for my research question is whether the number of players can explain variation in multilateral cooperation (or different pattern of cooperation) across the trade or investment domain. The World Trade Organization, and its predecessor, GATT, was the main engine behind the trade liberalization. However, multiple attempts to initiate talks on investment issues within WTO have failed (Tieleman 2000). The membership of the WTO is fixed at a particular point in time depending on whether it is hosting negotiation on trade or investment. Therefore, we cannot conclude that the number of players contributed to any different role in the stronger multilateral trade cooperation compared to shallower multilateral investment cooperation. Consequently, I have assumed an equal number of players in both domains for game-theoretic model to explain the different patterns of cooperation in these two issue areas. Free riding is more prevalent in large multilateral groupings (Kahler 1992). Developing countries were free riding in the first few multilateral trade negotiation rounds. Did developed countries resort to bilateralism in investment domain to avoid free ridings of developing countries? The failure of a multilateral investment agreement is not due to the free riding of developing countries. Otherwise, the multilateral investment agreement negotiated on the platform of the OECD would have been successful, as it mostly included the advanced economies with similar open policies. The question of free riding of developing countries does not arise in the investment negotiation on OECD platform.

2.3.2 Subsection II

In his influential research paper, Fearon (1998) argues that each episode of multilateral cooperation passes through two stages in a sequential order: bargaining[10] and enforcement. The countries would bargain harder over different possible sets of multilateral agreements if both the stakes involved, and the shadow of the future are high. The countries have conflicting preferences over the different possible sets of multilateral agreements.[11] We will see "little" multilateral cooperation in the domains where the countries are more concerned about the distribution of payoffs in the bargaining stage. Using this approach, the explanation for the state of multilateral cooperation in trade and FDI is as follows: the states care more about the payoffs in the FDI domain; therefore, there is a deadlock over the possible set of cooperative agreements (multilateral) at bargaining stage. However, the states care less about the payoffs in the trade domain; therefore, the states successfully achieved multilateral cooperation. It is difficult to argue that we do not have higher multilateral cooperation (in the domain with shallower multilateral cooperation) in the investment domain because the states care more about payoffs in that domain. Furthermore, the explanation does not tell us anything about the alternative patterns of cooperation emerging in the domain with shallower multilateral cooperation. Why do we have bilateralism in the FDI domain if we do not have multilateralism? The question is relevant to fully explain the variation in multilateral cooperation across the issue areas.

There is another strand of literature that hypothesizes that we have different strategic structures in different domains (Oye 1986). It is easier to have multilateral cooperation in domains

[10] Bargaining is about the how the surplus value will be distributed which is created when different players cooperate with each other.

[11] One possible source of conflict between the developed and developing countries is over the content of the multilateral agreement on investment. The developed countries prefer the stronger protection of investment through the inclusion of provisions like investor-state dispute settlement mechanism and comprehensive prohibitions of performance requirements. However, the developed countries need flexible multilateral regimes that supports economic development and employment in the host economies.

where the strategic structure of cooperation is characterized by "coordination games". Coordination games are ones in which both players prefer cooperation over non-cooperation. I will discuss the coordination games in detail in the later part of this section because the central argument of this research is based on the modification of stag-hunt game, which is a coordination game. Unlike coordination games, it is difficult to have multilateral cooperation in domains where the strategic structure of cooperation is characterized by "collaboration games." The collaboration game is characterized by Prisoner's dilemma type payoffs in which cooperation is strictly dominated. In simpler terms, it is much harder to achieve multilateral cooperation in the collaboration games.[12] The puzzle is how to decide which strategic structure to use in different domains to explain variation in multilateral cooperation. Fearon (1998) has argued that it is more realistic to assume a common strategic structure for different issue domains in international relations. There is no reason to believe that international trade and FDI have different strategic structures. Therefore, the model developed in the dissertation assumes the same strategic structure (coordination game) for the trade and FDI domains.

2.3.2.1 Coordination Game

An important property of the coordination game is that players receive higher payoff when they simultaneously coordinate on the same strategy. Examples of coordination games include assurance, the battle of the sexes and the stag-hunt game. None of the strategies in a coordination game are dominated. Pareto coordination games are coordination games in which one Nash equilibrium Pareto dominates the other equilibrium (Watson 2002). Stag hunt and assurance are

[12] It has been shown that it is even possible to achieve multilateral cooperation in the repeated Prisoner's dilemma game (collaboration game) if there is a sufficient long shadow of future (along with higher discount factor) and the players are playing tit-for-tat strategy).

the examples of Pareto coordination games because all players in those games prefer one Nash equilibrium (outcome) over the other. There is a vast literature on coordination games, but it is not possible to review all the literature in detail. I will focus solely on the traditional stag hunt game because the modified version, known as stag-elephant hunt game, can potentially describe the strategic situation of international cooperation, where countries choose whether to cooperate bilaterally or multilaterally. I will introduce the stag-elephant hunt game in the methods chapter (3) and analyze it in detail in game theory chapter (4).

In the one-shot version of the stag-hunt game, there are two pure strategy equilibria (payoff dominant vs risk dominant). Unlike the one-shot version of prisoner's dilemma game, cooperation is not strictly dominated in the stag-hunt game. The payoff dominant equilibrium pays every player higher payoff than any of the other alternatives available in the game. The reward for cooperation is very high in the game. (Stag, Stag) is a payoff dominant equilibrium in the game. Once the players achieve the (Stag, Stag) equilibrium in the game, there is no incentive for any player to unilaterally deviate from the equilibrium if the other player sticks to playing Stag. However, achieving the payoff dominant equilibrium is riskier because it requires the coordination with the other player in the game. There is strategic uncertainty whether the other player will coordinate on the payoff dominant equilibrium. If there is even the slightest doubt about the intentions of the other player regarding the play of (Stag, Stag) equilibrium, then the player will be reluctant to play the payoff dominant equilibrium. Achieving the payoff dominant equilibrium requires a high level of trust between the players. The player must believe with a very high probability that the other player will play (Stag, Stag) equilibrium. Coordination failures are even more prevalent in N-player stag-hunt games, where every player in the game must believe that all other players (N -1)

will coordinate to the preferred outcome with a high probability.[13] The risk-dominant equilibrium is less beneficial for every player in the game. However, it is less risky because it guarantees a reward to the player independent of the strategy of the other player. The risky equilibrium (Stag, Stag equilibrium) pays a higher reward to the players than the non-risky equilibrium (Hare, Hare). This research develops the modification of traditional stag-hunt game to model the different patterns of cooperation. The modified stag-hunt game is a three-players three strategies game with three pure strategy equilibriums in the one-shot version. Multilateralism is more rewarding but riskier because it requires the coordination of policies by at least three or more players simultaneously. The higher the number of countries engaged in multilateralism, the riskier and more rewarding the multilateralism is. On the other hand, bilateralism is less risky and less rewarding because it requires the coordination of policies by only two players.

Table 2.1 Two players stag-hunt game payoff matrix

	Stag	**Hare**
Stag	10, 10	0, 8
Hare	8, 0	5, 5

There is a strategic uncertainty whether the players will coordinate on one equilibrium or the other in the traditional stag-hunt game. One weakness of many coordination games is that they

[13] Initial distribution of strategies adds a strategic dimension in the game. If only some fraction of population is willing to coordinate to the multilateral equilibrium, then the evolution of multilateralism is still possible in the long-term in my model provided other conditions are favorable to the evolution of multilateralism. The difficulty of coordinating to the multilateral equilibrium in N-players stag hunt coordination game is addressed through EGT if the initial distribution of strategies is in the basin of attraction for multilateralism. Even if less than full membership is willing to coordinate to the multilateral equilibrium, then the multilateral cooperation is still possible in the long-term. EGT is less restrictive than the traditional game theory about the number of players (fraction of players) coordinating to the Pareto optimal Nash equilibrium in the N-players stag-hunt coordination game.

do not predict a unique equilibrium in the game. The existing literature proposes various equilibrium selection criteria to predict a unique equilibrium for coordination games (Cooper, DeJong et al. 1990). Evolutionary Game Theory (EGT) is also proposed as an equilibrium selection criterion for coordination games. The learning mechanism in EGT can resolve the strategic uncertainty behind equilibrium selection in coordination games (Skyrms 2004). Although the learning mechanism in EGT is very simple, it is also powerful in explaining the emergence of distinct pattern of cooperation in the issue area. The advantage the evolutionary game theory has over other selection criteria methods is that it not only predicts a unique equilibrium but also specifies how that equilibrium will emerge from the initial conditions.

The idea of investigating cooperation in evolutionary terms is very old. Axelrod was the first scholar to investigate the evolution of cooperation in repeated prisoner's dilemma games. I owe my interest in EGT to Axelrod's simple yet powerful computer simulations. His computer simulations demonstrated that tit-for-tat is the evolutionarily stable strategy. The main insight was that cooperation in any domain, including international relations, is possible if the players are conditionally cooperating to each other. Tit-for-tat (TFT) strategy is an example of the conditional cooperation. TFT strategy performs better against a wide range of other strategies in the two-person prisoner's dilemma game. TFT strategy also acknowledges the strategic nature of cooperation. Undoubtedly, this reciprocity is the most important norm of international cooperation. Indeed, reciprocity embodies the TFT strategy[14]. If the game is repetitive and the discount factor is high, then it is most rewarding for the players to play TFT strategy no matter what other players are playing. Everyone playing TFT strategy will lead to the evolution of cooperation in the international system. However, the slightest of doubt about the intentions of other players can lead

[14] TFT strategy is an example of specific reciprocity while multilateral trade cooperation is based on diffuse reciprocity.

to the permanent breakdown of international cooperation (irreversible cycle of retaliation). TFT strategy is evolutionarily stable against the invasion of single mutant strategy (Axelrod and Hamilton 1981). The studies have shown that TFT strategy is also not evolutionarily stable (Boyd and Lorberbaum 1987). There is no reason to believe that international trade and FDI differs significantly in terms of discount factors, repetitiveness, and reciprocity. Therefore, we cannot attribute the emergence of different patterns of cooperation to these factors.

2.4 WHY DO COUNTRIES CHOOSE TO COOPERATE EITHER BILATERALLY OR MULTILATERALLY?

To understand why countries cooperate bilaterally in some issue areas while they opt for multilateralism in others, I will situate the question of bilateralism vs multilateralism in the broader literature. Realism explains the choices made by great powers to cooperate either bilaterally or multilaterally at higher level of generality. It does not attempt to explain the choice made by countries to cooperate bilaterally or multilaterally in specific issue areas. However, all the other studies reviewed in the section addresses the question of bilateralism vs multilateralism within specific issue areas.

Kahler (1992) summarized the position of realist scholarship on the bilateralism vs multilateralism debate with the following powerful words, “multilateralism will fail because great powers wish to exploit their advantages and pursue their national interests in bilateral bargaining, immune from the scrutiny of other states.” This simple explanation raises the further question of why we observe different patterns of cooperation in different issue areas (such as trade vs FDI) when the same great power dominated most of the issue areas in the postwar period. Many scholars have noted the power asymmetry in the BITs signed between a few strong capital-exporting

countries and many weak capital-importing countries (Salacuse 2004; Sauvé 2006). However, BITs are no longer just between developed and developing countries. There is no shortage of BITs signed between developing countries, where the power asymmetry is minimal. Elkins, Guzman et al. (2006) showed that the mean difference in GDP per capita (in thousands) between country dyads signing BIT has diminished significantly over time. The mean difference in GDP per capita between country dyad signing BIT was very high in the 1960s but it is now on the downward trajectory. This demonstrates that BITs were signed between developed and developing countries with a large income differential in 1960s, but now BITs are signed between country dyads with much smaller average income differential.

Thompson and Verdier (2014) argue that the countries decide to cooperate bilaterally or multilaterally based on the relative tradeoff between two factors: transaction cost and member surplus[15]. The authors discuss the nature of cooperation in four policy domains, including international trade and FDI. They attribute the prevalence of bilateralism in FDI to low transaction cost and high member surplus. They attribute the prevalence of bilateralism and multilateralism in international trade to both high transaction cost and member surplus. However, the authors recognize the difficulties of measuring transaction cost and member surplus across different policy domains. Attributing bilateralism in FDI to low transaction cost is contentious. Despite the model investment templates developed by different countries, BITs are highly differentiated on a dyadic basis in terms of coverage of investment issues, protection of foreign investment, sectoral coverage, fiscal incentives, performance requirements, and dispute resolution mechanism. There is no single BIT template followed globally by all countries. Therefore, each BIT negotiation has its own specificities, which makes the transaction cost high across the investment domain. This

[15] The transaction cost is high for negotiating case-by-case bilateral agreements while it is low for negotiating a single multilateral agreement.

high transaction cost can be avoided by signing a single comprehensive investment agreement. While my model does draw upon the ideas of transaction costs and member surplus, it also shows the importance of strategic context and the relative strategic riskiness of adopting a multilateral strategy.

Rixen (2010) explores why countries cooperate bilaterally rather than multilaterally to address tax issues in the international arena. For instance, double tax avoidance treaties are concluded bilaterally rather than multilaterally. The author argues that tax issues are highly differentiated on a dyadic basis with limited impact (externalities) on third countries. The question of the distribution of tax revenues can be better accommodated bilaterally rather than multilaterally. Whether country A and country B signs or do not sign the double taxation avoidance treaty does not affect country C. The treaty partners decide whether to negotiate the double taxation avoidance treaty as a source country or as a residence country[16] based on the asymmetry of investment flows between them. In treaty negotiations, the interest of the residence country is to reduce the tax burden on the foreign investment of its citizens abroad, while the interest of the source country is to keep the larger tax revenues at home. While comparing bilateral cooperation in taxation to multilateral cooperation in trade, the author argues that the FTA/PTA between the two countries creates negative externalities on third countries. The competitive dynamics of liberalization[17] leads to proliferation of FTAs/PTAs in international trade. Other authors have also

[16] The source country is where the income is generated from the foreign investment, while the residence country is where the owner(taxpayers) of the foreign investment lives.

[17] The simplest explanation of competitive trade liberalization is as follows: for instance, if country A and country B sign FTA/PTA, then the exports of remaining countries will be less competitive in the two countries. Therefore, the other countries will rush to negotiate the FTA/PTA with the two countries. The competitive trade liberalization was visible in Asia-Pacific region in the first decade of twenty first century. China signed FTA with ASEAN in 2004. As a result of ASEAN-China FTA, Korean exports lost competitiveness in ASEAN region. Therefore, South Korea signed FTA with ASEAN in 2007 to help its exports regain competitiveness in ASEAN region. Subsequently, Japan signed FTA with ASEAN in 2008 to help its export regain competitiveness in ASEAN region vis-à-vis Chinese and South Korean exports to the region. Then followed by Australia, New Zealand and India signing FTAs with ASEAN.

explained the simultaneous rush to FTAs/PTAs using competitive trade liberalization phenomenon (Bergsten 1996; Zeng 2010). The multilateral cooperation is the optimal pattern of cooperation in international trade because of the negative effect of the bilateral trade cooperation on third parties. The broad conclusion of the research article is that multilateral cooperation is required in an issue area if the bilateral cooperation creates negative externalities on third parties. The prevalence of MFN principle in the multilateral trade negotiations acknowledges and corrects the negative consequences of bilateral cooperation in international trade. The author also highlights that there are very few double taxation avoidance treaties with MFN principle because double taxation treaties have limited impact on third parties.

De Bièvre and Van Ommeren (2021) have explored the role of multinational corporations whether they prefer countries to cooperate bilaterally or multilaterally. The authors highlighted that preference of multinational corporations depends on whether they are engaged in trading differentiated products or homogenous products. Multinational corporations engaged in trading differentiated products prefer bilateralism over multilateralism. However, Richard Baldwin has made a very strong argument that multinational corporations, which are at the heart of global value chains, prefer comprehensive liberalization (goods, services, investment, intellectual property rights) on a multilateral basis (Baldwin 2017). The multinational corporations, the major drivers of foreign trade and investment, support stronger multilateral cooperation in both the trade and investment domains, rather than bilateral or regional cooperation. Rixen (2010) did not explore the role of transnational corporations in international taxation cooperation issues. The existing international taxation system based on the web of bilateral tax avoidance treaties cannot properly tax the economic activities of multinational corporations spread over multiple countries. Thuronyi (2000) has argued that multinational corporations “can take advantage of the lack of coordination

to minimize the taxes they pay." Multinational corporations hinder multilateral tax cooperation while strongly supporting multilateral trade cooperation. In addition to addressing the issue of double taxation, the pattern of tax cooperation could also include the tax information sharing mechanism between states and the question of bringing balance between immobile sources (labor) of taxes and mobile sources (corporate) of taxes. Multinational corporations, with their business operations spread across multiple countries, are notorious for transferring their profits to low-tax jurisdictions. If countries do not share tax information multilaterally, multinational corporations can deduct the same expense in different tax jurisdictions thereby illegally reducing their corporate tax liability. Furthermore, we cannot reduce the imbalance between taxation on labor and capital in the network of bilateral tax cooperations. Labor is much more heavily taxed than the capital in the global economy leading to the fiscal deficits with larger accumulation of public debts in almost all countries. The multinational corporations have a very strong interest to hinder multilateral cooperation in tax issue area.

Why do countries give foreign aid sometimes multilaterally and sometimes bilaterally? Milner and Tingley (2013) argues that aid donors make this decision based on the relative trade-off between burden-sharing and control of foreign aid. Multilateral aid giving enables donor countries to coordinate their aid policies with other countries. However, providing aid through multilateral institutions like the world bank leads to a loss of control over foreign aid policy. Donor countries cannot tightly control which country should receive foreign aid for specific projects and how much aid they should receive. On the other hand, bilateral aid giving allows the donor country to exercise greater control over foreign aid but there is no burden sharing. When donor countries share aid objectives with other countries, they disburse foreign aid through multilateral means.

However, when donor countries require greater control over the aid distribution, they disburse the aid bilaterally.

Existing research provides different explanations for the different patterns of cooperation observed in different issue areas. However, none of these studies explains the process through which these different patterns of cooperation emerge in different issue areas. The model introduced in the game theory chapter will not only explain why a specific dominant pattern of cooperation emerges in an issue area but will also explain how that dominant pattern of cooperation emerges from the initial conditions.

The literature on variation in multilateral cooperation is more extensive in terms of methodology and contents compared to the literature focused on explaining bilateralism vs multilateralism. Game theory has generated a substantial body of literature examining different aspects of international cooperation. However, currently, there is a lack of game theory literature specifically addressing why countries choose to cooperate either multilaterally or bilaterally. I have only come across one game theory paper that touches upon the topic of bilateralism and multilateralism. However, this particular paper primarily explores whether bilateralism, in the form of regional trade agreements, acts as a building block or stumbling block to free trade in an era of multilateralism (Saggi and Yildiz 2010). The focus of this game theoretic paper does not delve into the reasons behind countries' choices to cooperate either bilaterally or multilaterally. Instead, it contributes to the debate concerning the relative merits of bilateralism versus multilateralism (trade creation versus trade diversion debate) in international trade (Krugman 1991; Bhagwati and Panagariya 1996).

2.5 EVOLUTIONARY GAME THEORY

EGT not only predicts which equilibrium will dynamically emerge in the issue area, but also assesses the stability of the equilibrium to the invasion of a mutant strategy. For instance, Krapohl, Ocelík et al. (2021) explore the stability of global trade cooperation to the invasion of trade protectionism and concluded that global trade cooperation is not resistant to the invasion of trade protectionism. EGT provides the theoretical framework to understand how and why different patterns of cooperation evolve in different issue areas. Countries do not make decisions about concluding multilateral or bilateral investment agreements in isolation. They decide whether to engage in bilateralism or multilateralism based on what other countries are doing at the same time in the international system. Therefore, a country's decision is strategic in nature. Countries interact strategically over the time to conclude a multilateral or bilateral investment treaties.[18] The expected payoff of the same action (strategy) is different under different prevailing distributions of strategies.[19] Whether a multilateral investment agreement is successfully concluded or not depends on the proportion of countries willing to adopt and adhere to the agreement.[20] The success of a strategy is frequency-dependent: if the proportion of countries willing to adopt a multilateral

[18] Countries can engage in bilateralism and multilateralism at the same time. These two different means of investment protection are not mutually exclusive.

[19] Countries decide whether to engage in multilateralism or bilateralism based on the expected payoffs. The expected payoff is the most appropriate indicator because countries don't know in advance what proportion of FDI will originate from the countries with whom they are having a multilateral or bilateral or no agreement at all. The expected payoff is the average payoff a country would expect to receive in FDI over the long run. The expected payoff is based on the probabilities of different strategies (actions) being played in the population. Countries can protect and promote FDI multilaterally, bilaterally, or unilaterally. If a higher proportion of countries are willing to adopt and adhere to multilateral investment agreement, then the multilateral investment agreement has higher probability of being played. The higher the proportion of countries willing to adopt and adhere to multilateral investment agreement, the higher the expected payoff for the multilateral investment agreement. In evolutionary game theory, the expected payoff plays a significant role in determining which strategy will be replicated though the international system.

[20] In the hawk-dove game, neither the hawk nor the dove strategy is the "universally" best strategy. If the proportion of the hawks in the population is too high, then they will end up fighting with each other. Therefore, the expected payoff of the hawk strategy is less if the proportion of the hawks in the population is very high. If the proportion of doves in the population is too high, then the hawks can exploit them. Therefore, the expected payoff of the dove strategy is low if the proportion of the doves in the population is very high. The success of hawk or dove strategy depends on the prevailing distribution of the strategies in the population.

investment agreement is low, then the multilateral agreement may fail to be established. The strategy with a higher expected payoff will progressively replace the strategy with lower expected payoff in the international system. The successful strategy yields higher and higher expected payoff with the passage of time making it more difficult for countries to resist the most successful strategy. Countries observe the successful economic policies of other countries to imitate them. Every country follows a simple learning rule: every country adopts the most successful economic strategy in the previous round. Learning happens gradually through imitation. Countries are not required to remember the longer play of history to learn the most successful strategy. Only one of the strategies in the initial set of strategies can be learnt as the most successful strategy.

It is clear that multilateralism in international trade or bilateralism in FDI did not happen in one big leap. The growing fraction of countries adopted the most successful strategy over time. There were only 23 countries in the first GATT rounds. However, GATT, with its simple coverage of trade issues and smaller membership, evolved into the WTO with almost universal membership and a much more comprehensive coverage of trade issues. Similarly, the first BIT was signed between Germany and Pakistan in 1959. However, BITs became the dominant mode of protecting and liberalizing FDI. The aggregate pattern of cooperation does not emerge in one giant leap.

The solution concept in evolutionary game theory is the evolutionary stable strategy (ESS), which is a strategy that is resistant to any mutant strategy that may arise in the future (McNamara and Weissing 2010). In other words, an ESS is a strategy that, once adopted by a population, will remain in that population over time and will not be replaced by any alternative strategy. The process of dynamic adjustment will lead to a point where all the players in the game are playing the same strategy. This strategy is also known as the resident strategy. The resident strategy is ESS if it resists all possible mutations in the future. EGT not only explains the emergence of a unique

equilibrium, but also explains the trajectory taken to reach that unique equilibrium from initial conditions. EGT resolves the problem of multiple equilibria by selecting the unique Nash equilibrium in a game (Kandori, Mailath et al. 1993). The simulation of coordination games is particularly useful in evolutionary context because it resolves the issue of multiple equilibria in coordination games.

International trade and FDI meets the requirements for applying EGT. Friedman (1998) has identified the following requirements for the application of evolutionary game models in economic domain. 1. To represent strategic situations in the international economy, where countries change their strategies over time. 2. The countries interact strategically, meaning that the country's payoff depends not only on its own strategy but also on the strategy of the other country it is interacting with. 3. The countries should not try to deliberately change the future behavior of other countries in the game. 4. Strategic situations for which classical game theory predicts multiple equilibria. The question of equilibrium selection in evolutionary game models has been extensively studied in the context of economics (Bold, Löwe et al.; Samuelson 1998; Binmore and Samuelson 1999; Fudenberg and Levine 2009).

2.6 CONCLUSION

This chapter reviews the existing literature on explanations for variations in multilateral cooperation across the issue areas. Specifically, I have explored how countries decide whether to cooperate bilaterally or multilaterally in a strategic context. The key finding from the existing cooperation literature is that the dominant pattern of cooperation in international trade is multilateralism while in case of FDI, it is bilateralism. The main insight gained from the literature review is that the dominant pattern of cooperation is dynamically *evolved* over time when countries

decide to *coordinate* their strategies either towards multilateralism or bilateralism. Therefore, coordination game theory and evolutionary dynamics will guide the development of the game theoretic model in the next chapter, which aims to develop methodology to investigate different patterns of cooperation in the two issues. The existing research informs my choice to use the same strategic structure for the two different domains. The literature review also establishes that transnational corporations, power dynamics and the number of players do not play a central role in explaining the varying patterns of cooperation in international trade and FDI.

CHAPTER 3

METHODS

As argued in the previous chapters, it is nothing less than a puzzle why multilateralism is a dominant pattern of cooperation in international trade, and bilateralism is a dominant pattern of cooperation in FDI, despite striking similarities between the two domains. The purpose of this chapter is to provide a research design to develop theory and empirical analyses aimed at helping understand how and why different patterns of cooperation emerged in the two issue areas.

The first part of this chapter will justify the use of a game theoretic model, and then begin to sketch the set-up for the three players three strategies coordination game that is analyzed more fully in Chapter 4. Because this game is a generalization of the classic stag-hunt game to include multilateral as well as bilateral cooperation, I have somewhat jokingly named it the stag-elephant hunt game theoretic model. This model aims to capture the strategic situation that countries face in the international system while deciding whether to cooperate bilaterally or multilaterally. I will simulate the stag-elephant hunt game model in the evolutionary context within large populations of players in Chapter 4. Thus the next part of this chapter lays the theoretical foundation for that simulation work. I will then explain and justify the choice of methods used to evaluate the empirical implications of this theoretical model.

The laying of the methodological groundwork for the theoretical model is organized into four sections. In section 3.1, I will highlight the role of formal models in explaining the international cooperation. The section discusses the advantages and disadvantages of traditional game theory to understand various aspects of international cooperation. It also discusses how evolutionary game theory can fix the shortcomings of the traditional game theory. Section 3.2

presents a theoretical framework that narrates the story of evolution of different patterns of cooperation in international trade and FDI. The purpose of this section is to establish why we should think about different patterns of cooperation in evolutionary terms. This framework will later be explored in more detail in Chapter 5. Section 3.3 provides an initial description of the stag-elephant hunt game model, which captures the strategic situation faced by countries when deciding whether to cooperate bilaterally or multilaterally. Section 3.4 discusses the replicator dynamics that resolves the issue of multiple equilibria in static coordination games. This section also discusses the learning mechanism, the notion of dynamic stability and the solution concept in evolutionary game theory. Additionally, the section discusses the computational algorithm used to simulate the stag-elephant hunt game model using replicator dynamics. The section concludes with a brief discussion of the limitations of the model.

The next part of this chapter provides an introduction to and justification for the empirical methods used in Chapters 5 and 6. Section 3.5 narrates the history of emergence of different patterns of cooperation guided by the model developed for the two specific domains and explains the logic of paired analytic narratives that guides the work in Chapter 5. Section 3.6 will discuss the methodology for conducting empirical validations of the implications of the game theoretic model analyzed in Chapter 6. I will use the survival analysis to evaluate the theoretic implications of the model in the investment domain, utilizing the BITs data spanning from 1960 to 2023. The section also briefly introduces the survival analysis approach.

3.1 ROLE OF FORMAL MODELS IN INTERNATIONAL COOPERATION

The choice of method to investigate the research question is an important decision. Some methods are more appropriate than others for investigating specific research questions. Different

research methods are particularly suitable to capture different elements of the research problem. Ideally, we should get the same or similar answer for the research question even if we choose different methodologies. However, the research methods have their own strengths and weaknesses and no single method has absolute advantage over the others for investigating all research questions. Sometimes the conclusion we reach from the research questions are limited by the research method we have chosen. The choice of method is the most important question the research student must made in writing a good quality dissertation. To highlight the role of formal models in investigating international cooperation, Milner (2004) has argued that formal models have gone the furthest in the domain of international cooperation.

Formal models have comparative advantage over other methods when it comes to the study of international cooperation. They are clearer about the definition of actors, strategies available to actors, information structure and assumptions. Formal models incorporate the most fundamental elements of the research problem under investigation.[21] We can study the interrelationship of these fundamental elements in detail in formal models. In this regard, they help us understand the real causal mechanism by isolating the unnecessary detail. One of the limitations of other methods is that we cannot explore the counterfactuals. If X is causing Y, then does the absence of X also means absence of Y. Formal models become even more interesting and useful when simulations are run to explore counterfactuals (Pepinsky 2005). The usefulness of the formal model also comes out at the cost. They are more difficult to set up. But once they are set up, we can analyze the research question in a precise mathematical language. A formal model quickly gets complex (mathematically) with the inclusion of additional explanatory variables. Parsimony is advocated

[21] Formal model always leaves out the unnecessary details to focus on fewer factors causing the phenomenon. For instance, a map is a model but leaves out lot of unnecessary detail. Leaving out unnecessary information is important to make the model useful. A model as complex as the real world is not very useful. The purpose of the model is to simplify the reality so that we can draw useful insights from the model.

by international relations scholars coming from different methodological traditions. However, there is even a stronger case for parsimony in formal modeling to keep the mathematics simple.

I will highlight the contributions of two different formal models to the advancement of international cooperation/international institutions literature from two distinct formal modeling traditions: game theory and agent-based modeling. These are two of the simplest formal models, but have enriched debate on the cooperation literature. *Game theory tradition*: cooperation may be difficult to emerge in one-shot version of prisoner's dilemma. However, it is possible to generate cooperation if the prisoner's dilemma game is repeated. *Agent-based modeling tradition*: Axelrod's prisoner's dilemma game simulation showed that the tit-for-tat strategy is particularly important for sustaining international cooperation. There is very strong empirical support for both these insights in the real world. Issue areas with a longer shadow of the future and reciprocal relationships are particularly useful for supporting international cooperation.

The question then is why use formal game theoretic model to investigate the research question? How and why do different patterns of cooperation emerge in the international system. The popularity of a research method may rise and fall across the time. The field of international relations has continuously evolved in terms of research methods and issues it tackles. However, game theory has largely retained its popularity to investigate research questions related to international cooperation. This is because whether we are modeling international cooperation in the security domain or the economic domain, the relationship between states is highly strategic. The payoff of any country from cooperation depends not only on its actions but also depends on the actions of all the players in international system. International cooperation involves bargaining and negotiation between the players with different preferences and interests. Game theory provides the techniques to analyze the bargaining outcomes. The main solution concept in game theory is

of equilibrium which is also suited to analyze different patterns of cooperation prevailing in the international system. Multilateralism dominates international trade while bilateralism dominates FDI. We can think of these dominant pattern of cooperation as prevailing equilibriums in the two issue areas.

Traditional game theory is not without limitations. The main limitations of game theoretic literature are that it sometimes predicts multiple equilibria, and it assumes the rationality of actors. Fortunately, evolutionary game theory corrects for the weaknesses of the traditional game theory. Evolutionary game theory predicts the unique equilibrium, given starting conditions, and it also specifies the path taken to reach the unique equilibrium. Furthermore, through evolutionary processes, even myopic players can reach the equilibrium which is reserved for rational players in traditional game theory.

As is outlined below, I initially developed a traditional three-players three strategies game-theoretic model, which is the modification of stag-hunt game. The simulation of the model is then explained in evolutionary terms. The most successful strategy is reinforced in the model with a consequence that the most successful strategies are played by the growing fraction of the countries with the passage of time. Therefore, my model not only specifies which equilibrium (pattern of cooperation) will emerge but also specifies the trajectory from the initial conditions to the equilibrium. The simulation of the model also recognizes that the cooperation is inherently dynamic. Countries continuously and strategically interact with each other to reach the equilibrium. Even the equilibrium must be dynamically stable. Evolutionary Stable Strategy (ESS) is the solution concept in evolutionary game theory which incorporates the notion of dynamic stability.

Different game theoretic models emphasize different aspects of strategic interaction in international cooperation. Game theory, with its deductive logic, allow us to explore the implications of our assumptions with logical and mathematical precision. Game theory goes beyond stating correlations between variables X and Y and instead provides a causal framework that explains how changes in X cause changes in Y. The predictions made by game theory models also find strong support in empirical settings. Despite its weakness, game theory has retained its position as the most preferred modeling paradigm for analyzing strategic situations in international cooperation. It is not possible to confine the whole game theoretic scholarship on international cooperation into a few paragraphs. However, the game theory literature has advanced our understanding of different aspects of cheating, monitoring, trust, reciprocity, bargaining and coordination problems in international cooperation. In my dissertation, I am using evolutionary game theory, which addresses some of the shortcomings in traditional game theory models. Evolutionary game theory does not require players to be rational, resolves the prediction of multiple equilibria, and allows players to dynamically adjust their strategies reflecting changes in the environment.

3.2 THEORETICAL FRAMEWORK

Before the emergence of one ESS in any domain in the international system, the countries can potentially play a wide range of strategies between the two extremes of cooperation and non-cooperation. This is also true of multilateral cooperation in international trade. The strategic interaction that leads to different patterns of cooperation in the international system is “dynamic” rather than static. The countries are repeatedly deciding in every period whether to interact

multilaterally, bilaterally, or unilaterally. The dominant pattern of cooperation that we observe in any domain is a consequence of these repeated strategic interactions.

I will argue in more detail in Chapter 5 that the open and liberal economy of the early twenty first century was not established in a day. The open and liberal economy was established through an evolutionary process rather than any revolutionary big-bang economic reforms. The aggregate behavior did not change in one giant leap. Successful strategies spread throughout the system. These evolutionary forces helped the countries to learn and adopt the most successful strategies over the period.

Indeed, one could imagine such a process proceeding even if all the countries in the international system followed simple behavioral rules of learning/imitation. The countries have the agency to enter and exit the international system with different economic strategies. The successful strategy at the current time was adopted by the wider fraction of the countries in the next time in the international system. Therefore, even if countries don't consider the longer history of play or possess great strategic foresight between them when making decisions, patterns of cooperation can emerge through selection towards choosing the most successful strategy. Evolutionary game theory does not make demanding assumptions about the necessity of rationality of players for the emergence of a Nash equilibrium. Evolutionary game theory does not even require the countries (players) to best respond to each other at each stage of a game. Instead, ESS can arise as countries simply imitate each other's most successful strategies. The successful strategies replicate throughout the international system while the unsuccessful strategies die out over time. For instance, the payoff of a country with same liberal trade strategy might increase when it is surrounded by a higher fraction of countries with liberal trade strategies than when it is

surrounded by a smaller fraction of countries with liberal trade strategies, increasing the appeal of the strategy in one circumstance, and diminishing its appeal in the other.

It should be noted that the method chapter of dissertations does not usually involve narrating stories. However, before explaining the methodology of my model in detail, I will briefly narrate the story of the evolution of different patterns of cooperation in international trade and FDI, a story that is considered in more depth in Chapter 5. This story will illustrate the broad methodological direction I am adopting to explain the dominant pattern of cooperation in international trade and FDI.

3.2.1 International Trade

In the postwar period, initially only a few countries were willing to engage with each other on multilateral trade issues. When the participants in the first multilateral trade negotiation round experienced rapid economic growth, they created a strong demonstration effect in the international system. The brief of eight (08) multilateral trade negotiating rounds is obtained from the following weblink https://www.wto.org/english/thewto_e/whatis_e/tif_e/fact4_e.htm

Table 3.1 GATT trade rounds

Year	Place/name	Subjects covered	Countries
1947	**Geneva**	Tariffs	23
1949	**Annecy**	Tariffs	13
1951	**Torquay**	Tariffs	38
1956	**Geneva**	Tariffs	26
1960-1961	**Geneva** Dillon Round	Tariffs	26
1964-1967	**Geneva** Kennedy Round	Tariffs and anti-dumping measures	62
1973-1979	**Geneva** Tokyo Round	Tariffs, non-tariff measures, "framework" agreements	102
1986-1994	**Geneva** Uruguay Round	Tariffs, non-tariff measures, rules, services, intellectual property, dispute settlement, textiles, agriculture, creation of WTO, etc	123

There were only 23 participants in the first multilateral trade negotiating round, which was concluded in late 1940s. However, most of the other countries at that time were still protecting their economies with a complex combination of high tariff and non-tariff barriers. The protectionist countries (trade) that did not open their economies to foreign trade faced slower economic growth, massive unemployment, and balance of payment pressures. The protectionist countries learned about the superiority of open trade policies at different rates. Once a particular country learnt about the superiority of open trade policy it could not resist the temptation to adopt the open trade policies for long. Consequently, a growing fraction of countries participated in the subsequent multilateral trade negotiation rounds. The popularity of the open and liberal trade policies increased throughout the international system with an ever greater proportion of countries willing to adopt open trade policies. The liberal trade policy was the most successful strategy as compared to the protectionist trade policy at any given point in the international system. In the initial multilateral trade negotiation rounds, when the smaller fraction of liberal trade economies was surrounded by the

larger fraction of non-liberal trade economies, the liberal trade economies developed rapidly. This evolutionary dynamic was so powerful in the international system that the participants in the multilateral trade negotiations were progressively increasing. The evolutionary forces were slowly driving out the ghost of trade protectionism from the international system. Now we are at a point when all countries are members of the WTO with a firm commitment to multilateral trade liberalization. Whether the open and liberal trade strategy is rare or the most popular strategy, it is always relatively more advantageous at any point in international system. It is wrong to assume that the open and liberal trade policy will be subjected to exploitation if it is rare in the international system. If that were true, then the liberal trade policy would have died in the first few multilateral trade rounds when the small number of liberal economies were surrounded by the very large number of protectionist economies.

One limit on the ability of evolutionary processes to attain an equilibrium is if the most successful trade strategy does not exist in the system, it cannot spread through the system. The successful trade strategy must exist in the system for system wide imitation/adoption. Someone must introduce the most successful strategy into the system. Once the most successful trade strategy is introduced in the system, the evolutionary dynamics can take it to a point where most countries ultimately adopted that successful trade strategy. Great Britain was the first country to adopt a full-fledged free trade policy. In fact that Great Britain used coercion to impose free trade policies on its colonies. But even if Great Britain had not imposed free trade policy on its colonies, the free trade policy would still have spread throughout the international system due to evolutionary dynamics. Large populous countries like India and China started opening their economies to international trade in the last quarter of 20^{th} century. We cannot ignore the power of small evolutionary steps in the international system. It can even push around the large countries in

the international system against their will. Undoubtedly, evolutionary dynamics have had a very strong cumulative effect in the evolution of multilateral trade cooperation. The whole communist bloc ultimately accepted in-principle most of the open and liberal trade policies.

3.2.2 Foreign Direct Investment

There was only one bilateral investment agreement (BIT) in the world (between Germany and Pakistan) in 1959. However, bilateralism in investment domain became more prevalent with the progression of time. The evolutionary dynamics continuously increased the popularity of BITs. Now we have more than 2856 BITs[22] in the international system. As noted previously, there are more bilateral agreements (BITs) in investment than in any other issue area.

To explain the variation in multilateral cooperation across the two issue areas, we cannot afford to ignore the evolutionary dynamics of the strategies that lead to the emergence of dominant pattern of cooperation. Evolutionary game theory captures the dynamics of how and why the dominant pattern of cooperation emerges in different domains, and hence evolutionary game theory will be used to model the emergence of multilateral and bilateral cooperation in the international system. Evolutionary game theory provides the appropriate theoretical context to investigate the variation in multilateral cooperation across the issue-areas of international trade and FDI. I will use a three-player symmetric generalization of the stag-hunt game -- the stag-elephant hunt game -- to capture the strategic situation (for cooperation) prevailing across various domains in international relations. I will simulate the stag-elephant hunt model (using replicator

[22] The UN Investment Policy hub maintains the complete record of investment treaties signed by different countries. The UN database was accessed on 02/24/2023 using the following weblink https://investmentpolicy.unctad.org/international-investment-agreements

dynamics) to demonstrate the contexts in which the multilateralism is an ESS in international trade, and bilateralism is an ESS in FDI.

3.3 DESCRIPTION OF GAME THEORETIC MODEL

The simplest definition of multilateral cooperation requires the simultaneous mutual adjustment of policies by *at least* three countries, resulting in a situation where all countries are better off than they would be without cooperation. Here a simple game theoretic model is developed to capture the strategic situation faced by countries regarding the different patterns of multilateral or bilateral cooperation. The game is the modification of stag-hunt game. The game is named "stag-elephant hunt" game. And like the stag-hunt game, the stag-elephant hunt game is also a coordination game. What makes a particular game a coordination game is that for each strategy, when all players select that strategy, no player has an incentive to deviate to playing different strategies. This dissertation frames the choice that countries face between multilateralism and bilateralism as a *coordination problem* in the international system. The same stag-elephant hunt game model is used to model the choice of countries regarding whether to cooperate bilaterally or multilaterally in both international trade and FDI. Coordination games were discussed in detail in the literature review chapter. The decision in a strategic setting by the country whether to cooperate multilaterally, bilaterally, or unilaterally (non-cooperation) is captured by the stag-elephant hunt game. The analogy used in the stag-elephant hunt game can be summarized in the following table.

Table 3.2 Summary of stag-elephant hunt game

Number of cooperators	Nature of cooperation	Analogy
All three hunters (countries) cooperating with each other.	Multilateral cooperation	Hunting elephant in the game is an analogy for the multilateral cooperation. The hunters share the reward equally. Elephant is the most rewarding, but it is the riskiest of all as well.
The subset of two hunters (countries) cooperating with each other.	Bilateral cooperation	Hunting stag in the game is equivalent to bilateral cooperation. The hunters share the reward equally. Hunting stag is less risky than hunting elephant.
If a hunter is not cooperating at all.	Non-cooperation (unilateral strategy).	Hunting nothing is equivalent to non-cooperation. There is no reward for non-cooperation.

Figure 3.1 Summary of stag-elephant hunt game

There are only three hunters in the game and three possible actions in the simple game-theoretic model. If all the hunters cooperate with each other for the highest payoff, they will hunt elephant. If only a subset of the hunters cooperate, the hunters will not be able to capture the elephant, but they would be able to capture the stag if they choose to hunt for it. If the hunters decide not to cooperate at all, they will hunt neither elephant nor the stag. The reward of all the hunters cooperating with each other is higher than the reward of a subset of hunters cooperating with each other. The hunters have no conflicting preference rankings: all the hunters prefer hunting

elephant over stag and hunting stag over nothing. However, hunting elephant is riskier because all the hunters must have strong belief that all other hunters would cooperate simultaneously with each other. If a single hunter cheats (does not hunt), they will miss the elephant. The opportunistic behavior of one hunter is enough to negate the efforts of all other hunters to capture elephant.

There is strategic uncertainty about the intentions and actions of hunters in the game. If the hunters hunt the elephant successfully, they will split the reward equally. Hunting stag is less risky because it needs fewer hunters cooperating with each other to hunt a stag. In a way, the reward is smaller but more guaranteed when the subset of hunters is cooperating with each other. If the subset of hunters hunts the stag, they will also split the reward equally. If the hunter commits to run after the prey (elephant or stag), the hunter will incur cost whether the hunter catches the prey or not. The cost could be understood as the energy spent by the hunter to catch the prey. Once the hunter commits to catch the prey (either elephant or stag), the hunter will incur the cost whether the prey is caught or not. There is no uncertainty about the costs of hunting, but there is uncertainty about the benefits. If two hunters are running after the elephant, they will incur the cost but not the benefit. If a single hunter is running after the elephant, he will incur the cost but not the benefit. The moment the hunter decides to run after the elephant or stag, he will incur the cost. However, benefit for the hunter depends on whether the minimum number of (other required) hunters jump in to hunt the same animal. We need a minimum of three hunters to hunt elephant while we need two hunters to hunt the stag. Whether the prey is caught or not depends on the cooperation of other players in the stag-elephant hunt game. If the hunter decides not to hunt elephant or stag, he will neither incur any cost nor any benefit.

The essential question is what hunters should do when they face the option of hunting between elephant, stag, or nothing. In other words, how do hunters decide what to hunt in the stag-

elephant hunt game. Multilateral cooperation requires the cooperation of almost all players in the system. Therefore, multilateral cooperation is like hunting the elephant. The bilateral cooperation requires the cooperation between at least two players. There is a greater possibility of bilateral cooperation than the multilateral cooperation. There is a greater strategic uncertainty about the multilateral cooperation. The issue of cooperation in international relations is indeed a stag-elephant hunt game. The stag-elephant hunt game captures the strategic situation of the cooperation issues in all domains. We need at least three players to capture the strategic settings of multilateral cooperation problems in international relations.

Three players are required to distinguish the notion of multilateralism, bilateralism, and unilateralism. Three players in the game represent three different countries. Each country is playing the strategy of either multilateralism, bilateralism, or unilateralism.[23] In the real world, the countries play a continuum of strategies ranging between multilateralism and unilateralism. There is a possibility of observing more than one pattern of cooperation in an issue area. The mixed strategy can model multiple equilibria in an issue area. For example, the countries are usually playing some combination of multilateralism, bilateralism, and unilateralism in any issue area. It is very common that some pattern of cooperation dominates in an issue area. For instance, multilateral cooperation dominates other patterns of cooperation in international trade while the bilateral cooperation dominates other patterns of cooperation in investment. In our simple game theoretic model, multilateral cooperation is achieved when all three countries are playing the multilateral strategy simultaneously. In this simple game theoretic model, it is assumed that all three countries will derive the same net benefit from the multilateral cooperation. Bilateral cooperation requires a minimum of two countries. It is again assumed that both countries will

[23] Unilateralism means that a player is not considering the strategies of other players in the game. Unilateralism is non-strategic.

derive the same benefit from the bilateral agreement. It is also possible for all three players to play a bilateral cooperation strategy simultaneously. It will lead to three bilateral agreements. It is important to note that three bilateral agreements are not equivalent to a single multilateral agreement. If the two countries are playing multilateral strategy and the third one is playing the bilateral strategy, then there will be neither multilateral cooperation nor bilateral cooperation. The cost of playing a given strategy for a player is independent of the strategy of other players. In other words, there is no uncertainty regarding the cost of playing a given strategy.[24] However, the benefit of a cooperative strategy (multilateral or bilateral) for a player depends on the strategy of other players. Details of the game structure and the specific terminology will be developed and explained in Chapter 4.

The formal game-theoretic model is a simplification of real world. Many elements of the real world were not modeled in the stag-elephant hunt game. The formal model assumes that the state is a unitary and primary actor in the international system. The model does not incorporate the role of transnational actors (multinational corporations) in explaining the variation in multilateral cooperation. Additionally, the model ignores the role of powerful actor(s) and the North-South divide in explaining variation in multilateral cooperation. The two domains (international trade versus FDI) are strikingly similar in terms of transnational actors, North-South divide, and the role of powerful actors. Therefore, these common factors are not modeled in the stag-elephant hunt game to explain difference of dominant patterns of cooperation in international trade and FDI.

Since the stag-elephant hunt game is a coordination game, it is not surprising that we have multiple equilibria in the one-shot version of the game. The stag-elephant hunt game predicts three

[24] This is because various trade ministries permanently maintain team of experts to negotiate bilateral and multilateral agreement. The cost incurred on maintaining these experts is largely independent of the success or failure of bilateral and multilateral episodes.

unique pure strategy Nash equilibria in the game: multilateralism, bilateralism, and unilateralism. The next chapter on game theory will demonstrate that multilateralism, bilateralism, and unilateralism are indeed Nash equilibria.

Multilateralism represents an equilibrium in which all three players in the game are simultaneously playing the multilateral strategy. Bilateralism, on the other hand, is an equilibrium in which all three players are playing bilateral strategies, resulting into three bilateral agreements among the three players. Unilateralism, the third equilibrium, describes a situation where none of the players are cooperating with each other. Multilateralism is a payoff dominant equilibrium (Pareto efficient equilibrium), as all the players prefer multilateralism over bilateralism. However, multilateralism is riskier than bilateralism. The one-shot version of stag-elephant hunt game cannot conclusively resolve the question of whether countries will coordinate towards multilateralism or bilateralism in either domain.

The question of equilibrium selection in evolutionary game models has been extensively studied in the context of economics (Bold, Löwe et al.; Samuelson 1998; Binmore and Samuelson 1999; Fudenberg and Levine 2009). Coordination games, with multiple equilibria, are particularly suited to combine with evolutionary game theory for the selection of unique equilibrium. The evolutionary game theory does more than simply resolving the multiple equilibria problem in coordination games: It explains how the equilibrium will emerge by specifying the trajectory taken from initial conditions to the emergence of equilibrium. It is precisely the learning mechanism (e.g. imitating the best strategy) in the evolutionary game theory that resolves the puzzle of whether the countries will coordinate towards multilateralism or bilateralism in the issue area.

Net payoff ratio is defined in the game model as = $\frac{B_m - C_m}{2B_b - C_b}$.

where

C_m : cost of playing multilateral strategy

C_b: cost of playing bilateral strategy

B_m: benefit of playing multilateral strategy

B_b: benefit of playing bilateral strategy.

The net payoff ratio measures the relative attractiveness of multilateral benefit versus bilateral benefit. The core assumption of the model is that multilateralism is more beneficial than bilateralism for all countries in both issue areas i.e., $(B_m - C_m) > (2B_b - C_b)$. The puzzle is why multilateralism emerges in one issue area while bilateralism in the other, even though multilateralism is more beneficial than bilateralism in both issue areas. I have argued that net payoff ratio is much higher for international trade than for FDI i.e.,

$$\left(\frac{B_{mt} - C_{mt}}{2B_{bt} - C_{bt}}\right) > \left(\frac{B_{mi} - C_{mi}}{2B_{bi} - C_{bi}}\right) \quad (1)$$

The lowercase subscript t stands for trade and the lowercase subscript i stands for investment.

The simulation of the model is based on replicator dynamics. I will simulate two models, one for international trade and the other for FDI. The only difference between the two replicator dynamics simulation is that net payoff ratio is much higher in international trade than in FDI. Specific net payoff ratios used for replicator dynamics simulation will be discussed in next chapter about game theory. I will explain the replicator dynamics, along with computational algorithm, in next section.

3.4 REPLICATOR DYNAMICS

The replicator dynamics equation provides the mathematical framework to capture the evolution of successful strategies in dynamic strategic settings. There are many variants of the replicator dynamics equation that could model the growth of successful strategies and shrinkage

of unsuccessful strategies. The following replicator equation is taken from the second edition of the Gintis' game theory book on page 277 (Gintis 2000).

$$\dot{p}_i = p_i \, (w_i(t) - \, w(t) \,) \tag{2}$$

$\dot{p}_i$ is the new proportion of players having strategy i.

p_i is the old proportion of players having strategy i.

$w_i(t)$ is the expected payoff of the player having strategy i.

$w(t)$ is the average payoff of the population in the game.

From the above equation, it is clear that $\dot{p}_i > p_i$ only if $w_i(t) > w(t)$. In simple terms, the proportion of players playing strategy i will increase in the later round if the expected payoff of player having strategy i is higher than average payoff of the population in the previous round. The rate of growth of the successful strategy depends on the difference between the expected payoff of the successful strategy and average payoff of the population ($w_i(t) - \, w(t)$). The higher the difference, the higher the growth rate in the proportion of players playing the successful strategy. Conversely, when $\dot{p}_i < p_i$ only if $w_i(t) < w(t)$, the proportion of players playing strategy i will decrease in the later round if the expected payoff of player having strategy i is lower than average payoff of the population in the previous round. The replicator dynamics equation precisely tells us which strategies will grow and which strategies will shrink in the system over the period.

Countries decide whether to engage in multilateralism or bilateralism based on the expected payoffs. The expected payoff of a strategy depends on the proportions of different strategies in the system. For instance, the higher the proportion of countries willing to adopt and adhere to multilateralism, higher the expected payoff for the multilateralism.[25] In evolutionary

[25] It is to be noted that *both* the relative payoff (of multilateralism versus bilateralism) and the initial distribution of strategies (proportion of strategies) determine the evolution of dominant pattern of cooperation in issue areas. The relative payoffs are different for international trade and FDI, therefore, we may see the different pattern of cooperation

game theory, the expected payoff plays a significant role in determining which strategy will be replicated though the international system. As the proportion of strategies changes due to the spread of successful strategies and shrinkage of unsuccessful strategies, the expected payoff of a strategy also varies from one round to next. The expected payoff of the successful strategy continuously increases while the expected payoff of the unsuccessful strategies continuously decreases. The cost of not adopting the most successful strategy is enormously high in later rounds.[26] Therefore, it becomes increasingly difficult to resist the successful strategies and adopt the unsuccessful strategies in later rounds. The expected payoff of any strategy when the players are strategically interacting on **"dyadic basis"** is given below.

$$w_i(t) = \sum_{j=1}^{n} w_{ij}\ p_j(t) \tag{3}$$

Where w_{ij} is the payoff of a player having strategy i when that player is playing against a player having a strategy j and $p_j(t)$ is the proportion of players having strategy j; n is the different number of strategies (players) in the game. The average payoff of the population is given as the weighted (proportion of different strategies is the weight) sum of expected payoffs of all strategies in the population.

$$w\ (t) = \sum_{i=1}^{n} p_i\ w_i(t) \tag{4}$$

The essence of the replicator dynamics equation is that players playing any strategy that gives higher expected payoff than all the other strategies in the population will spread that strategy

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evolving in each one of them even from the same initial distribution of strategies. Setting the relative payoff discussion aside, in the two domains, the main intuition of evolutionary game theory is that any strategy, adopted by higher proportion of countries, becomes *more likely* to evolve as the dominant pattern of cooperation in an issue area.

[26] The simple example will clarify the point. English language has now become the global language. It is being spoken by very large fraction of global population. The cost of not learning the English language is much higher today than when it was spoken by a smaller fraction of global population during its evolution. The cost of resisting the successful strategy was so high in the later period that even China and India, the two Asian giants, ultimately adopted the successful strategy in the international trade and investment domain.

through the population while the players playing a strategy that gives lower expected payoff will gradually decrease through the system over the time.

There are three strategies in the stag-elephant hunt game model. The type of players and strategies are synonymous in the evolutionary game theory. The three strategies (types of players) are multilateralism, bilateralism, and unilateralism. The most successful strategy in the domain gradually crowds out the two unsuccessful strategies. For the purpose of the replicator dynamics simulations, we need to introduce a large number of players playing the multilateral, bilateral or unilateral strategy. The starting point for the analysis of evolutionary game theory requires the calculation of expected payoffs for each strategy based on the distribution of strategies in the game. It should be noted that each player is playing three player stag-elephant hunt game within a large population, rather than playing two-player game (dyadic interaction) as is often the case in evolutionary models. Therefore, the expected payoff of the strategies in the game must be computed based on the strategic interaction of *three-players* rather than two-players strategic interaction. It is worth highlighting that introduction of a three-player game to capture the strategic situation of multilateral cooperation is the methodological contribution of this dissertation. The expected payoffs of playing three different strategies for country 1 are as follows (and given the symmetry of the game these equations also reflect the payoffs for other countries).[27]

$$EU_1(B) = B_b(2P_b\,P_m + 2P_bP_u + 2(P_b)^2) - C_b \quad (5)$$

$$EU_1(M) = B_m(P_m)^2 - C_m \quad (6)$$

$$EU_1(U) = 0 \quad (7)$$

$$P_m + P_b + P_u = 1 \quad (8)$$

[27] The expected payoff equations below for three strategy game are developed in the Appendix A.

In the evolutionary context, the probability of a strategy could be understood as the proportion of players playing the strategy in a large population. $P_m, P_b and\ P_u$ represents the proportion of players playing the multilateral, bilateral and unilateral strategy in the game. Equation 5 clearly shows that the higher the proportion of players playing bilateral strategy in the game, higher the expected payoff of a bilateral strategy. Similarly, equation 6 demonstrates that the higher the proportion of players playing multilateral strategy in the game, higher the expected payoff of the multilateral strategy. The strategy with the highest expected payoff will spread through the system. the above mathematical equations are in line with the main intuitions of evolutionary game theory, which posits that the strategy which is played by higher fractions of the players is more likely to emerge as an equilibrium in dynamic simulations.

3.4.1 Learning in Replicator Dynamics

Learning is an important mechanism through which countries switch strategies over time. The cumulative impact of this learning mechanism in evolutionary game theory is that all countries eventually adopt the single strategy. In the brief historical sketch above, countries gradually switch to multilateralism in trade while they progressively adopt bilateralism in FDI. It is assumed that countries follow a very simple learning rule: imitation of the most successful strategy based on the expected payoff. All countries in the game follow this simple learning rule all the time. Learning does not require observing a longer history of play of high-performing countries. All any country needs to know is the most successful strategy in the last round for adopting it in the next round. A country observes the expected payoffs associated with strategic interactions of all the players in the previous round and then picks the strategy for imitation that is optimally performing at the global level.

However, if the country limits its learning to fewer countries in its neighborhood (region), then it is possible that country may learn a different successful strategy regionally than globally.[28] This can happen only if there is a different prevailing distribution of strategies regionally (in the immediate neighborhood of a country) than globally.[29] The replicator dynamics simulation does not explore the spatial dimensions across the globe. Countries learn the best strategy that is performing optimally at the global level. Evolutionary game theory does not require players to have perfect rationality to learn the best strategy based on imitation. However, countries should have complete information regarding the type of other players in the game and their payoffs from the strategic interactions. Learning in evolutionary game theory is bounded because countries can only learn one of the strategies (successful) from the set of available strategies in the game. Countries can only learn either multilateralism, bilateralism or unilateralism, nothing else. And potentially if one of those strategies is eliminated or absent, they may not be able to learn it.

The replicator dynamics model assumes that relative position of countries in the international system does not play any significant role in learning dynamics. One of the realist arguments is that great powers, using their coercive power, can extract more favorable terms from countries bilaterally than multilaterally (Kahler 1992). However, the learning dynamics in the stag-

[28] It is a separate question whether countries put more weight on learning the successful economic experience from neighboring countries than from distant countries. If the distribution of strategies is the same across space, then it does not make any difference whether a country puts more weight on learning from the successful experience of neighboring countries.

[29] For instance, the prevailing distribution of strategies in the neighborhood of country A is (Multilateralism, bilateralism, unilateralism) = (0.05, 0.90, 0.05). On the other hand, the prevailing distribution of strategies globally for all countries in the system is (Multilateralism, bilateralism, unilateralism) = (0.90, 0.02, 0.03). If the country A limits its learning to its neighborhood, then it is more likely to adopt bilateralism. However, if the country A learns the best performing strategy on global basis, then country A is more likely to adopt multilateral strategy because we have higher proportion of countries (90 percent) with multilateral strategy. The replicator dynamics simulation model assumes that there is no spatial difference in the distribution of strategies regionally or globally. The country will learn the same best strategy in the well-mixed population whether the country bases its decision regarding the imitation of best strategy regionally or globally. One potential recommendation for an extension of this research study is to explore how temporal and spatial factors affect the evolution of different patterns of cooperation in different issue areas. By temporal factor, I mean that countries that have interacted in the past are more likely to interact in the future. By the spatial factor, I mean that a country has different probabilities of interaction across space (regional versus global).

elephant hunt game model challenges the realist explanation for bilateralism in international system. A big country can learn the best performing strategy from a small country, and vice versa. China was a closed economy until 1980s, but it learnt from the Singaporean experience of trade and investment openness. There is evidence that suggests big countries can and do learn from the successful economic experiences of small countries. Allison, Blackwill et al. (2013) highlight how the Singaporean economic policies were copied in Asia. China, drawing inspiration from Singapore, gradually opened its economy to foreign trade and investment in late 1970s under the leadership of Chinese President Deng Xiaoping (Vogel 2011). Another Chinese President, Xi Jinping explained how this learning happened between Singapore and China: tens of thousands of Chinese scholars were sent to Singapore to study the Singaporean economic model.[30] The Singaporean economic growth model was in turn inspired by the Japanese growth model. These learning dynamics are also arguably in line with the constructivist literature in international relations which argues that state identities are not fixed. The strategy of a country is an identity of a country in evolutionary game theory. Countries can dynamically change their strategies (identities) through learning (imitation) mechanisms. Chinese identity was of a protectionist economy in the international system until late 1970s. However, Chinese economic liberalization culminated in becoming the member of WTO in 1999. Therefore, China adopted full-fledged trade multilateralism after unilaterally protecting its economy for many decades.

3.4.2 Equilibrium in Replicator Dynamics

The literature review chapter discusses the advantages and solution concept (evolutionarily stable strategy) of evolutionary game theory. The cumulative impact of the dynamic adjustment

[30] Please refer to the article published on diplomat available at this web link https://thediplomat.com/2015/03/lee-kuan-yew-the-father-of-modern-china/.

process in evolutionary game is that every player ends up adopting the most successful strategy. Evolutionary game theory does not assume the perfect rationality of players but still achieves the outcome that is reserved for perfectly rational players in traditional game theory. The ESS will also capture the notion of dynamic stability for the dominant pattern of cooperation in the international system. Every ESS must be a Nash equilibrium, while the converse is not true. It is possible for one of the pure strategy Nash equilibria in stag-elephant hunt game to be ESS. Replicator dynamics leads to the emergence of an ESS. When the stag-elephant hunt game is simulated using replicator dynamics, a single unique pattern of cooperation emerges in both international trade and FDI, conditional on the initial distribution of strategies. An ESS is a strategy that is resistant to any mutant strategy that may arise in the future (McNamara and Weissing 2010). We can only claim that the dominant pattern of cooperation is multilateralism (bilateralism) in international trade (FDI) if a multilateral (bilateral) strategy is an ESS in international trade (FDI). The next chapter on game theory will show that multilateralism is an ESS in international trade for a larger set of initial distributions of strategies, while bilateralism is an ESS in FDI for a larger set of initial distributions of strategies. We also need to explore the notion of dynamic stability of equilibrium: once a strategy becomes the resident strategy in an issue area, what fraction of mutants (players with alternative strategy) are required to replace the resident strategy? If we need very high fraction of mutants to successfully invade the resident strategy, then equilibrium, the dominant pattern of cooperation, is dynamically stable. I will show that multilateralism is resistant to the invasion of bilateralism in international trade and bilateralism is resistant to the invasion of multilateralism in FDI, but that the converse is less true, given the assumed differences in payoff ratios.

The following simulation algorithm, based on replicator dynamics, is used to depict the evolution of strategies in the stag-elephant hunt game in the context of international trade and FDI. It is important to note that the computational algorithm remains essentially the same for international trade and FDI, with the only difference being the payoffs in two domains. The central argument of the dissertation is based on different relative payoffs between multilateralism and bilateralism in these two domains, along with initial distribution of strategies. This distinction is captured through different game matrices for international trade and FDI.

1. Randomly initialize the number of players (with multilateral strategy, bilateral strategy, and unilateral strategy) with sum of players equal to some constant (say total 9000 players)

   x: number of players playing multilateral strategy.

   y: number of players playing bilateral strategy.

   z: number of players playing unilateral strategy.

   t (total players) = x +y +z = constant

2. Set the payoffs based on stag-elephant hunt game for international trade (different payoffs for FDI).

   $B_m = 65$, $C_m = 5$, $B_b = 10$, $C_b = 3$, unilateral strategy cost: $C_n = 0$

3. Calculate the expected payoff for each strategy.

   $$EU(M) = B_m(P_m)^2 - C_m$$

   $$= 65 * \left(\frac{x}{t}\right)^2 - 5$$

   $$EU(B) = B_b(2P_b P_m + 2P_b P_u + 2(P_b)^2) - C_b$$

   $$= 10\left((2 * \frac{y}{t} * \frac{x}{t}) + (2 * \frac{y}{t} * \frac{z}{t}) + \left(2 * \left(\frac{y}{t}\right)^2\right) - 3\right.$$

   $$EU(U) = 0$$

While there is no change in the number of players in two successive generations (rounds) repeat step 4 and step 5. The process of updating the number of players playing different strategies continues until all the players play a single strategy. The single strategy that crowds out all other strategies is known as the evolutionarily stable strategy (resident strategy).

4. Update the number of players (strategies) using replicator dynamics:

The strategy with the highest expected payoff is played by *one more* player in the next round while the strategy with the lowest expected payoff is played by *one less* player.[31] If any strategy is not played by any player, then it is removed from the international system. Any strategy played by zero number of players simply dies out. Once the strategy dies out it cannot reproduce. Therefore, the dead strategy cannot increase or decrease in number. It is to be noted that the unique equilibrium is guaranteed to emerge from any initial distribution of strategies provided that model is allowed to run for the sufficient time.

a. The strategy with highest (maximum) expected payoff will increase in number (reproduce) by one in the subsequent generation. Maximum (EU(M), EU(B), EU(U)) will decide whether x, y or z will be played by *one more* player in the next round.
b. The strategy with lowest expected payoff will decrease in number (die) by one in subsequent generation. Minimum (EU(M), EU(B), EU(U)) will decide whether x, y or z will be played by *one less* player in the next round. It is to be noted that worst performing

[31] The computational algorithm hard codes the number of countries that can switch the strategies in each round, i.e., only one country is hardcoded to switch the strategy in each round in both issue areas. It is also possible that countries may be imitating (learning) the best strategy at different rates in the two issue areas. Moreover, multiple countries, rather than the single country, may be adopting the successful strategy in a single time step. Allowing a greater or lesser number of countries to imitate the best strategy does not change the pattern of cooperation evolving in an issue area. It only affects how quickly or slowly we will reach the dominant pattern of cooperation in the two issue areas. It may be the case that the dominant pattern of cooperation evolves more quickly in one domain than the other. However, the speed with which different patterns of cooperation evolve in the two domains is not the focus of this dissertation. This research limits itself to explaining how and why different patterns of cooperation evolve in the two issue areas.

strategy will crowd out first from the game followed by the crowding out of the second worst performing strategy.

5. Recalculate the expected payoff based on the updated number of players (strategies).

3.4.3 Limitation of the Model

I have examined the impact of small random errors (normally distributed with a mean of zero and a standard deviation of 2) in learning the cooperation strategies in both the investment and trade domains on the evolution of the dominant pattern of cooperation.[32] Despite countries making small errors in learning the cooperation strategies, multilateralism emerges as the dominant pattern of cooperation in international trade. Similarly, even when countries make errors in learning the cooperation strategies, bilateralism still emerges as the dominant pattern of cooperation in Foreign Direct Investment (FDI).

Countries in the stag-elephant hunt game theoretic model learn the best strategy in any domain on a global basis. But what if the players puts more weight on learning from their regional peers than from any country in the globe? What if the players cannot observe the strategic interactions of every other player? They have to infer the most successful strategy from observing the limited number of players in the game. I also did not explore the spatial and temporal dimension in the replicator dynamics. We can introduce more parameters to make the model richer. However, this may require running an agent-based model with a large number of parameters. The research recommends that future students may examine the impact of these parameters on the evolution of dominant patterns of cooperation in the domain of international trade and FDI.

[32] Please refer to Appendix D for full discussion related to error in learning the best strategy in international trade and FDI.

3.5 ANALYTIC NARRATIVES

After the model is fully developed and analyzed in the next chapter, Chapter 5 will address the need to carry out coherent and structured analysis of the history of cooperation in the postwar period in order to understand how and why different pattern of cooperation emerged in the two domains. There is a need to further explore the role of initial distribution of strategies in the emergence of distinct pattern of cooperation. As we will see, the replicator dynamics simulation model does not exclude the possibility of bilateralism in international trade or multilateralism in investment domains. Therefore, it is important to further investigate the usefulness of the model to understand the pattern of cooperation that we actually observe in the real world in the issue area. Analytic narratives provide the theoretical framework to investigate this history of cooperation in two domains. Analytic narrative is the narration of history guided by the model. It should be noted that the analytic narratives chapter is not an attempt to fully validate the model.

The analytic narratives method was introduced in the book *Analytic Narratives* by Bates, Greif, Levi, Rosenthal, and Weingast. Mongin (2016) has defined analytic narratives as studies that attempt "to explain specific historical events by combining the usual narrative way of historians with the analytic tools that economists and political scientists find in rational choice theory." Analytic narratives can significantly improve the historical explanation for the evolution of different patterns of cooperation in the two issue areas.

The stag-elephant hunt game theoretic model is a rational choice model in which every country is trying to maximize its expected payoff (benefit) given the strategies of other countries. The game theoretic model and replicator dynamics simulation outline sequences of interaction to predict long-term outcomes (equilibrium) in both domains. The net payoff ratio and initial distribution of strategies determine the evolution of different patterns of cooperation with a high

degree of certainty. These two factors are important for predicting the evolution of a specific pattern of cooperation in the two issue areas. However, there is contingency when multiple equilibria are possible from the same initial distribution of strategies in the same domain. It is possible that the stag-elephant hunt game theoretic model predicts a pattern of cooperation in the domain that fails to occur. This suggests that the exact details of the evolution of specific pattern of cooperation cannot be fully predetermined. There is no confusion about the evolution of a specific pattern of cooperation after first few time steps in the two issue areas. Once countries decide to adopt a specific path to an equilibrium, they are likely to follow that path until they reach an equilibrium.

Levi and Weingast (2016) have defined narratives as "the story being told but as a detailed and textured account of context and process, with concern for sequence, temporality, and key events." Historians narrate stories. However, their textured account is not guided by any formal model. The stag-elephant hunt game theoretic model will bring structure into the historical account while exploring the role of contingencies in the evolution of different patterns of cooperation. The analytic narratives approach is unique in a sense that we can explore the counterfactual or off the path equilibrium behavior. For instance, we can explore what pattern of cooperation would have evolved in the investment domain had the US ratified the Havana Charter. Would we have observed multilateralism in the investment domain, instead of bilateralism? It will also help us understand why multilateralism failed to emerge in the investment domain despite repeated attempts.

Alexandrova (2009) has argued that the model should provide the "lion share of explanation" in analytic narratives. However, if the model fails to predict a specific outcome in the domain, then narratives are engaged to identify the additional factors (not incorporated in the

simplified model) that are required to explain the outcome. The narrative provides additional context to the historical account, even when the rational choice model correctly predicts the long-term outcome. The replicator dynamics simulation, based on the stag-elephant hunt game theoretic model, not only predicts the pattern of cooperation correctly for each of the two domains, but also possess the strong explanatory power in elucidating the emergence of a specific pattern of cooperation relying on the imitation learning mechanism.

I will construct a structured paired analytic narrative to understand the specific pattern of cooperation that is observed in the two domains. A structured paired analytic narrative is used to examine and compare the evolution of different patterns of cooperation in the trade and investment domains in the context of the corresponding model to be developed (in Chapter 4) for that specific domain. This approach enables a coherent and well-structured analysis of how and to what extent the stag-elephant hunt game theoretic model effectively guides and explains the evolution of different patterns of cooperation in the two domains. The narration of history will be guided by the model developed for the respective domains.

3.6 SURVIVAL ANALYSIS

There are several testable implications of the game theoretic model introduced in the last section of game theory chapter (next chapter) that need empirical validation. The empirical validation of these testable implications is required to establish the credibility, reliability, and practical applicability of the main findings of the dissertation regarding the pattern of cooperation. This empirical analysis will be undertaken in Chapter 6. These testable implications apply to both the trade and investment issue areas. For instance, the simulation of the formal model employs the same learning mechanism for both international trade and FDI issue areas. However, whether

countries follow this learning rule in both domains in the real world is an empirical question that requires validation to bolster the main findings of the dissertation.

I will test the empirical implications of the model in the investment domain, although it is possible to test them in the trade domain. This choice is made to limit the scope of the dissertation and manage it within the available time. I will conduct survival analysis to test the various implications of the model *solely* in investment domain using BITs dataset spanning from 1958 and 2023 freely available on UNCTAD Investment Policy hub.

As will be explored more fully in Chapter 5 (see Figures 5.2 and 5.4) a growing fraction of country-dyads adopted multilateralism in international trade and bilateralism in FDI. In other words, the probability of signing a BIT between a country dyad in investment domain has continuously grown if that country dyad had not already signed the BIT. Similarly, the probability of countries joining multilateral arrangement has steadily risen if they had not yet joined the multilateral trade agreement. The probability of signing a BIT between country-dyads varies with the passage of time. Survival analysis is particularly useful for modeling the events whose probability varies with the progression of time, such as, time-to-death, time-to-disease incidence, time-to-recovery. Survival analysis helps us model how the probability of signing a BIT between country-dyads changes with the passage of time.

Survival analysis is designed for modeling time-to-event data. Kleinbaum and Klein (1996) have defined survival analysis as "a collection of statistical procedures for data analysis for which the outcome variable of interest is time until an event occurs." In the context of investment domain, the event in the survival analysis could be signing, termination or renegotiation of a BIT between 1958 and 2023. However, in my study, the event of interest is the signing of BITs. The time variable represents the time for each BIT to be signed since the start of the study. To conduct

survival analysis, I will create a dataset comprised of all the BITs signed between 1958 and 2023. This dataset will include information on when each BIT was signed (i.e., the date of treaty signing) between a country-dyad and whether the treaty has been signed (this binary variable serves as a censoring variable) between the country-dyad by year 2023.

The first BIT was signed between Pakistan and West Germany in 1959 and not all country-dyads have signed the BITs by 2023. None of the country-dyads had the event of interest in 1958 (starting year), which means that the survival probability is 1. In language of survival analysis, "not signing" a BIT between a country dyad is a "survival event" while "signing" a BIT between a country dyad is a "death event" or "failure event". Therefore, the probability of not signing a BIT between country dyad is highest (probability equals one) just before the start of period and continuously decreases as more and more country dyads begin signing BITs. Conversely, the probability of signing a BIT between country dyad is lowest just before the start of period (since no BITs were signed in year 1958) and continuously increases as the time passes. The Kaplan-Meier (KM) Survival Curve can be used to visualize the probability of country dyads "not signing" BITs over time. The KM Survival Curve typically resembles a step function that starts with a horizontal line at survival probability of 1, indicating that all country dyads had not signed any BITs in 1958 (time t =0) and the curve then steps down to other survival probabilities as the time passes.

The Survival function models the probability of not experiencing an event of interest, while the hazard function models the probability of having an event of interest. In my case, the survival function represents the probability of a country dyad not having a BIT while the hazard function models the probability of a country dyad signing a BIT in the next instance. The hazard function h(t) gives the instantaneous potential (rate) at time t for a country dyad to sign a BIT given that the

country dyad has not signed one up to that point (survival up to time t). The hazard rate for signing a BIT is instantaneous, therefore the graph for hazard rate is not guaranteed to monotonically increase or decrease.

Survival analysis encompasses a collection of statistical techniques. I will use the Cox proportional hazard model to assess the testable implications of my model. This survival analysis technique enables us to understand how a key explanatory variable, after controlling for alternative explanations for signing BITs, affects the hazard rate of signing BITs in next time interval (year). If the key explanatory variable is statistically significant at conventional level and the hazard ratio is greater than one, then it indicates that the key explanatory variable has positive effect on the odds of signing a BIT.

One of the most frequently cited papers in the investment domain uses the Cox proportional hazard model to investigate the diffusion of BITs in the international system (Elkins, Guzman et al. 2006). There is a lot that I will borrow from this research article, including the statistical approach and set of covariates (variables) used in the analysis. However, it is to be noted that the research article does not test the full empirical implications of my model. The research article was published in 2006 and used BITs dataset from 1960-2000 for statistical analysis. The authors also acknowledged that the data for some covariates (FDI inflows) were not available for 1960s. I am planning to use the longer dataset spanning, from 1960-2023 to conduct survival analysis. This extended time frame will allow me to test the empirical implications of my model while also capturing the new trends and changes in the investment domain, including the impact of rising investor-state disputes on the hazard rate of signing new BITs.

One example of using Cox Proportional Hazard model to test empirical implication is as follows:

I will use the Cox Proportional Hazard model to assess whether countries imitate the most successful strategy from the previous round. Do countries sign new BITs in the current period because bilateralism was a successful strategy in the investment domain in the previous round?

The game theoretic model suggests that countries would consider the bilateral strategy worth emulating in the investment domain in the future only if countries that actively signing BITs in past year experienced greater success in receiving FDI inflows or achieving higher economic growth in that year. We can view the payoffs of signing BITs as higher economic growth or FDI inflows. The impact of the total number of BITs signed by a country on higher FDI inflows or economic growth is something all countries in the international system can readily observe. The observation of these payoffs from BITs does not necessarily require countries to be completely rational actors.

I will follow a similar approach to that used by Elkins, Guzman et al. (2006). The authors regressed "the average FDI inflows as a percentage of GDP for the previous five years on the average number of treaties in force for that country during that period as well as its average GDP per capita." Essentially, this means that countries will adopt the bilateral strategy in future if it had proven beneficial (on average) over five years. Therefore, I will regress average FDI inflows as a percentage of GDP for the previous five years on the average number of BITs for that country during that period as well as its average GDP per capita.

$$(\text{FDI inflow/GDP})_{it} = B_0 + B_1(\text{Total BITs})_{it} + B_2(\text{GDPpercapita})_{it}$$

Then I will regress the dependent variable in survival analysis on the B_1 coefficient and on other covariates (alternative explanations for BITs signing). If the B_1 coefficient is statistically significant and the hazard ratio is greater than one, then we can draw the conclusion that the

successful bilateral strategy in the previous years is more likely to affect the odds of signing a BIT for country dyads in the next year.

3.7 CONCLUSION

This chapter has developed the methodology for the remainder of the project. In Chapter 4 I will develop the game theoretic model and analyze its equilibria using replicator dynamics. Chapter 4 will also demonstrate that multilateralism is stable against the invasion of a higher fraction of bilateralism in international trade while bilateralism is stable against the invasion of a higher fraction of multilateralism in FDI. In Chapter 5 I will develop a paired comparison of two analytic narratives, one of which applies the model to trade, and the other to foreign direct investment. Furthermore, in Chapter 5 I will also explore why multilateralism failed in the investment domain despite repeated attempts. This will be followed in Chapter 6 by a large N quantitative analysis which explores the learning dynamics postulated in the game theoretic model using a survival model framework.

CHAPTER 4

A GAME THEORETIC MODEL OF BILATERAL VERSUS MULTILATERAL COOPERATION

Why does multilateral cooperation sometimes fail to emerge even in contexts where multilateral cooperation would be more beneficial for all the parties than bilateral cooperation? To explore this puzzle, a generalization of the stag-hunt game was introduced in the method chapter. Now the game will be presented and analyzed fully. Unlike previous games developed in the literature, this game is able to fully incorporate the possibility of cooperation developing in either multilateral, or bilateral ways. The key finding from analysis of this "stag-elephant" hunt game is that because pursuing multilateral cooperation (the elephant) is a riskier strategy, due to the need for a larger number of players to cooperate to achieve it, multilateral cooperation can fail to emerge even when the payoffs from multilateral cooperation substantially exceed those of bilateral cooperation (the stag). Because of the multiple equilibria and variation in the size of the attraction basins, the development of cooperation in various forms is the result of both the relative payoffs of different forms of cooperation / non-cooperation and the previous / initial conditions that favor one form or another.

Any explanation for the variation in multilateral cooperation will be incomplete if we do not explain the reasons for the emergence of alternative patterns of cooperation. If there is weaker multilateral cooperation in the issue area, it is usually complemented by the emergence of bilateral cooperation. For example, FDI has shallower multilateral cooperation, however, the bilateral

cooperation in investment is quite strong.[33] To a lesser extent a similar pattern is seen in the area of taxation policy.

Any argument that aims at explaining the variation in multilateral cooperation across issue areas must therefore also explain the emergence of alternative (bilateral) patterns of cooperation in the issue areas with the shallower multilateral cooperation. The central puzzle of this study can therefore be rephrased as: why are some issue areas dominated by multilateral cooperation, while others have more bilateral cooperation (while others have non-cooperation)? I will try to explain the variation in the multilateral cooperation across the issue areas by explaining why the dominant pattern of cooperation is "multilateralism" in one issue area and "bilateralism" in another issue area.

The existing IR research acknowledges the variation in multilateral cooperation across issues without giving any low-level (concrete) explanation for this variation. The literature review chapter shows that we do not fully understand the subtleties of the variation in multilateral cooperation between the trade and investment domains. Despite much intellectual work on international cooperation, international regimes, and international organizations, we cannot explain the variation in multilateral cooperation in the two issue-areas. Why do we observe multilateralism as a dominant pattern of cooperation in the international trade and bilateralism as a dominant pattern of cooperation in investment? There must also be an explanation of how different patterns of cooperation dynamically emerge in an issue area. How and why the specific

[33] International tax cooperation is another issue area where we have no single comprehensive multilateral agreement although desirable. We have patchwork of bilaterally negotiated double taxation treaties Thuronyi, V. (2000)."International Tax Cooperation and a Multilateral Treaty." Brook. J. Int'l L. 26: 1641.The example is being presented just to highlight the fact that the complete absence of multilateral agreement does not rule out other patterns of cooperation. Similarly, we also have bilateralism in the FDI domain in the absence of multilateralism.

pattern of cooperation emerged in the two issue areas is a fundamental puzzle of international cooperation that needs to be explained.

This puzzle is interesting because we have the same transnational actors and same states involved in the two issue areas, yet we observe different patterns of cooperation in the two issue areas. The comparison of multilateral cooperation in these two issue areas is particularly interesting because there are many striking similarities: the same transnational actors (multinational corporations) and the same states are engaged in the two issue areas. There is no difference in the strategic or repetitive nature of relationships between the countries in the two domains. The nature of relationships between the states and between states and firms in both issue areas is repetitive and the participants presumably care about the gains from cooperation into the distant future to similar degrees. The two issue areas are thus very similar, yet we observe substantial variation in multilateral cooperation. The dominant pattern of cooperation in the domain of international trade is "multilateralism" while it is "bilateralism" in FDI.

Multilateral cooperation is characterized by strategic interaction between more than two countries. Thus, the payoffs from a decision of a particular country to liberalize the economy is not independent of the decisions of other countries. To explore variation in multilateral cooperation this paper studies a generalization of the stag-hunt game to three strategies and three players. In this "stag-elephant hunt" game players can choose whether to pursue multilateral cooperation which requires cooperation by all three participants to succeed, bilateral cooperation which can partially succeed even with only cooperation by two participants, and noncooperation which does not depend on the strategies of other players for its payoffs.

A core game assumption is that countries usually prefer multilateral cooperation over bilateral cooperation: that multilateral cooperation offers higher payoffs than bilateral cooperation

in the same domain. However, because of the need to establish cooperation among more players multilateral cooperation is riskier than bilateral cooperation. Firstly, it is difficult to establish multilateral cooperation because it requires all participant countries simultaneously to give up a high level of policy independence for very long period in the future. Thus, for instance, it is very difficult for the countries at the varying level of socioeconomic development to make the same or similar policy commitments. We see these differences becoming more apparent in contradictory negotiating positions of countries in multilateral negotiations. Secondly, the continuity of multilateral cooperation requires stronger mechanisms to monitor and punish the violations of multilateral rules. The successful episodes of multilateral regimes are intrusive.

The central argument of the research is that cooperation can evolve to a particular pattern of cooperation through a combination of the effects of the initial distribution of strategies (initial conditions) and the net payoff ratio. Multilateralism emerged in international trade due to favorable initial conditions and because multilateralism is much more beneficial than bilateralism in international trade. On the other hand, as will be examined in more detail in Chapter 5, bilateralism emerged in FDI due to favorable initial conditions, strategic mistakes by the principal proponent of multilateralism (the US) and multilateralism being comparatively less beneficial than bilateralism in FDI.

The central argument developed in this research paper will serve two purposes. First, it will explain *how* and *why* different patterns of cooperation emerge as a function of initial conditions and relative payoffs in the three-player "stag-elephant" (bilateral versus multilateral) hunt coordination game in the two issue areas. Secondly, it will also introduce the notion of the stability of the dominant pattern of cooperation in the two issue areas.

This chapter is divided into three sections. In section 4.1, I will present the model and show that multilateralism, bilateralism, and unilateralism are three pure strategy Nash equilibria in the stag-elephant hunt game for the two domains. In section 4.2, I will discuss the Excel and R programming replicator dynamic simulations to demonstrate that multilateralism is not only an ESS in international trade but also resistant to the invasion of bilateralism. This section also demonstrates that bilateralism is not only ESS in FDI but also resistant to the invasion of multilateralism. The basin of attraction triangle created from simulating the stag-elephant hunt game clearly shows that multilateralism has a larger basin of attraction in international trade, while bilateralism has a larger basin of attraction in FDI, based upon the assumptions concerning the relative benefits of multilateral and bilateral cooperation in each area. Even when multilateral cooperation has higher payoffs, it can be difficult to arrive at an equilibrium in which this pattern emerges. In section 4.3, I will discuss the testable implications of the formal game theoretic model which highlight the impact of historical contingency on the evolution of a specific (or alternative) pattern of cooperation, the role of learning, and the importance of relative payoff ratios in different issue areas.

4.1 GAME STRUCTURE AND MULTIPLE EQUILIBRIA IN STAG-ELEPHANT HUNT COORDINATION GAME

This section presents the multilateral versus bilateral coordination game (stag-elephant hunt game) and analyzes the Nash equilibria of the game. There are three pure strategy Nash equilibrium in the three-players stag-elephant hunt game. The stag-elephant hunt game is a three-player generalization of the stag hunt coordination game. As discussed previously, a coordination game with at least three players is essential for study of the difference between coordination at

bilateral and multilateral types of coordination. All coordination games have multiple equilibria; therefore, it is not surprising to have multiple equilibria in this coordination game. The coordination problem lies in determining which pattern of cooperation will emerge in an issue area. The puzzle is whether countries will coordinate their strategies towards multilateralism or bilateralism in an issue area.

As we will see, one common property of all pure strategy Nash equilibrium in the stag-elephant hunt game is that all players are playing the same strategy in equilibrium. Nash equilibrium is reached when there is no incentive for any country to unilaterally deviate from the given strategy, holding constant the strategies of other countries.

The three pure strategy equilibria are thus:

a. Multilateralism: when all countries are playing multilateral strategy (highlighted with yellow color in payoff matrix below). The multilateral strategy is the "elephant" strategy, typically with the highest payoffs in equilibrium. But achieving multilateralism requires coordination by more players.

b. Bilateralism: when all countries are playing a bilateral strategy (highlighted with blue color in payoff matrix below). The bilateral strategy is the "stag" strategy requiring the combined efforts of at least two players. In equilibrium its payoffs are assumed to be higher than unilateralism, but lower than multilateralism.

c. Unilateralism: when all countries are playing non-cooperation strategy (unilateral strategy) (highlighted with pink color in payoff matrix below). The unilateral strategy is the "hare" strategy, a strategy with payoffs (normalized to zero) that do not depend upon the choices of the other players.

4.1.1 Notation

C_m > 0: cost of playing multilateral strategy

C_b > 0: cost of playing bilateral strategy

B_m: benefit of playing multilateral strategy

B_b: benefit of playing bilateral strategy

$B_m - C_m$: net welfare gains to each country from multilateral cooperation

$B_b - C_b$: net welfare gains to each country from bilateral cooperation

P_m: probability of playing multilateral strategy[34]

P_b: probability of playing bilateral strategy[35]

P_u: probability of playing unilateral strategy (non-cooperation)[36]

$EU_i\ (M)$: Expected utility of playing a multilateral strategy for player i

$EU_i\ (B)$: Expected utility of playing a bilateral strategy for player i

$EU_i\ (U)$: Expected utility of playing a unilateral (non-cooperative) strategy for player i

4.1.2 Assumptions of Stag-elephant Hunt Game

1. Stag-elephant hunt game is a three-player symmetric game model to explain the emergence of dominant pattern of cooperation in the issue area.

2. Each country is playing either multilateralism, bilateralism, or unilateralism.

3. Due to assumption of symmetry, each country will derive the same benefit from the multilateral cooperation (bilateral cooperation). There are no distributional issues. However, a special case is

[34] We can also think of multilateral probability as proportion of players (agents) playing multilateral strategy.
[35] We can also think of bilateral probability as proportion of players (agents) playing bilateral strategy.
[36] Similarly, we can think of unilateral probability as proportion of players playing unilateral strategy.

included in the Appendix B in which countries are concerned about the relative distribution of gains in the stag-elephant hunt game.

4. The countries derive a higher benefits ratio from multilateral cooperation than bilateral cooperation in each domain. Specifically, $B_m - C_m > 2B_b - C_b$. As discussed below, the extent to which multilateral cooperation performs better than bilateral cooperation can vary, and in the empirical application I assume that there is a much larger advantage for multilateral cooperation in international trade than in investment.

5. There is an uncertainty about the benefits from different patterns of cooperation (multilateralism or bilateralism) but there is no uncertainty about the costs. The following assumptions are made about the costs and benefits of the different patterns of cooperation in the stag-elephant hunt model.

a) There is neither any cost nor any benefit for a non-cooperating country (playing unilateral strategy): the payoff is normalized to zero.
b) The benefit of bilateral cooperation and multilateral cooperation is negative if an insufficient number of other countries select the relevant strategy. Specifically, the costs are both greater than zero ($C_m > 0$ and $C_b > 0$).
c) The cost of negotiating a single multilateral agreement is greater than the cost of negotiating a bilateral agreement.
d) The benefit of multilateral (bilateral) cooperation is greater than the cost of multilateral (bilateral) cooperation.

6. Each country has the following same preference ranking over available pure strategies when one of the pure strategy equilibria is being played: multilateralism > bilateralism > unilateralism. Specifically, $(B_m - C_m) > (B_b - C_b) > 0$

The net payoff ratio is defined in the game model as = $\frac{B_m - C_m}{2B_b - C_b}$.

The net payoff ratio measures the relative attractiveness of multilateral benefit versus bilateral benefit. The core assumption of the model is that multilateralism is more beneficial than bilateralism for all countries in both issue areas i.e., $(B_m - C_m) > (2B_b - C_b)$. The puzzle is why multilateralism emerges in one issue area while bilateralism in the other, even though multilateralism is more beneficial than bilateralism in both issue areas. I have argued that net payoff ratio is much higher for international trade than for FDI i.e.,

$$\left(\frac{B_{mt} - C_{mt}}{2B_{bt} - C_{bt}}\right) > \left(\frac{B_{mi} - C_{mi}}{2B_{bi} - C_{bi}}\right) \quad (9)$$

The lowercase subscript t stands for trade and the lowercase subscript i stands for investment.

The simulation of the model is based on replicator dynamics. I will simulate two models, one for international trade and the other for FDI. The only difference between the two replicator dynamics simulation is that net payoff ratio is much higher in international trade than in FDI. In other words, I have argued that multilateralism is relatively more beneficial than bilateralism in international trade compared to FDI. Specific net payoff ratios used for replicator dynamics simulation are discussed in the next section of this chapter.

Table 4.1 Three player three strategy stag-elephant hunt game matrix

		MC	BC	NC
MC	MC	$B_m - C_m, B_m - C_m, B_m - C_m$	$-C_m, \quad -C_m, \quad -C_b$	$-C_m, \quad -C_m, \quad 0$
	BC	$-C_m, \quad -C_b, \quad -C_m$	$-C_m, \ B_b - C_b, B_b - C_b$	$-C_m, \quad -C_b, \quad 0$
	NC	$-C_m, \quad 0, \quad -C_m$	$-C_m, \quad 0, \quad -C_b$	$-C_m, \quad 0, \quad 0$
BC	MC	$-C_b, \quad -C_m, \quad -C_m$	$B_b - C_b, -C_m, B_b - C_b$	$-C_b, \quad -C_m, \quad 0$
	BC	$B_b - C_b, B_b - C_b, -C_m$	$2B_b - C_b, 2B_b - C_b, 2B_b - C_b$	$B_b - C_b, B_b - C_b, 0$
	NC	$-C_b, \quad 0, \quad -C_m$	$B_b - C_b, 0, B_b - C_b$	$-C_b, \quad 0, \quad 0$
NC	MC	$0, \quad -C_m, \quad -C_m$	$0, \quad -C_m, \quad -C_b$	$0, \quad -C_m, \quad 0$
	BC	$0, \quad -C_b, \quad -C_m$	$0, \ B_b - C_b, B_b - C_b$	$0, \quad -C_b, \quad 0$
	NC	$0, \quad 0, \quad -C_m$	$0, \quad 0, \quad -C_b$	$0, \quad 0, \quad 0$

Where

MC stands for multilateral cooperation.

BC stands for bilateral cooperation.

NC stands for non-cooperation (unilateralism).

4.1.3 The Pure Strategy Equilibrium of Multilateral Cooperation

All the countries are cooperating multilaterally only when $P_m = 1$ and $P_b = P_u = 0$. The Nash equilibrium is achieved when no country in the game has any unilateral incentive to deviate from the multilateral strategy. The payoff of the country 1 when other two countries are cooperating multilaterally is given below.

$$U_1(M) = B_m - C_m \tag{10}$$

To check whether each country playing the multilateral strategy is a Nash equilibrium I check whether there is an incentive for any country (say country 1) for any profitable unilateral deviation from the multilateral cooperation. The game is symmetric therefore I will make same conclusion

about the country 2 and country 3. First, I will check whether the unilateral deviation of country 1 from multilateral strategy to the bilateral one is profitable.

$$U_1(M) > U_1(B)$$

$$B_m - C_m > -C_b \tag{11}$$

Fixing the strategy of the country 2 and country 3 to multilateral strategy, there is no incentive for the country 1 to deviate to bilateral strategy from the multilateral one. The net benefit for country 1 from multilateral cooperation is greater than the cost of bilateral strategy by assumption because we have assumed that for each strategy the benefits of coordination outweigh the costs. Next, I will check whether the unilateral deviation of country 1 from a multilateral strategy to a non-cooperation (unilateral) strategy is profitable.

$$U_1(M) > U_1(U)$$

$$B_m - C_m > 0 \tag{12}$$

The country 1 has no incentive to profitably deviate from the multilateral strategy either to bilateral strategy or the unilateral one. Again, the net benefit for country 1 from the multilateral strategy is greater than if the same country had played a non-cooperation strategy (while all other countries are playing the multilateral strategy). All the countries playing multilateral strategy is indeed a Nash equilibrium.

4.1.4 Pure Strategy Equilibrium of Bilateral Cooperation

All the countries are cooperating bilaterally only when $P_b = 1$ and $P_m = P_u = 0$. For all countries cooperating bilaterally to be a Nash equilibrium, we must answer the question: is there any incentive for any player in the game to unilaterally deviate from the bilaterally strategy. The payoff of the country 1 when other two countries are cooperating bilaterally is given below.

$$U_1(B) = 2B_b - C_b \quad (13)$$

Please note that all the countries playing the bilateral strategy have the same utility. Let us check whether the country 1 has an incentive to unilaterally deviate from the bilateral strategy to multilateral strategy.

$$U_1(B) > U_1(M)$$

$$2B_b - C_b > -C_m \quad (14)$$

There is no incentive for country 1 to unilaterally deviate to a multilateral strategy when everyone else is playing a bilateral strategy in the game since the payoff from the bilateral strategy is assumed to be positive, and the payoff from selecting the multilateral strategy is negative. Let us check whether there is any incentive for the country 1 to profitably deviate to the unilateral strategy from the bilateral one.

$$U_1(B) > U_1(U)$$

$$2B_b - C_b > 0 \quad (15)$$

The game is symmetric therefore, there is no incentive (profit) for a unilateral deviation for country 2 or country 3. All the countries playing the bilateral strategy is indeed a Nash equilibrium in the game.

4.1.5 Pure Strategy Equilibrium of Non-cooperation

I will show that all countries playing a unilateral strategy is indeed a Nash equilibrium. There is no incentive for any player to unilaterally deviate from the unilateral strategy. The payoff of the country when other countries are playing the same strategy of non-cooperation (unilateral strategy) is, as discussed above, normalized to zero. Thus

$$U_1(U) = 0 \quad (16)$$

The stag-elephant hunt game assumes that the non-cooperative strategy has the same payoff irrespective of other players strategies. First, I will see if there is any incentive (profit) for a unilateral deviation for player 1 from the non- cooperative strategy to the multilateral strategy.

$U_1(U) > U_1(M)$

This is because $0 > -C_m$.

With only one player selecting the strategy, any effort at multilateral cooperation will fail, producing costs without commensurate benefits. Similarly, there is no unilateral profitable deviation for player 1 to shift from the non-cooperative strategy to the bilateral strategy.

$$U_1(U) > U_1(B)$$

This is because $0 > -C_b$.

All the countries playing a unilateral strategy is indeed a Nash equilibrium.

Thus, the one-shot version of stag-elephant hunt game has more than one pure strategy Nash equilibrium. Any pattern of cooperation is possible including multilateral cooperation, bilateral cooperation, or non-cooperation (unilateral) so long as the basic assumption that the benefit of multilateral and bilateral cooperation exceeds the costs is maintained. Since I maintain this assumption in both issue areas, the analysis so far does not distinguish between them. Exploring the pure strategy Nash equilibrium in the stag-elephant hunt game does not give us a decisive answer as to which equilibrium will emerge in any issue area.

4.1.6 Expected Payoff under Strategic Uncertainty

Given the prevalence of multiple equilibria in international cooperation issues, there is no certainty about the outcome of the stag-elephant hunt game. Therefore, the countries' expected payoff from the choice of strategies will reflect their uncertainty regarding the commitment of

other countries to different strategies, as modeled with a probability distribution over the various possible strategies. A rational country will play the multilateral strategy with sufficiently high probability only if all other countries also play the multilateral strategy with sufficiently high probability. In short, the probability of playing a particular strategy in the stag-elephant hunt game depends on the probability of other players playing the same strategy in an issue area. The main insight of evolutionary game theory, as elaborated in the methods chapter, is that the strategy adopted by higher proportion of countries is more likely to emerge as an equilibrium. This is because the higher the proportion of countries having adopted the strategy, the higher the expected payoff for that strategy. The strategy with the highest expected payoff is more likely to spread through the population of countries.

The expected payoffs of playing three different strategies for country 1 are reproduced below, as already introduced in the method chapter.

$$EU_1(B) = B_b(2P_b\,P_m + 2P_bP_u + 2(P_b)^2) - C_b \quad (17)$$

$$EU_1(M) = B_m(P_m)^2 - C_m \quad (18)$$

$$EU_1(U) = 0 \quad (19)$$

$$P_m + P_b + P_u = 1 \quad (20)$$

In the evolutionary context, the probability of a strategy could be understood as the proportion of players playing the strategy in a large population. $P_m, P_b and\, P_u$ represents the proportion (probability) of players playing the multilateral, bilateral and unilateral strategy in the game. Equation 5 clearly shows that the higher the proportion of players playing bilateral strategy in the game, higher the expected payoff of a bilateral strategy. Similarly, equation 6 demonstrates that the higher the proportion of players playing multilateral strategy in the game, higher the expected payoff of the multilateral strategy. The strategy with the highest expected payoff will spread

through the system. The above mathematical equations are in line with the main intuitions of the evolutionary game theory, which posits that the strategy which is played by higher fractions of the player is more likely to emerge as an equilibrium in dynamic simulations.

4.2 SIMULATION FOR STAG-ELEPHANT HUNT MODEL

The central question of this chapter and the next is which pattern of cooperation emerges in a domain and why does that pattern of cooperation emerge in the domain? This section shows that the evolution of the most successful strategy (pattern of cooperation) depends on the initial distributions of strategies and net the payoff ratio. Each initial distribution of strategies leads to the emergence of a unique equilibrium in a stag-elephant hunt game. The strategy with the highest expected payoff will be played by a growing fraction of countries in the subsequent rounds. Consequently, the successful strategy will become more popular in the international system. The strategy with lowest expected payoff will progressively die out from the international system. The multilateralism (or bilateralism) will evolve as all countries shift towards playing a multilateral (or bilateral or unilateral) strategy. Overall, the simulations show that the payoffs of multilateralism must greatly exceed those of bilateralism in order for multilateralism to emerge – bilateralism emerges more readily, even though its payoffs are assumed to be lower.

I will specify the initial distribution of strategies under which the different pattern of cooperation (multilateralism or bilateralism) emerge. The multilateral strategy will invade the unilateral strategy under the following condition.

$$EU_1(M) > EU_1(U) \tag{21}$$

$EU_1(M) = B_m(P_m)^2 - C_m$ and $EU_1(U) = 0$ which implies that at the indifference point $EU_1(M) = B_m(P_m)^2 - C_m = 0$. A bit of simplification reveals that this implies that:

$$P_m > \sqrt{\frac{C_m}{B_m}} \tag{22}$$

Equation (5) specifies the condition under which the proportion of countries playing multilateral strategy will invade the countries playing unilateral strategy.

The bilateral strategy will invade the unilateral strategy under the following condition.

$EU_1(B) > EU_1(U)$. This implies that:

$$P_b > \frac{C_b}{2B_b}\,. \tag{23}$$

Equation (23) specifies the condition under which the countries playing bilateral strategy will invade the countries playing unilateral strategy.

Simulation will give life to the static stag-elephant hunt game theoretic model. The only difference between the game theoretic models used in the international trade and FDI simulations is the net payoff ratio. A higher net payoff ratio is used for international trade simulations, while a lower net payoff ratio is used for the investment simulations. I will simulate the same stag-elephant hunt game theoretic model in both international trade and FDI to demonstrate that the lower net payoff ratio is associated with the emergence of bilateralism in the investment, whereas the higher net payoff ratio is associated with the emergence of multilateralism in international trade from the same initial conditions. However, it is important to clarify that the net payoff ratio alone does not determine the pattern of cooperation. Both the net payoff ratio and initial distribution of strategies will determine the evolution of the pattern of cooperation in a given issue area. It is possible for bilateralism to emerge in the domain of international trade despite the higher net payoff ratio, due to an unfavorable initial distribution of strategies for multilateralism. Similarly, multilateralism may arise in the domain of FDI despite the lower net payoff ratio, owing to a more favorable initial distribution of strategies for multilateralism in FDI. The strategy that is played by a sufficiently

large fraction of population initially is *more likely* to emerge as an equilibrium, but how large that fraction needs to be is conditioned by the relative payoffs. Neither the net payoff ratio alone nor the initial distribution of strategies alone determine the evolution of a specific pattern of cooperation. Therefore, the central result of the analysis is that a combination of net payoff ratio and initial distribution of strategies determine the evolution of particular pattern of cooperation in both domains.

The game theoretic model captures the intuition that there is a greater strategic uncertainty surrounding multilateral cooperation. Therefore, the countries engage in multilateralism only when the gains from it are much higher than the gains from bilateralism. The greater strategic uncertainty of engaging in multilateral behavior must be offset with higher net payoffs for the participating countries. Otherwise, countries will prefer to engage in bilateral cooperation. Although the bilateral cooperation is less beneficial, the gains are more certain for the countries engaged in bilateral cooperation. There is less strategic uncertainty about the gains in bilateral cooperation.

I will carry out two different types of simulations to demonstrate the conditions under which various patterns of cooperation emerge and to provide the basis for the explanation for why multilateralism dominates international trade and bilateralism dominates FDI.

I will simulate (using an Excel sheet) the one-shot version of stag-elephant hunt game with different initial distributions of strategies. The relative payoffs determine the pattern of cooperation in the one-shot version of the stag-elephant hunt game. Using R software, I also dynamically simulate the stag-elephant hunt game model with varying initial distributions of strategies using a replicator dynamics computational algorithm. It is reiterated that replicator dynamics resolves the multiple equilibria puzzle in a stag-elephant hunt game, which is a coordination game. In evolutionary game theory, the solution concept is an evolutionary stable strategy, which always

coincides with a Nash equilibrium. In the replicator dynamics model, players follow a simple and intuitive learning rule by observing the outcome of the strategic interactions of all players and then mimicking the most successful players. The most successful strategy, or player, is the one with the highest expected payoff. players disregard the longer history of play and only consider the most successful strategy in the previous round, leading to the progressive increase of players using the most successful strategy in the system. As will be shown below, for some plausible initial conditions, in international trade, multilateralism is the ESS, while bilateralism is the ESS in FDI.

Table 4.2 Summary table for excel sheet simulations

	Domain	Assumption	Simulated variables	Result
Simulation#1	Trade	Major assumption in this simulation is that the net payoff ratio is higher in the international trade domain.	Increasing the probability of multilateral cooperation while decreasing the probability of unilateral cooperation. The probability of bilateral cooperation is fixed at zero.	Multilateralism invades the unilateralism at higher multilateral probability. Multilateral cooperation evolves from non-cooperating players with higher net payoff ratio. Multilateral cooperation is the Nash equilibrium.
Simulation#2	FDI	Major assumption in this simulation is that the net payoff ratio is lower in the FDI domain.	*First simulation*: Increasing the probability of bilateral cooperation while decreasing the probability of unilateral cooperation. The probability of multilateral cooperation is fixed at zero. *Second simulation:* Increasing the probability of multilateral cooperation while decreasing the probability of unilateral cooperation. The probability of bilateral cooperation is fixed at zero.	*First simulation:* Bilateralism invades the unilateralism even at lower bilateral probability (Figure 4.1(a)) in FDI. The bilateral cooperation evolves from non-cooperating players with lower net pay-off ratio. Bilateral cooperation is the Nash equilibrium. *Second simulation*: Multilateralism invades the unilateralism at higher multilateral probability in FDI (Figure 4.1(b)). The multilateral cooperation does evolve in FDI but at higher multilateral probability, showing difficulty of achieving multilateralism in FDI as compared to bilateralism in FDI.
Simulation#3	No domain/all domains	Players are playing multilateralism, bilateralism, and unilateralism with uniform probability (1/3).	Simulating the different net payoff ratios.	An important result is obtained from this simulation. The assumption of uniform probability captures the player's uncertainty whether to choose multilateralism, bilateralism, or unilateralism. Despite the initial uncertainty, the multilateral cooperation emerges only if the net payoff ratio is greater than 5.18. Thus, multilateralism must have a much larger benefit that bilateralism to evolve as the strategy from this initial even mix of strategies.

Table 4.2 (continued)

	Domain	Assumption	Simulated variables	Result
Simulation#4	International trade	The assumption is that the single mutant strategy invades the dominant pattern of cooperation in both domains. The combination of strategies can also invade but here I am assuming only single strategy invades the dominant pattern of cooperation.	Keeping the probability of non-cooperation (unilateral) fixed at 0, probability of multilateral cooperation is gradually decreased from 1 by 0.01, and the probability of bilateral cooperation is increased from 0 by 0.01. Here the bilateral strategy is being introduced as a mutant strategy in international trade to explore the dynamic stability of multilateralism, which is an ESS.	The simulation result shows that a high fraction of bilateral cooperators is required to successfully invade multilateralism in international trade. We need more than 56 percent of bilateral cooperators in the initial distribution of players to successfully establish multilateralism in international trade (based upon the assumed payoff ratios). The simulation result clearly shows that multilateralism is not only ESS in international trade but also resistant to the invasion of very high fraction of bilateral cooperators. In simpler words, multilateralism is highly stable equilibrium in international trade.
	FDI		Keeping the probability of non-cooperation (unilateral) fixed at 0, probability of bilateral cooperation is gradually decreased from 1 by 0.01, and the probability of multilateral cooperation is increased from 0 by 0.01. Here the multilateral strategy is being introduced as a mutant strategy in FDI to explore the dynamic stability of bilateralism, which is an ESS.	The simulation result in the FDI domain shows that a high fraction of multilateral cooperators is required to successfully invade bilateralism in FDI. We need more than 65 percent of multilateral cooperators in initial distribution of players to successfully invade bilateralism in FDI (under the assumed payoff ratios). The simulation results clearly show that bilateralism is not only ESS in FDI but also resistant to the invasion of very high fraction of multilateral cooperators. In simpler words, it is more difficult to switch from bilateralism to multilateralism in FDI domain.

4.2.1 Investment Cooperation Pattern when Multilateralism and Bilateralism have similar benefits

The payoffs are assumed to develop the central idea of the paper. However, the payoffs are in line with the assumptions of the model discussed above.

Assumed payoffs: $B_m = 22$, $C_m = 5$, $B_b = 10$, $C_b = 3$, $C_n = 0$

$B_m - C_m$ = 22 – 5 = 17 (Net benefit from multilateral cooperation in investment domain)

$B_b - C_b$ = 20-3 =17 (Net benefit from bilateral cooperation in investment domain)

Net Payoff ratio = $\frac{22-5}{20-3} = \frac{17}{17}$ =1

The assumption of a payoff ratio of 1 captures the idea that the net benefits from multilateral cooperation are very close to net benefit from bilateral cooperation in some domains. When the net benefit from multilateral cooperation is remarkably close to the net benefit from the bilateral cooperation, the simulations show that it is much easier for bilateral cooperation to emerge than multilateral cooperation. As noted in the description of stag-elephant hunt game theoretic model, the multilateral cooperation is much riskier than the bilateral cooperation because it has no benefit unless multiple other countries select the same strategy. Therefore, countries need much higher payoff (or much high probability of encountering other players playing the same strategy) to engage in a risky multilateral episode over the less risky bilateral episode. I will argue in subsequent chapters that it is plausible that a lower net payoff ratio is the reason for the emergence of bilateral cooperation in the investment domain.

Simulating the different values of bilateral probability in the stag-elephant hunt game model indicates that the bilateralism emerges at a relatively low probability. In Figure 4.1 (a), the red line segment indicates the range of bilateral probabilities (versus unilateral) for which bilateral cooperation emerges as a Nash equilibrium with the assumed payoffs in the investment domain. Conversely, the multilateral strategy requires a substantially larger portion of the countries to adopt the strategy before it can emerge.

Figure 4.1(a) changing pattern of cooperation with bilateral probability simulations in FDI

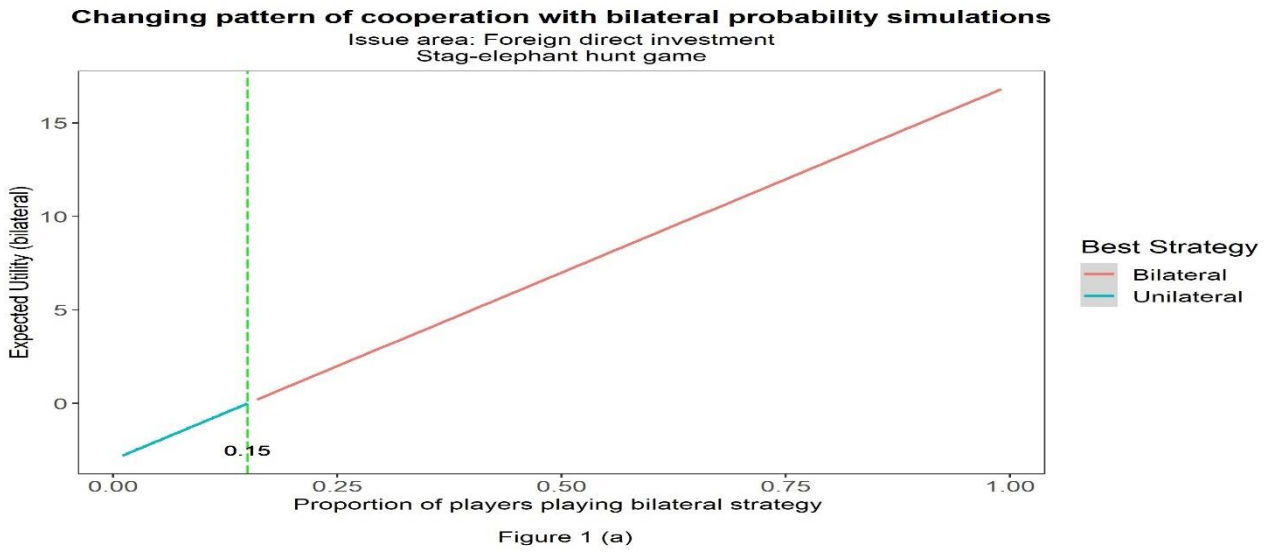
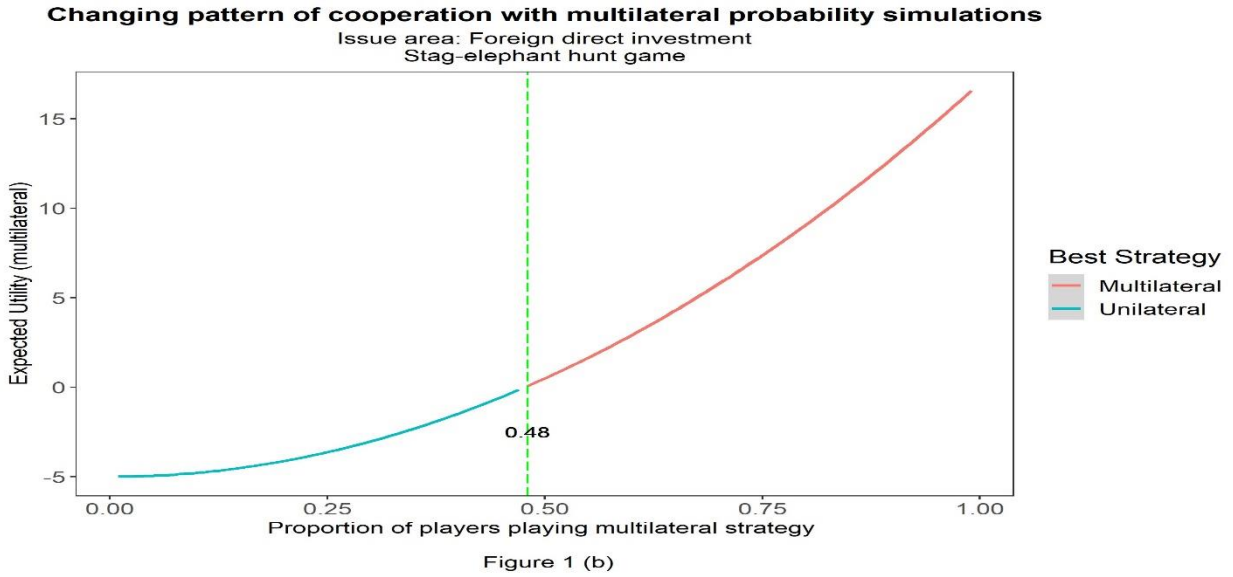


Figure 4.1(b) changing pattern of cooperation with multilateral probability simulations in FDI



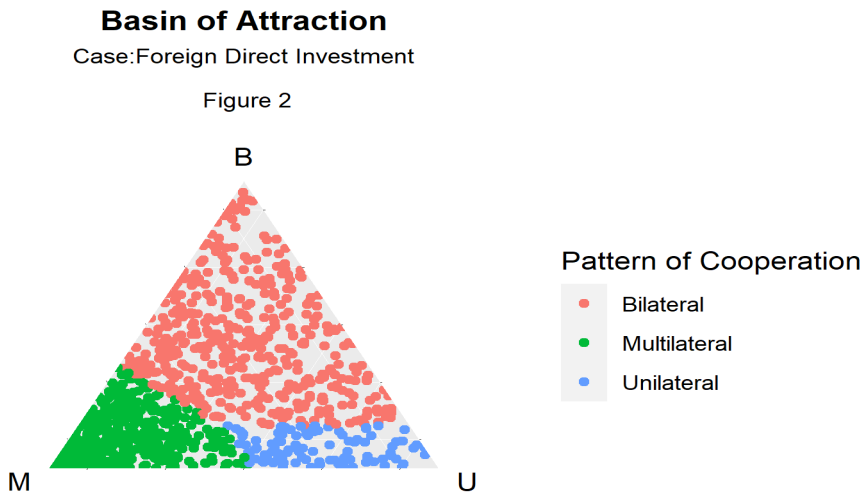
The simulation corresponds with the analysis in the equation above. $P_b > \frac{C_b}{2B_b}$ implies $P_b > 0.15 = \frac{3}{20}$. Contrast this with the probability required for multilateralism. The equation above indicates that multilateralism will have at least equal payoffs with unilateralism (enabling possible establishment when $P_m > \sqrt{\frac{C_m}{B_m}}$ which implies $P_m > 0.477 = \sqrt{\frac{5}{22.}}$ In Figure 4.1(b) the red line segment indicates the range of multilateral probabilities (versus unilateral) for which multilateral cooperation emerges as a Nash equilibrium with the assumed payoffs (again in the investment domain).

A comparison of Figure 4.1(a) and Figure 4.1(b) shows that if the countries are not initially cooperating at all, then it is much easier to establish bilateral cooperation. It is much easier for the countries to move to bilateral cooperation from non-cooperation (instead of moving to multilateral cooperation from non-cooperation). There is less doubt about the intentions of other countries regarding bilateralism vis-à-vis multilateralism. If the countries derive relatively similar benefits from the multilateralism and bilateralism, then the countries would not risk engaging in multilateralism unless they were very confident that a substantial number of other countries will also engaging in multilateralism. The bilateral cooperation is robust to a wide range of probability distributions. It is clear from the Figure 4.1(a) that the bilateralism invades unilateralism at a very low probability in FDI domain. And Figure 4.1(b) shows that multilateralism invades unilateralism at a very high probability in FDI domain.

The excel simulation for the investment domain in Figure 4.1(a) fixes the probability of multilateral cooperation (P_m) at zero, and the simulation in Figure 4.1(b) fixes bilateral cooperation at zero. The question naturally arises: what would the pattern of cooperation be if the proportion of countries playing a multilateral strategy is non-zero in the initial distribution of strategies? The

replicator dynamics simulation will comprehensively answer this question. If we use replicator dynamics to simulate the stag-elephant hunt game model, assuming the same payoffs as in the one-shot version of the game, but with varying initial distributions of strategies, we can observe the different patterns of cooperation that emerge.

Figure 4.2 Basin of attraction triangle for FDI



The triangle in Figure 4.2 above, is the basin of attraction that represents all the possible distributions of initial strategies in the FDI domain. The basin of attraction triangle summarizes the complete result of replicator dynamics (computational algorithm discussed in method chapter) in the FDI domain. This basin of attraction figure was created after running the replicator dynamics computational algorithm for a thousand (1000) different initial distribution of strategies that were randomly initialized. Each vertex of a triangle represents a pure strategy. The top vertex of a triangle represents all the players are playing bilateral strategy; the bottom left vertex represents all the players are playing multilateral strategy; the bottom right vertex represents all the players are playing unilateral strategy. The interior of the triangle represents all the possible distributions

of multilateral, bilateral and unilateral strategies in FDI. The basin of attraction triangle has three distinct regions. Each region of attraction is associated with a particular equilibrium point, and it represents the set of initial conditions that will converge to that equilibrium point. The strategy with a larger area of the basin of attraction is "more" likely to dominate the international system in the long run. On the other hand, the strategy with smaller area of the basin of attraction is "less" likely to dominate the country population in the long run. It is clear from the Figure 4.2 that the bilateral strategy comprises a much larger portion of the basin of attraction. Therefore, bilateral cooperation is more likely to dominate the FDI domain in the long run. The red dot area in the figure below shows the set of initial strategy distributions for which bilateral cooperation will dominate FDI domain. It is important to reiterate that neither the net payoff ratio alone nor the initial distribution of strategies alone can determine the evolution of specific pattern of cooperation in FDI. Despite the lower net payoff ratio, there exists a set of initial distributions of strategies (green area in basin of attraction triangle below) for which multilateralism, rather than bilateralism, will evolve in the FDI domain. The red dot region describes the set of initial distribution of strategies for which bilateralism will emerge in FDI when the net payoff ratio is low.

The point separating the red and blue dots along the right edge of the basin of attraction triangle indicates that bilateralism indeed invades unilateralism at a very low probability (P_b around 0.15). This is the same result we obtained from the simulation of one-shot version of stag-elephant hunt game with zero multilateral cooperators.

There are four different initial distributions of strategies where more than one equilibrium (pattern of cooperation) is possible in the above basin of attraction triangle.[37] This analysis is also applicable to the basin of attraction triangle for international trade. Any pattern of cooperation can

[37] For all other sets of initial distribution of strategies, it is possible to accurately predict in advance which of the unique equilibrium will be emerged.

emerge from the unique point (initial distribution of strategies) on the basin of attraction triangle where the boundaries of three distinct regions of attraction *intersect*. We cannot predict in advance which pattern of cooperation will emerge from this unique point (initial condition). In path dependency literature, this type of initial condition is known as "critical juncture" (initial condition from which any of multiple equilibria is possible) (Sydow, Schreyögg et al. 2009). The expected payoff of all three strategies is the same for this initial distribution of strategies (unique point). Evolutionary game theory (replicator dynamics model) does not provide guidance on which strategy to choose when all strategies have the same expected payoff. Thus, pure random chance will decide which of the three possible equilibria will evolve. The small choices made at critical junctures have disproportionately large consequences regarding the evolution of a specific pattern of cooperation (Pierson 2000). For instance, if one country switches its strategy to multilateral cooperation from a point where the expected payoff of all three strategies is the same, the multilateral strategy will be positively reinforced and eventually become the equilibrium strategy. In Chapter 5, I identify a possible critical juncture involving the abandonment of a weak multilateral investment treaty by the U.S. because it wanted a stronger treaty.

Each edge of the basin of attraction triangle has a point where both equilibria are equally likely. The expected payoffs of the two strategies (at the edge of a basin of attraction triangle) is equal and no strategy has an advantage over the other. A random choice will decide which of the two equilibria will evolve at each of the three points where both equilibria are equally likely.

4.2.2 Trade Cooperation Pattern

The central argument of the paper is based on this "critical assumption" that net benefits from multilateral cooperation are "much higher" than net benefits from bilateral cooperation in the

trade domain as compared to the investment domain. The results of the game theoretic model are based on this assumption. The payoffs are assumed rather than observed in the real world.

Assumed payoffs: $B_m = 65$, $C_m = 5$, $B_b = 10$, $C_b = 3$, $C_n = 0$

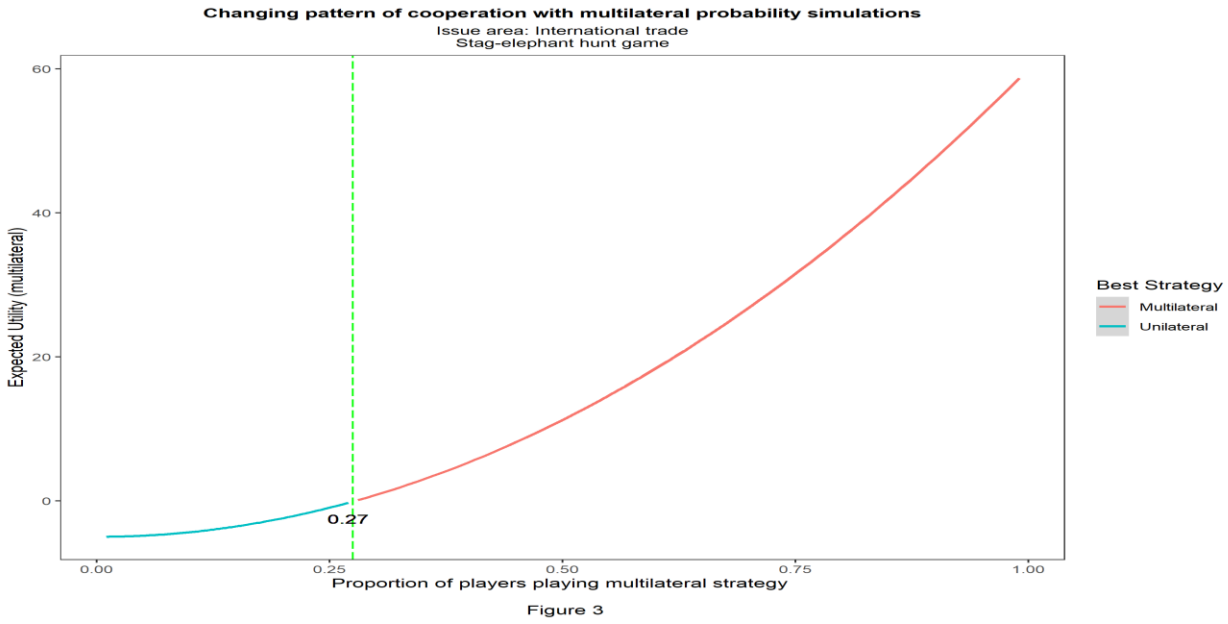
$B_m - C_m$ = 65 – 5 = 60 (Net benefit from multilateral cooperation in investment domain)

$B_b - C_b$ = 20-3 = 17 (Net benefit from bilateral cooperation in investment domain)

Net Payoff ratio = $\frac{65-5}{20-3} = \frac{60}{17}$ =3.53

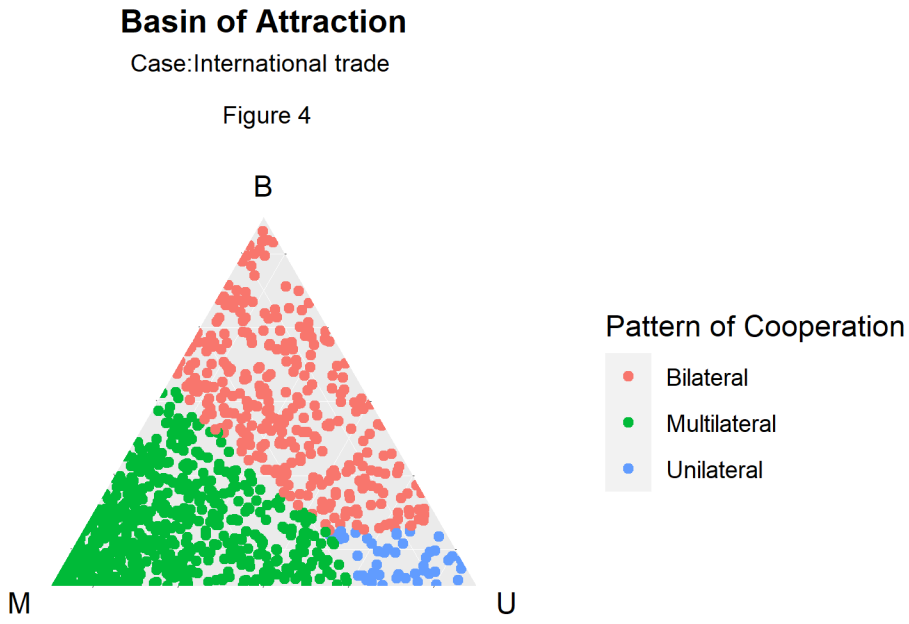
When the net benefit from multilateral cooperation is much higher than the net benefit from bilateral cooperation, all countries prefer multilateral cooperation over bilateral cooperation for a wider range of probabilities and will select multilateralism. It is plausible to argue that the higher payoff ratio is the reason for the emergence of multilateral cooperation in the trade domain. Even with this much higher payoff for multilateralism, multilateralism still has a harder time emerging against unilateralism than bilateralism does. As before, bilateralism can emerge against unilateralism when the probability of bilateralism is at least 0.15. The equation above indicates that multilateralism will have equal payoffs with unilateralism (enabling possible invasion when $P_m > \sqrt{\frac{C_m}{B_m}}$ which implies $P_m > 0.277 = \sqrt{\frac{5}{65}}$.

Figure 4.3 Changing pattern of cooperation with multilateral probability simulations in trade



Simulating the different values of multilateral probability reveals that multilateral cooperation emerges with a higher multilateral probability and with higher net payoff ratio. The multilateral cooperation is a Nash equilibrium. The multilateralism invades unilateralism when the multilateral probability (P_m) exceeds 0.27. The simulation captures the difficulty of achieving multilateral cooperation in two ways. First, we need a higher net payoff ratio in this issue area (compared to in investment) to achieve multilateral cooperation. Secondly, the players need to play a multilateral strategy with a higher probability. There is a greater strategic uncertainty about the intentions of other players in multilateral episode. The players engage in multilateral cooperation only if they could derive higher net benefits from multilateralism as compared to bilateralism.

Figure 4.4 Basin of attraction triangle for trade

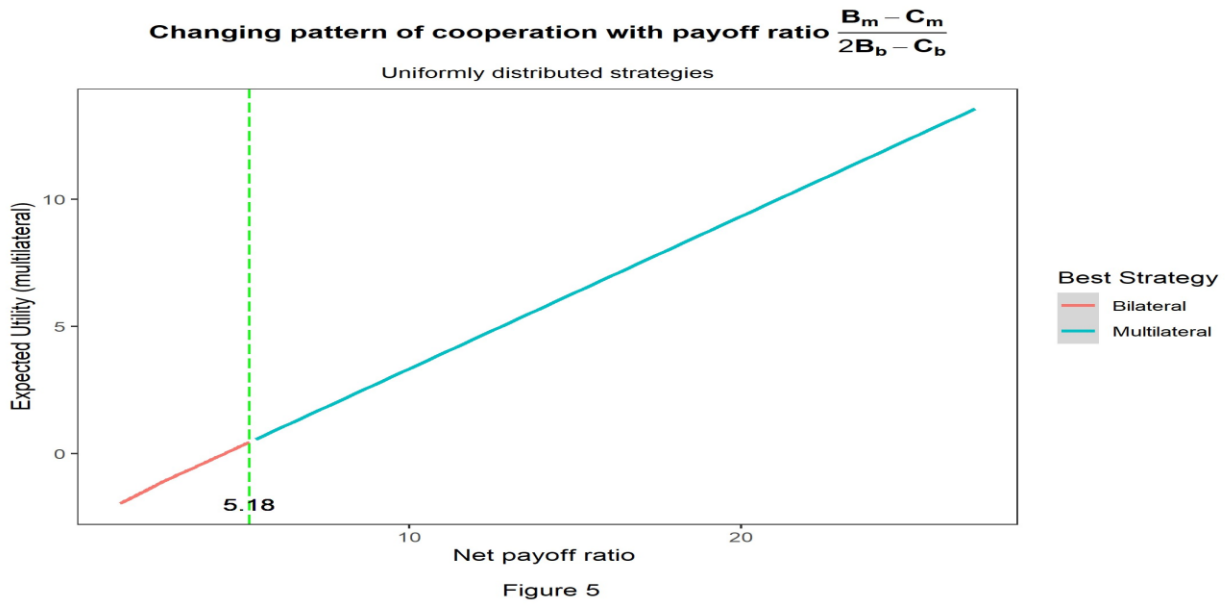


After executing the replicator dynamics computational algorithm with one thousand (1000) distinct randomly initialized initial distributions of strategies, the above basin of attraction figure was generated for a payoff ratio of the trade domain. It is clear from above figure that the multilateral strategy has a much larger basin of attraction than it did in the investment domain. Therefore, multilateral cooperation is more likely to dominate the trade domain in the long run. Despite the higher net payoff ratio in the trade domain, there exists a set of initial distributions of strategies (red area in basin of attraction triangle above) for which bilateralism, rather than multilateralism, will evolve in the trade domain. The green dot region describes the set of initial distribution of strategies for which multilateralism will emerge in trade domain, with higher net payoff ratio. The point separating the green and blue dot of the bottom edge of the basin of attraction triangle indicates that multilateralism indeed invades unilateralism at 0.27.

I included the corner case (multilateral benefits very close to bilateral benefits) in my analysis for the domain of foreign direct investment in which the assumed payoff ratio was exactly equals to one. On the other hand, the assumed payoff ratio for the domain of international trade was 3.53. As we increase the assumed payoff ratio for international trade, the basin of attraction region for multilateralism increases. For instance, an assumed payoff ratio of 5 in international trade means that the basin of attraction for multilateralism will be larger than the basin of attraction for multilateralism with assumed payoff ratio of 3.53. In simple words, multilateralism becomes more *likely* in the domain of international trade as the net benefit of multilateralism far exceeds bilateralism. I did not carry out the sensitivity analysis (due to the computational intensity of the model) regarding how the basin of attraction for various strategies changes with the changes in assumed payoff ratios. However, a sensitivity analysis would help to investigate the magnitude of changes in the basin of attraction regions for various strategies when assumed payoff ratios are changed.

4.2.3 Uniformly Distributed Strategies

Figure 4.5 Changing pattern of cooperation with payoff ratio simulations



The previous two excel simulations indicate that a higher net payoff ratio is associated with the emergence of multilateral cooperation while the lower net payoff ratio is associated with emergence of bilateral cooperation. However, the previous two simulation also indicates that the probability distribution over the pure strategies also play important role in the emergence of different patterns of cooperation. The value of the net payoff ratio in the trade domain was assumed to be 3.53. If we assume a higher net payoff ratio, multilateral cooperation will emerge at an even lower value than 0.27 (which is the value of multilateral probability at which multilateral cooperation emerged). This indicates that there is a tradeoff between the net payoff ratio and the multilateral probability. In this simulation, we will neutralize the impact of the probability distribution and try to understand the relationship between the net payoff ratio and pattern of cooperation. If the countries are playing the multilateralism, bilateralism, and unilateralism with

1/3 probability (uniform probability), then the countries are not biased in favor of any strategy. Is there any relationship between net payoff ratio and pattern of cooperation? The probability distribution (uniform) is kept fixed in this simulation, while the value of the net payoff ratio is varied. It is clear from the Figure 4.5 that multilateral cooperation indeed emerges at higher net payoff ratio. If the net payoff ratio is less than 5.18, bilateralism will emerge as the Nash equilibrium. If the net payoff ratio is greater than 5.18. multilateralism will emerge. This simulation further strengthens the central argument of the paper. This is a simple yet the powerful result from the stag-elephant hunt game simulations. The multilateral cooperation will typically emerge only if countries derive substantially higher benefits from the multilateral cooperation than from bilateral cooperation in the issue area.

The purpose of the simulation is not to compute the specific value of net a payoff ratio at which the multilateral cooperation will emerge vis-à-vis bilateral cooperation in any issue area. The purpose is to demonstrate that the higher net payoff ratio is associated with the multilateral cooperation, while the lower net payoff ratio is associated with bilateral cooperation. These simple simulations give further credence to the central explanation of the research. The game theoretic simulations clearly specify the conditions under which we observe different pattern of cooperation in an issue-area. This implies that we observe multilateral cooperation in international trade because the multilateral cooperation is much more beneficial than the bilateral cooperation. On the other hand, we observe bilateral cooperation in the investment domain because there is not much difference between the net benefits of multilateral cooperation and bilateral cooperation.

4.2.4 Notion of Stability of Equilibrium

It is important to explore the notion of dynamic stability of the dominant pattern of cooperation in the two issue areas. The replicator dynamics simulation shows that multilateralism is an ESS in the domain of international trade, whereas bilateralism is an ESS in the domain of FDI. The method chapter briefly discussed the criteria for the stability of the resident strategy. If we require a higher fraction of mutants to successfully invade the resident strategy in the issue area, then the resident strategy is highly dynamically stable. The invasion of the resident strategy means that the mutant strategy spreads through the population, ultimately replacing the existing stable strategy.

Table 4.3 Stability of dominant pattern of cooperation against invasion of single strategy

Issue area (payoff assumptions)	**Mutant strategy**	**Fraction of mutants for successful invasion**
International trade	Bilateral strategy	56 percent
FDI	Multilateral strategy	65 percent

The simulation results show that multilateralism in international trade is resistant to a very high fraction of players with bilateral strategy in international trade. If fewer than 56 percent of players with bilateral strategy invade multilateralism in international trade, then the bilateral strategy will not be able to replace the equilibrium pattern of cooperation in international trade. However, if more than 56 percent of players with bilateral strategy invade multilateralism in international trade, then bilateralism will ultimately replace the multilateralism as an ESS in international trade. Similarly, the simulation results show that bilateralism in FDI is resistant to the invasion of a very high fraction of the multilateral strategy in FDI. The interpretation of the above results is that if fewer than 65 percent of players with multilateral strategy invade

bilateralism in FDI, then the multilateral strategy will not be able to replace bilateralism in FDI. It is more difficult to switch to multilateralism from bilateralism in FDI domain, and to switch to bilateralism from multilateralism in international trade. In short, multilateralism is resistant to the invasion of bilateralism in international trade while the bilateralism is resistant to the invasion of multilateralism in FDI.

The application of the game theoretic model is not limited to the issue areas of international trade and FDI. International trade and FDI were picked to instantiate the central argument. The stag-elephant hunt game theoretic model can be used to explain variation in international cooperation across different issue areas. The existing body of literature on multilateral cooperation does not explain the emergence of an alternative pattern of cooperation in an issue area with weaker multilateral cooperation. The explanation provided by the stag-elephant hunt game complements the existing literature on multilateral cooperation. While looking for the reasons for the variation in multilateral cooperation, we should not ignore the payoff ratios.

4.3 TESTABLE IMPLICATIONS (HYPOTHESIS) OF STAG-ELEPHANT HUNT GAME THEORETIC MODEL

In this section, I will briefly explore the testable implications of the evolutionary game theoretic model developed in this chapter.

1. The basin of attraction figures presented earlier for both the investment and trade domains clearly indicate that multilateralism (bilateralism) is more likely in international trade domain (investment domain) however bilateralism (multilateralism) is also possible. Thus, one implication is that even substantially higher payoff ratios for multilateralism are insufficient to guarantee its emergence versus bilateralism.

2. That said, the analysis clearly points to a role for payoff ratios: in policy domains where multilateralism has a much higher payoff ratio relative to bilateralism, multilateralism has a better chance to emerge.
3. The emergence of a specific pattern of cooperation within each domain is contingent on initial conditions in terms of the frequency with which countries adopt a strategy. Path dependency within the evolutionary game theoretic model suggests that the cooperation outcome in a particular evolutionary process depends on historical events. Historical contingency plays a pivotal role in shaping the evolution of a specific pattern of cooperation in each domain, as even small differences in initial conditions can lead to the evolution of significantly different patterns of cooperation.[38] The simulations of the game theoretic model exemplify path dependency, where minor variations in initial conditions can lead to divergent evolutionary trajectories, reinforcing the previous steps and ultimately leading to the evolution of a unique equilibrium.
4. Another set of testable implications involve the "learning mechanism" that countries employ over time to dynamically adjust their strategies in the real world. This learning mechanism ultimately determines whether countries converge towards one strategy or another in any given domain. Learning does not necessitate the observation of an extensive

[38] For example, we can examine the impact of US rejection of a weak (shallow) multilateral investment agreement initially in the Havana Charter in the anticipation of signing a stronger multilateral investment agreement. The initial rejection had a lasting effect and virtually eliminated multilateralism in the investment domain. Some multilateral trade agreements include provisions on foreign investment, but they could not be considered as multilateral agreement on investment. Despite subsequent efforts by the US to promote multilateralism in investment, it never emerged as the dominant pattern of cooperation in that domain. One testable implication of the path-dependent evolutionary game theoretic model is to evaluate how the early rejection of investment multilateralism by the US influenced the evolution of an alternative pattern of cooperation in the investment domain. This implication will be explored further in the history chapter. However, it is important to note that the purpose of the history chapter is not to validate or invalidate any specific testable implication of the game theoretic model but rather to provide historical context of the evolution of different patterns of cooperation in the investment and trade domain.

history of game play by high-performing countries. What any country requires is knowledge of the most successful strategy employed in the previous round, which it can then adopt in the subsequent round. The formal model employs a simple learning rule of imitation in both domains and all countries in the game consistently adhere to this simple learning rule all the time. Most critically, this implies that when it comes to coordination on bilateral or multilateral coordination, growth in the extent to which countries are adopting one strategy will tend to lead to further increases in the adoption of that strategy.

5. The claim above should apply particularly when countries appear to others to benefit from the strategy they adopted.
6. Failed efforts to adopt a strategy (e.g. failed multilateral negotiation rounds) will increase the odds of adopting a different strategy (e.g. bilateralism).
7. Surprise failures to gain benefits from a strategy (e.g. major arbitration losses) may lead countries to adopt a different strategy.
8. Evolutionary dynamics can overpower even ‘strong’ or ‘powerful’ countries. There is no role of power in learning dynamics. As will be seen in Chapter 5, the US learned the most successful strategy in the investment domain from the smaller European countries. This observation aligns with the idea that learning dynamics in evolutionary game theory can be influenced by the strategies that have been successful in practice, and countries may imitate these strategies, even if they originate from smaller and less powerful actors. This is discussed in detail in the history chapter. A growing fraction of countries embrace the most successful strategy in the previous time step in the two domains. It is noteworthy countries need not have any past experience with the most successful strategy.

These implications of the model can be tested using real-world data to determine whether successful strategies spread due to the simple learning rule of imitation, which is followed by all countries and only necessitates the knowledge of the most successful strategy employed from the previous round. Existing quantitative research, such as the work of Elkins, Guzman et al. (2006), has already demonstrated that the adoption of BITs was driven by the strategy's success, as the countries that embraced BITs experienced greater average FDI inflow. The authors model the imitation learning mechanism of countries in the investment domain "by regressing, each year, the average FDI inflows as a percentage of GDP for the previous five years on the average number of treaties in force for that country during that period as well as its average GDP per capita." Their study relied on a learning mechanism that required observing a longer history of game play by high-performing economies. In contrast, the learning mechanism in the stag-elephant hunt game theoretic model only requires countries to have the knowledge of the most successful strategy in the previous round, making it an interesting area for empirical validation using real world data.

The study by Elkins and Guzman (2006) tested some but not all of the implications outlined above. I will also use more recent data. To examine the type of learning mechanism that countries use in the real world within the investment domain, I will utilize the BITs dataset (1959-2023) available on the UNCTAD website to evaluate the learning mechanism employed in the model. I will conduct a survival analysis on the BITs dataset to determine whether the same learning mechanism employed in the evolutionary game theory model contributed to the proliferation of bilateralism in investment domain in the real world. The results of these tests are described in Chapter 6.

4.4 CONCLUSION

This chapter demonstrated that multilateralism emerged in a strategic context where it was much more beneficial than bilateralism, and the initial distribution of strategies favor multilateralism. Similarly, bilateralism emerged in a strategic context where multilateralism was relatively less beneficial, and the initial distribution of strategies favor bilateralism. It should be noted that international trade and FDI are chosen merely as examples to develop and instantiate the central argument of the research. This central argument can be used to explain the variation in multilateral cooperation across the issue areas beyond international trade and FDI. For instance, we can also use the same game theoretic model to explain prevalent “bilateralism” in tax cooperation.

In Chapter 5, I will narrate the history and evolution of different patterns of cooperation utilizing the corresponding models developed for the two domains discussed in this chapter. In Chapter 6, I will employ survival analysis to evaluate the testable implications of the model developed in Section 3 of this chapter.

CHAPTER 5

NARRATING THE HISTORY OF INTERNATIONAL COOPERATION

5.1 THE STARTING POINT

The history of international cooperation is very long. This raises an important question: from what starting time should I begin the historical account of international cooperation and why? Countries have traded and invested in each other's territories for centuries. However, I will limit myself to study the question of bilateralism versus multilateralism in the post-World War II period within the two issue areas. The main reason for this is that many countries did not have the sovereignty to decide whether to engage in bilateralism versus multilateralism in any economic policy domain prior to this time. Many countries were colonized until after the first half of twentieth century; therefore, they did not have the agency to decide whether to engage in bilateralism versus multilateralism. Each colonial power created its own sphere of economic influence through an imperial system of preferences. Colonies had limited trading and investing relationships with countries outside the sphere of that economic influence. Things started to change when former colonies gained independence in the second half of the twentieth century. Newly created countries could adopt economic policies in the best interests of their population. They could adopt bilateralism or multilateralism depending on which strategy would be best for their population. It is meaningless to investigate whether countries would coordinate to multilateralism versus bilateralism in the colonial period when they did not have the agency to decide. Countries subjected to foreign rule could not make economic decision in any area of international economic policy.

This chapter argues that the replicator dynamics simulation explains the emergence of different pattern of cooperation in the two issue areas (trade and investment) in the postwar period because the game theoretic simulation model assumes that each agent (country) in the population of agents has the agency to adopt the most successful strategy in the two domains. Countries imitate the most successful strategy in the previous period. Countries can switch a strategy to the most successful strategy only if they have the agency. Almost all countries gained independence in the 2nd half of the twentieth century, therefore, it makes sense to model the choice of countries regarding pattern of cooperation in the postwar period. Furthermore, the war was a gigantic cataclysm that destroyed the pre-war world and set the stage for new patterns of cooperation (Buruma 2014). Immediately after WWII, most countries did not adopt either bilateral or multilateral strategy in any domain. Non-cooperation (unilateral strategy) was the dominant strategy in the international system. However, the US and UK, despite their mutual differences, were early proponents of multilateralism (Irwin 1993). The Atlantic Charter of 1941 incorporates the broad vision for the establishment of international order in the postwar period. International organizations like United Nations, International Monetary Fund and World Bank were established in line with the vision of the Atlantic Charter. All of these international organizations embody multilateral cooperation which is intergovernmental in nature. Transnational actors have limited or no direct role in these international organizations. Thus, the replicator dynamics simulation models the choice of *countries*, rather than transnational actors, regarding the pattern of cooperation within the trade and investment domains from 1959 to 2023.

5.2 PAIRED STRUCTURED ANALYTIC NARRATIVES

To explain the historical evolution of different patterns of cooperation within the investment and trade domain during the postwar period I use an analytic narratives approach. It is important to mention that the stag-elephant hunt game theoretic model that structures the analysis is the same for both domains, except for the payoff ratios. The model will serve as a foundational framework to guide my narrative on the historical progression of distinct patterns of cooperation in the two domains during the postwar period.

My approach involves constructing a structured paired analytic narrative, where the evolution of each specific pattern of cooperation will be understood in the context of corresponding model developed for that specific domain. The chapter addresses why alternative patterns of cooperation did not emerge in the two domains. In this regard, this chapter will focus on the question of why multilateralism failed to emerge in the investment domain despite repeated attempts, and why it did emerge to a much more substantial degree in the trade domain. The chapter will provide a single coherent explanation for the repeated failure of multilateralism to emerge in investment domain, and the successful emergence in the domain of trade. This approach enables a coherent and well-structured analysis of how and to what extent the stag-elephant hunt game theoretic model effectively guides and explains the emergence of different patterns of cooperation in the two domains.

As I explore the historical account, I will draw parallels between the theoretical constructs of the stag-elephant hunt game and the actual events that shaped the evolution of different pattern of cooperation in the trade and investment domains. By aligning the model with historical developments, I will illustrate how it serves as a valuable guide in comprehending the evolution of different patterns of cooperation. However, it is important to note that this is a history chapter.

The purpose is to accurately narrate the actual history of emergence of different patterns of cooperation in the two domains. The purpose of this chapter is not to empirically validate the model.

The remainder of the chapter is divided into three sections. According to the stag-elephant hunt game theoretic model, the initial distribution of strategies (initial conditions) holds importance in the emergence of specific patterns of cooperation. Hence, all three sections will focus on how the initial conditions helped or hindered the evolution of a particular pattern of cooperation. In section 5.3, I will describe the prevailing alternative pattern of cooperation in international trade. I will also narrate the history of evolution of multilateralism in international trade during the postwar period. The section explains to what extent the stag-elephant hunt game theoretic model helps in understanding the evolution of multilateralism from initial conditions. The section concludes that multilateralism is a dominant pattern of cooperation and bilateralism is distant second with little prospect of successfully invading it. In section 5.4, I will narrate the history of the evolution of bilateralism in investment during the postwar period. This section highlights that bilateralism can emerge even from unfavorable initial conditions not foreseen by the formal game theoretic model. In section 5.5, I will explain why multilateralism failed to emerge in the investment domain despite the repeated attempts, even when it holds greater advantages over bilateralism. This section will provide the singular explanation, rooted in the insights of evolutionary game theoretic model developed in the last two chapters, for the failure of all instances of multilateral investment cooperation to date.

5.3 HISTORY OF MULTILATERALISM IN INTERNATIONAL TRADE

The most successful episode of multilateralism is in the domain of international trade. Multilateral trade cooperation not only survived the geopolitical confrontation between East and West, it had also weathered multiple regional and global economic crises (VanGrasstek and Pascal 2013). The successive multilateral trade rounds dramatically lowered trade barriers, resulting in global trade growing faster than global output in the postwar era. Multilateral cooperation in trade began with a small membership and simple trade issues to tackle. However, the cumulative impact was such that multilateralism became the most dominant pattern of cooperation in international trade.

Figure 5.1 Global trade to GDP ratio (1970-2023)

The game theoretic model analyzed in the previous chapters envisions the pattern of cooperation as a dynamic process. Countries strategically interact in each multilateral trade round to expand multilateral cooperation. Multilateralism became more attractive as it was adopted by a wider fraction of countries over time in the international system. In the language of replicator dynamic simulation, the expected payoff of the multilateral strategy increases as more and more countries adopt multilateralism. It is clear that as more and more countries were committed to liberalizing trade multilaterally through GATT, the multilateral platform became more attractive for the non-members. Joining the multilateral arrangement not only means enhanced market access (wider market) for its exports but also brings predictability and stability in the trading relationship with those trading partners who had already joined GATT. The attractiveness of the multilateral trade regime to non-members increased from one multilateral trade round to the next as the membership of the regime progressively expanded.

One implication of the game theoretic model is that once a country adopts the most successful strategy, it would almost never switch to a less successful strategy (bilateralism or unilateralism). By and large, the history of the multilateral trading system confirms the fact that newer countries joined the multilateral episode without existing countries leaving the multilateral trade arrangement. Therefore, not only did the cumulative membership grow, but the multilateral coverage of trade issues also expanded over time.

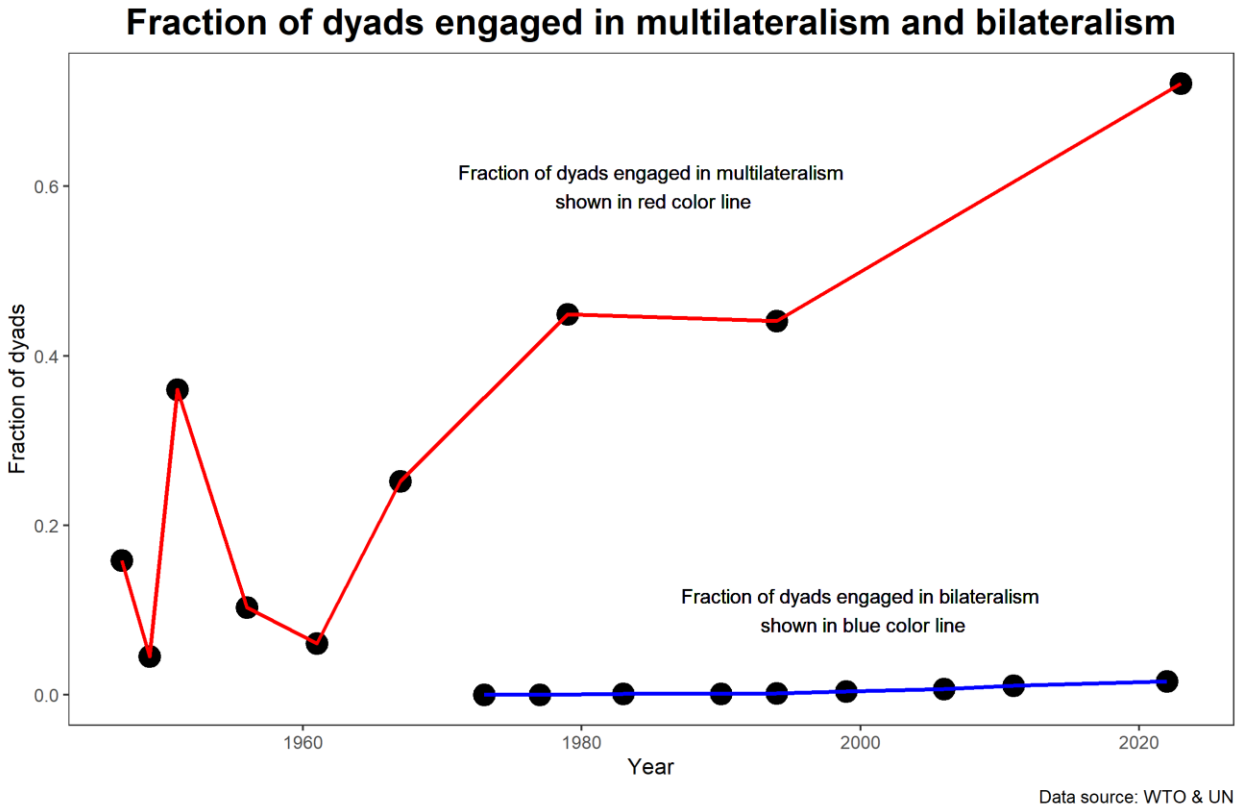
Initially, there was no institutional form supporting the expansion of multilateralism. The General Agreement on Tariff and Trade (GATT) was a temporary multilateral arrangement for almost half a century (1948-1994), established to facilitate multilateral trade negotiations among the contracting parties (Hoekman and Kostecki 2009). Even the multilateral dispute settlement mechanism of GATT was quite weak. GATT even allowed its contracting parties to deviate from

its multilateral trading principles if they were facing an extraordinary economic situation. There was a recognition that the open trading regime requires temporary deviations from the multilateral rules. Several escape clauses were built into the different multilateral trade agreements to protect industries from sudden surge in imports (Pelc 2009). Ruggie (1982) termed this phenomenon as "embedded liberalism."

It is noteworthy that GATT allows contracting parties to engage in bilateral cooperation as well. Countries that had already embraced multilateralism also occasionally engaged in limited bilateralism. Importantly, bilateralism never attained dominance as the primary mode of cooperation in international trade as seen in Figure 5.2 below.

GATT required all its contracting parties to grant immediately and unconditionally tariff concessions to all their trading partners. This is known as the most-favored nation (MFN) principle. The MFN principle prohibits discrimination against a country's foreign trading partners. Nevertheless, GATT did provide provisions for countries to establish preferential trade relationship under specific conditions. GATT's Article XXIV and the General Agreement on Trade in Services Article V allows countries to establish more preferential bilateral trading relationships in goods and services sectors respectively (Ravenhill 2011). Countries are allowed to enter any number of preferential trading arrangements on a bilateral basis. However, bilateralism has never emerged as the most successful pattern of cooperation in international trade.

Figure 5.2 Fraction of dyads engaged in multilateralism and bilateralism in trade



Multilateralism has proven far more advantageous than bilateralism in international trade, as evidenced by its widespread adoption. According to the WTO database, only 298 bilateral trade agreements have been signed to date, representing a small fraction of the possible dyadic trade relationship among the 193 countries in the international system. The graph above (see Figure 5.2) illustrates the cumulative progression of bilateral trade agreements over time. The black dots represent the actual data points, while the blue solid line represents a trend line. The graph was created in RStudio using data retrieved from WTO website on regional trade agreements. The graph above shows a fraction of dyads engaged in bilateralism and multilateralism. The graph clearly shows that higher fraction of dyads is engaged in multilateralism (red trend line) as compared to the fraction of dyads engaged in bilateralism (blue trend line). It should be noted that

the Doha Development round, the current multilateral trade round, is not moving at a desirable pace, with rising bilateralism (and regional trade agreements). However, bilateralism is still far from becoming the dominant pattern of cooperation in international trade. The graph also shows that bilateralism is not in a position to replace multilateralism in the trade domain.

The model relies on the initial distribution of strategies and the net payoff ratio (relative benefit of multilateralism over bilateralism) for explaining the emergence of multilateralism in international trade. The initial distribution of strategies played a significant role in the evolution of multilateralism in international trade. According to information provided by the United Nations website (https://www.un.org/en/about-us/growth-in-un-membership), there were 58 sovereign countries in 1948. Among these 58 sovereign countries, 23 were the founding members of GATT. The remaining countries adopted a unilateral strategy, meaning they neither engaged in bilateral nor multilateral cooperation. This clearly shows that initial conditions were highly favorable for the evolution of multilateralism in international trade. The fact that 23 out of 58 countries, nearly half of them, chose to cooperate multilaterally demonstrates the significant initial support for this strategy. The commitment of a substantial fraction of countries to multilateralism created a foundation upon which the pattern of cooperation could thrive and evolve over time. The initial distribution of strategies contributed to subsequent growth and dominance of multilateralism in international trade.

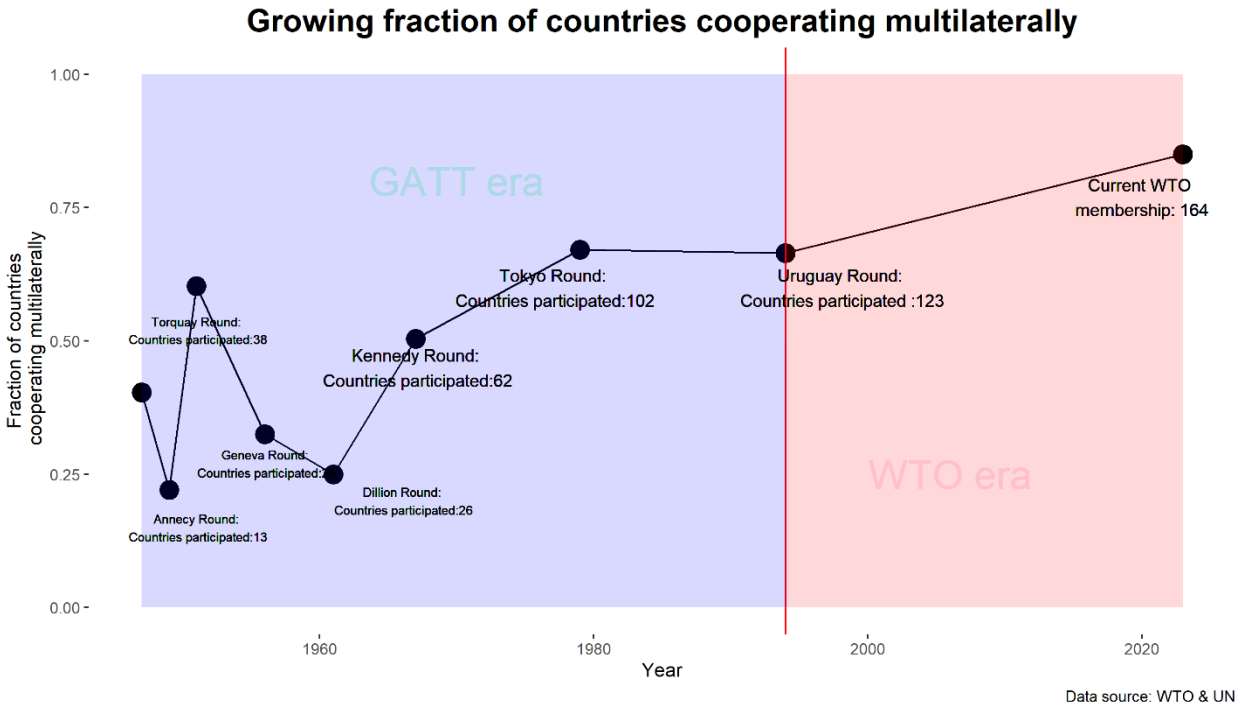
The GATT membership progressively expanded over time as more countries gained independence from colonial rule. A growing fraction of countries realized that trade protectionism hindered economic growth and development. Baldwin (2016) has argued that the combination of growing trade and incomes reinforced the belief that multilateral trade liberalization was an effective trade policy. Consequently, more and more countries switched their strategies from

unilateralism (non-cooperation/protectionism/import substitution) to multilateralism in international trade.

It is important to note that the stag-elephant hunt game theoretic model does not condition the learning of the best strategy on the actor's level of development in the international system. The formal model does not distinguish the level of development, except to the extent that the model endogenously determines variation in payoffs as a function of strategic choice. However, it is likely that adoption of the best strategy through learning by imitation was influenced by the level of development of the countries. In other words, the learning by imitation was not completely independent of the level of development of countries. Developed countries embraced multilateralism much earlier than developing countries in the realm of trade.[39] Even when developing countries joined initial multilateral trade negotiation rounds, they did not necessarily reciprocate concessions to developed countries. Developing countries were the beneficiary of the most-favored nation (MFN) principle and non-discrimination. Initially, multilateral trade cooperation was effectively about the cooperation among the United States, Canada, Western European countries, and Japan.

[39] The following web link (https://www.wto.org/english/thewto_e/gattmem_e.htm) lists GATT accessions dates for different countries. The list of accession dates broadly indicates that developed countries embraced multilateralism long before developing countries did.

Figure 5.3 Growing fraction of countries cooperating multilaterally in trade



GATT with a smaller initial membership and coverage of simpler trade issues evolved into the World Trade Organization, a permanent trade organization, with universal membership and comprehensive trade coverage. The WTO covers trade in goods, trade in services, intellectual property, and also includes shallow investment rules.[40] GATT's weaker trade dispute settlement mechanism also transformed into a stronger and more permanent multilateral dispute settlement mechanism.[41] The evolution of multilateralism was only possible because the multilateral strategy

[40] It should be noted that there is no quantitative indicator that accurately measures the state of multilateral cooperation in any domain. However, the progressive growth in membership and coverage of trade issues strongly suggest that multilateral trade cooperation has expanded over time.

[41] It should be noted that the dispute settlement mechanism was multilateral both procedurally and substantively in both the GATT and WTO eras. On the other hand, the dispute settlement mechanism in the investment domain was multilateral only procedurally. ICSID and UNCITRAL are not multilateral substantively. I will discuss in detail in the next section why ICSID and UNCITRAL are not multilateral substantively.

was much more beneficial than alternative trade strategies (bilateral or unilateral), even when it was rare initially.

The figure above clearly shows that the multilateral strategy was adopted by a growing fraction of countries in the next multilateral trade round compared to the previous round. The history of multilateralism in the trade domain is in line with the insights generated by replicator dynamics simulations based on the stag-elephant hunt game. For instance, a growing fraction of countries were dynamically adjusting their strategies over time to adopt the most successful strategy in the trade domain. No country outside the multilateral arrangement could experience the sustained economic growth and development over the longer period. Multilateralism became more appealing for the non-members as more and more countries joined the multilateral trading arrangement. The expected payoff for the multilateral strategy was so high in later multilateral trade negotiation rounds that even communist countries ultimately adopted the multilateral strategy by joining WTO at different points in time.

To sum up, multilateralism in trade evolved because the initial distribution of strategies was favorable to the evolution of multilateralism. The relative benefit of multilateralism vis-à-vis bilateralism (or unilateralism) increased as the growing fraction of countries embraced multilateralism over time. The replicator dynamics simulation predicted that successful strategy will completely replace the other unsuccessful strategies in equilibrium. However, in reality, one pattern of cooperation does not entirely replace the other patterns of cooperation in equilibrium, perhaps reflecting a slower learning process than that included in the model. For instance, multilateralism did not completely replace bilateralism, although multilateralism is a dominant pattern of cooperation in international trade. At the moment there does not appear to be a real threat of the multilateral trading system being fragmented into dyadic trading relationships due to the

extremely limited presence of bilateralism in the trade domain, and the relative benefits of multilateralism compared to bilateralism.[42] Not only does the dominant pattern of cooperation in trade align with the insights generated by replicator dynamics simulation, but the actual trajectory followed by countries was also in line with the insights generated by the model developed for the trade domain. One limitation of the model is that there is some evidence that the learning mechanism in trade domain is influenced by the level of development of countries, although this could also reflect the payoff differences anticipated in the model.

5.4 HISTORY OF BILATERALISM IN INVESTMENT DOMAIN

The first Bilateral Investment Treaty (BIT) was signed between West Germany and Pakistan in 1959. According to the UNCTAD investment policy hub database (https://investmentpolicy.unctad.org/international-investment-agreements), a total of 2827 BITs have been signed so far, and out of which 2218 BITs are currently in force. BITs exhibit differentiation on a dyadic basis concerning the scope of investment issues; the extent of protecting foreign investment, sectoral coverage, fiscal incentives, regulations related to performance requirements, and the dispute resolution mechanism. A universally adopted, singular template for BITs across all countries is absent. Despite the wide variation in the coverage of BITs, the primary focus of all BITs is the protection of foreign direct investment through international arbitration. It should be noted that BITs differ from preferential trade agreements in one important aspect: many

[42] Global Value Chains (GVCs) have become the most important feature of the international trade. The fragmentation of the multilateral trading system into dyadic relationship would be a major obstacle to GVCs. Production of a good in multiple countries (geographical fragmentation) requires stronger multilateral cooperation in the trade domain Miroudot, S., et al. (2013). "Trade policy implications of global value chains: Case studies."

Therefore, it is not possible for the dyadic trade relationship to supplant multilateral cooperation for practical reasons.

BITs contain some multilateral provisions such as the MFN provision. In contrast, MFN provisions are limited only to multilateral agreements in the trade domain.

The pattern of adoption of BITs reflects learning dynamics as expected based upon the model. One of the best examples involves the US a relative latecomer in adopting bilateralism. According to the US government website (https://www.state.gov/investment-affairs/bilateral-investment-treaties-and-related-agreements/united-states-bilateral-investment-treaties/), the US signed its first BIT with Panama in 1982. By the time the US signed its first BIT, Japan, West Germany and British had already signed several BITs (Jandhyala, Henisz et al. 2011). The testimony of Harvey Bale Jr, the assistant trade Representative for investment policy, in 1982 before the House of representatives clearly shows that the US was imitating the successful investment strategy (bilateral) of Japan, Britain and West Germany. In his testimony, he said, ‘‘We are starting late in this game. The West Germans, the British, and the Japanese have been negotiating BITs for the last several decades. Some of those treaties, a good number of them, in fact, are less demanding than the type of treaty that we are negotiating’’ (Congress 1982). By 1986, the US had signed six BITs with Turkey, Morocco, Haiti, Panama, Senegal and Zaire, Secretary of State George Schultz informed the president that “our BIT approach followed similar programs that had been undertaken with considerable success by a number of European countries, including the Federal Republic of Germany and the United Kingdom, since the early 1960s.”[43] These statements from the highest level of the US administration confirm that the US embraced a bilateral strategy in the investment domain in imitation of the approach that had already been adopted by other countries. This previous statement clearly indicates that the US embraced the bilateralism in

[43] The quoted statement is found in the transmittal letter, which is accessible via the following web link : http://www.sice.oas.org/Investment/BITSbyCountry/BITs/US_Turkey_e.asp. This same quoted statement is also reproduced in one of the most cited research articles titled, “Competing for Capital: The Diffusion of Bilateral Investment Treaties, 1960 – 2000.”

the investment domain because it was seen as the most successful strategy. One of the insights of the stag-elephant hunt game theoretic model is that the emulation of a successful strategy in the domain becomes more likely once the higher fraction of the countries adopts the successful strategy. The US embraced the bilateral strategy in the investment domain because the US learned that a similar strategy was "undertaken with considerable success by a number of European countries." The US case is particularly interesting because it suggests the evolutionary dynamics are so powerful that even the most powerful country must sooner or later imitate the most successful strategy in the domain.

The history of all three failed attempts at multilateralism in the investment domain indicates that the US was the leading proponents of multilateralism. Therefore, we cannot attribute the rise of bilateralism in investment domain to the interests and preferences of the most powerful country. Elkins, Guzman et al. (2006) have explained why the US embraced the bilateral strategy in the investment domain so late and so reluctantly. They argued that the US was a strong proponent of multilateral cooperation in the investment domain and therefore, continuously hoped to achieve multilateral cooperation in the investment domain. Embracing bilateralism would have weaken its position on multilateral cooperation in the investment domain. It is important to emphasized that the US had earlier rejected the shallow investment cooperation in the Havana Charter in anticipation of a stronger multilateral investment cooperation in the future.

The US investment approach differed from the European one in terms of the coverage of investment agreements. The European investment approach mainly focused on the protection of foreign investment. However, the US investment approach focused on investment liberalization in addition to investment protection. The difference in the investment approach between the two regions is reflected in their bilateral and multilateral investment strategies. Despite the subtle

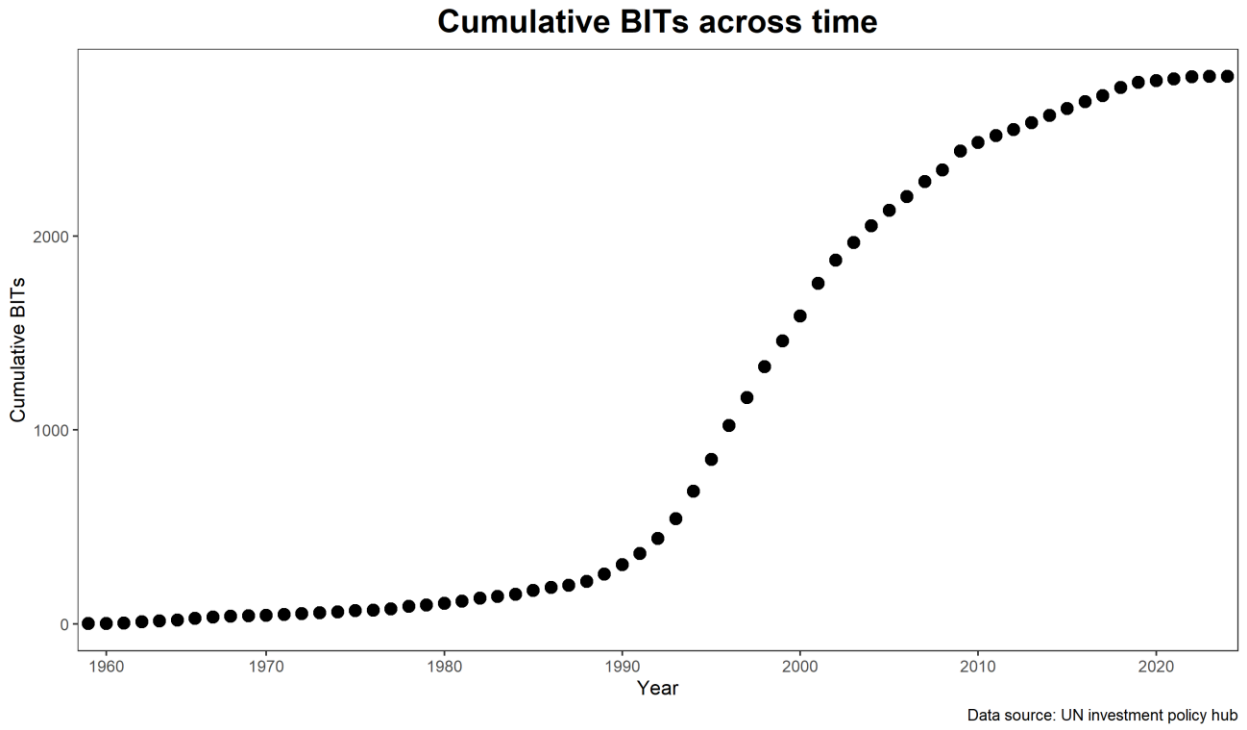
differences in the investment approaches of countries, the bilateral strategy was most widely adopted in the investment domain.

When the first BIT was signed in late 1950s, there was no episode of multilateral cooperation in the investment domain. Except for West Germany and Pakistan, all other countries were engaged in unilateralism in that period. However, by this time the Havana Charter, which embodied multilateral investment cooperation, had already been abandoned after the US refused to ratify the Charter. The core assumption of the model developed in the previous chapters is that full multilateralism is more advantageous than full bilateralism and fully realized bilateralism is more beneficial than unilateralism. In the next section, I will explore, in the light of insights from the game theoretic model, why multilateralism did not emerge in investment despite repeated attempts and the perceived benefits of multilateralism over bilateralism.

The analysis of the game theoretic model in Chapter 4 indicates that bilateralism can be successful even when it surrounded by a large fraction of countries employing unilateralism. The basin of attraction triangle indicates that bilateralism emerges under the "investment domain" assumptions (See Figure 4.1(a)) when approximately 15 percent of countries are initially committed to bilateralism while the remaining countries are playing unilateralism. According to the UN database, there were 82 sovereign countries in 1958, and out of which only two countries had adopted bilateralism in 1959, which accounted for less than 3 percent of countries having adopted bilateralism. The actual history of bilateralism shows that the bilateralism emerged as the successful strategy when it was even extremely rare in the initial population of countries (distribution of strategies), suggesting some limits to the model assumptions, probably related to random matching. The history of bilateralism indicates that bilateralism can become a dominant

pattern of cooperation even under initial conditions that are far more unfavorable than those anticipated by the model specifically developed for the investment domain

Figure 5.4 Cumulative BITs across time

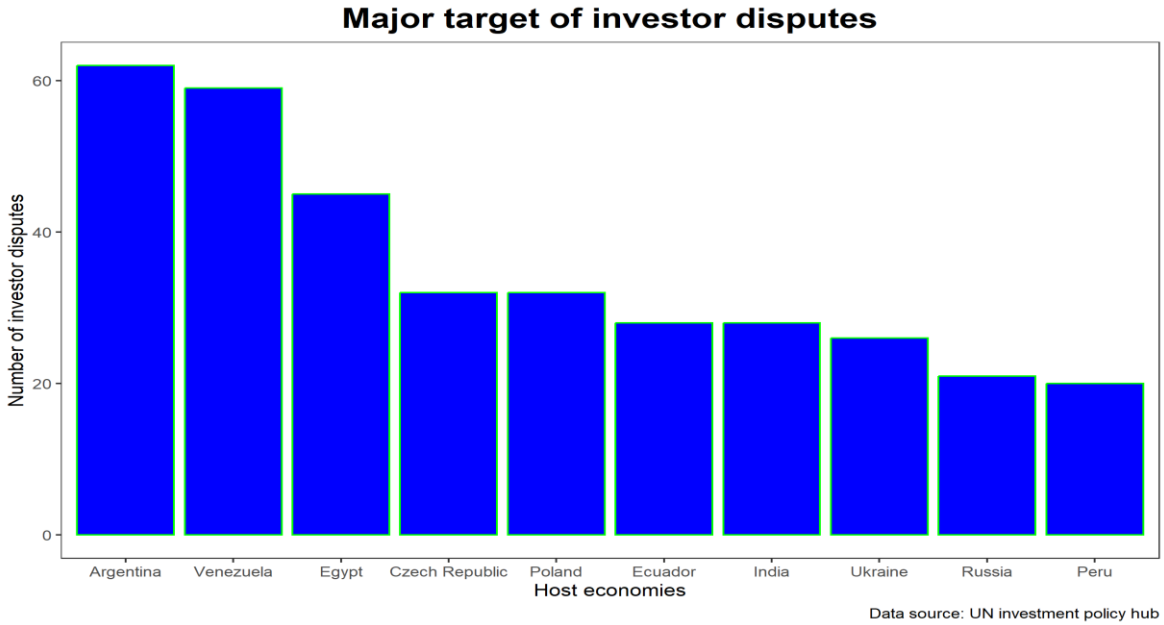


The proportion of countries adopting bilateralism has increased over time (see Figure 5.4). Initially, BITs were established between developing and developed countries. However, in recent years FDI flows have been in all directions, from developed to developing countries, from developing-to-developing countries, and even from developing to developed countries. Therefore, BITs are signed between developed and developed countries, and between developing and developing countries. This clearly suggests the widespread embrace of bilateralism within the investment domain. The above graph shows the increase in the cumulative number of BITs.

It is important to note that the adoption of bilateralism did not occur across the international system in a single monumental step. Instead, countries gradually emulated this strategy as they became aware of its impact on economic performance. Elkins, Guzman et al. (2006) have discussed whether the global diffusion of BITs is attributed to IMF coercion or policy maker's learning regarding the perceived benefits of BITs. By conducting analysis of a survival model of the formation of BITs the authors reached the conclusion that countries entered into BITs due to their understanding of the benefits these agreements offer to countries. The same authors concluded that IMF loan conditionality does not force loan recipients to sign BITs.

The model predicts once a country adopts the most successful strategy, it never abandons that strategy. Approximately 200 BITs have been renegotiated for different reasons since the early 1990s (Haftel and Thompson 2018). Some countries have even terminated certain BITs. Jandhyala, Henisz et al. (2011) have argued that the increasing number of investor-state disputes has not only slowed down the pace of signing BITs but has also led to a rise in the renegotiation or termination of existing BITs. However, it should be noted that countries that are respondents in the largest number of investor disputes are not the ones that have renegotiated or terminated BITs. Despite being the target of over 60 investor disputes, Argentina has not terminated any BIT (Huikuri 2020).

Figure 5.5 Major target of investor disputes



The slow pace of BITs signing may be attributed to the fact that many current BITs already covered the existing FDI flows. While some countries have chosen to renegotiate (or terminate) BITs, even those engaged in such renegotiations have not abandoned bilateralism in the investment domain. Notable examples include India, South Africa, and Indonesia that have terminated or renegotiated some BITs. Countries renegotiate to carve out greater regulatory space to protect the public interest, replace outdated provisions with newer provisions, and to redefine investor criteria to prevent treaty shopping. Bilateralism remains a dominant pattern of cooperation within the investment domain. The renegotiation or termination of a small fraction of BITs does not pose any significant threat to dominant pattern of cooperation in the investment domain.

History demonstrates that bilateralism was gradually established as a growing fraction of countries dynamically adjusted their strategies from unilateralism to bilateralism. The gradual evolution of bilateralism is in line with insights generated by the replicator dynamics model

developed for the investment domain. There exists ample historical evidence, such as the US following the lead of Japan, West Germany, and Britain, and the work of (Elkins, Guzman et al. 2006) to suggest that countries adopted bilateralism due to their belief in its success as an investment strategy. The historical record of bilateralism illustrates that it had the capacity to establish itself as a prevailing pattern of cooperation, even when confronted with initial conditions (initial distribution of strategies) considerably less favorable than those anticipated by the model. Furthermore, at present termination or renegotiation does not appear to pose any significant threat to bilateralism. Bilateralism not only stands as a dominant pattern but also proves highly stable in the realm of investment. The evolution of bilateralism has survived at least three attempts of countries to reach multilateral cooperation in the investment domain. It appears that countries have abandoned multilateralism in the investment domain, given the absence of any subsequent initiatives aimed at a broad multilateral agreement after the breakdown of investment discussions on the OECD platform more than 20 years ago.

5.5 HISTORY OF MULTILATERALISM IN THE INVESTMENT DOMAIN

The purpose of this chapter is to explore how the stag-elephant hunt model serves as a valuable guide for understanding stronger multilateral trade cooperation and the shallower multilateral investment cooperation. Throughout the postwar period, various attempts were made to establish a multilateral investment agreement. However, despite these repeated efforts, a single comprehensive multilateral investment agreement was never successfully achieved. While there is no research conclusively proving that the core assumption (which suggests that multilateralism is more beneficial than bilateralism in both trade and investment domains) aligns perfectly with the real world, the multiple attempts by countries to negotiate such an agreement do indicate that

multilateralism was indeed perceived as more advantageous than bilateralism in the investment domain. The question arises: why did multilateralism fail to emerge in the investment domain despite its apparent benefits over bilateralism and despite repeated attempts?

It is interesting to note that these multiple attempts varied significantly in terms of the size of countries involved in multilateral investment negotiations, the scope and ambition of the negotiations, investment asymmetry (home versus host division) and the developmental profiles of the countries. Notably, the attitude of developing countries towards FDI underwent a transformation after 1980. Instead of restricting it, the developing world now aims to attract FDI using a wide range of fiscal and regulatory incentives. Additionally, the distinction between home and host countries in terms of foreign investment has become less clear, with many developing countries joining almost all developed countries in acting as home and host countries for foreign investment. Despite these changes, the world has been unable to achieve a single comprehensive multilateral investment agreement. This raises the question of whether the game theoretic model provides any insight into understanding the repeated failures of multilateral investment cooperation? The goal of this chapter is to investigate the history of investment multilateralism through the lens of game theoretic model. How can the stag-elephant hunt model help us understand the instances of repeated failures of multilateral cooperation? Existing literature offers various explanations for each instance of failure to sign multilateral investment agreements. However, no unified framework has been proposed in prior research to explain the multiple failed instances of multilateral investment cooperation. This section will attempt to provide a single coherent explanation, based on the insights of evolutionary the game theoretic model developed in the last two chapters, for the failure of all instances of multilateral investment cooperation.

Recall from the previous chapter that the central argument for the different patterns of cooperation is based on the initial distribution of strategies along with net payoff ratio. However, this central argument does not rule out the possibility of multilateral cooperation in the investment domain. The replicator dynamics computational algorithm, which randomly initialized the initial distribution of strategies in both domains, reveals that there is a substantial set of initial distributions of strategies from which multilateralism, rather than bilateralism, emerges as an equilibrium in the investment domain (See Figure 4.2). However, this randomness in the initial distribution of strategies can pose a challenge when attempting to explain the real world pattern of cooperation in any domain. The contingencies at play also hold significant importance in explaining the pattern of cooperation in any domain. Therefore, the model requires further elaboration to effectively understand the multiple failures of multilateralism in the investment domain.

5.5.1 Havana Charter

It is essential to note that absence of stronger multilateral cooperation in the investment domain is not due to lack of attempts. The first attempt to achieve multilateral investment cooperation in the postwar period occurred around 75 years ago when 56 countries participated in 1948 to establish an International Trade Organization (ITO) (Toye 2003). The single organization planned to regulate both international trade and foreign investment. However, the failure to ratify the Havana Charter by the US, the world's largest economy and capital exporter, ultimately led to the collapse of the ITO. One significant reason for the rejection of the Havana Charter by the US was its failure to pursue a stronger multilateral investment agreement (Hart and Spero 2013). The stronger multilateral investment agreement would cover investment liberalization, investment

protection, and dispute settlement. The Charter only contained some basic provisions for the protection of foreign investment in the host economies which alienated the US business community (Toye 2003). The investment issues (and not trade) were the key bone of contention between the negotiating parties (Graz 2016). Developed countries were seeking stronger protection of foreign direct investment in the newly independent developing countries. However, the developing countries considered stronger foreign investment protection as an encroachment on their sovereignties. Foreign direct investment is different than international trade because the commercial entity acquires lasting business interest in the host economies. Therefore, the attitude of developing countries towards foreign direct investment was very hostile. The death of the ITO killed the multilateral investment cooperation for many decades. The developed countries aimed for a multilateral framework that gave stronger investment protection while developing countries aimed for a framework that gave shallower investment protection. The tension between the developed and developing countries regarding the level of foreign investment protection effectively killed the prospects of multilateral investment cooperation.

It should be noted that the Havana Charter did not envision a stronger multilateral trade cooperation either. Developing countries were allowed to free ride on the tariff concessions negotiated between the Quad (Europe, US, Canada, and Japan). The shallower multilateral trade cooperation gradually became stronger with the passage of time as more members joined and more issue areas were added to the original agenda. General Agreement on Tariffs and Trade (GATT), a temporary multilateral arrangement, responsible for liberalizing international trade evolved itself into a more permanent multilateral trade arrangement with almost universal membership. GATT had only 23 founding members but now every major country, that is a member of United Nations, is either a member of WTO or in the process of accession. Therefore, the path to successful

multilateral trade cooperation involved starting with a less ambitious agreement and gradually expanding the membership and issue areas over time. This stands in contrast to the failed attempt to achieve stronger multilateral investment cooperation in a single step.

It is highly likely if the shallow multilateral investment agreement was not killed, it would have evolved into a stronger multilateral investment agreement with comprehensive coverage of investment issues. One of the main insights of the evolutionary game theoretic model is that successful episodes of multilateralism will often evolve gradually over time. Simply killing the shallow multilateral investment agreement in the anticipation of signing the stronger multilateral agreement in the future defies the basic evolutionary logic of the model. The model emphasizes that the small *initial* step taken in the evolutionary process can have a significant impact on the eventual outcome. The game theoretic model also provides an explanation for why, once a particular path of cooperation is rejected, it becomes increasingly difficult to revert to the discarded trajectory once and an alternative (in this instance bilateral) path has become widely adopted. The evolutionary game theoretic model suggests that historical decisions and the sequences of events influences the possibilities for future cooperation strategies in a significant way.

5.5.2 Period of the 1960s and 1970s

The foreign investments made during the colonial period did not enjoy any legal protection immediately after WWII. Only customary law was available to provide some basic protection to foreign investment. However, the United Nations General Assembly passed multiple resolutions to grant newly independent countries sovereign rights to expropriate foreign investment made during the colonial period. According to the UN General Assembly 1973's resolution 3171, countries were not only free to expropriate but also had the freedom to determine the amount of

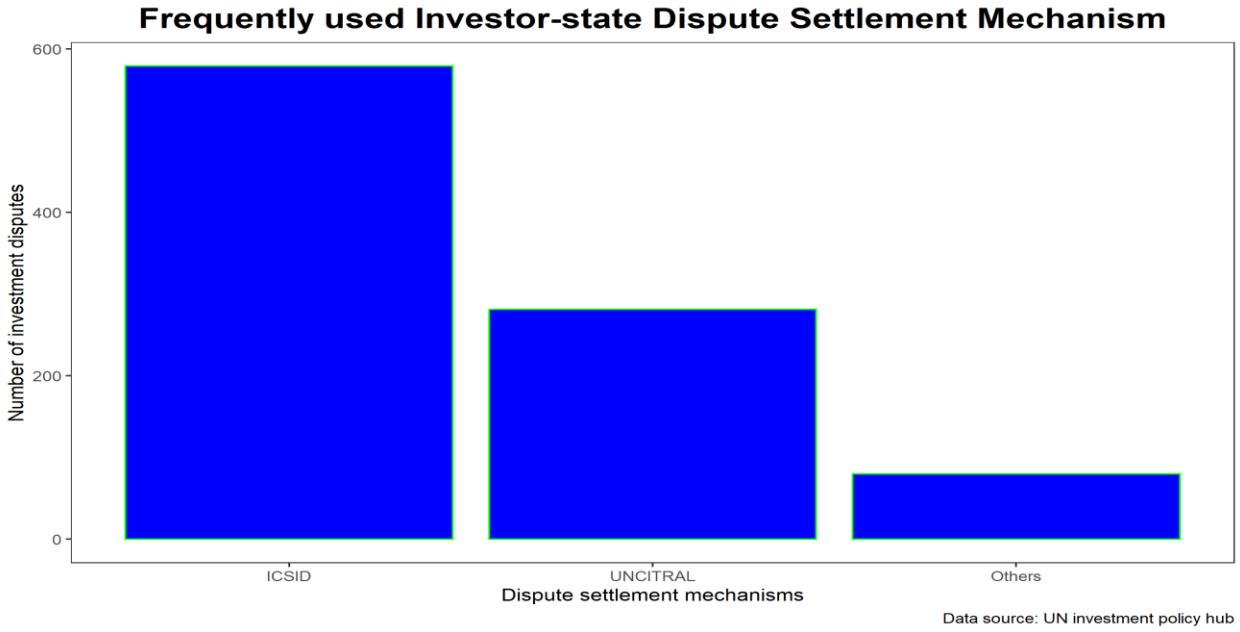
monetary compensation (Kelley 2000). The disputes between foreign investors and states must be decided according to the domestic law/domestic courts of the host country in which foreign investment was located. The central theme of the UN General Assembly resolutions was that these agreements regarding foreign investments were made when colonies did not have representative governments. Therefore, newly independent governments were not bound by the terms of an agreement agreed foisted upon their people during foreign rule. The wave of independence was followed by the mass expropriation of foreign investment in former colonies across the globe. In the two decades after the WWII, developing countries were very skeptical of foreign investment, and of protections granted to it. The general attitude of developing world until the late 1970s was to discourage international trade and foreign investment. Most were following import-substitution as their broader development strategy. However, even during this period, their attitude towards foreign investment was more hostile compared to their attitude towards international trade. No major attempt was made to initiate a multilateral investment agreement during this period. None-the-less and in contrast to this pattern, an increasing number of BITs were signed, as shown in the previous section. Where cooperation developed, it did so through BITs instead of a multilateral agreement.

It is important to understand why the attitude of developing countries changed towards FDI after the 1980s. Countries with inward looking development strategies ultimately faced balance of payment crises. They could not establish internationally competitive industries through the complex combination of direct fiscal subsidies and high tariff protection. The plan that these industries would generate exports in the future after a brief initial period of government support never materialized for many countries. The industries picked for government support were often not in line with the comparative advantage of those countries, and the industries failed to acquire

a comparative advantage as time went on. Consequently, they were unable to pay their foreign loans as they could not generate foreign exchange reserves through exports and/or FDI. However, countries with outward oriented development strategies did not run into as many balance of payment issues. The attitude of the developing world gradually shifted towards welcoming foreign direct investment and international trade as they tried to emulate the economic experiences of the first generation of East Asian tigers. The shift in the attitude of developing countries towards FDI must be seen as a broader change on the part of the developing world to adopt more open economic policies with a greater role for the private sector. The attitude of the developing world towards foreign investment was the major impediment to reaching a stronger multilateral investment agreement during the 1960-70s, which underwent a change in 1980s and onward.

However, one major success was the establishment of the Convention on the Settlement of Investment Disputes between States and Nations of Other States (ICSID convention) in 1966 under the umbrella of World Bank. The convention grants private investors the right to sue the host government for the alleged violations of certain provisions of investment treaties. ICSID only multilateralizes the *procedure* for the resolution of investment disputes between a state and foreign investor only if the host country has explicitly given assent previously in an investment treaty to submit the investor-state dispute to ICSID.

Figure 5.6 Frequently used investor-state Dispute Settlement Mechanism



Most BITs or investment chapters of regional trade agreements include provisions to submit the investment disputes either to ICSID or UNCITRAL. ICSID has been the most widely used forum for settling investment disputes between states and investors (see Figure 5.6). However, even with its widespread use, it does not constitute a multilateral investment dispute settlement mechanism because it decides the investment disputes between host government and investors based on the rights and obligations agreed upon bilaterally or regionally between the host state and home state (as outlined in a bilateral investment treaty or investment chapter of a regional trade agreement). BITs include the substantive rights and obligations of parties. For example, whether MFN treatment or National treatment will be extended to a foreign investor depends on the specific provisions of the bilateral or regional agreement signed between the host government and home government, rather than any specific provisions of the ICSID convention. ICSID does not even have its own definition of foreign investment. And there is no one definition of foreign

investment followed across all BITs. Therefore, ICSID introduces uniformity only in the procedure for resolving investment disputes. The uniformity in the procedure for resolving investment disputes was a big step in 1960s and 1970s, given the hostility of developing countries to foreign investment. A true multilateral investment dispute resolution mechanism would not only require the uniformity in procedure adopted to resolve the investment disputes but also require the uniformity in the rights and obligations (substantive content) of different host countries and foreign investors. However, the dispute settlement mechanism in international trade was always multilateral both procedurally and substantively, although the multilateral dispute settlement mechanism was much weaker in GATT era than in the WTO era.

5.5.3 Second Attempt for Multilateral Investment Cooperation

There is no single comprehensive multilateral investment agreement, despite the shift in the attitudes of developing countries towards foreign investment. The second attempt to frame multilateral investment rules began in the Uruguay Round (1986-1994) in which 123 countries participated. The attempt was partially successful leading to the patchwork of FDI rules incorporated into different multilateral trade agreements. There are FDI provisions incorporated into TRIMs, TRIP, and GATS (mode 3). However, the multilateral rules on investment included in trade agreements are insufficient to create a predictable and stable environment for the protection of FDI. There are number of scholars who have emphasized the importance of (and contemporary absence of) a single comprehensive multilateral investment agreement that covers investment liberalization, investment protection and dispute settlement (Vocke 1997; Åslund 2013; Baumgartner 2016).

The US was continuously pushing for a stronger multilateral agreement on investment. US policy makers attributed the partial success (lack of meaningful progress on investment issues) to the numerical strength and diversity of countries within WTO platform (Graham 2000). However, the model suggests that the partial success of WTO can be attributed to the widespread participation of countries on the WTO platform. When OECD countries attempted to push for a single comprehensive multilateral investment agreement amongst advanced economies (excluding developing countries altogether) in one giant leap, they completely failed to reach any investment agreement at all. A powerful insight of the model is that a strategy has a better chance when higher proportion of countries are willing to adopt it, compared to when it is adopted by a smaller proportion of countries. Contrary to the belief of the US policymakers regarding the lack of meaningful progress on investment issues, the universal membership of the multilateral trading system helped countries reached at least some sort of multilateral agreement. Shallow multilateral cooperation evolves into stronger multilateral cooperation over time. If the model is correct, excluding some set of countries altogether actually makes it difficult to reach an agreement.

5.5.4 Third attempt for Multilateral Investment

The latest attempt to conclude a multilateral agreement on investment was made in 1998 from the platform of OECD. However, the multilateral negotiations stalled after the period of two years. It is surprising why the MAI failed amongst the advanced OECD countries with open trade and investment policies. Despite being signatories to BITs and RTAs with comprehensive investment chapters, the advanced economies failed to reach a MAI. Since the agreement was negotiated on the OECD platform, only a small fraction of countries engaged in negotiating the agreement. Initially, OECD countries aimed to establish a single comprehensive multilateral

investment agreement among OECD countries. Subsequently, they planned to open the agreement to like-minded developing countries for accession.[44] However, advanced economies failed to reach the agreement and no major attempts were made afterwards to establish the MAI on any platform.

The existing literature attributes the failure of MAI within OECD to a range of different factors. Kennedy (2003) contends that the downfall of the MAI occurred because the OECD tried to address the complex investment issues in a single ambitious step. In their discussion of the evolution of multilateralism in climate change, Bodansky and Diringer (2010) have argued that a successful multilateral regime begins with a smaller membership and simpler issues to resolve initially. Neumayer (1999) attributes the failure of MAI within the OECD to the opposition of NGOs. However, Graham (2000) argues that serious internal disagreements among the members of the OECD regarding the various provisions of draft agreement played a crucial role. These disagreements exacerbated the public opposition to the MAI by NGOs. Muchlinski (2000) attributes the failure of MAI to the contents of the draft agreement which included, among other things, an asset-based definition of investment, performance requirements, and dispute resolution provisions.

One of the insights provided by the model developed in the previous chapter is that such negotiation efforts do not take place in a vacuum. The extant patterns of cooperation matter. The replicator dynamics simulation shows that the expected payoff of the successful strategy kept on increasing from one round to the next, while the expected payoff of the unsuccessful strategy kept on decreasing from one round to the next. The first BIT was signed between Germany and Pakistan

[44] A MAI between advanced economies without the accession of non-OECD countries would have been "less" useful because there are no significant risks of capital of one advanced economy expropriated into another advanced economy without adequate compensation. The judicial system of advanced economies was quite efficient in administering justice. However, the real benefits of proposed MAI had to come from accession of developing countries to the agreement in the second stage. There are still considerable risks to foreign investment in the developing countries due to institutional weaknesses.

in 1959. With such treaties becoming more and more widespread, the model implies that the expected payoff of attempting to establish bilateral treaties (the bilateral strategy) kept on increasing as more countries adopted the bilateral strategy in investment domain. By the time, the negotiations on MAI started in 1996, a very large number of countries had already signed BITs. The expected payoff of the bilateral strategy was high and increasing at the time when a large fraction of countries decided to engage in bilateralism in the investment domain. Therefore, it was difficult for the countries to establish a multilateral investment agreement. The expected payoff of a strategy is contingent on the prevailing distribution of strategies. The expected payoff of a country playing bilateral strategy is high when it surrounded by large fraction of players playing bilateral strategy. A major insight of the evolutionary game theory model is that countries do not decide in isolation whether to cooperate bilaterally or multilaterally in an issue area. They decide whether to engage in bilateralism or multilateralism based on what other countries are doing at the same time in the international system. The game theoretic model analyzed in Chapter 4 shows that switching a strategy to the unsuccessful one became more difficult as the time progressed in the evolutionary game. Once a trajectory was abandoned, it was increasingly difficult to return to it later. The result is so powerful that even changing the negotiating platform cannot overturn the evolutionary logic. The multilateral investment trajectory was abandoned by countries participating in the Havana Charter.

In the game theoretic model, the expected payoff of a strategy depends on the proportion of players adopting that strategy. Advanced economies chose the OECD platform to exclude developing countries from negotiations. The implicit assumption of the advanced economies was that they could not reach a strong MAI on the platform of WTO due to the diversity and numerical strength of WTO membership. However, the small number of participants involved was not a

strength; it became the ultimate weakness that permanently killed the MAI on the OECD platform, whose members even had similar investment policies. The expected payoff of a multilateral strategy was low, given non-OECD countries (mostly developing countries) were not part of negotiations. It is plausible that a MAI without the participation of developing countries (large proportion of countries) would have little immediate significance which made it more difficult for policymakers in the OECD countries to overcome the barriers to reaching an agreement.

However, if the fewer developed countries had established a multilateral investment agreement immediately after the postwar period, the multilateralism would likely have emerged as an equilibrium in the investment domain. The shallow multilateral investment agreement with fewer member would have progressed to a stronger multilateral investment agreement with a larger membership. With the passage of time, developing countries would have progressively adopted the multilateral investment strategy.

No serious attempts have been made to conclude a multilateral investment agreement in the last 25 years following the failure of the MAI on OECD platform. The investment landscape is characterized by the prevalence of bilateralism (bilateral investment treaties). BITs serve as the primary means for investment protection, investment liberalization and dispute settlement. The multiple instances of failure to conclude a MAI and the prevalence of bilateralism strongly indicate that bilateral strategy has become the most successful approach in the investment domain. The evolutionary logic of the model implies that the fraction of countries adopting bilateral strategy increases until the point at which the bilateral strategy is embraced universally, resulting in it becoming the evolutionarily stable strategy. It should be noted that model predicts every country should have bilateral investment relationship with every other country in the model. The total number of possible dyadic relationship among 193 countries is 18,528. However, we only observe

2827 BITs signed between the countries. Thus, the claim that the dominant pattern of cooperation in the investment domain is bilateralism rests on the fact that the existing number of BITs provides adequate protection for the investment flows. Given the many dyads not covered, the possibility for the development of a more successful multilateral approach may still exist. None-the-less, if the model assumptions are right, the simulation results in Chapter 4 clearly indicate that bilateralism (equilibrium in investment domain) is highly stable. Achieving multilateralism in the investment domain would require a substantial fraction of countries to cooperate in a multilateral framework, replacing the existing bilateralism.

CHAPTER 6

SURVIVAL ANALYSIS

There are number of testable implications of the formal stag-elephant hunt game theoretic model, discussed in the last section of the game theory chapter, which require empirical validation. Granato, Lo et al. (2010) have described formal models, in the absence of empirical validation, as "elegant models of irrelevant universes" and statistical analysis without formal analysis as "data dredging". Useful insights, they argue, can only be generated through the empirical validation of formal models. The statistical analysis often tells us only what happened, and a formal model tells us why that something happens. It is important to tell the full story by combining the formal model with some empirical validation techniques, such as statistical analysis.

As outlined in the methods chapter of the dissertation, I will test these implications only for the investment domain. While it is possible to assess these implications in both the international trade and investment domains, the latter is chosen to limit the scope of the dissertation. The second reason for selecting the investment domain was to build upon the existing quantitative research on the evolution of BITs, which has already provided quantitative evidence for some of the testable implications of stag-elephant hunt game theoretic model. This research project will extend the previous research by considering a longer time frame and by testing more of the theoretical implications. It may be noted that it is even possible to quantitatively evaluate the theoretical implications of the stag-elephant hunt game beyond international trade and FDI.

As discussed in Chapter 4, the equilibrium pattern of cooperation emerges in an issue area when all countries play the same strategy. This is a characteristic of coordination games, in which countries strategically decide whether to coordinate their strategies towards one strategy

(multilateralism) or another (bilateralism). Countries dynamically adjust their strategies over time to reach the ESS. The formal game theoretic model introduced in the methods chapter and analyzed in the game theory chapter generates a number of testable implications for empirical validation. Three testable implications will be considered for evaluation.

a.) The failure to coordinate on one strategy increases the odds of adopting an alternative strategy. For example, failure to adopt multilateral strategy in the investment domain increases the odds or likelihood of adopting a bilateral strategy.

b.) As the cumulative number of countries adopting the successful strategy increases, the probability of other countries adopting the same strategy also increases. For example, as the cumulative number of countries signing bilateral investment treaties increases, the probability of signing a BIT for countries that have not yet signed a BIT also increases.

c.) The successful strategy in the past is adopted by the growing fraction of players in the future. The third testable implication relates to capturing the notion of learning regarding the historical success of bilateral strategy in the investment domain. The future adoption of bilateral strategy in investment domain depends on learning about the historical benefits of adopting this strategy in the past.

It is more difficult to validate some testable implications. In part this is because contra Granato and Lo, such implications may offer stand-alone theoretical insights. One such implication is that even substantially higher payoff ratios (relative benefits of multilateralism versus bilateralism) cannot guarantee the emergence of multilateralism versus bilateralism, even when multilateralism begins with a higher frequency of adoption. It is difficult to evaluate this theoretical implication in the investment domain because we do not directly observe the payoffs of multilateral cooperation or bilateral cooperation.

Another implication of the model that cannot be validated in the investment domain alone is that the higher relative benefits (payoff ratio) of multilateralism against bilateralism increase the chance of an evolution of multilateralism. This argument was, however, discussed extensively in the historical narrative of the previous chapter. There is not enough data available now to evaluate these testable implications in the investment domain. However, I will investigate the three testable implications of the formal model *solely* in the investment domain using the BITs dataset freely available on UNCTAD Investment Policy hub.

The remaining chapter is divided into two sections. The first section introduces the survival analysis approach, justification for using it, and the terminology associated with it. The section also elaborates the organization of data for survival analysis, including details of the methodology and the measurement of the variables used in the Cox proportional hazard model. The second section interprets and discusses the results for the tests of the three implications of the stag-elephant hunt game theoretic model.

6.1 SURVIVAL ANALYSIS METHODS

Survival analysis is designed for modeling time-to-event data. It is important to differentiate between logistic regression and survival analysis. Logistic regression explores whether the unit of analysis will experience an event or not. Logistic regression does not model the length of time from some initial point until the unit of analysis experiences an event of interest. However, survival analysis models how long it will take for unit of analysis, from some initial point, to experience an event of interest (Kartsonaki 2016). Survival analysis makes more sense to evaluate the implications of the game theoretic model, which is based on the gradual evolution of the bilateral strategy in the investment domain. Pakistan and Germany signed the first BIT in 1959.

The first BIT exposed every country dyad to experience an event of interest (signing of a BIT). The probability of signing a BIT does not necessarily remain the same over time, however. One insight from the simulation of the stag-elephant hunt game theoretic model in the investment domain is that the probability for any country dyad to sign a BIT increases progressively as the cumulative number of BIT signing country dyads increases. Survival analysis considers the changing probabilities and the time it takes for events to unfold. In the evolutionary game theoretic model, where strategies evolve progressively, survival analysis provides a more appropriate framework than logistic regression, which ignores the temporal dimension of the event.

Kleinbaum and Klein (1996) have defined survival analysis as "a collection of statistical procedures for data analysis for which the outcome variable of interest is time until an event occurs." In the context of the investment domain, the event in the survival analysis could be signing, termination or renegotiation of a BIT between 1958 and 2023. However, in my study, the event of interest is the signing of a BIT by a country dyad. Most BITs, once signed, are neither renegotiated, nor terminated. There are some countries that have terminated BITs with other countries, but even those countries have not completely abandoned a bilateral strategy in the investment domain. Evaluation of testable implications revolves around the notion of replication of the successful strategy. Only the signing of BITs suggests the adoption of the successful strategy in investment domain. Therefore, the most relevant event of interest to evaluate different testable implications of the formal model is the signing of BITs. To conduct survival analysis, I have created a dataset comprised of all the country dyads for the period 1958-2023. The dataset includes all possible country dyads whether they have experienced an event of interest between 1958- 2023 or not. There are 15,796 country dyads included in the dataset. However, only 2,302 experienced an event of interest (signed a BIT) during the time considered. An observation will be included in

the dataset as long as dyad does not sign a BIT (event of interest). The year the dyad experienced an event of interest, no more observations will be included for that specific dyad for remaining years until 2023. Therefore, there will be a different number of observations for each dyad depending on when that dyad first signed a BIT. The unit of analysis for survival analysis is dyad-years. However, the dataset is not balanced panel data. For example, the first BIT was signed between Pakistan and West Germany in 1959 and not all country-dyads had signed the BITs by 2023. The dataset will therefore include only two observations for the Pakistan-Germany dyad. And for dyads that never signed a BIT during the period of analysis, there will be observations for each of the years from 1958 and 2023 for dyads where both countries were in existence through the entire time period. It is noteworthy that not every country was independent on or before 1958. A country was at risk of signing a BIT only after achieving independence. For instance, until the fall of the Soviet Union it was not possible for anyone to sign a BIT with Latvia. Thus, dyads involving Latvia should only be at risk after Latvian independence; there will be no observations in the dataset for dyads involving Latvia until its independence. In short, there will be a different number of observations for each dyad in a survival dataset depending on when the countries in a dyad achieved independence and when the dyad signed a BIT.

The dependent variable in the dataset includes whether a country dyad signed a BIT or not. This binary variable serves as a censoring variable. The survival data for the analysis is right censored which means that we cannot observe country dyads experiencing the event of interest after 2023, the study's endpoint. We do not know the exact time point at which these dyads will experience an event of interest. All we know about these country dyads is that their survival time exceeds a certain endpoint (2023) in our study. The censoring variable is a binary variable which tells us whether we know the exact length of survival time for a country dyad or only whether

survival time exceeds a certain endpoint (Moore 2016). If we know the exact year in which a country dyad signed a BIT, then the censoring variable will be one. For all country dyads that were in existence from 1958 to 2023, but did not sign a BIT, the censoring variable will take the value of zero for each of their observations included in survival data.

It is obvious that the probability of signing a BIT between country-dyads could vary with the passage of time. Survival analysis is particularly useful for modeling the events whose probability varies with the progression of time, such as, time-to-death, time-to-disease incidence, and time-to-recovery. Survival analysis helps us model how the probability of signing a BIT between country-dyads changes with the passage of time.

None of the country-dyads had the event of interest in 1958 (starting year), which means that the survival probability is 1. In language of survival analysis, “not signing” a BIT between a country dyad is a “survival event” while “signing” a BIT between a country dyad is a “death event” or “failure event”. The Kaplan-Meier (KM) Survival Curve can be used to visualize the probability of country dyads “not signing” BITs over time. The KM Survival Curve typically resembles a step function that starts with a horizontal line at survival probability of 1, indicating that all country dyads had not signed any BITs in 1958 (time t =0) and the curve then steps down to other survival probabilities as the time passes.

The survival function models the probability of not experiencing an event of interest, while the hazard function models the probability of having an event of interest. In my case, the survival function represents the probability of a country dyad not having a BIT while the hazard function models the probability of a country dyad signing a BIT in the next instance. The hazard function h(t) gives the instantaneous potential (rate) at time t for a country dyad to sign a BIT given that the country dyad has not signed one up to that point (survived up to time t). The hazard rate for signing

a BIT is instantaneous, therefore the graph for the hazard rate is not guaranteed to monotonically increase or decrease.

Survival analysis encompasses a collection of statistical techniques. I will use the Cox proportional hazard model to test the hypotheses outlined above. The Cox proportional model is a robust model because the results obtained from it are comparable to the results obtained from correct parametric form (Kleinbaum and Klein 1996). Therefore, Cox proportional hazard model can be used for a wide range of survival data situations. One of the most frequently cited papers analyzing BIT treaty signing in the investment domain uses the Cox proportional hazard model to investigate the diffusion of BITs in the international system (Elkins, Guzman et al. 2006). This survival analysis technique enables us to understand how a key explanatory variable, after controlling for alternative explanations for signing BITs, affects the hazard rate of signing BITs in the next time interval (year). If the key explanatory variable is statistically significant at a conventional level and the hazard ratio is greater than one, then it indicates that the key explanatory variable has a positive effect on the odds of signing a BIT.

6.1.1 Theoretical Variables of Interest

I introduced three key explanatory variables to capture each of the three testable implications introduced above in the survival model. These variables result from the hypotheses presented below.

6.1.1.1 Hypothesis 1

A successful strategy gradually penetrates through the international system. One of the testable implications of the model is that as the growing fraction of countries adopt the most

successful strategy, it becomes more difficult for the remaining countries to resist the most successful strategy. Once countries adopt the most successful strategy, they never give it up and the remaining countries that have not yet adopted it also gradually imitate it. The bilateral strategy is the most successful strategy in the investment domain. As discussed in the previous chapter, bilateralism appears to have gradually evolved in the investment domain while unilateralism has been gradually reduced. The cumulative number of bilateral investment treaties steadily increased during the period 1958-2023 despite the termination of such treaties by a few countries after the 1990s. Therefore, the testable hypothesis, that needs empirical support, is whether the probability that country dyads will sign a bilateral investment treaty increases as the cumulative number of bilateral investment treaties rises in the international system.

The first key explanatory variable captures the impact of the cumulative number of BITs globally signed every year on the probability of country dyads entering BITs.[45] The variable aims to capture the role of basic imitation in the spread of the bilateral strategy among countries when it comes to signing BITs. The key explanatory variable tests the impact of cumulative number of BITs signed on the probability of signing BITs by country dyads. In the light of the theoretical framework introduced in previous sections of the dissertation, it is expected that the rising cumulative number of BITs signed globally will increase the probability of signing BITs by country dyads. This explanatory variable is meant to assess the evidence for the basic mechanism of imitation for the spread of strategies in evolutionary game theoretic model.

[45] It would have been a problem to run the logit model with cumulative number of global BITs as a key explanatory variable. This is because the logit model would not have excluded the observations for a dyad after signing a BIT. Therefore, the dependent variable would also be affecting this variable due to reverse causality. This may not be the case for survival analysis because once the dyads experience an event of interest no more observations are included for that dyad. Therefore, the dependent variable has no way of affecting the independent variable. In short, the survival analysis prevents the dependent variable from affecting the independent variable due to the absence of further observations after the occurrence of the event.

It is important to highlight the difference between the cumulative number of bilateral investment treaties over time for each country versus the cumulative number of bilateral investment treaties globally over time. I did not include a variable for cumulative bilateral investment treaties for each country over time in my survival analysis model because the imitation of the successful strategy by a country in the stag-elephant hunt game theoretic model does not depend on whether the same successful strategy was ever adopted by the same country in the past. On the other hand, if the successful strategy is played by any country, the same successful strategy will be imitated by other countries.

6.1.1.2 Hypothesis 2

The second key explanatory variable aims to investigate whether the failure of one pattern of cooperation leads to an alternative pattern of cooperation. Specifically, it examines the hypothesis that *the failure of a multilateral strategy favors the adoption of a bilateral strategy.* As noted above, one testable implication of the stag-elephant hunt game theoretic model is that if countries failed to coordinate on one strategy, they will adopt an alternative strategy. For instance, if countries cannot coordinate on a multilateral strategy, then they may resort to a bilateral strategy. As discussed in the previous chapter, there were multiple instances of failures in multilateral investment cooperation. The first attempt occurred in Havana to establish a multilateral investment agreement, followed by second attempt during the Uruguay round, which resulted in the inclusion of few investment provisions in various multilateral trade agreements. The third attempt, originating from OECD platform, also failed. These episodes differed in terms of the number of countries involved in investment negotiations, the development profile of countries and investment issues considered in those negotiations.

The key explanatory variable in this case is a binary variable for each country dyad, with a value of 1 coded if a country dyad was part of failed multilateral investment episode and 0 otherwise.[46] The variable is coded as 1 for all the dyads engaged in the Uruguay Round in year 1994 because those dyads failed to conclude a comprehensive multilateral agreement on investment at the end of Uruguay Round. Similarly, the variable is coded as 1 for all the dyads engaged in OECD initiative on investment in 1998 because the failure for the third attempt on multilateral agreement on investment was formally announced in that year. Therefore, the variable is coded as 1 for all dyads engaged in the failed second and third multilateral episode in year 1994 and 1998 respectively, and it is coded as 0 for the remaining years.[47] This variable aims to assess whether the country dyads engaged in failed multilateral episode are at a higher risk of signing a BIT in future if they had not signed a BIT in the past. Table 6.1 below summaries how this variable is applied.

[46] One country cannot break an individual dyadic relationship in truly multilateral relationship without breaking its dyadic relationship with all other countries in a multilateral episode. Therefore, the network of dyadic relationship between all countries is never equivalent to multilateral relationship. However, the decision to break down the multilateral cooperative relationship among the countries engaged in multilateralism into respective dyadic relationships is aligned with my specific research objective to test how the failure of a multilateral strategy affects the subsequent adoption of a bilateral strategy.

[47] The third model also includes the lagged effect of failed multilateral investment episodes to evaluate the impact of failed multilateral episodes not just on the current BITs but also on the conclusion of BITs with a delay. The inclusion of lagged effect of failed multilateral investment episodes also serves as the robustness check.

Table 6.1: Summary of failed episodes of investment multilateralism

Failed multilateral investment episode	Description of failed multilateral episode	Number of dyads part of failed multilateral episode	Whether the multilateral episode is included in the survival data
Havana Charter	The first attempt to sign multilateral agreement on investment was made in Havana Charter in 1947-48. The participants of Havana Charter were aiming to sign shallow multilateral agreement on investment giving little protection to foreign investment. However, the agreement did not see the light of day due to refusal of the US to ratify the agreement.	In the Havana negotiations in 1947-48, 53 countries participated (Charter 1948). The failure of multilateral investment negotiations among 53 countries mean that 1378 dyadic relationships were not established. Therefore, the variable is coded as 1 for 1378 dyads engaged in first failed multilateral episode on investment in 1948.	The first bilateral investment treaty was signed between Pakistan and Germany in 1959. The survival dataset consists of dyadic panel data (dyad-year) covering the period 1958-2023. Consequently, the dataset does not contain the first failed episode of multilateral investment negotiations in Havana in 1948.
Uruguay Round	The Uruguay round concluded in 1994 without reaching a comprehensive multilateral agreement covering investment protection, investment liberalization and a dispute resolution mechanism (Batlu 2000). From the investment viewpoint, the Uruguay round only led to the inclusion of investment provisions in different multilateral trade agreements. However, these investment provisions in different multilateral trade agreements do not lead to the comprehensive multilateral coverage of investment issues	In this round, 123 countries participated in multilateral investment negotiations. The dyads are undirected meaning that a dyad AB is the same as a dyad BA. Since the undirected dyads are a combinatorial problem, the total number of dyads for 123 countries is 7503. The failure of multilateral investment cooperation essentially means that these 7503 dyadic relationships were not established. Therefore, the variable is coded as 1 for 7503 dyads engaged in second failed multilateral episode on investment in 1994	Yes
OECD episode	The third attempt to conclude multilateral investment agreement failed in 1998, only 29 OECD countries participated in the failed multilateral investment negotiations.	With only 29 OECD countries involved in the third failed multilateral investment episode, there were only 406 dyadic relationships involved in multilateral investment episode. Therefore, the variable is coded as 1 for the 406 dyads engaged in third failed multilateral episode on investment in 1998.	Yes

It is expected based on the stag-elephant hunt game theoretic model, relying on replicator dynamics simulation, that country dyads engaged in failed multilateral episode (and with no previous BIT) are more likely to sign a BIT. The testable implication is that the failure of multilateral strategy increases the probability of the adoption of a bilateral strategy. Are dyads engaged in investment multilateralism are at a higher risk of concluding bilateral investment treaties when the same dyads failed to conclude a multilateral investment agreement? The shift to the alternative (bilateral) strategy after the failure of a multilateral strategy may require some time. The failure of a multilateral strategy may not be accompanied by the adoption of bilateral strategy in the same year. The negotiation of a bilateral investment treaty requires less time than negotiating multilateral investment treaty. Therefore, it is also reasonable to explore whether failed episodes of investment multilateralism led to the conclusion of BITs with a *delay* amongst the same dyads which were once part of the failed episode.

6.1.1.3 Hypothesis 3

The third key explanatory variable aims to capture the notion of learning from success in a previous period. Specifically, the third key explanatory variable aims to investigate the hypothesis *that the historical success of the bilateral strategy in the investment domain increases the probability of signing a BIT among country dyads in the future.* The notion of success of bilateral strategy is captured by following the same methodological approach as outlined in the paper (Elkins, Guzman et al. 2006) for the period 1958 -2000. However, the dataset used in my survival analysis covers the longer period of 1958 – 2023. The authors captured the notion of learning by "regressing, each year, the average FDI inflows as a percentage of GDP for the previous five years on the average number of treaties in force for that country during that period as well as its average

GDP per capita." The yearly standardized regression coefficient for the BIT, which measures the historical success of bilateral strategy in terms of attracting more investment, is the third key explanatory variable. It is expected that the coefficient of the third key explanatory variable will be greater than one and statistically significant. In simpler terms, if the coefficient is greater than one and statistically significant, it would suggest that countries are more likely to adopt the bilateral strategy on a global scale because it has demonstrated itself to be the most successful strategy in investment domain.

6.1.2 Control Variables

To evaluate the implications of the stag-elephant hunt game theoretic model empirically, a number of explanatory variables for bilateral investment treaties are required to be controlled in the survival model. I have borrowed the survival analysis approach and the covariates from the well-cited paper (Elkins, Guzman et al. 2006) to evaluate some of the testable implications of stag-elephant hunt game theoretic model in investment domain. This paper makes the distinction between host and home country for foreign direct investment in terms of GDP per capita. The authors of the paper classified a country in a dyad either as a host country or home country. I also classified a country into a host or home country based on GDP per capita. The country with higher GDP per capita in a dyad is classified as the home country whereas the country with lower GDP per capita (measured in constant 2015 US Dollars) is classified as the host country in my dataset. It is to be noted that this distinction is less meaningful for the later period of data when the same countries were acting as both host and home countries. However, the home-host distinction is required to account for the different motives of the host and home countries to sign bilateral investment treaties. The original paper introduced three different types of control variables.

6.1.2.1 Control Variables related to Host Countries

a) GDP of host country

b) GDP growth of host economy

c) FDI inflows to host country in previous year

d) Short term debt of host economy

e) IMF credit to host economy

6.1.2.2 Control Variables related to Home Countries

a) FDI outflow home country

6.1.2.3 Control Variables related to Dyad

a) Colony

b) Common official language

c) Common colonizer

d) Trade volume

The main purpose of host countries to sign BITs is to attract foreign direct investment through better investment protection, investment liberalization and the investor-state dispute resolution mechanism (Swenson 2005). On the other hand, the main purpose of home countries to sign BITs is to protect its foreign investment against the expropriation risk. High-income countries are home to major transnational corporations that invest in different parts of the world. On the other hand, low-income countries are host countries to the foreign direct investment.

According to prior literature, host economies facing prolonged current account deficits, high foreign debt and short-term external debt are more likely to sign BITs. FDI inflows is one of

major sources of foreign currency inflows that can ease the external pressure on host economies. It is also generally argued that host countries opened their economies to foreign investment and foreign trade due to IMF coercion (Kalderimis 2004). However, the loan conditionality attached to IMF credit is the major instrument with which IMF could possibly coerce any borrower to open its economy to foreign investment and trade. Furthermore, GDP per capita for the host economies is another important explanatory variable for signing a BIT. Overall, these variables are important explanatory variables that are required to be controlled in the survival analysis model to account for the motives of host countries to sign BITs. Other host variables include GDP growth rate and one-year lagged FDI inflows.

The protection of foreign investment is the major motive for home countries to sign the bilateral investment treaties (Simmons 2014). It is expected that countries with higher outflows of foreign investment will be more willing to sign a BIT. From the perspective of home countries, it is therefore very important to control for the outflow of FDI. Then there are other variables that are measured at the dyadic level. Common official language, bilateral trade volume, and common colonizer for dyads are some of the other variables that were controlled in the original paper.

6.2 INTERPRETATION OF RESULTS

This section interprets the results from Cox proportional hazard model (see Table 6.2) and what these results mean for the assessment of the three testable implications.

Table 6.2: Results for Cox proportional hazard models

Variables	Model (1) Hazard Ratio coefficient (Standard error)	Model (2) Hazard Ratio coefficient (Standard error)	Model (3) Hazard Ratio coefficient (Standard error)
Cumulative bits globally by year	1.071019*** (.006)	1.106*** (0.015)	1.083*** (0.016)
Is dyad part of failed multilateral episode?	1.827767*** (.254)	1.5** (0.303)	2.46*** (0.53)
Learning	107227.5*** (126314.7)	4494489*** (11500000)	29995.41*** (83153.05)
GDP of host country (constant US$)		1.000*** (0.000)	1.000*** (0.000)
GDP growth of host economy		1.024*** (0.006)	1.032*** (0.006)
FDI inflows to host country in previous year		1.013*** (0.004)	1.012*** (0.004)
FDI outflow home country		1.001 (0.002)	1.001 (0.002)
Colony		4.344*** (0.777)	4.028*** (0.739)
Common official language		1.221** (0.113)	1.262** (0.118)
Short term debt of host economy		1.024*** (0.002)	1.023*** (0.003)
Common colonizer		1.174 (0.124)	1.187 (0.127)
Trade volume		0.999 (0.000)	0.999 (0.000)
IMF credit to host economy		1.000*** (0.000)	1.000** (0.000)
1-year lag failed multilateralism			1.797*** (0.362)
2-year lag failed multilateralism			1.927*** (0.377)
3-year lag failed multilateralism			1.282 (0.29)
4-year lag failed multilateralism			1.998*** (0.357)
Observations	621,657	155,445	152,942
Log Likelihood	-20744.675	-8062.96	-7772.1185

*** p<0.01, ** p<0.05, * p<0.1

6.2.1 Interpretation of Variable “Is Dyad Part of Failed Multilateralism”

The variable “is dyad part of failed multilateralism” is statistically significant at five percent significance level in Cox proportional hazard model in all three models. The coefficient of

variable is also greater than one in all three models. However, the magnitude of the hazard ratio varies between 1.5 and 2.46 for this variable in the three models. Therefore, the results from the Cox proportional survival analysis clearly show that there is a greater likelihood for dyads to sign the bilateral investment treaty if they were part of failed episode of investment multilateralism. This variable is a categorical variable with two levels coded as 1 and 0. Coding of 1 represents dyad is a part of failed multilateralism and 0 represents dyad is not a part of failed multilateralism. The interpretation of a categorical variable is how many times the hazard increases for experiencing an event of interest if the categorical variable is at value 1 than at value 0, controlling for the effect of covariates in the model. The Cox proportional results from model III clearly show that the dyads that were part of failed multilateral investment episodes were 2.46 times more likely to sign a BIT than dyads that were not part of failed multilateral episodes in investment domain.

However, it is possible that the failure to coordinate to one pattern of cooperation may lead to a shift to an alternative pattern of cooperation with a delay.[48] The above results shows that the failure of multilateralism does lead to a conclusion of a BIT in the same year. It is possible that the dyads engaged in failed multilateral episode may sign a BIT in the next few years. BITs are less risky, easier to negotiate and faster to sign. However, signing of BITs could take a few years.

[48] Out of the 6701 dyads that were part of the failed episode of investment multilateralism in the Uruguay Round and did not have a BIT before 1994, 911 dyads of them concluded a bilateral investment treaty before 2023. Furthermore, 241 dyads out of 6701 dyads concluded a BIT before the next episode of multilateral investment negotiation in 1998 or within four years of the failure of investment multilateralism in the Uruguay Round. Similarly, among the 346 dyads that were involved in unsuccessful OECD episode of investment multilateralism in 1998 and did not have a BIT before 1998, 24 of them concluded a bilateral investment treaty before 2023. Furthermore, 14 dyads concluded a BIT within four years (i.e., by 2002) following the breakdown of multilateral investment negotiations on OECD platform in 1998. This simple analysis suggests that it is reasonable to explore whether dyads engaged in failed multilateralism adopt bilateral investment strategy with a delay. This hypothesis can be explored by including lag terms in a survival analysis model. In other words, we can explore with lag terms how much of delayed BITs signing could be explained with two failed multilateral episodes included in the survival data.

To evaluate the delayed impact of the failure of multilateralism on the signing of BITs, the Cox proportional model also includes one-year, two-year, three-year, and four-year lags of failed investment multilateralism. For example, BITs concluded, say in 1996, may be due to the lag effect of dyads engaged in second failed multilateral episode (Uruguay Round). The results clearly show that hazard ratios for one-year, two-year and four-year lags of failed investment multilateralism are not only greater than one but are also statistically significant at a five percent significance level. Therefore, dyads engaged in a failed multilateralism episode are likely to sign a BIT even after the delay of a few years following the failed multilateral episode. Interestingly, there is no impact of failure of investment multilateralism on signing of BITs in the third year.

6.2.2 Interpretation of Variable "Cumulative Number of Global BITs"

The impact of a one unit change of the independent variable (cumulative number of global BITs) on the dependent variable (hazard of signing a BIT) was very small. To meaningfully interpret this variable, the one-unit is rescaled to 100 BITs from 1 BIT. Therefore, the one-unit of cumulative number of global BITs represents 100 BITs. This is done by simply dividing each value of cumulative number of BITs by 100 before the Cox proportional hazard regression. The cumulative number of global BITs have the usual interpretation of a continuous variable in the multiple linear regression i.e., change in the dependent variable for the unit change in independent variable, controlling for the effects of other independent variables in the Cox proportional model. However, in the case of survival analysis, the change in the dependent variable represents a change in hazard rate of an event of interest for a unit change in the independent variable (Abd ElHafeez, D'Arrigo et al. 2021). If the cumulative number of BITs globally increases from 100 to 200, how does this change affect the hazard rate of signing a BIT for a country dyad? If the hazard ratio is

greater than one, it means that country dyads have a higher likelihood of experiencing an event for one unit change in the cumulative number of global BITs. On the other hand, if the hazard ratio is less than one, it means that the country dyads have a lower likelihood of experiencing an event of interest. It is to be noted that change in hazard rate of an event is constant whether the one-unit increase is from 100 to 200 BITs or from (say) 1300 to 1400 BITs.

I found support for the hypothesis that as cumulative number of dyads adopting a bilateral strategy increase, there is a greater likelihood for the dyads to adopt the bilateral strategy. The statistical significance and magnitude of the effect is robust to the inclusion or addition of different control variables as evidenced by the three models. The coefficient for the variable "cumulative number of bilateral investment treaties globally signed" is not only greater than one but also statistically significant at a five percent significance level in all three models. The interpretation of the variable in the third model is as follows: If the cumulative number of global BITs increases from 100 BITs to 200 BITs, model 3 shows that hazard rate for signing a BIT increases by 8.3 percent. The higher likelihood is for both the existing countries having adopted the bilateral investment strategy to sign more bilateral investment treaties and the remaining countries that have not yet adopted any bilateral investment strategy to sign such treaties. However, the net result is that the bilateral investment treaty network is becoming denser over time. All of the important dyadic relationships in investment are covered by bilateral investment treaties.

In short, the survival analysis clearly shows that an increase in the cumulative number of BITs signed globally over time increases the likelihood of the adoption of a bilateral investment strategy.

6.2.3 Interpretation of Variable "Learning"

The analytic narrative approach adopted in the previous chapter showed that the bilateral strategy was ultimately imitated even by the chief proponents of multilateralism because it was established as the successful strategy in the investment domain. The detailed discussion of the US case in the previous chapter showed that even powerful countries had to ultimately adopt/learn the most successful strategy. A growing fraction of countries adopted the successful strategy as they gradually learned about the benefits of adopting the most successful strategy. The successful strategy cannot spread to the whole population without some sort of learning mechanism. The formal game theoretic model uses the same simple learning mechanism of imitation for both international trade and FDI. Elkins, Guzman et al. (2006) have found strong support for the evolution of bilateral investment treaties through the learning mechanism used in their Cox proportional hazard model. Therefore, there is qualitative and quantitative support for the learning mechanism.

I also tested the learning hypothesis using the methodology outlined in Elkins, Guzman et al.'s 2006 paper for the longer period of 1958 -2023. The learning variable is statistically significant in all three models, and its coefficient is also greater than one. Therefore, I found strong support for the learning hypothesis in the dataset covering the longer period of 1958-2023. The coefficient of learning was much greater than one in the Cox proportional hazard model suggesting a strong effect of learning on the adoption of BITs. It is important to emphasize that it is challenging to measure learning directly. I have only used the same proxy measure for learning which was used by the authors. The notion of success captured by the proxy measure is based on how much FDI a country attracts because of BITs in force in the last five years for that country. The more FDI the country attracts because of BITs in force in last five years, the more successful

that country will be. Despite the favorable results for the learning variable, it is important to acknowledge the limitation of measuring the notion of success accurately associated with learning.

6.2.4 Interpretation of some "Control Variables"

It is often argued that open trade and investment policies are associated with IMF coercion. Countries with a higher short term foreign debt and that rely on IMF for balance of payment support are more likely to be the subject of IMF coercion. The IMF can impose conditionality only on those developing countries which borrow from it. Although the coefficient of IMF credit is statistically significant at the five percent level, the hazard ratio is almost exactly 1 in the models 2 and 3 suggesting that the IMF credit to host economy did not increase or decrease the odds of signing a BIT. However, the original paper authored by Elkins, Guzman et al. in 2006 did find that some degree of IMF coercion was responsible for investment liberalization and protection through BITs. There is no equivalent effect in the dataset covering the longer period 1958-2023. This result is not surprising given that many countries sign BITs when they are not a borrower from IMF. This may also signal a change in IMF policy stance in different time periods. However, the quantitative analysis did provide support that short-term foreign debt of host economies increases the likelihood of signing BITs.

Furthermore, the existing trade volume between country pairs does not increase or decrease the likelihood of signing a BIT between the same country pairs. The results are nothing less than surprising because trade and investment are linked in an era of GVC. Trade and investment (and by extension signing a BIT) are positively associated in an era of GVC. It is expected that there will be higher bilateral trade between the home and host countries of foreign investment. The phenomenon is more prevalent after the 1990s when many countries became part of the GVC. I

reran the survival analysis for a smaller period covering only 1990-2023. However, I did not get any evidence, either in the support or opposition, to the hypothesis that an increase in bilateral trade between a country pair increases the likelihood of signing of a BIT between the same country pair. The possible explanation is that only handful of country dyads (developing countries) of all the possible dyads became part of the GVC (Baldwin 2018). And even within those countries, GVC has touched only few industries. Therefore, there is still limited trade and investment linkage for every possible dyad in the international system.

It is to be noted that the statisticians recommend using the Cox proportional hazard model if we are not sure about the correct parametric form that fit to the survival data. The Cox proportional hazard model is a robust model that "closely approximates the results for the correct parametric form" (Kleinbaum and Klein 1996). However, I also ran the survival analysis assuming that the Weibull distribution correctly specifies the BITs survival dataset. There is no big difference in the statistical significance of key explanatory variables and covariates across the three models between the Cox proportional hazard model and the survival model run with the assumption of a Weibull distribution. The results of the model are shown in the Table 6.4 of Appendix E.

6.3 CONCLUSION

The stag-elephant hunt game theoretic model was developed to explain why countries coordinate their strategies to multilateralism or bilateralism in any domain. The strong support for three testable implications of the model shows that stag-elephant hunt game theoretic model provides a useful guide to understand the behavior of countries in the real world when they had to decide whether to coordinate their strategies to multilateralism or bilateralism. The validation of

the stag-elephant hunt model requires evaluating all the testable implication of the model. However, testing all implications of the model requires a richer dataset with associated net benefit of multilateral and bilateral strategies. Evaluation of some of the testable implications of the model provides strong empirical support regarding the usefulness of the model in the real world. The result clearly shows that the failure of multilateral cooperation in the investment domain leads to the adoption of a bilateral investment strategy. The significance of this result can be understood in the trade domain. Multilateral trade cooperation is the most successful pattern of cooperation in trade so far. However, after the Uruguay Round, multilateral cooperation in trade stalled leading to the adoption of an alternative trade strategy (Free Trade Agreements/Regional Trade Agreements). The failure of one pattern of cooperation leads to alternative pattern of cooperation that we observe in the international system more widely.

CHAPTER 7

CONCLUSIONS AND IMPLICATIONS

This dissertation broadly investigates variation in multilateral cooperation across different issue areas. More specifically, it explores how and why different patterns of cooperation emerge in international trade and FDI. The dissertation provides an explanation for how and why different *dominant* patterns of cooperation emerge in different issue areas. For instance, multilateral cooperation dominates other patterns of cooperation in international trade while bilateral cooperation dominates other patterns of cooperation in FDI (Thompson and Verdier 2014). It is interesting to highlight that bilateralism can emerge in some issue areas despite multilateralism being more beneficial. The dissertation frames cooperation in international relations as strategic, dynamic (evolutionary), and state centric.

a) The strategic nature of cooperation means that the decision of one country to cooperate bilaterally or multilaterally depends on the decisions of other countries surrounding that country. If higher fraction of countries chooses to cooperate bilaterally (multilaterally), then bilateral (multilateral) cooperation becomes more beneficial, and it is more *likely* to evolve as an equilibrium.

b) The evolutionary context of cooperation means that no pattern of cooperation comes to dominate any issue area in one giant leap. Any pattern of cooperation that ultimately dominates an issue area gradually evolves over time. The multilateralism in international trade and bilateralism in FDI gradually evolves over multiple periods as the growing fraction of countries progressively adopt multilateralism in international trade and bilateralism in FDI. The analytic narratives chapter strengthened the central argument by

providing evidence for the evolution of dominant pattern of cooperation in the two domains in the postwar period. The patterns of cooperation gradually evolved over the period.

c) Although there are different nonstate actors (for example, multinational corporations) that indirectly influence cooperation, countries are principal actors when it comes to decision making regarding different patterns of cooperation.

The central argument of this dissertation is developed by introducing a three player three strategy symmetric coordination game, the stag-elephant hunt game. Subsequently, it is simulated using the evolutionary logic of replicator dynamics in a computational algorithm. The stag-elephant hunt game theoretic model, a coordination game, is combined with evolutionary game theory to provide the central explanation of the dissertation. Evolutionary game theory addresses some of the weaknesses of traditional game theory. The coordination game is a static game, and it assumes perfect rationality and generates multiple equilibria. This dissertation follows the recommendation of the existing literature to combine coordination games and evolutionary game theory to rectify the weaknesses of traditional game theory (Skyrms 2004).

The replicator dynamic simulation of the underlying formal model (stag-elephant hunt game) is guaranteed to converge to some equilibrium pattern of cooperation after enough iterations. The criteria used in this dissertation to determine regarding which pattern of cooperation is dynamically dominating is based on ESS. A strategy is ESS when it is ultimately adopted by all the agents, and it is resistant to future mutations. The conception of ESS also coincides with more traditional notion of Nash equilibrium in traditional game theory as every ESS is a Nash equilibrium, while the converse is not true.

The pattern of cooperation that is more likely to be evolutionarily stable in the issue area is the dominant pattern of cooperation. Multilateralism is evolutionarily stable in international

trade while bilateralism is evolutionarily stable in FDI. The key assumption of the stag-elephant hunt game theoretic model is that multilateral cooperation is more beneficial than bilateral cooperation in any issue area. The central argument of the dissertation is that the multilateral cooperation is more likely to dominate an issue area if multilateral cooperation is much more beneficial than bilateral cooperation and the initial distribution of strategies is more favorable for multilateralism. On the other hand, bilateral cooperation is more likely to emerge in an issue area if multilateral cooperation is relatively less beneficial than bilateral cooperation and the initial distribution of strategies is more favorable for bilateralism.

Neither the payoff ratio nor the initial distribution of strategies alone can guarantee the emergence of hypothesized equilibrium in the two domains. It is possible that multilateralism may not emerge despite it being much more beneficial than bilateralism in any domain if the initial distribution of strategies is not favorable for multilateralism. Similarly, it is possible that multilateralism may emerge in any domain where it is not relatively as beneficial, but the initial distribution of strategies is favorable for multilateralism. In short, the central argument does not completely exclude the possibility of the emergence of bilateralism in international trade nor does it not completely exclude the possibility of the emergence of multilateralism in investment. Initial distributions of strategies play a very important role in the emergence of multilateralism in international trade and bilateralism in the investment domain in the postwar period.

To further strengthen the central argument, the dissertation employed the comparison of paired structured analytic narratives in international trade and FDI in Chapter 5 to explore the role of initial distributions of strategies and payoff ratios in the two domains in the postwar period regarding the evolution of the dominant pattern of cooperation in the two domains. Chapter 5 also presented rich qualitative evidence for the phenomenon of learning by imitation employed by the

US, the chief proponent of multilateralism in investment, to ultimately adopt bilateralism despite initial reluctance.

The complete research project should include the evaluation of testable and falsifiable implications of theoretical work using real-world data. The theoretical work in this dissertation generates eight testable and falsifiable theoretical implications. One of the attributes of scientific knowledge is that it should be testable and falsifiable. While it was not possible to directly test (quantitatively) all eight testable implications due to limitations of measuring payoffs, the dissertation evaluated the three testable implications in the investment domain to measure the usefulness of the theoretical work developed in this dissertation in the real world. To evaluate these three implications, the dissertation employed the survival analysis model as was used in previous research to explain the penetration of BITs. However, the dissertation used a longer dataset (1959 -2023) than prior work to evaluate the three testable implications.

Chapter 6 in the dissertation provided robust quantitative support for the three implications tested. Specifically, the quantitative research found strong support that the cumulative number of BITs in the past increases the likelihood of future BITs. Furthermore, the quantitative research also found strong quantitative evidence that the dyads engaged in failed multilateral episodes in the investment domain are more likely/inclined to sign bilateral investment treaties. The analysis also found quantitative support for the impact of learning on the evolution of a dominant pattern of cooperation. Additionally, the dissertation presented qualitative evidence for the phenomenon of learning by imitation in Chapter 5. The dissertation successfully demonstrates the practical applicability of the theoretical framework through rigorous evaluation and provides valuable insights into the dynamics of cooperation.

7.1 MAIN CONTRIBUTION OF THE DISSERTATION

The main contribution of the dissertation lies in the development of the novel theoretical framework to model and analyze the choice of different countries regarding the patterns of cooperation in a *strategic context*. To model the strategic situation faced by countries regarding different patterns of cooperation, the dissertation introduces three player three strategy stag-elephant game, a modification of more traditional two player two strategy stag hunt game. The game frames the choice of countries between different patterns of cooperation (multilateralism, bilateralism, and unilateralism) as a coordination problem. The game captures the risk-reward dynamics inherent in different patterns of cooperation in a strategic situation i.e., the more rewarding pattern of cooperation is also riskier. The game is general enough to capture the strategic situation of different patterns of cooperation in any issue area.

All countries get higher payoffs when they coordinate to a same strategy. The equilibrium of the game occurs when all countries coordinate and adopt the same strategy. The multilateral cooperation is an equilibrium when all countries coordinate/adopt the multilateral strategy. Analogously, bilateral cooperation is an equilibrium when all countries coordinate/adopt the bilateral strategy. The game employs an analogy of different animals to represent different patterns of cooperation, with elephant symbolizing multilateral cooperation, stag representing bilateral cooperation and rabbit symbolizing unilateralism. There are three hunters which can capture either the elephant, stag or rabbit. All three hunters need to coordinate their strategies to capture an elephant. Any two hunters are required to coordinate their strategies to capture a stag. Capturing a rabbit does not require the coordination of strategy with any other player. The stag-elephant hunt game is a symmetric game in which the hunters after capturing any animal shared the reward equally. The multilateral cooperation is more beneficial for every player however it is riskier since

it requires the coordination of at least three countries to the multilateral strategy. On the other hand, bilateral cooperation is less beneficial however it is less risky than multilateral cooperation since it requires the coordination of only two players to the bilateral strategy. The unilateral strategy is the least risky as it does not require the coordination of any other player in the game. The game essentially captures the risk-reward dynamics inherent in decision making of countries regarding different patterns of cooperation.

The dissertation makes a significant methodological contribution by extending and improving upon the previous literature that often breaks down any cooperation relationship into simpler dyadic relationships (Axelrod and Hamilton 1981). It is much simpler to simulate two player games among the population of players. However, we cannot understand multilateralism by dividing the countries engaged in multilateralism into respective dyadic relationships. The simplest definition of multilateralism includes three players (Keohane 1990). The dissertation recognizes that the essence of multilateralism involves interaction among three players, and it addresses the gap in previous research by formalizing a game-theoretic model that explicitly considers three-players interaction. The stag-elephant hunt model and its simulation employing replicator dynamics are both rooted in the framework of a three player three strategy game. This approach not only aligns with the basic definition of multilateralism but also contributes significantly to the formal modeling literature on cooperation.

The third major contribution of the dissertation is that the research framework does not only answer why different patterns of cooperation emerge but also explains how different patterns of cooperation evolve in each issue area. This is achieved through simulating the stag-elephant hunt game using a computational algorithm employing simple replicator dynamics. The simulation demonstrates how different patterns of cooperation emerge from varying initial conditions.

Countries adapt their strategies in the next period to the strategy which was the most successful strategy in the previous period. This leads to the proportion of countries following the most successful strategy to increase gradually until it is adopted by all countries in the international system.

Overall, the contribution of the dissertation is to provide a flexible and generalizable framework for understanding and analyzing the *strategic situation* in which countries decide regarding different patterns of cooperation in any issue area.

7.2 APPLICABILITY AND GENERALIZABILITY

The dissertation provides a central explanation for how and why different patterns of cooperation came to dominate in international trade and FDI. These two issue areas were chosen to instantiate the central argument of the dissertation. At various points in the dissertation, I have argued that these two issue areas are similar in many aspects, yet different patterns of cooperation dominate within them. These two issue areas were considered because they provided the most compelling application of the central argument of the dissertation. The central argument of the dissertation is generalizable to other issue areas. The methodological combination of a formal game and computational simulation developed in this dissertation lay the groundwork for a broadly applicable theoretical framework that captures the strategic, evolutionary, and state-centric nature of different patterns of cooperation in any issue area. The core assumption of the model is that multilateralism is more beneficial than bilateralism. While it is true that payoffs are not directly observable for any issue area, the core assumption of the research arguably holds for many other issue areas. The core assumptions along with methodological framework developed in this dissertation not only help us understand the evolution of different patterns of cooperation in

international trade and FDI but also provides a more general research framework to understand the evolution of different patterns of cooperation in other issue areas. Climate change and international taxation (double taxation treaties) offer promising areas to evaluate the generalizability of the methodological framework developed in this dissertation.

It may be noted that the extensibility of the theoretical framework to other issue areas requires considering the fundamental difference between collaboration versus coordination games. The equilibrium is not self-enforcing in collaboration games, and there is a greater incentive to cheat in the issue areas characterized by the payoffs of the collaboration games. We do have a dispute resolution mechanism (enforcement and monitoring) in all issue areas. However, monitoring and enforcement is more important in issue areas in which the equilibrium is not self-enforcing, as is the case in collaboration games. That said, most international cooperation settings likely include aspects that resemble both coordination and collaboration games. For example, if international trade is a collaboration game involving the choice to cooperate or not by countries, that cooperation is in itself built upon the development of mechanisms to collaboratively resolve trade conflicts such as dispute resolution procedures that transform what might have previously been a collaboration game into something more akin to a cooperation game.

7.3 EXTENSION OF RESEARCH

While the dissertation provides insights regarding how and why different patterns of cooperation evolve in different issue areas, the dissertation could be further extended to capture the nuanced dynamics by including spatial and temporal dimensions in the model. In this dissertation, countries learn the best strategy in the international system on a global basis. However, it is possible that each country puts more weight on learning the best strategy regionally

(from countries in its immediate neighborhood) rather than globally. The incorporation of spatial dimensions could refine and strengthen the research framework by recognizing that countries may learn from their immediate regional neighbors rather than adopting a purely global perspective. In my dissertation, each country could observe the outcome of strategic interaction of all other countries in the international system. It is possible that some countries may not be able to observe the strategies of all other countries in the international system. And if a different distribution of strategies is prevailing regionally than globally, then it is possible to learn the strategy that is not globally optimal. The incorporation of spatial dimension would require a modification of computational algorithm, but the underlying stag-elephant hunt game theoretic model remains unchanged. Furthermore, the computational algorithm does not fully incorporate the temporal dimension. In my dissertation, the probability of interaction of one country with another country does not depend on the past interactions. However, it is common in international trade and FDI that past interactions between countries increases the probability of future interactions. Again, the computational algorithm is required to be modified to extend the research in this direction. These two extensions would not only contribute to theoretical robustness of the dissertation but also enhance its practical relevance.

The stag-elephant hunt game theoretic model is a symmetric game in which all countries get the same gains from the same pattern of cooperation. However, Appendix B develops the condition showing that distributional concerns might affect the choice of a country in a strategic context whether to engage in multilateralism, bilateralism, or unilateralism. If countries are very sensitive to relative gains in a domain, then it is possible for them to shift to an alternative pattern of cooperation in which relative gains are not so unfavorable to them. The extension of research, incorporating the distributional concern, will show the extent to which the evolution of a dominant

pattern of cooperation is robust when confronted with the participating countries having higher distributional concerns. Overall, the future research, if built on this dissertation, will show the vulnerability or resilience of the evolution of the dominant pattern of cooperation in any domain in the face of distributional concerns.

There has not been any quantitative measure developed yet to quantify the multilateral cooperation across international trade and FDI. An extension of the research could address the existing gap in the quantitative measurement of multilateral cooperation in international trade and FDI. It is difficult to compare multilateral cooperation in different issue areas without a meaningful quantitative indicator. There is no single comprehensive multilateral agreement on investment covering investment liberalization, investment protection and the dispute settlement mechanisms. However, there are multiple agreements on trade. This simple fact was used in the dissertation to argue that there is more multilateral cooperation in international trade than in FDI. To develop a more comprehensive measure of multilateral cooperation, it is essential to move beyond the sole consideration of the number of participating countries. The measure should also incorporate the breadth and depth of issues covered in each multilateral cooperation episode. Some studies have argued that multilateralization is happening in the investment domain through the inclusion of MFN clauses and multilateral dispute settlement procedures in bilateral investment treaties. However, these studies fall short of providing any quantification of the state of multilateral cooperation in the investment domain. With the progress in natural language processing, it is possible to automatically compare the multilateralism embedded in the text of different BITs to come up with some basic indicator of multilateralism in investment domain.

7.4 LIMITATIONS OF THE RESEARCH

One of the limitations of the model developed in this dissertation is that it can only designate the successful strategy as one of the strategies in the initial set. Multilateralism, bilateralism, and unilateralism were the three strategies in the initial set of strategies. The notion of success is confined to predetermined strategies. The model may not capture emergent strategies that could prove successful over time. In replicator dynamics, the proportion of strategies will vary in the population of agents depending on the relative payoffs. Only one of these strategies with a higher relative payoff will evolve to become the evolutionarily stable strategy in any domain. However, it is to be noted that countries cannot learn strategies which were not included in the initial set.

Like replicator dynamics, the genetic algorithm is also an optimization algorithm to model the evolutionary dynamics in different domains (Riechmann 2001). However, in genetic algorithms, the agents can learn very different strategies that were not included in the initial set of strategies. The phenomenon of crossover and mutation introduces novel strategies among the population of agents over time (Carr 2014). Consequently, the notion of success comes from exploring the more diverse strategy space. It is possible that agents may ultimately adopt a strategy that is completely different from the strategies in the initial set.

Crossover ensures that *elements* of the parents are recombined to form the strategy for the offspring. Unlike replicator dynamics, in which offsprings (agents) fully adopts one of the strategies of its parents, the genetic algorithm recombines the successful *elements* of the strategies of their parents. The strategy is encoded as a vector of parameters representing different *elements* of that strategy at a disaggregated level. Each pattern of cooperation could be encoded as a vector of parameters (0s and 1s). For example, if the two agents, one with bilateralism and the other with

multilateralism interacts, the offspring in the genetic algorithm will recombine the successful elements of bilateralism and multilateralism to come up with a new strategy. The offspring never fully adopts one of the strategies (bilateralism or multilateralism) of its parents in the genetic algorithm. Instead, it recombines the successful *elements* from both the strategies.

Replicator dynamics uses a more aggregated conception of success for passing on the most successful strategy to offspring. On the other hand, genetic algorithm uses a more disaggregated concept of success for replication. Furthermore, a mutation introduces some random changes in the population of agents to explore an even wider solution space. The table below shows the possible elements of different patterns of cooperation, in the light of the stag-elephant hunt game theoretic model, which could be recombined to introduce novel strategies in the game. These elements of different patterns of cooperation (benefits, riskiness, efficient negotiations, tailor made agreements and asymmetric payoffs) are just included to illustrate how a genetic algorithm would work with the stag-elephant hunt game as underlying game. The crossover and mutation of strategies will ensure that the strategy ultimately adopted by the agents may look very different after few iterations than as represented by the encodings of bilateralism and multilateralism in initial set of strategies.

Table 7.1 Possible elements of bilateralism versus multilateralism

	Bilateralism	**Multilateralism**
More beneficial	0	1
Riskiness	0	1
Efficient negotiations	1	0
Tailor made agreement to accommodate the interests of participants	1	0
Asymmetric relative payoffs	Not sure about its encoding	Not sure about its encoding

Utilizing a genetic algorithm for computational simulation with the underlying stag-elephant hunt model requires adopting an agent-based approach to model how and why different patterns of cooperation evolve in different domains. The agent-based approach, relying on a genetic algorithm, can also model the strategic, dynamic (evolutionary) and state-centric aspects of different patterns of cooperation with learning of best strategy not confined to predetermined initial set of strategies. Despite the apparent simplicity of replicator dynamics, the dissertation yields powerful insights explaining the evolution of different patterns of cooperation in the real world.

7.5 IMPLICATIONS OF RESEARCH

The main implication of the research is that the stronger and deeper pattern of cooperation frequently does not occur in one giant leap. No matter how desirable the dominant pattern of cooperation is in any domain, we cannot achieve the dominant pattern of cooperation if we defy the evolutionary logic in a strategic context. The issue area of international trade offers the most

successful example of multilateralism (Goldstein, Rivers et al. 2007). However, the number of countries engaged in multilateral trade and its scope gradually expanded. In the first multilateral trade round, only 23 countries participated in multilateral trade cooperation to negotiate a much simpler multilateral agreement on trade in goods. However, the multilateral trade cooperation ultimately evolved towards the WTO with almost universal membership and a much broader coverage of trade issues. The successful pattern of cooperation evolves gradually. It is possible that multilateral cooperation in trade would have been killed permanently if participating countries had insisted on achieving stronger multilateral trade cooperation in one big step. Countries gradually adopted the most successful strategy as they gradually learned about the benefits of that strategy over time.

Multilateral cooperation is the more beneficial pattern of cooperation in the investment domain. However, multilateralism did not emerge as the dominant pattern of cooperation. It did not emerge as the dominant pattern of cooperation because the chief proponent of multilateralism, the US, insisted on signing the much stronger multilateral agreement on investment in one giant leap. It rejected the Havana Charter because it did not include comprehensive coverage of investment issues (Hart and Spero 2013). It is plausible that by so doing it not only rejected the Havana Charter but also permanently killed multilateralism in the investment domain. The research also highlights the role of the initial few steps on the emergence of a dominant pattern of cooperation in any domain. Evolutionary forces are weak initially, but they become more powerful later with the growing adoption of the most successful strategy. Once a path to a particular pattern of cooperation is abandoned initially, it becomes challenging to reestablish that pattern of cooperation later. There were two more attempts made to achieve multilateralism in investment domain but they both ultimately failed, and each failure triggered additional bilateral-treaty-

making. It was possible that if multilateralism had initially been allowed to follow the evolutionary trajectory in the investment domain, multilateralism would have emerged instead of bilateralism. Multilateralism did not emerge even though it was much more desirable than bilateralism in investment domain.

The broader implication of the research for multilateral cooperation in other domains is that we should not kill shallower multilateral cooperation in anticipation of stronger multilateral cooperation. The multilateral cooperation in climate change (and other domains) may be shallow but it is potentially setting a foundation for broader and more effective multilateral cooperation later if it is allowed to follow an evolutionary trajectory. Therefore, this research cautions policy makers against defying evolutionary logic in domains where multilateral cooperation is shallower for the time being.

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APPENDIX A

EQUATIONS FOR EXPECTED UTILITIES FOR DIFFERENT STRATEGIES IN STAG-ELEPHANT HUNT GAME

$$EU_1(B) = B_b(2P_b\,P_m + 2P_bP_u + 2(P_b)^2) - C_b \quad (1)$$

$$EU_1(M) = B_m(P_m)^2 - C_m \quad (2)$$

$$EU_1(U) = 0 \quad (3)$$

$$P_m + P_b + P_u = 1 \quad (4)$$

$$P_m = \sqrt{\frac{C_m}{B_m}} \quad (5)$$

Setting equation (1) and (3) equal and substituting the value of P_m

$$EU_1(B) = B_b(2P_b\,P_m + 2P_bP_u + 2(P_b)^2) - C_b = 0$$

$$P_u = \frac{C_b - 2B_b(P_b)^2 - 2B_bP_b\sqrt{\frac{C_m}{B_m}}}{2B_bP_b} \quad (6)$$

Putting the values of P_m and P_u from equation (5) and equation (6) respectively into equation (4)

$$P_b = \frac{C_b}{2B_b} \quad (7)$$

Putting the values of P_m and P_b from equation (5) and equation (7) into equation (4) we get

$$P_u = 1 - \sqrt{\frac{C_m}{B_m}} - \sqrt{\frac{C_b}{2B_b}} \quad (8)$$

APPENDIX B

DISTRIBUTIONAL CONCERNS IN STAG-ELEPHANT HUNT GAME MODEL

It makes sense to explore how the distribution of gains affect the pattern of cooperation in stag-elephant hunt game theoretic model. Realist scholars have often alleged that liberal scholars have misunderstood (or misinterpreted) their position on international cooperation (Grieco 1988). Realists predict less international cooperation because of the concern of countries about relative gains in international cooperation. Realists argue that liberals have completely left out the relative gains question from their empirical models. The most popular method to study the cooperation issue is game theory. Conventionally, game theory is concerned only about the absolute payoffs of the players. The players usually try to maximize their absolute payoffs in the game. However, we know that the relative distribution of gains can also play an important role in the emergence of a pattern of cooperation. Any country not satisfied with the relative distribution of gains can veto the whole multilateral episode. What is the maximum payoff difference the country will tolerate in any pattern of cooperation before it vetoes that specific pattern of cooperation? Grieco introduced the "K" factor (sensitivity to payoff gaps) in the two-player prisoner's dilemma game to demonstrate that the evolution of cooperation is even more difficult than what liberals thought earlier (Grieco 1988). We will try to derive the value of K for which the countries will prefer multilateralism over bilateralism. In other words, how much payoff difference the countries will tolerate in multilateralism before shifting to alternative patterns of cooperation (i.e., bilateralism). I will adapt Greico's approach for three player stag-elephant hunt game

$$E = V - K(W - V)$$

E is the expected utility of country 1

V is the absolute payoff of country 1

K is the sensitivity factor for country 1. Each player has its own sensitivity factor. Higher value of K means country 1 is more sensitive to payoff gap from partner (country 2)

W is the absolute payoff of partner (country 2)

Pure strategies:

I will compute the expected utility for the pure multilateral and bilateral strategies in the stag-elephant hunt game.

$$U_1(M) = (B_{1m} - C_{1m}) - K(Max(B_{2m} - C_{2m}, B_{3m} - C_{3m}) - (B_{1m} - C_{1m}))$$

It is assumed that country 1 is concerned about the *maximum* gains made by any of the other two countries in the stag-elephant hunt game. The utility of country 1 goes down if any of the other player makes larger gain from the multilateral episode.

$$U_1(B) = (2B_{1b} - C_{1b}) - K(Max(2B_{2b} - C_{2b}, 2B_{3b} - C_{3b}) - (2B_{1b} - C_{1b}))$$

Country 1 will prefer multilateralism over bilateralism if

$$U_1(M) > U_1(B)$$

We can derive the value of K (sensitivity factor) from the above equation for which country 1 will still prefer multilateralism over bilateralism. Therefore, the maximum payoff difference that country 1 will tolerate in multilateralism before shifting to bilateralism is given as

$$K < \frac{(B_{1m} - C_{1m}) - (2B_{1b} - C_{1b})}{((Max(B_{2m} - C_{2m}, B_{3m} - C_{3m}) - (B_{1m} - C_{1m})) - (Max(2B_{2b} - C_{2b}, 2B_{3b} - C_{3b}) - (2B_{1b} - C_{1b}))}$$

If the value of K is less than the fraction on the right of inequality, then country 1 will be satisfied with the distributional gains in multilateralism. Otherwise, the country 1 will shift from multilateralism to bilateralism.

APPENDIX C

PATH DEPENDENCY ARGUMENT

We can explain the emergence of different patterns of cooperation in different domains using the path dependency argument because history matters in the evolution of different patterns of cooperation. This is not to say that history solely determines the pattern of cooperation (Pierson 2000). It is important to clarify the role of history in the evolution of patterns of cooperation and to what extent it matters. Apparently, evolutionary game theory (based on the replicator dynamics model) and path dependency make conflicting claims about the role of history in the evolution of different patterns of cooperation. Replicator dynamics is based on the shorter history of play in a game where countries adopt in the current period the strategy that is most successful in the previous period. The countries learn the best strategy to adopt from the immediate past, and the longer history of play is very heavily discounted in replicator dynamics. On the other hand, path dependency emphasizes the role of initial actions (learning of successful strategy in the earlier period) on the long-term evolution of pattern of cooperation. The strategy that countries find to be the "most successful" in the initial period (using replicator dynamics) has a constraining effect on the ability of countries to learn about the new successful strategies in the future. The choices made by the countries in the earliest period regarding the pattern of cooperation is reinforced throughout the path. The strategy for which the expected payoff is highest in the initial distribution of strategies will be positively reinforced along the path. The successful strategy in the earlier period becomes more and more successful in the later period as it is adopted more widely by countries. For a given initial distribution of strategies, the most successful strategy in the initial period will also be the most successful strategy at any point along the trajectory. Therefore, whether we

consider the long-term history (in case of path dependency) or short-term of history (in case of replicator dynamics) the countries will learn the same most successful strategy. For instance, if the multilateral strategy is the most successful strategy in the initial distribution of strategies in the trade domain, then the expected payoff for multilateral strategy will continue to increase in the next generations as more countries will learn to adopt the multilateral strategy (the most successful strategy). The expected utility for the most successful strategy shows the increasing return phenomenon that is characteristic of path dependence. It becomes progressively more difficult for countries to switch to a different pattern of cooperation once the countries start moving along the path leading to a specific pattern of cooperation. The initial distribution of strategies has a very large cumulative effect on the emergence of the pattern of cooperation.

There is an element of unpredictability and uncertainty for each of the four points (one point on each edge of the basin of attraction triangle and one unique point in the interior of the triangle) regarding which of the possible equilibria will evolve. Path dependency provides a very strong explanation for the emergence of a specific pattern of cooperation from initial distribution of different strategies (whether the expected payoff of different strategies in the initial distribution is the same or different).

APPENDIX D

ERROR (MISTAKES) IN LEARNING THE BEST STRATEGY

The model does not allow any country to make mistakes when learning the most successful strategy. It is plausible to consider that countries can make random mistakes while following the simple behavioral rule of imitation in their learning process. The model developed in this chapter assumes that all countries imitate the best strategy at every time step without making any mistakes. This implies that countries have no difficulty in identifying the most successful strategy in any domain in the previous period and adopting that strategy in the future. However, in the real world, it is possible for countries to make mistakes in identifying the best strategy. It is interesting to observe the impact of learning noise on the emergence of dominant patterns of cooperation in the two domains. The possibility of making random errors in learning the best strategy varies for a single country over time. Furthermore, the possibility of making random errors in learning the best strategy varies from one country to another. Therefore, there is randomness in learning the best strategy both spatially and temporally. The most pertinent question is whether we would observe the same dominant pattern of cooperation in international trade and FDI if we allow countries to make small random errors in learning the most successful strategies in the two domains. Consequently, I have also explored the special case in which all countries are allowed to make small errors in learning the best strategy at each time step. The small random error is modeled using the normal distribution with a mean of zero and a standard deviation of 2. The replicator dynamic simulation algorithm introduced in Chapter 3 remains the same, with one difference: we now include random error in the calculation of expected payoffs for each strategy in step 3 of the algorithm.

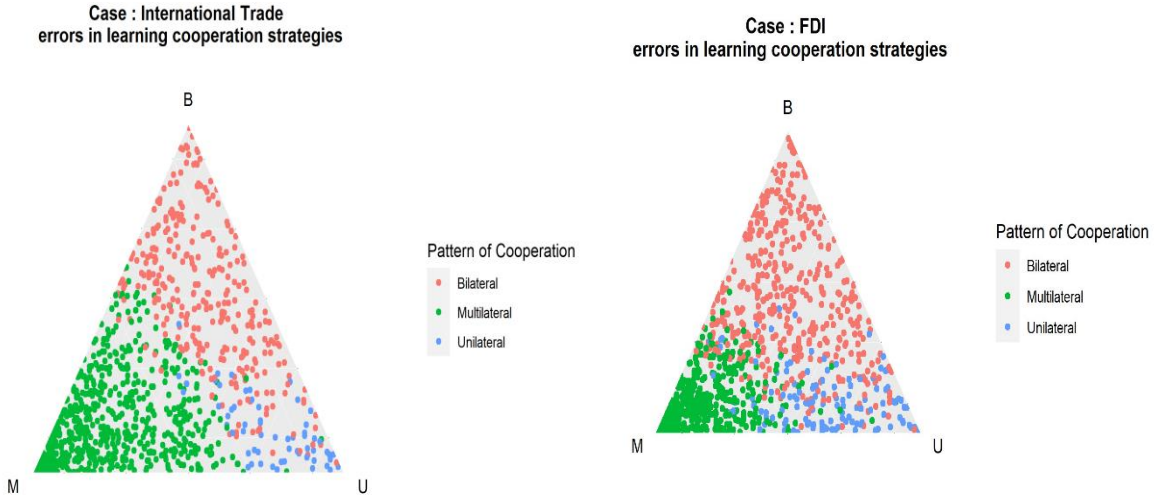
$$EU(M) = B_m(P_m)^2 - C_m + rnorm(mean = 0, sd = 2)$$

$$EU(B) = B_b(2P_b\,P_m + 2P_bP_u + 2(P_b)^2) - C_b + rnorm(mean = 0, sd = 2)$$

$$EU(U) = 0 + rnorm(mean = 0, sd = 2)$$

The basin of attraction triangle demonstrates that the evolution of the dominant pattern of cooperation remains robust in the face of small random errors in each domain. It is evident from the basin of attraction triangle figures that multilateralism continues to be an ESS for a large set of initial distributions of strategies in international trade, and bilateralism remains an ESS for a significant range of initial distributions of strategies in FDI. However, the boundaries between the basins of attraction for different patterns of cooperation (in each domain) are less distinct or fuzzier.

Error in learning the best strategy in trade and FDI



APPENDIX E

ROBUST CHECKS FOR SURVIVAL ANALYSIS

Results for Cox proportional hazard models (with defense variable)

Variables	Model (1) Hazard Ratio coefficient (Standard error)	Model (2) Hazard Ratio coefficient (Standard error)	Model (3) Hazard Ratio coefficient (Standard error)
Cumulative bits globally by year	1.071019*** (.0068342)	1.178636*** (.0532152)	1.146012*** (.0550158)
Is dyad part of failed multilateral episode?	1.827767*** (.2546491)	4.076983** (2.447159)	10.92391*** (7.108742)
Learning	107227.5*** (126314.7)	38772.54 (341446.3)	4.460492 (42.69804)
GDP of host country (constant US$)		1.000 (4.43e-13)	1.000 (4.73e-13)
GDP growth of host economy		1.027225 (.0195151)	1.031977 (.0208163)
FDI inflows to host country in previous year		.9963272 (.0180858)	.9943622 (.0186258)
FDI outflow home country		1.019439 (.0245474)	1.019064 (.0246178)
Defense arrangement between dyad		.2072861*** (.0421394)	.2038032*** (.0429462)
Colony		3.363736 (1.875084)	2.344796 (1.744162)
Common official language		1.382456 (.3058286)	1.512422 (.343594)
Short term debt of host economy		1.007889 (.0069121)	1.007574 (.007438)
Common colonizer		1.588524** (.3355786)	1.742409*** (.37185)
Trade volume		.9999621 (.0000781)	.9999621 (.0000814)
IMF credit to host economy		1.000 (5.44e-11)	1.000 (5.60e-11)
1-year lag failed multilateralism			2.31174 (1.923896)
2-year lag failed multilateralism			5.444772*** (2.502901)
3-year lag failed multilateralism			1.131619 (.8791548)
4-year lag failed multilateralism			.6748025 (.5091658)
Observations	621,657	12580	12509
Log Likelihood	-20744.675	-587.09	-569.19

*** p<0.01, ** p<0.05, * p<0.1

Results for survival analysis with Weibull distribution

Variables	Model (1) Hazard Ratio coefficient (Standard error)	Model (2) Hazard Ratio coefficient (Standard error)	Model (3) Hazard Ratio coefficient (Standard error)
Cumulative bits globally by year	1.067*** (0.006)	1.09*** (0.012)	1.07*** (0.013)
Is dyad part of failed multilateral episode?	1.867*** (0.247)	1.611*** (0.29)	2.346*** (0.451)
Learning	123932.7*** (128990.9)	1354733*** (2804622)	8582.341*** (19482.44)
GDP of host country (constant US$)		1.000*** (0.000)	1.000*** (0.000)
GDP growth of host economy		1.023*** (0.006)	1.033*** (0.007)
FDI inflows to host country in previous year		1.009** (0.004)	1.008* (0.004)
FDI outflow home country		1.001 (0.002)	1.002 (0.002)
Colony		4.119*** (0.737)	3.916*** (0.718)
Common official language		1.208** (0.112)	1.253** (0.117)
Short term debt of host economy		1.022*** (0.002)	1.021*** (0.003)
Common colonizer		1.205* (0.128)	1.2* (0.129)
Trade volume		1.000 (0.000)	1.000 (0.000)
IMF credit to host economy		1.000*** (0.000)	1.000*** (0.000)
1-year lag failed multilateralism			2.18*** (0.391)
2-year lag failed multilateralism			2.345*** (0.407)
3-year lag failed multilateralism			1.664** (0.347)
4-year lag failed multilateralism			3.044*** (0.479)
Constant	0.004*** (0.00)	0.006*** (0.001)	0.005*** (0.001)
Observations	621,657	155,445	152,942
Log Likelihood	-8063.7972	-2842.7932	-2628.1869

*** p<0.01, ** p<0.05, * p<0.1

Cox proportional hazard model with net FDI flows to GDP

Variables	Model (2) Hazard Ratio coefficient (Standard error)	Model (3) Hazard Ratio coefficient (Standard error)
Cumulative bits globally by year	1.102*** (0.015)	1.08*** (0.016)
Is dyad part of failed multilateral episode?	1.468* (0.296)	2.38*** (0.513)
Learning	4289512*** (11000000)	30733.52*** (85465.9)
GDP of host country (constant US$)	1.000*** (0.000)	1.000*** (0.000)
GDP growth of host economy	1.024*** (0.006)	1.032*** (0.006)
Net FDI inflows to host GDP country in previous year	1.013*** (0.004)	1.012*** (0.004)
Net FDI outflow to home GDP	1.001 (0.002)	1.001 (0.002)
Colony	4.332*** (0.774)	4.023*** (0.737)
Common official language	1.221** (0.113)	1.262** (0.118)
Short term debt of host economy	1.024*** (0.002)	1.023*** (0.003)
Common colonizer	1.159 (0.122)	1.172 (0.125)
Trade volume	0.999 (0.000)	0.999 (0.000)
IMF credit to host economy	1.000*** (0.000)	1.000** (0.000)
1-year lag failed multilateralism		1.759*** (0.354)
2-year lag failed multilateralism		1.885*** (0.369)
3-year lag failed multilateralism		1.262 (0.285)
4-year lag failed multilateralism		1.97*** (0.352)
Observations	152,687	150,203
Log Likelihood	-8052.2194	-7762.5115

*** p<0.01, ** p<0.05, * p<0.1

Results for Cox proportional hazard models (with fixed effects)

Variables	Model (1) Hazard Ratio coefficient (Standard error)	Model (2) Hazard Ratio coefficient (Standard error)	Model (3) Hazard Ratio coefficient (Standard error)
Cumulative bits globally by year	1.082*** (0.009)	1.117*** (0.019}	1.104*** (0.019)
Is dyad part of failed multilateral episode?	1.144 (0.168)	1.549** (0.334}	2.384*** (0.551)
Learning	75784.44*** (101497.2)	6320908*** (17800000}	59711.67*** (179697.9)
GDP of host country (constant US$)		1.000 (0.000}	1.000 (0.000)
GDP growth of host economy		1.013* (0.007}	1.016** (0.007)
FDI inflows to host country in previous year		1.017** (0.007}	1.016** (0.008)
FDI outflow home country		1.001 (0.003}	1.000 (0.003)
Colony		0.543*** (0.119}	0.475*** (0.107)
Common official language		3.19*** (0.369}	3.348*** (0.39)
Short term debt of host economy		1.009*** (0.003}	1.007* (0.004)
Common colonizer		2.302*** (0.313}	2.205*** (0.302)
Trade volume		1.000*** (0.000}	1.000*** (0.000)
IMF credit to host economy		1.000 (0.000}	1.000 (0.000)
1-year lag failed multilateralism			2.407*** (0.516)
2-year lag failed multilateralism			2.204*** (0.462)
3-year lag failed multilateralism			1.541* (0.367)
4-year lag failed multilateralism			2.29*** (0.435)
Observations	621,657	155,445	152,942
Log Likelihood	-18191.5	7000.6029	-6762.28

*** p<0.01, ** p<0.05, * p<0.1

Note: Country fixed effects for both members of each dyad were included but are not shown in the table for the models

APPENDIX F

R CODE FOR SIMULATIONS AND SOME VISUALIZATIONS

R CODE FOR REPLICATOR DYNAMICS SIMULATION OF STAG-ELEPHANT HUNT GAME

```
Cooperation_pattern <- function(num_all, expected_all, num_players = 9000, num_generations =30000 ){
for ( i in seq_along(1:num_generations)){
## Below code chunk ensures that the strategy with the highest expected payoff is played by one
## more player in the next round while the strategy with the lowest expected payoff is played
## by one less player. If any strategy is not by played by any player, then it is removed from
## the international system.Any strategy played by zero number of players simply dies out. Once
## the strategy dies out it cannot reproduce. Therefore, the dead strategy cannot increase or
## decrease in number.
if (any(num_all <=0)){
zero_index <- which(num_all<=0)
zero_element_name <-names(num_all[zero_index])
num_all <- num_all[-zero_index]
expected_all  <- expected_all[-which(names(expected_all)==zero_element_name)]
}
max_index <- which.max(expected_all)
num_all[max_index] <- num_all[max_index] + 1
min_index <- which.min(expected_all)
num_all[min_index]<- num_all[min_index] - 1
## EU1(M) = Bm(Pm)2 ??? Cm
Expected_payoffs_m <-  sum( (65*(((num_all["Multilateral"])/num_players)^2)),-5, na.rm = T)
## EU1(B) = Bb(2PbPm + 2PbPu + 2PbPb) ??? Cb
Expected_payoffs_b <-
sum((2*10*((num_all["Multilateral"])/num_players)*(num_all["Bilateral"]/num_players) ) ,
```

```
(2*10*(num_all["Bilateral"]/num_players)*(num_all["Unilateral"]/num_players)),
(2*10*(num_all["Bilateral"]/num_players)^2), -3 ,na.rm = T)

Expected_payoffs_u <-  0
if(sum(num_all) > num_players){
break
}

}
print(num_all)
}
num_players = 9000
payoffs <- matrix(c(60,-5,-5,-3, 7,-3,0,0,0), nrow = 3, byrow = T)
## "M" stands for multilateral "B" stands for bilateral and "U" stands for "unilateral strategy"
rownames(payoffs) <- c("Multilateral","Bilateral","Unilateral")
colnames(payoffs) <- c("Multilateral","Bilateral","Unilateral")
output_storage <- vector("list", 1000) ## list data structure to store output distribution of strategies
storage <- vector("list",1000)        ## list data structure to store initial distribution of strategies
for (k in seq_along(1:1000)){
sample_to_fixed_sum <- function(fixed_sum){
sample_vector <- numeric(3)
sample_vector[1] <- sample(1:(fixed_sum-2), 1)
sample_vector[2] <- sample(1:(fixed_sum-sample_vector[1]-1), 1)
sample_vector[3] <- fixed_sum - sum(sample_vector)
names(sample_vector) <- c("Multilateral","Bilateral","Unilateral")
return(sample_vector)
}
storage[[k]] <-sample_to_fixed_sum(9000)
```

```
num_all      <- storage[[k]]


#num_all <- c(200, 0, 8800)

#names(num_all) <-c("Multilateral","Bilateral","Unilateral")

Expected_payoffs_m <-  sum( (65*(((num_all["Multilateral"])/num_players)^2)),-5, na.rm = T)

Expected_payoffs_b <-
sum((2*10*((num_all["Multilateral"])/num_players)*(num_all["Bilateral"]/num_players) ) ,

(2*10*(num_all["Bilateral"]/num_players)*(num_all["Unilateral"]/num_players)),

(2*10*(num_all["Bilateral"]/num_players)^2), -3 ,na.rm = T)

Expected_payoffs_u <-  0

expected_all <- c("Multilateral" = Expected_payoffs_m,"Bilateral"= Expected_payoffs_b,
"Unilateral"= Expected_payoffs_u)

output_storage[[k]] <-Cooperation_pattern(num_all = num_all, expected_all= expected_all,
num_players = 9000, num_generations =30000 )

}

library(tidyverse)

multilateral_inital <- map_dbl(storage, function(x) x[[1]] )

bilateral_initial   <- map_dbl(storage, function(x) x[[2]] )

unilateral_initial  <- map_dbl(storage, function(x) x[[3]] )

Cooperation_outcome <- map_chr(output_storage, function(x) names(x))

df <- data.frame(m_inital = multilateral_inital,

b_initial   = bilateral_initial,

u_initial  = unilateral_initial,

coop_outcome = Cooperation_outcome)

df_trade <- as_tibble(df)
```

R CODE FOR BASIN OF ATTRACTION TRIANGLE VISUALIZATION

```
#install.packages("ggtern")

library(ggtern)
```

```
library(tidyverse)

trade_Simulation <- read_csv(file.choose())

ggtern(data = trade_Simulation, aes(x = m_inital, y = b_initial, z = u_initial))+
  geom_point(aes(colour = coop_outcome))+
  scale_color_discrete(name = "Pattern of Cooperation")+
  scale_L_continuous(name ="M"  , breaks = NULL, labels = NULL) +
  scale_R_continuous(name ="U" , breaks = NULL, labels = NULL ) +
  scale_T_continuous(name ="B" , breaks = NULL , labels = NULL ) +
  labs(
    title = "Case : International Trade \n errors in learning cooperation strategies"
  )+
  theme(plot.title = element_text(size = 12, face = "bold", hjust = 0.50))
```

R CODE FOR EXCEL SIMULATION VISUALIZATIONS

```
##**********Uniform Probability**********##
##*************************************************************##
library(tidyverse)
library(readxl)
uniform_probability = read_xlsx(file.choose(), sheet = 2)
colnames(uniform_probability)
ggplot(data = uniform_probability, mapping = aes(x = `Net payoff ratio`, y = `E U(M)`))+
  geom_smooth(aes(color = BestStrategyChoice))+
  labs(
    x = "Net payoff ratio \n\n Figure 5",
    y = "Expected Utility (multilateral)",
    title = "Changing pattern of cooperation with payoff ratio",
    subtitle = "Uniformly distributed strategies",
  ) +
  geom_vline(xintercept = 5.18, color = "green",linetype =5)+
  scale_color_discrete(name = "Best Strategy")+
  geom_text(x = 5.18, y = -2.0, mapping = aes(label = "5.18"))+
  theme_bw()+
  theme(plot.title = element_text(face = "bold", size = 12, hjust = 0.50),
        plot.subtitle = element_text( size = 10, hjust = 0.50),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank())+
  ggtitle(expression(bold(paste("Changing pattern of cooperation with payoff ratio"," ",
frac(B[m]-C[m], 2*B[b]-C[b])))))
ggsave("uniform_dist2.png")
##**********International trade**********##
trade = read_xlsx(file.choose(), sheet = 3)
```

```
colnames(trade)
ggplot(data = trade, mapping = aes(x = `P(M)`, y = `E U(M)`))+
  geom_smooth(aes(color = BestStrategyChoice))+
  labs(
    x = "Proportion of players playing multilateral strategy \n\n Figure 3",
    y = "Expected Utility (multilateral)",
    title = "Changing pattern of cooperation with multilateral probability simulations",
    subtitle = "Issue area: International trade\nStag-elephant hunt game",
  ) +
  geom_vline(xintercept = 0.275, color = "green",linetype =5)+
  scale_color_discrete(name = "Best Strategy")+
  geom_text(x = 0.27, y = -2.5, mapping = aes(label = "0.27"))+
  theme_bw()+
  theme(plot.title = element_text(face = "bold", size = 11, hjust = 0.50),
        plot.subtitle = element_text( size = 10, hjust = 0.50),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank())
 ggsave("Trade_figure_3proportion.png")

##**********Foreign Direct Investment**********##
##*************************************************************************##
fdi = read_xlsx(file.choose(), sheet = 5)
colnames(fdi)
ggplot(data = fdi, mapping = aes(x = `P(B)`, y = `E U(B)`))+
  geom_smooth(aes(color = BestStrategyChoice))+
  labs(
    x = "Proportion of players playing bilateral strategy \n\n Figure 1 (a)",
    y = "Expected Utility (bilateral)",
```

```
    title = "Changing pattern of cooperation with bilateral probability simulations",
    subtitle = "Issue area: Foreign direct investment\nStag-elephant hunt game",
  ) +
  geom_vline(xintercept = 0.15, color = "green",linetype =5)+
  scale_color_discrete(name = "Best Strategy")+
  geom_text(x = 0.15, y = -2.5, mapping = aes(label = "0.15"))+
  theme_bw()+
  theme(plot.title = element_text(face = "bold", size = 12, hjust = 0.50),
        plot.subtitle = element_text( size = 10, hjust = 0.50),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank())
ggsave("FDI_1aproportion.png")

##**F**********Foreign Direct Investment****
##*********************************************
fdi = read_xlsx(file.choose(), sheet = 4)
colnames(fdi)
ggplot(data = fdi, mapping = aes(x = `P(M)`, y = `E U(M)`))+
  geom_smooth(aes(color = BestStrategyChoice))+
  labs(
    x = "Proportion of players playing multilateral strategy \n\n Figure 1 (b)",
    y = "Expected Utility (multilateral)",
    title = "Changing pattern of cooperation with multilateral probability simulations",
    subtitle = "Issue area: Foreign direct investment\nStag-elephant hunt game",
  ) +
  geom_vline(xintercept = 0.48, color = "green",linetype =5)+
  scale_color_discrete(name = "Best Strategy")+
  geom_text(x = 0.48, y = -2.5, mapping = aes(label = "0.48"))+
```

```
  theme_bw()+
  theme(plot.title = element_text(face = "bold", size = 12, hjust = 0.50),
        plot.subtitle = element_text( size = 10, hjust = 0.50),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank())
 ggsave("FDI_1bproportion.png")
```

R CODE FOR ERROR IN LEARNING THE BEST STRATEGY IN FDI

```
library(tidyverse)
current_path_history <- vector("list",30000)
Cooperation_pattern <- function(num_all, expected_all, num_players = 9000, num_generations
=30000 ){
  for ( i in seq_along(1:num_generations)){
    ## Below code chunk ensures that the strategy with the highest expected payoff is played by
one
    ## more player in the next round while the strategy with the lowest expected payoff is played
    ## by one less player. If any strategy is not by played by any player, then it is removed from
    ## the international system.Any strategy played by zero number of players simply dies out.
Once
    ## the strategy dies out it cannot reproduce. Therefore, the dead strategy cannot increase or
    ## decrease in number.
    if (any(num_all <=0)){
      zero_index <- which(num_all<=0)
      zero_element_name <-names(num_all[zero_index])
      num_all <- num_all[-zero_index]
      expected_all  <- expected_all[-which(names(expected_all)==zero_element_name)]
    }
    current_path_history[[i]] <<- num_all  ## list data structure to store path histories
    max_index <- which.max(expected_all)
```

```
    num_all[max_index] <- num_all[max_index] + 1

    min_index <- which.min(expected_all)

    num_all[min_index]<- num_all[min_index] - 1

    ## EU1(M) = Bm(Pm)2 ??? Cm

    Expected_payoffs_m <-  sum( (22*(((num_all["Multilateral"])/num_players)^2)),-5, na.rm =
T) + rnorm(n = 1, mean = 0, sd = 2)

    ## EU1(B) = Bb(2PbPm + 2PbPu + 2PbPb) ??? Cb

    Expected_payoffs_b <-
sum((2*10*((num_all["Multilateral"])/num_players)*(num_all["Bilateral"]/num_players) ) ,


(2*10*(num_all["Bilateral"]/num_players)*(num_all["Unilateral"]/num_players)),

                          (2*10*(num_all["Bilateral"]/num_players)^2), -3 ,na.rm = T) + rnorm(n = 1,
mean = 0, sd = 2)

    Expected_payoffs_u <-  0 + rnorm(n = 1, mean = 0, sd = 2)

    if(sum(num_all) > num_players){

      break

    }


  }

  print(num_all)

}

num_players = 9000

payoffs <- matrix(c(60,-5,-5,-3, 7,-3,0,0,0), nrow = 3, byrow = T)

## "M" stands for multilateral "B" stands for bilateral and "U" stands for "unilateral strategy"

rownames(payoffs) <- c("Multilateral","Bilateral","Unilateral")

colnames(payoffs) <- c("Multilateral","Bilateral","Unilateral")

output_storage <- vector("list", 1000) ## list data structure to store output distribution of
strategies

storage <- vector("list",1000)         ## list data structure to store initial distribution of strategies

current_path_history <- vector("list",300)
```

```
path_histories <- vector("list",1000)
for (k in seq_along(1:1000)){
  sample_to_fixed_sum <- function(fixed_sum){
    sample_vector <- numeric(3)
    sample_vector[1] <- sample(1:(fixed_sum-2), 1)
    sample_vector[2] <- sample(1:(fixed_sum-sample_vector[1]-1), 1)
    sample_vector[3] <- fixed_sum - sum(sample_vector)
    names(sample_vector) <- c("Multilateral","Bilateral","Unilateral")
    return(sample_vector)
  }
  storage[[k]] <-sample_to_fixed_sum(9000)
  num_all      <- storage[[k]]
  #num_all <- c(200, 0, 8800)
  #names(num_all) <-c("Multilateral","Bilateral","Unilateral")
  Expected_payoffs_m <-  sum( (22*(((num_all["Multilateral"])/num_players)^2)),-5, na.rm = T)
+ rnorm(n = 1, mean = 0, sd = 2)
  Expected_payoffs_b <-
sum((2*10*((num_all["Multilateral"])/num_players)*(num_all["Bilateral"]/num_players) ) ,

(2*10*(num_all["Bilateral"]/num_players)*(num_all["Unilateral"]/num_players)),
                        (2*10*(num_all["Bilateral"]/num_players)^2), -3 ,na.rm = T) + rnorm(n = 1,
mean = 0, sd = 2)
  Expected_payoffs_u <-  0 + rnorm(n = 1, mean = 0, sd = 2)
  expected_all <- c("Multilateral" = Expected_payoffs_m,"Bilateral"= Expected_payoffs_b,
"Unilateral"= Expected_payoffs_u)
  output_storage[[k]] <-Cooperation_pattern(num_all = num_all, expected_all= expected_all,
num_players = 9000, num_generations =30000 )

  path_histories[[k]] = current_path_history
```

```
}
multilateral_inital <- map_dbl(storage, function(x) x[[1]] )
bilateral_initial   <- map_dbl(storage, function(x) x[[2]] )
unilateral_initial  <- map_dbl(storage, function(x) x[[3]] )
Cooperation_outcome <- map_chr(output_storage, function(x) names(x))
df <- data.frame(m_inital = multilateral_inital,
                 b_initial   = bilateral_initial,
                 u_initial  = unilateral_initial,
                 coop_outcome = Cooperation_outcome)
df_fdi <- as_tibble(df)
write_csv(df_fdi, "Stag_elephant_fdi_learning_Oct06.csv")
```

STATA CODE TO EVALUATE THE TESTABLE IMPLICATIONS OF STAG-ELEPHANT HUNT GAME

```
*** Cox Proportional Hazard model to evaluate the testable implications of stag-elephant hunt game

*** Import the dataset

*****************************

stset Year, id(dyad_combine)  failure(Bit_agreement) origin(time atrisk)

*****************************MODEL1*************************************

**************************************************************************

**************************************************************************

***Simplest survival model contains variables for all hypotheses without any covariates
```

```
stcox Cum_bits_byYear is_dyad_in_multilateral learning

set maxvar 100000

//fixed effects model version 1

stcox Cum_bits_byYear is_dyad_in_multilateral learning i.ccode_1 i.ccode_2

**************************MODEL2*****************************************

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*** Model contains contains variables for all hypotheses with full set of covariates

stcox Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host
FDI_inflow_hostLagOneYear FDI_outflow_home colony common_official_lang
shortTermDebt_host comcol  trade_volume Imfcredit_host

 //fixed effects version of model 2

stcox Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host
FDI_inflow_hostLagOneYear FDI_outflow_home colony common_official_lang
shortTermDebt_host comcol  trade_volume Imfcredit_host  i.ccode_1 i.ccode_2

**************************MODEL3*****************************************

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*************************************************************************
```

```
stcox Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host
FDI_inflow_hostLagOneYear FDI_outflow_home colony common_official_lang
shortTermDebt_host comcol  trade_volume Imfcredit_host dyad_Multi_1yrlag
dyad_Multi_2yrlag dyad_Multi_3yrlag dyad_Multi_4yrlag

//fixed effects version of model 3

stcox Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host
FDI_inflow_hostLagOneYear FDI_outflow_home colony common_official_lang
shortTermDebt_host comcol  trade_volume Imfcredit_host  dyad_Multi_1yrlag
dyad_Multi_2yrlag dyad_Multi_3yrlag dyad_Multi_4yrlag i.ccode_1 i.ccode_2


*********Runing the same model assuming weibull distribution**********************

*******************************************************************************

**********************Model 1 with weibull distribution**************************

streg Cum_bits_byYear is_dyad_in_multilateral learning, distribution(weibull)

*******************************************************************************

**********************Model 2 with weibull distribution**************************

streg Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host
FDI_inflow_hostLagOneYear FDI_outflow_home colony common_official_lang
shortTermDebt_host comcol  trade_volume Imfcredit_host, distribution(weibull)

*******************************************************************************
```

**********Model 3 with weibull distribution**********

streg Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host FDI_inflow_hostLagOneYear FDI_outflow_home colony common_official_lang shortTermDebt_host comcol trade_volume Imfcredit_host dyad_Multi_1yrlag dyad_Multi_2yrlag dyad_Multi_3yrlag dyad_Multi_4yrlag, distribution(weibull)

****

****with "net fdi inflows to GDP" and "net fdi outflows toGDP"**********

****

**********Model2**********

stcox Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host Net_fdiInflow_Gdp_host_lag Net_fdiOutflow_Gdp_home colony common_official_lang shortTermDebt_host comcol trade_volume Imfcredit_host

**********Model3**********

****

stcox Cum_bits_byYear is_dyad_in_multilateral learning GDP_constant_host GDP_growth_host Net_fdiInflow_Gdp_host_lag Net_fdiOutflow_Gdp_home colony common_official_lang shortTermDebt_host comcol trade_volume Imfcredit_host dyad_Multi_1yrlag dyad_Multi_2yrlag dyad_Multi_3yrlag dyad_Multi_4yrlag

VITA

Imran Khan
Graduate Program in International Studies
Batten Arts and Letters Bldg., Room 7045
Old Dominion University
Norfolk, VA 23529

Imran holds a bachelor's degree in mechanical engineering from the UET, Lahore, Pakistan. He earned a MPP degree with a specialization in Economic Policy and Analysis from National University of Singapore (NUS) in 2015 on a full scholarship. He is pursuing a PhD in International Studies from Graduate Program in International Studies (GPIS), Old Dominion University on Fulbright scholarship. His primary concentration is Modeling and Simulation and secondary concentration is International Political Economy. Currently, he serves as an adjunct professor, offering an undergraduate level Public Policy course at GPIS, ODU.

He has been working in Ministry of Commerce (Pakistan) and its attached departments since 01st January 2010. His experience encompasses strategic trade policy formulation, negotiating market access initiatives (such as PTAs, FTAs, RTAs, GSP+, etc.) and trade promotion. He has also offered a graduate level course titled, "WTO, Globalization, and economic integration" in the fall of 2016, 2017 and 2018 to the students at Pakistan Institute of Development Economics (PIDE). In his free time, he also teaches Python, R programming language, Machine Learning, Deep Learning and Natural Language Processing to online students freely.

His research interest focuses on developing formal models and simulating them to investigate the various aspects of international cooperation. Specifically, his research focuses on investigating the questions related to international cooperation in the domains of international trade and investment. He speaks English, Urdu, and Pahari.