國立臺灣大學法律學院科際整合法律學研究所

碩士論文

College of Law

Graduate Institute of Interdisciplinary Legal Studies

National Taiwan University

Master Thesis

國際商務仲裁判斷後審查系統之立法模型

Legislative Control of Post-award Procedural Dynamics: Modeling Judicial Behaviors of Post-award Review Systems in International Commercial Arbitration

張雅菲

Ya-Fei Chang

指導教授：王文宇博士、郭鴻基博士

Advisors: Wen-Yeu Wang, J.S.D. & Hung-Chi Kuo, Ph.D.

中華民國 105 年 7 月

July 2016

doi:10.6342/NTU201601682

國立臺灣大學碩士學位論文
口試委員會審定書

國際商務仲裁後判斷審查系統之立法模型

Legislative Control of Post-award Procedural Dynamics: Modeling Judicial Behaviors of Post-award Review Systems in International Commercial Arbitration

本論文係張雅菲（Ya-Fei Chang，學號 R98A41016）君在國立臺灣大學科際整合法律學研究所完成之碩士學位論文，於西元 2016 年 7 月 29 日承下列考試委員審查通過及口試及格，特此證明

指導教授：_____

_____

口試委員：_____

_____

Acknowledgements

I would like to express my deepest gratitude and dedicate this thesis to my parents Yi-Ming Chang and Yu-Ying Chen.

It would have been very difficult to accomplish this research work without the support of my advisors: Prof. Wen-Yeu Wang and Prof. Hung-Chi Kuo. I am grateful to my advisors for their enlightening guidance, inspiring discussions, strong encouragements to start my thesis with interdisciplinary approaches, and letting me have freedom in my research.

I also want to thank Prof. Andrew Jen-Guang Lin and Prof. Chien-Chung Lin, for their insightful comments. My appreciation is extended to Prof. George A. Bermann for his encouragements, and Prof. Inez Fung for her path-breaking academic stories, that strengthened my resolve to take the road less travelled by.

Special thanks are due to my teachers and friends during these years at National Taiwan University, and the participants of the 18th Annual Interdisciplinary Legal Studies Graduate Student Conference, *Reflective Law*, 6-7 May 2013, University of British Columbia. Their helpful comments improved this thesis.

Ya-Fei Chang

July 29, 2016

doi:10.6342/NTU201601682

摘要

當一個國際商務仲裁判斷做成後，能否實現其國際可執行性，即為國際商務仲裁系統運作之最核心目標。

若欲研究國際商務仲裁判斷之國際可執行性，須從國際商務仲裁判斷後審查系統入手，特別須瞭解各國存在其內涵上差異之仲裁判斷後審查程序。關於各國內國法院審理內國撤銷仲裁之訴，擴及審理外國商務仲裁判斷之承認與執行與否，主要權限來源即為各國之內國仲裁法，此時，研究一個內國仲裁法應如何訂定、修改、引入國際商務仲裁法律原則等，即為非常重要之研究課題，值得關注。

本論文為了探討國際商務仲裁判斷後審查系統之立法模型，主要分三大部分做進一步研討：

第一部分，在進入撤銷仲裁之訴之前，當事人針對其爭端之內國或國際商務仲裁判斷進行協商，此時，如何找出雙方或多方於合約中之利益偏好與平衡點，即為決定是否進入仲裁判斷後審查程序之關鍵。一旦進入仲裁判斷後審查程序，當事人考量之行為策略即為司法決策與仲裁庭決策之權力分布，與各方可能進行結盟之最佳平衡策略。此一部份，本論文針對在進入撤銷仲裁之訴之前設計一個協商模型，探討當事人維持仲裁利益與法院撤銷仲裁判斷之權力之消長關係。

第二部分，在進入撤銷仲裁判斷之訴之後，本論文主要探討如何能夠去強化仲裁判斷之國際可執行性。這是一個理想的研究課題。雖然其重要性不言而喻，但是真實世界中，於國際商務仲裁之法律實務而言，如何才能夠有實現的一天，這也是本論文所期盼的。此一部分，本論文分析了一個國際商務仲裁判斷做成後

doi:10.6342/NTU201601682

之國際執行面，包括各國內國可能提出之拒絕承認、拒絕執行之各種主要條件，容易被各國內國法院擴大其撤銷外國仲裁判斷之權力者，主要在於提出仲裁判斷與其內國公共政策有違。本論文亦進一步探討，當一個已被外國法院撤銷之仲裁判斷，能否於他國再被重新執行之法律實務問題。針對此部分，本論文擴及相關系統與演化理論以及行為經濟等面向，導入數學社會學與大尺規社會模擬觀點，最後結合承上理論，設計後仲裁判斷程序動態之齊次系統，就其相平面之穩定性分析，顯示出倘若一個內國仲裁法所設計之撤銷外國仲裁判斷之理由密度過強，勢必會影響到一個國際仲裁判斷之國際可執行性，並關連於其內國仲裁法於國際商務仲裁判斷後審查系統中之永續運作可能性。

第三部分，在內國法院進行撤銷仲裁判斷之訴之審理時，針對無論是內國或國際商務仲裁程序本身，其具有去地域化之特性應有所瞭解並予以尊重。本論文於此脈絡下，將進一步延伸探討關連於仲裁之當代目前新興之立法和諧化潮流，擴及美國學界亦興起內國商務仲裁之法律重述，以及相關跨國界法律原則於仲裁程序可能產生之各種影響。本論文亦考量既定商業或社會規範對於立法取決可能產生之影響，乃至於一個內國仲裁之立法設計與政策，應如何針對外國仲裁判斷之承認與執行作出回應。針對此部分，須同時考慮眾多條件之互動關係，本論文設計兩個自主系統做比較，探討政治介入之控制與內國立法之控制對於外國仲裁判斷之可執行性之互動關係，顯示較少的政治介入之控制外國仲裁判斷可執行性，將會帶來國際後仲裁判斷審查系統的穩定性，有利其長期發展。

本論文最後提出建議：針對台灣仲裁立法，應積極規劃採納紐約公約並建設啟動國際商務仲裁相關配套措施，刻不容緩；同時，亦應增訂台灣內國仲裁法，於內國仲裁判斷做成後，在不影響判斷結果之情形下，賦予當事人享有針對仲裁判斷中之明顯錯誤，得要求仲裁庭限期更正並重新詮釋系爭仲裁判斷之權利。

關鍵字：國際商務仲裁；立法模型；仲裁判斷後審查系統；演化動態；數學建模

doi:10.6342/NTU201601682

Abstract

Ensuring the international enforceability of arbitral awards is an ideal research topic for international commercial arbitration. Constructing national legislative control of post-award procedural dynamics in domestic or international commercial arbitration is the initial conditions of modeling post-award judicial review systems. Building up theories for the national or uniform legislative modeling depends on how the judicial behaviors evolve in post-award review systems. Hence, apart from typical scenarios of legal studies, this thesis applied the legislative modeling as the approach to study the stability of international post-award review systems.

The purpose of this thesis is to study the theories-building basis of constructing international enforceable awards. Three research approaches include comparative legal studies, evolutionary dynamics, mathematical modeling. Legislative modeling is based on these approaches for controlling the post-award procedural dynamics, predicting the sustainability of national arbitration laws, analyzing the grounds for international post-award review systems.

Firstly, this thesis studied the strategic behaviors in dispute resolution bargaining processes and analyzed the distribution of power in multilateral dispute resolution procedures. Secondly, this thesis modelled the judicial behaviors in evolutionary

doi:10.6342/NTU201601682

multilevel hierarchy of orders based on the heuristics decision-makings with the preferences of social agents. Thirdly, this thesis schemed procedural delocalized arbitrations for the national legislative management of arbitration laws. Finally, this thesis explored the theoretical grounds for constructing the international legislative control of post-award review systems.

The contributions of this thesis include filling the gaps of traditional research methodologies and interdisciplinary legislative modeling and building three models for finding the equilibria of interests in post-award bargaining processes, showing that the intensity of the vacatur grounds for foreign arbitral awards made great impacts on post-award procedural dynamics, studying the influence of the political control in international post-award review systems.

This thesis concluded that finding the preferences of contracts and the strategic equilibria of the parties improved the efficacy of settlement bargaining; for studying the sustainability of national arbitration laws, analyzing the long-term behaviors of post-award review systems was helpful; constructing the international legislative control of post-award review systems was based on the functions of the transnational political agents and the non-state actors. This thesis suggested to ratify the New York Convention and to add the grounds for modifications or corrections on the evident material miscalculation or mistakes and reinterpretations of arbitral awards in Taiwan Arbitration Law.

Key Words: International Commercial Arbitration; Legislative Modeling; Post-award Review Systems; Evolutionary Dynamics; Mathematical Modeling.

doi:10.6342/NTU201601682

Contents

doi:10.6342/NTU201601682

doi:10.6342/NTU201601682

doi:10.6342/NTU201601682

doi:10.6342/NTU201601682

List of Figures

doi:10.6342/NTU201601682

Chapter 1

Introduction

1.1 Introduction

This thesis began with the evolving nature of dispute resolution bargaining and searches for the equilibrium strategies and the coalitions in multilateral procedures. In the first part, this thesis focused on the distribution of power between the arbitral tribunals and the courts, and arbitral autonomy of post-award reviewing systems in forming the consent-based arbitrations and the orientations of party autonomy in arbitral proceedings.

This thesis explored how roles of power, reputation, reciprocity performed in a competitive cooperation situation between the courts and the arbitral tribunals in the arbitral proceedings and how the doctrines of competence-competence and separability made impacts on balancing legitimacy interests and efficacy costs.

In the second part, this thesis explored in effort to modeling the sustainability of national arbitration laws in competitive interactions of the courts and the arbitral tribunals, exploring substantive issues of the international or national public policy

doi:10.6342/NTU201601682

defence for the vacatur grounds for arbitral awards, and analyzing the grounds for constructing the international enforceable awards.

In the third part, this thesis schemed procedural delocalized arbitrations for the national legislative management of arbitration laws in trends of harmonization and analyze the overlooked *lex arbitri* of procedural autonomy in arbitral proceedings and *lex mercatoria*. This thesis referred to the prisoner's dilemma games and the cooperative games for analyzing legislative choices in norm-governed space and take post-award reviews as self-organized processes in complex adaptive systems. This thesis converged the frameworks of legislative modeling on post-award reviews and the conceptual policy modeling on artificial societies.

1.2 Methodological Concerns

1.2.1 Legislative Modeling: A Theory-building Research

Legislative Control of Post-award Procedural Dynamics

In methodological concerns of this thesis, this thesis derive the legislative modeling as the main approach to make legislative control of post-award procedural dynamics. In order to make the sequential control on the post-award judicial review systems by national legislative design, this thesis will disassemble the systems into several topics to explore.

Discovering a Methodological Synthesis

Legislative modeling is mainly based on a methodological synthesis of game-theoretical analysis, evolutionary game theory, mathematical modeling, agent-based computing.

doi:10.6342/NTU201601682

Mathematical Legal Science

In order to build the conceptual frameworks of legislative modeling will require a methodological convergence of mathematical sociology, artificial societal theories, evolutionary analysis, systems thinking, behavioral principles, conceptual policy modeling, etc. In this thesis, this thesis applied mathematical sociological modeling such as mathematical modeling, evolutionary game theory, Lyapunov functions of replicator dynamics, as approaches of the study.

1.2.2 Conceptual Frameworks of Legislative Modeling

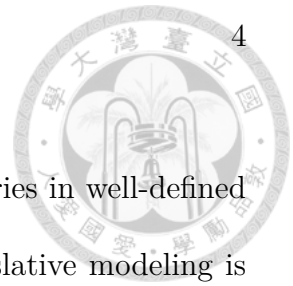
Mapping Conceptual Frameworks of Legislative Modeling

Similar with conceptual policy modeling, legislative modeling is oriented to a branch of legislative management connected with the public policy analysis in the political dimensions. This thesis converged these approaches for mapping the conceptual frameworks for modeling the judicial strategic behaviors in multilevel hierarchy of decision space in the post-award dispute bargaining analogous to the approach of examining the policy-makings in public choice analysis.

Case Study or Without Loss of Generality

In typical legal studies, this thesis took the case study to develop theories. This thesis demonstrated the theories without loss of generality as the methods of the mathematical proofs and theoretical reflections on some methodological debates and the difference of the two approaches.

doi:10.6342/NTU201601682



Crossing Disciplinary Boundaries

Disciplinary boundaries do not actually exist. For building theories in well-defined disciplinaries with uncategorized approaches, in this thesis, legislative modeling is applied for the ideal of constructing international enforceable awards and modeling judicial behaviors for studying the sustainability of national arbitration laws.

1.2.3 Modeling the Judiciary for the Legislature

Modeling Judicial Behaviors of Post-award Review Systems

Elaborating the possible relevant approaches towards the purpose of modeling the judiciary for the legislature focusing on the judicial behaviors of post-award review systems, this thesis needed the systems thinking on the distribution of power of the political entity as well as the evolutionary theories for modeling the norms in the multilateral structures between the courts and the arbitral tribunals in national legislative design.

Macro-micro Linkages: Macro-analysis and Micro-predictions

Similar with many approaches of distinguishing the macro-micro linkages of systems, in this thesis, the work this thesis was going to model the judiciary for the legislature includes the macro-analysis of international legislative control of enforceability of arbitral awards, the micro-predictions of the sustainability of national arbitration laws and the strategic decision-makings for dispute resolution bargaining processes.

doi:10.6342/NTU201601682

Mathematical Modeling Methods

Mathematical modeling methods for the three models constructed in this thesis are: (1) adopting the methods of solving Lyapunov functions to build the Post-award Review Bargaining Model, (2) adopting the methods of solving homogeneous systems to build the Post-award Judicial Review Model, (3) adopting the methods of solving autonomous systems to build the International Legislative Control Model.

1.3 Scope of the Thesis

The parameters this thesis was going to operate in this thesis include the distribution of power in multilateral dispute resolution procedures and the extensions of strategic behaviors in post-award bargaining processes, modeling the judicial behaviors for the national legislative design on arbitration laws, scheming procedural delocalized arbitrations for the legislative management for international arbitral resilience of enforceability of arbitral awards. However, the legislative modeling approach is limited by lacking of the empirical data to show the equilibrium of the international arbitral jurisprudence and the distinctive values of fairness, finality, efficacy. There is still a long way to go.

doi:10.6342/NTU201601682

Chapter 2

Power, Reputation, Reciprocity in Dispute Resolution Bargaining

2.1 Introduction

In this chapter, to begin with, this thesis was mainly going to explore the dynamical states of the dispute resolution bargaining, especially for the influence generated by the distribution of judicial power and the arbitral autonomy of the post-award reviewing systems. Power, reputation, reciprocity are crucial factors in bargaining proceedings. This thesis started from how the interest-based arbitrations evolve with the distribution of power in a competitive cooperation situation between the courts and the arbitral tribunals in the arbitral proceedings. This thesis made a brief theoretical reflection on the methodological debates towards taking legal systems as reproductive social systems.

This thesis showed that the doctrines of competence-competence and separability are crucial roles for balancing legitimacy interests and efficacy costs. In addition,

doi:10.6342/NTU201601682

this thesis rethought the orientations of party autonomy in arbitral proceedings as well as arbitral autonomy in the constructing part of forming the consent-based arbitrations, as an whole view introductory remarks for the theoretical basis of legislative modeling. After that, this thesis explored the features of bargaining dynamics of gaining reputation in trust games, performing reciprocal altruism in order to bring benefits to cooperative relationships in settlements from a long-term perspective, and so, this thesis brought the court-facilitated settlements and the costs of bargaining into an overall consideration. Finally, strategic behaviors in multilateral dispute resolution bargaining procedures will be our cases for building the post-award review bargaining model.

2.2 Distribution of Power in Arbitral Proceedings

2.2.1 Interest-based Arbitration in Post-award Bargaining

In order to properly understand the power in post-awards review bargaining, there were three remarks on distributions of power, mapping from "power - society" system of law to the natural world, quoted as follows: [1][541]

> 1. There is always a unique stationary power distribution in a hierarchical structure for a legal system, and the magnitude of power monotonously falls with transition from the higher to lower levels.
>
> 2. Even in a legal system there is always an area of parameters, in which the realization the power distinction oversteps the boundaries of the legal

[1] *See* A. A. Samarskii & A. P. Mikhailov, Principles of Mathematical Modeling: Ideas, Methods, Examples 216 (2002).

doi:10.6342/NTU201601682

field.

3. If there was zero reaction the hierarchy would cease to interact with the partner – civil society.

Parties-Arbitration-Court: Competitive Cooperation

Taken as a whole, judicial autonomy, when it comes to court-to-court relations of intersystemic judicial communications in post-award review bargaining, was notable in pursuing the purpose of efficacy of dialectical reviews in order to resolve conflicts of courts and arbitral institutions. [2][119] However, modern arbitration statutes would not be too extensive to adopt arbitration settlements in the pre-trail bargaining to maintain the competitive cooperation relationships between the triangle tensions of post-award judicial reviews. [3][136] And so, if the arbitration agreement was originally incomplete, it would take risks on the falsely filling gaps by substantive laws; for business-to-business transactions, the parties had a tendency to resolve the incomplete agreements problems by default rules to keep the arbitration proceeding rather than turning back to litigation models to review the arbitration agreements by national courts for the efficacy and confidential concerns. [4][90]

---

[2] *See generally* Robert B. Ahdieh, *Between Dialogue and Degree: International Review of National Courts*, 79 N.Y.U. L. Rev. 2029 (2004).

[3] *See* Bruce L. Benson, *An Exploration of the Impact of Modern Arbitration Statutes on the Development of Arbitration in the United States*, 11 J.L. Econ. & Org., no. 2, 1995, at 479, 497-99.

[4] *See* Jack M. Graves, *Arbitration as Contract: the Need for A Fully Developed and Comprehensive Set of Statutory Default Legal Rules*, 2 Wm. & Mary Bus. L. Rev. 227, 237-42 (2011).

doi:10.6342/NTU201601682

Interests-based Arbitrations

Among the present international societies, American civil justice exercising the ADR proceedings in litigations, but the risks of impartiality for settlements determined by judges or the effects of ADR in litigation subordinate were hard to compete against due to the repeat games of the costs in the private ADR professionals. [5][45] It is becoming increasingly difficult to ignore that the interest-based analysis showed that altruism replaced egoism in national legislations of private laws for the purposes of achieving fairness with public goods concerns and resorting balancing of interests in resolving jurisdictional disputes. [6][38] At the very least, the compelling power of national courts or roles of obligating the recalcitrant parties to stay proceedings of arbitrations at the courts of the arbitral seats was passive and indirect in guidance of pre-arbitration agreements. [7][102] There were many reasons why the obligations of the dispute-adjudicating forums excluded the assessment of submitting jurisdiction justifications of national courts thus made the settlements available in international organizations. [8][39]

But once in a great while, in theories, foreign judicial adequacy standards in transnational litigation processes could be very divergent in ways of non conveniens doctrines and the judgment enforcement doctrines which led different results with

---

[5] *See* Peter L. Murray, *The Role of American Judges in Alternative Dispute Resolution*, *in* International Contract Litigation, Arbitration and Judicial Responsibility in Transnational Disputes 305, 312-3 (Rolf Stürner & Masanori Kawano eds., 2011).

[6] *See* Mahmood Bagheri, International Contracts and National Economic Regulation: Dispute Resolution Through International Commercial Arbitration 87-93, 164-70 (2000).

[7] *See* Julian D.M. Lew, *Does National Court Involvement Undermine the International Arbitration Process?* 24 Am. U. Int'l L. Rev. 489, 527-30 (2009).

[8] *See* August Reinisch, International Organizations Before National Courts 323 (2000).

doi:10.6342/NTU201601682

respect to the private and public interest factors in different kinds of cases. [9][350] The scope of the principle of *forum non conveniens* are narrowed and obstructed in practices of post-award review systems of the U.K. or EU arbitral jurisprudence due to lack of justifications. [10][22] For instance, applying international public orders insulated in the role of courts of supervising arbitrations would expand the statutory grounds for the vacatur of arbitral awards. [11][66] Logically it follows that, to look at this another way, the international arbitrability of mandatory U.S arbitration laws was permitted the second look on the enforceability of arbitral awards and firstly reviewing the grounds of public policies with public interests of the state that contemplated by national courts. [12][133] In the comparisons with Germany laws, national courts would not investigate the foreign judicial judgments on the grounds for annulments of foreign arbitral awards in post-award review systems in German based on ZPO §1061 (2). [13][35][2]

Apart from this, to be sure, the non-arbitrability doctrine based on the New

[9] *See* Christopher A. Whytock & Cassandra Burke Robertson, *Forum Non Conventions and the Enforcement of Foreign Judgments*, 111 COLUM. L. REV. 1444, 1472-9 (2011).

[10] *See* PEDRO J. MARTINEZ-FRAGA, THE AMERICAN INFLUENCE ON INTERNATIONAL COMMERCIAL ARBITRATION: DOCTRINAL DEVELOPMENTS AND DISCOVERY METHODS 169 (2009).

[11] *See* L. Yves Fortier, *The Never-ending Struggle Between Arbitrators and Judges in International Commercial Arbitration*, *in* LAW OF INTERNATIONAL BUSINESS AND DISPUTE SETTLEMENT IN THE 21TH CENTURY 177, 183-5 (Robert Briner et al. eds., 2001).

[12] *See* Philip J. McConnaughay, *The Risks and Virtues of Lawlessness: A "Second Look" at International Commercial Arbitration*, 93 NW. U. L. REV. 453, 514-20 (1999).

[13] *See* MENNO ADEN, INTERNATIONALE HANDELSSCHIEDSGERICHTSBARKEIT: KOMMENTAR ZU DEN SCHIEDSVERFAHRENSORDNUNGEN ICC-DIS-WIENER REGELN-UNCITRAL-LCIA 74-7 (2d ed. 2003) ("Der bei einem ausländischen schiedsspruch vorkommende verfahrensverstoss ist für das inländische gericht als solcher kein grund, gemass §1061 ZPO den antrag auf vollstreckbarerklärung abzulehnen. ... Der inländische Richter prüft nicht, ob der ausländischer Schiedsspruch nach der *lex fori* seines Erlaßortes aufhebbar ist."). *See also* §1061 ZIVILPROZESSORDNUNG [ZPO] [CODE OF CIVIL PROCEDURE], Sep. 12, 1950, §1025-66 (Ger.) (amended, 2012) ("§1061 (2) Ist die Vollstreckbarerklärung abzulehnen, stellt das Gericht fest, dass der Schiedsspruch im Inland nicht anzuerkennen ist.").

doi:10.6342/NTU201601682

York Convention §II provided the substantive propositions of the review of national judicial forum but more often applied in securing the public values or legislative design instead applied in foreign non-arbitrate issues which could be resolved by the competence of arbitral tribunals or national courts as a substitute approach. [14][37] Yet another theories applying on class arbitrations, it would not change the fundamentals of arbitral proceedings on account of the adjudication of the hybrid procedural consensual grounds governed by national arbitration laws and a-national legal principles in international commercial arbitrations. [15][76][11]

2.2.2 Theoretical Reflections on Methodological Debates

Theoretical Reflections on Reproduceable Social Systems

Considered from systemic perspectives, as the initial stage of theories, paradigms of the voting power distribution in political decisions were introduced as spatial votings, which measured modified power in policy spaces. [16][362] Political decision-making processes as voting competitive models were promoted by political distribution of

[14] *See* Gary B. Born, International Commercial Arbitration: Commentary and Materials 243-7 (2d ed. 2001).

[15] *See generally* S.I. Strong, *Does Class Arbitration "Change the Nature" of Arbitration? Stolt-Nielsen, AT&T, and A Return to First Principles*, 17 Harv. Negot. L. Rev. 201 (2012). *See also* AT&T Mobility LLC v. Conception, 563 U.S. 321 (2011) ("The switch from bilateral to class arbitration sacrifices arbitration's informality and makes the process slower, morecostly, and more likely to generate procedural morass than finaljudgment. And class arbitration greatly increases risks to defendants. The absence of multilayered review makes it more likely thaterrors will go uncorrected. That risk of error may become unacceptable when damages allegedly owed to thousands of claimants are aggregated and decided at once. Arbitration is poorly suited to these higher stakes. In litigation, a defendant may appeal a certificationdecision and a final judgment, but 9 U. S. C. §10 limits the grounds on which courts can vacate arbitral awards.").

[16] *See generally* Nicola F. Maaser, Decision-making in Committees: Game-theoretic Analysis (2010).

doi:10.6342/NTU201601682

power with political culture to work through. [17][530] Conversely, decentralization of public decisions was displayed in public good games which traditionally focused on the social welfare and public policy modeling. [18][404]

Equally relevant studies could be the newly emerged research on the linkages of systemic processes between social systems (and the relevant subsystems such as legal systems for governments) and global ecosystems retained the adaptability in applications of ecological principles differentiating from the abstract symbols in evolutionary controls and sustainability on human systems. [19][529] Make no mistake about it, developmental complex dynamics of long-term and short-term changes in levels of organizations can be simplified by linearizing the developmental processes. [20][556] But some methodological concerns were pointed out the problematic grounds simplified the applications of mathematical theories, eg. some of the postmodernist applications of catastrophe theory in social science. [21][550] Poststructuralism studies showed that social orders incapable of being avoided from functions of human agency were conceptually structured by disorders, where the boundaries of human agency

[17] *See* Rem G. Khlebopros et al., Catastrophes in Nature and Society: Mathematical Modeling of Complex Systems 298-304 (2007).

[18] *See generally* Mordecai Kurz, *Game Theory and Public Economics*, *in* 2 Handbook of Game Theory with Economic Applications 1153 (Robert J. Aumann & Sergiu Hart eds., 1994).

[19] *See* Hartmut Bossel, Systems and Models: Complexity, Dynamics, Evolution, Sustainability 235-49, 253 (2007) (advocating an approach to study human systems and social sustainability).

[20] *See* Paul van Geert, *Nonlinear Complex Dynamical Systems in Developmental Psychology*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 242 (Stephen J. Guastello et al. eds., 2009).

[21] *See* Tim Poston & Ian Stewart, Catastrophe Theory and its Applications 410-1 (1978) ("Self-proclaimed 'scientific' and 'objective' economic theories notwithstanding, ideology/world view/paradigm is crucial to the choice of a model. ..... The role of mathematics is not to mediate between models, but to clarify individual theories and reveal more of their implications than meets the eye, so that these implications may be compared with observation.").

doi:10.6342/NTU201601682

are mentioned in systems theory on the control mechanisms. [22][528]

Mathematical modeling was very powerful for providing macro-view insights for analyzing ecological and social phenomena or finding solutions to the real-world problems by making pertinent interpretations of the outcomes of the models and concisely verifying the modeling processes. [23][538] In the following examples, this thesis introduced that the evolutionary theories from systemic perspectives motivate the evolution processes of manufacturing social institutions which are driven by noise and affected by emergent behaviors. [24][557]

Complex adaptive system theory as its nature of self-organizing properties and reconstructing complexity of systems is a newly tool to study adaptive behaviors of agents and to help transfer informations of social networks. [25][558]

Perhaps it is worth acknowledging here that, from the systemic perspectives, corresponding to the interactions of human and non-human agents, theories were conceptualized in theoretically boundless and indiscriminate definitions that differed between functionalist or agent-based computing perspectives on complex social-

[22] *See* Norman Jackson & Pippa Carter, Rethinking Organisational Behaviour: A Poststructuralist Framework 55-6, 226 (2d ed. 2007).

[23] *See* Horst R. Thieme, Mathematics in Population Biology 1-2 (2003) ("Modeling is an attempt to see the wood for the trees.").

[24] *See* Peter Allen, *Complexity, Evolution, and Organizational Behavior*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 452, 459-72 (Stephen J. Guastello et al. eds., 2009) ("In ecological and human systems, emergent structural attractors can occur simply because their particular emergent capabilities or behaviors succeeds in getting resources from the environment.").

[25] *See* Matthijs Koopmans, *Epilogue: Psychology at the Edge of Chaos*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 506, 521-2 (Stephen J. Guastello et al. eds., 2009) ("The interest in emergence in terms of the behaviors of lower-level components also justifies the need for agent-based modeling. ..... Agent-based modeling can analyze emergent social phenomena (e.g., the emergence of hierarchy) and evolutionary dynamics (e.g. patterns of change) as being dependent on the behavior and characteristics of individual agents, such as the rate at which they learn and interact with other units.").

doi:10.6342/NTU201601682

ecological systems. [26][478] In all actuality, adaptive traits for modeling decisions of agents while artificially evolved traits for modeling complex evolving behaviors by individual-based modeling focused on how to make good choices by evaluations, thus the decision heuristics played a central and crucial part of the individual-based modeling. [27][491] For instance, considering highly multi-dimensional uncertainty analysis, the approaches mentioned above applied in settlements were once emerged, regarding the prey species models moving towards realism by constructing a agent-based model, however this approach could not imply human societies. [28][519]

Nevertheless, this thesis accepted the fact that nonlinear dynamical systems with strong hypothesis which generating the data set with the peripheral properties showed significant results in modeling nonlinear processes. [29][555] For instance, there was a reasonable systemic application that considering the traffic dynamics for the micro-macro modeling on the objects of finding equilibria solutions, it generalized the known elements of social agents but shocked from social values out of the modeling control. [30][533]

---

[26] *See* Andrew Halliday & Marison Glaser, *A Management Perspective on Social Ecological Systems: A Generic System Model and Its Application to A Case Study From Peru*, 18 Human Ecology Review, no. 1, 2011, at 1, 2-4.

[27] *See* Volker Grimm & Steven F. Railsback, Individual-based Modeling and Ecology 255-60 (2005).

[28] *See* David O'Sullivan & George L. W. Perry, Spatial Simulation: Exploring Pattern and Process 258-64 (2013) ("Similar decisions about the movement of the prey species and its relevance to the questions of interest would have to be addressed and would raise further difficult questions about chance encounters between humans and prey, along with our usual concerns about spatial and temporal scale, grain and extent.").

[29] *See* Stephen J. Guastello & Larry S. Liebovitch, *Introduction to Nonlinear Dynamics and Complexity*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 1, 32-5 (Stephen J. Guastello et al. eds., 2009).

[30] *See* Reinhard Illner et al., Mathematical Modelling: A Case Studies Approach 184-92 (2005).

doi:10.6342/NTU201601682

2.2.3 Competence-competence and Separability

Performing Doctrines of Competence-competence and Separability

In harmony with the New York Convention 1958, the power and the mirroring effect of national courts and arbitrators in arbitral proceedings would be governed by the principles of competence-competence and the timing of judicial reviews; in this trends, more and more countries put in practice exercising the negative effect of the principles competence-competence in order to exemplify the international arbitral autonomy of international commercial arbitration. [31][56] It was noticeable that the ambiguity of doctrines of competence-competence and separability would be not explicitly convergent into the scope of arbitral agreements or the statute of *res judicata* effects but the liberal interpretations of national courts intervening to arbitral proceedings to resolve the ambiguity and dilemma situations. [32][72]

The UNCITRAL Model Law §16 applied the doctrines of competence-competence and separability that would provide international commercial arbitration efficiency in the scopes of jurisdictions. [33][52][5] One should consider the theme from another angle, as doctrines of competence-competence applied in the mixture of positive and negative dimensions that determined the equilibrium of interests between arbitral

[31] *See generally* Emmanuel Gaillard & Yas Banifatemi, *Negative Effect of Competence-competence: the Role of Priority in Favour of the Arbitrators*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 257 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

[32] *See generally* George A. Bermann, *Arbitrability Trouble*, 23 Am. Rev. Int'l Arb. 367 (2012).

[33] *See* Marianne Roth, *UNCITRAL Model Law on International Commercial Arbitration*, *in* Practitioner's Handbook on International Commercial Arbitration 953, 1021-3 (Frank Bernd Weigand ed., 2d ed. 2009). *See also* UNCITRAL Model Law (amended, 2006) ("Article 16. Competence of arbitral tribunal to rule on its jurisdiction (1) The arbitral tribunal may rule on its own jurisdiction, including any objections with respect to the existence or validity of the arbitration agreement.").

doi:10.6342/NTU201601682

jurisdictions, the national courts would be incentivized to bargain with the private contracting parties on the international enforceability of the primary or the second arbitral jurisdictions. [34][83][12] But under some extrinsic circumstances of national arbitral forums, competence-competence and doctrines of separability were taken as extraneous principles in adopting presumptions of international arbitral procedural functions. [35][20]

Balancing Legitimacy Interests and Efficacy Costs

The new French arbitration law had simplified the post-award procedures. [36][74] In comparisons from another way of looking at this legal transformation would be that competence of arbitral tribunals under federal arbitration policies was limited in interstate arbitrations with unitary implements on the case law regarding the principles of arbitrability, in other words, the enforcement of the state arbitration law in conflicts of FAA Sec. 10 (c) would change the interstate grounds for defenses

[34] *See* George A. Bermann, *The UK Supreme Court Speaks to International Arbitration: Learning From the Dallah Case*, 22 Am. Rev. Int'l Arb. 1, 14-20 (2011). *See also* Dallah Real Estate v. Pakistan [2010] UKSC 46 ("Lord Hope: 148. The essential question in this case, as Lord Mance and Lord Collins explain in paras 2 and 132 of their judgments, is whether the Government of Pakistan has proved that there was no common intention (applying French law principles) between it and Dallah that it should be bound by the arbitration agreement. This is a matter which goes to the root of the question whether there was jurisdiction to make the award. As such, it must be for the court to determine. It cannot be left to the determination of the arbitrators. 149. For the reasons set out in the opinions of Lord Mance and Lord Collins, I agree that the facts point inevitably to the conclusion that there was no such common intention. As Lord Mance says in para 66, the agreement was deliberately structured to be, and was agreed, between Dallah and the Trust. I also agree that the Court of Appeal was right not to interfere with the judge's exercise of his discretion to refuse enforcement of the award. I too would dismiss the appeal.").

[35] *See* 1 Gary B. Born, International Commercial Arbitration 402-4 (2009).

[36] *See* Thomas Clay, *Liberté, Égalité, Efficacité: La devise du nouveau droit français de l'arbitrage Commentaire article par article*, 139 Journal du Droit International, no.2, 2012, at 443, 464 ("Le dispositif a été totalement repensé et simplifié puisque les sentences n'ont plus besoin d'être assorties de l'exequatur pour faire courir les délais de recours (art. 1494 et 1519), et elles n'ont même plus besoin d'être signifiées: une simple notification suffit si les parties le décident (art. 1484, al. 3, 1519, al. 3 et 1522, al. 3).").

doi:10.6342/NTU201601682

between interstate and international commercial arbitration. [37][63][8] At any rate, validity of arbitration clauses insulated from the doctrines of separability would be transformed into legal issues of enforceability in civil justice systems through the lens of procedural rule-makings. [38][87] As it turns out, finding the equilibria of arbitral efficacy and legitimacy interests was on the main stage of autonomy of arbitration agreement built on the legal basis of doctrines of competence-competence and separability by §1447, §1448, §1465 French Code of Civil Procedure; the negative competence-competence of French courts would increase the problems of generating superfluous efficacy costs. [39][71][3]

---

[37] *See* Richard E. Speidel, *Common Legal Issues in American Arbitration Law*, *in* ARBITRATION LAW IN AMERICA: A CRITICAL ASSESSMENT 29, 43-5 (Edward Brunet et al. eds., 2006). *See also* FEDERAL ARBITRATION ACT [FAA], 9 U.S.C. §1-16, §201-8, §301-7 (amended, 1990) ("Sec. 10 (c) The United States district court for the district wherein an award was made that was issued pursuant to section 580 of title 5 may make an order vacating the award upon the application of a person, other than a party to the arbitration, who is adversely affected or aggrieved by the award, if the use of arbitration or the award is clearly inconsistent with the factors set forth in section 572 of title 5.").

[38] *See* David Horton, *Arbitration as Delegation*, 86 N.Y.U. L. REV. 437, 449-66 (2011).

[39] *See* George A. Bermann, *The "Gateway" Problem in International Commercial Arbitration*, 37 YALE J. INT'L L. 1 (2012). *See also* CODE DE PROCÉDURE CIVILE [C.P.C.] [CODE OF CIVIL PROCEDURE] art. 1442-1527 (Fr.) (amended, 2011) ("§1447 La convention d'arbitrage est indépendante du contrat auquel elle se rapporte. Elle n'est pas affectée par l'inefficacité de celui-ci. Lorsqu'elle est nulle, la clause compromissoire est réputée non écrite. §1448 Lorsqu'un litige relevant d'une convention d'arbitrage est porté devant une juridiction de l'Etat, celle-ci se déclare incompétente sauf si le tribunal arbitral n'est pas encore saisi et si la convention d'arbitrage est manifestement nulle ou manifestement inapplicable. La juridiction de l'Etat ne peut relever d'office son incompétence. Toute stipulation contraire au présent article est réputée non écrite. §1465 Le tribunal arbitral est seul compétent pour statuer sur les contestations relatives á son pouvoir juridictionnel.").

doi:10.6342/NTU201601682

2.2.4 Arbitration and the Constitution

Macro-view on Dispute Resolution Processes

It was generally thought that procedural irregularity or discovering vacatur the grounds for the annulments of arbitral awards under the domestic arbitration laws controlled by arbitral autonomy would be contractually modifying the grounds for judicial review proceedings. [40][19] The *Hall Street* case on the Supreme Court's opinions toward the Federal Arbitration Act was apparently divergent. [41][68][13] In *Hall Street* case, the U.S. Supreme Courts refused to recognize the validity of contracting to expand the scope of post-award judicial reviews in predispute stages of domestic arbitrations but did not countermine the manifest disregard standard as the grounds for vacatur. [42][96] Addressing the issues on separation of powers with a vertical observations of courts and arbitration, generating insights of the federalism on the enforcements of arbitration awards, focusing on the individual liberties in arbitration proceedings were the three parts of the book *Arbitration and*

---

[40] *See* Peter B. Rutledge, Arbitration and the Constitution 115-9 (2013).

[41] *See* George A. Bermann, Book Review, 24 Am. Rev. Int'l Arb. 197, 199 (2013) (reviewing Peter B. Rutledge, Arbitration and the Constitution (2013)). *See also* Hall Street Associates, L.L.C. v. Mattel, Inc., 552 U.S. 576 (2008) ("The Federal Arbitration Act (FAA or Act), 9 U. S. C. §1 et seq., provides for expedited judicial review to confirm, vacate, or modify arbitration awards. §§9-11 (2000 ed. and Supp. V). The question here is whether statutory grounds for prompt vacatur and modification may be supplemented by contract. This thesis held that the statutory grounds are exclusive. ... This argument comes upshort because, although there may be a general policy favoring arbitration, the FAA has textual features at odds with enforcing a contract to expand judicial review once the arbitration is over. ... In holding the §10 and §11 grounds exclusive with regard to enforcement under the FAA's expedited judicial review mechanisms, this Court decides nothing about other possible avenues for judicial enforcement of awards.").

[42] *See* W. Michael Reisman & Heide Iravani, *The Changing Relation of National Courts and International Commercial Arbitration*, 21 Am. Rev. Int'l Arb. 5, 24-5 (2010).

doi:10.6342/NTU201601682

the Constitution. [43][69] As previously demonstrated, judicial control on the scope of reviewing arbitral awards should be rigorously differentiated from the adoption of principles of party autonomy in domestic arbitral jurisdictions, as *Hall Street* case. [44][111] Notwithstanding, party autonomy regarding the freedom of contract for the parties contracting in advance the procedural control subjecting to post-award judicial reviews was declined by the courts for jurisprudential legitimacy and state policy on arbitration in the *Hall Street* case, it renovated the rhetoric-reality gaps in national arbitral jurisprudence. [45][79]

2.2.5 Party Autonomy in Arbitral Proceedings

The doctrine of party autonomy for arbitral agreements of consolidating arbitrations involving the judicial control, for the purposes of efficient settlements of multiparty disputes, the multiparty clauses are required to form the base of multiparty or classwide arbitrations by unifying the allegements of the parties and balancing the multiple interests in arbitral proceedings. [46][122] Internationality of international business-to-business transactions was also constitute of substantive neutrality and

---

[43] *See* S.I. Strong, *Constitutional Conundrums in Arbitration*, 15 Cardozo J. Conflict Resol. 41, 46-69 (2013) (reviewing Peter B. Rutledge, Arbitration and the Constitution (2013)).

[44] *See* David W. Rivkin & Eric P. Tuchmann, *Protecting Both the FAA and Party Autonomy: the Hall Street Decision*, 17 Am. Rev. Int'l Arb. 537, 540-2 (2006).

[45] *See* Lawrence A. Cunningham, *Rhetoric Versus Reality in Arbitration Jurisprudence: How the Supreme Court Flaunts and Flunks Contracts*, 75 Law & Contemp. Probs. 129, 146-57 (2012).

[46] *See* Okuma Kazutake, *Party Autonomy in International Commercial Arbitration: Consolidation of Multiparty and Classwide Arbitration*, 9 Ann. Surv. Int'l & Comp. L. 189, 212-4 (2003).

doi:10.6342/NTU201601682

party autonomy. [47][92] In effect, it could be seen that the international cooperation constructed not only in avenues of judicialization of international laws but also the international adjudication which proceeded in international dispute resolutions that ratified the independence of international tribunals got weak influence of the parties or international institutions. [48][115]

Transnational Aspects of Party Autonomy

Over the decades there has been an increase in cooperative trends of uniformly internal legislations of harmonization in determining jurisdiction and choice of law has sprung up in private international law principles in Europe, party autonomy in the world-wide trends would be enhanced. [49][65] The scope of party autonomy in Canadian arbitral jurisprudence was expanded as emphasizing the primacy to the international comity of international commercial arbitration and private global market actors. [50][120] Approving the party autonomy doctrine applied in national procedural laws would be found in the Sec. 1 (6) the English Arbitration Law 1996. [51][121][7] Scopes of the independence and impartiality in international adjudication in correspondence with the party autonomy would be extended by the recognitions

[47] *See* Markus A. Petsche, *International Commercial Arbitration and the Transformation of the Conflict of Laws Theory*, 18 Mich. St. J. Int'l L. 453, 471 (2010).

[48] *See* Eric A. Posner & John C. Yoo, *Judicial Independence in International Tribunals*, 93 Cal. L. Rev. 1, 72-4 (2005).

[49] *See* Ronald A. Brand, *Balancing Sovereignty and Party Autonomy in Private International Law*, *in* Liber Memorialis Petar Šarčević: Universalism, Tradition, and the Individual 35, 41-4 (J. Erauw et al. eds., 2006).

[50] *See* Catherine Walsh, *The Uses and Abuses of Party Autonomy in International Contracts*, 60 U.N.B. L.J. 12, 31 (2010).

[51] *See* C. Chatterjee, *The Reality of the Party Autonomy Rule in International Arbitration*, 20 J. Int'l Arb. 539, 542 (2003). *See also* Arbitration Act (U.K.) (1996) ("1. (b) the parties should be free to agree how their disputes are resolved, subjectonly to such safeguards as are necessary in the public interest.").

doi:10.6342/NTU201601682

of the principle *res judicata*. [52][86] The principles *res judicata* effect, that widely held, deeply rooted in civil and common laws, was reasoned from the vacant position of the legal concept of *stare decisis* in international commercial arbitration. [53][28] Role of *stare decisis* was sometimes perplexed in the international adjudication, which held destabilized values of international legal legitimacy, should be integrated in proper legal statutes enhancing the domestically enforceability of international laws on foreign affairs. [54][80] It is interesting to note that lack of legal precedents that caused uncertainty and reverseless mechanisms of arbitrations made the legal scholarships refuse to choose arbitrations as the main dispute resolution approaches in international space laws. [55][148]

It was quite clear from those observations mentioned above that substantive neutrality created by the arbitral tribunals in choosing the applicable governing rules of substantive laws for arbitral proceedings should not be any party's domestic laws; this ways of promoting substantive neutrality somewhat enhanced the functions of party autonomy in international commercial contracts. [56][97] For alleviating the tension of judicial supervisions and post-award control on multiple interest-based arbitrations, the UNCITRAL Model Law §35 was suitable for most country to ratify the rules and to apply it as the grounds for securing the uniform treatments of

---

[52] *See* Fabien Gélinas, *The Independence of International Arbitrators and Judges: Tampered With or Well Tempered?*, 24 N.Y. Int'l L. Rev. 1, 38-48 (2011).

[53] *See* Jane Jenkins & Simon Stebbings, International Construction Arbitration Law 281-2 (2006).

[54] *See generally* Michael P. Van Alstine, *Stare Decisis and Foreign Affairs*, 61 Duke L.J. 941 (2012).

[55] *See* Gérardine Meishan Goh, Dispute Settlement in International Space Law: A Multi-Door Courthouse for Outer Space 117-8 (2007).

[56] *See* Joshua D. H. Karton, *Party Autonomy and Choice of Law: Is International Arbitration Leading the Way or Marching to the Beat of Its Own Drummer?*, 60 U.N.B. L.J. 32, 49-54 (2010).

doi:10.6342/NTU201601682

arbitral awards in multiparty contractual arbitrations. [57][40][5]

2.2.6 Arbitral Autonomy for Consent-based Arbitrations

Distinguishing the judicial control of national and non-national arbitral tribunals from arbitral legislations of international spheres was referred to the international arbitral autonomy on the doctrine of separability and the interference of national courts for arbitral autonomy in adopting national procedural laws. [58][62]

The English judicial predisposition in early time toward arbitral autonomy was unique compared with the modern time that the judges could expand their power in supervisions of arbitrations for the purposes of protecting the arbitral autonomy. [59][142] Arbitral procedures revealed the key roles as the enforcement of awards in self-contained trade group arbitrations. [60][145] According to doctrines of sovereign immunity, if international commercial arbitration proceedings involved the states, it will be a barrier to the arbitral jurisdictions that the states will not be substantially bound by the arbitration agreements. [61][88][149]

---

[57] *See* Isaak I. Dore, Theory and Practice of Multiparty Commercial Arbitration With Special Reference to the UNCITRAL Framework 122-3 (1990). *See also* UNCITRAL Model Law (amended, 2006) ("Article 35. (1) An arbitral award, irrespective of the country in which it was made, shall be recognized as binding and, upon application in writing to the Part One. UNCITRAL Model Law on International Commercial Arbitration 21 competent court, shall be enforced subject to the provisions of this article and of article 36.").

[58] *See* Julian D.M. Lew, *Achieving the Dream: Autonomous Arbitration?*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 455, 471-9 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[59] *See* William W. Park, *The Lex Loci Arbitri and International Commercial Arbitration*, 32 Int'l L. & Comp. L.Q., no. 1, 1983, at 21, 45-7.

[60] *See* Soia Mentschikoff, *Commercial Arbitration*, 61 Colum. L. Rev. 846, 857-8 (1961).

[61] *See* Renata Brazil-David, *International Commercial Arbitration Involving A State Party and the Defense of State Immunity*, 22 Am. Rev. Int'l Arb. 241, 255-6 (2011). *See also* Mary Ellen O'Connell, International Dispute Resolution: Cases and Materials 370-7 (2006).

doi:10.6342/NTU201601682

2.3 Trust, Reputation, Reciprocity in Settlements

2.3.1 Trust Game and Dispute Resolution Bargaining

Trust games are based on two-stage games playing by an investor and a trustee. The game rules of trust games are about offering and returning actions, where the investor can decide to donate or not donate, while the trustee can decide to return or not. The players take actions without knowing any learning information of the other in advance. Through the study on replicated dynamics of payoffs of the trust game, this thesis found out that the Trustee who returns part of the donation will gain reputation, otherwise, he became notorious. [62][419]

The trust game rules can be connected with the multistage disputes resolution bargaining. More specifically, corporate trust games with asymmetric information may face the loss of equilibria, in that case, enhancing the value of trust with full information in firms would be better business policies. [63][391]

Multistage negotiations or mediation-arbitration-bargaining models designed by Kissinger's works were introduced, which emphasized the convergence of settlements in procedures. [64][372] In addition of that, renegotiation of equilibrium in finitely or infinitely repeated games, as the latter with weak renegotiation-proofness, is by definition the Pareto optimality of the equilibrium restriction risen by the players renegotiating the coordinate agreements without bounded by the law where the sce-

[62] *See* Karl Sigmund, The Calculus of Selfishness 116-20 (2010).

[63] *See* Leonardo Becchetti & Noemi Pace, *Corporate Trust Games in Modern Knowledge Economies*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 353, 368-74 (Lorenzo Sacconi et al. eds., 2011).

[64] *See* Steven J. Brams, Negotiation Games: Applying Game Theory to Bargaining and Arbitration 93-6 (2d ed. 2003).

doi:10.6342/NTU201601682

narios are distinctive from negotiating processes of legal contracts. [65][380] Classical efficiency in Bayesian collective choice problems becomes difficult to be found in an incomplete information game, but it can be improved by the renegotiation-proofness though it is not in the Pareto. [66][406]

In trust games, one argument in support of the applications above is that the self-interested parties' taking actions of trust in legal contracts were similar with the players gaining from learning in finitely repeated centipede games as multistage trust games. [67][370] Social environments would be the key elements to alter the evolution mechanisms of dissident behaviors among social individuals, where the social intelligence was directly proportional to the general trust. [68][418]

2.3.2 Reputation

Gaining Reputation in Bargaining

As the thesis noticed in the previous section on the trust game rules, one of the most striking features is that when the players involving into the bargaining processes of dispute resolution, consolidating the reputation formation of every interacting agent in finitely or infinitely repeated multilateral bargaining games approaching the equilibrium would meet the efficacy of conjecturing the movements of other agents in

[65] *See* Drew Fudenberg & Jean Tirole, Game Theory 174-82 (1991).

[66] *See* Françoise Forges, *Some Thoughts on Efficiency and Information*, *in* Frontiers of Game Theory 133, 135-6 (Ken Binmore et al. eds., 1993).

[67] *See* Colin F. Camerer, Behavioral Game Theory: Experiments in Strategic Interaction 83-95, 218-21, 446-59 (2003).

[68] *See* Toshio Yamagishi, Trust: the Evolutionary Game of Mind and Society 110-2 (2011).

doi:10.6342/NTU201601682

bargaining processes. [69][371] Multistage decision models of contract formation were under cooperative bargaining game structures, where would exist the bifurcations for bargaining processes of justice. [70][389] However, the reputational model was set in a uni-directional procedure that a sophisticated short-run player would learn the strategies of a long-run player to play the best response, which was excluded from typical learning theories but categorized in the equilibrium theories which made contributions of carrying the equilibrium learning into the nonequilibrium learning. [71][375] Reputation showed the social learning. [72][489] Thus, tracking behaviors of agents and collecting feedbacks after interactions of the reputation systems of a organization would be an important analysis model for observations of macro-view social simulations or predictions of micro-view peer incentive reports. [73][394]

It is important to recognized that norms in social contracts for corporate social responsibility in analysis borrowed from a source of trust game for stakeholders. [74][388] By many accounts of transactional examples, repeated trust games with replicator dynamics were possibly studied for the reputation interests evaluations

---

[69] *See* Fernanado Vega-Redondo, Economics and the Theory of Games 294-320 (2003).

[70] *See* Lorenzo Sacconi, *A Rawlsian View of CSR and the Game Theory of Its Implementation (Part II): Fairness and Equilibrium*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 194, 214-6, 224-8 (Lorenzo Sacconi et al. eds., 2011).

[71] *See* Drew Fudenberg & David K. Levine, The Theory of Learning in Games 261-3 (1998).

[72] *See* Flaminio Squazzoni, Agent-based Computational Sociology 63 (2012).

[73] *See generally* Eric Friedman et al., *Manipulation-Resistant Reputation Systems*, *in* Algorithmic Game Theory 677 (Noam Nisan et al. eds., 2007).

[74] *See* Lorenzo Sacconi, *A Rawlsian View of CSR and the Game Theory of Its Implementation (Part I): the Multi-Stakeholder Model of Corporate Governance*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 157, 179-82 (Lorenzo Sacconi et al. eds., 2011).

doi:10.6342/NTU201601682

of the firms. [75][390] In addition, sophisticated votings of political game-theoretical models showed that agenda-independent amendments procedures harmonized the differences or conflicts. [76][397]

2.3.3 Reciprocal Altruism in Bargaining Processes

Role of Reciprocal Altruism

Reciprocity hypothesis was, rather than social preferences, in trust games based on cooperative behaviors with trust-worthy response showed in the decentralized social or ecological systems as well. [77][314] With categorized information, kin selection, direct reciprocity, indirect reciprocity, network reciprocity, group selection were the five mechanisms of cooperation in evolutionary processes illustrated mathematically by Nowak. [78][551] Kin-directed altruism behaviors as an abstract social process emerged at times in common culture of human adaptations. [79][501] The possible reasons for the indistinction of reciprocal altruism in animal behaviors lacked of the

---

[75] *See* Luciano Andreozzi, *When Reputation Is Not Enough: Justifying Corporate Social Responsibility*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 253, 261-70 (Lorenzo Sacconi et al. eds., 2011).

[76] *See* Jeffrey S. Banks, *Strategic Aspects of Political Systems*, *in* 3 Handbook of Game Theory with Economic Applications 2203, 2207-11 (Robert J. Aumann & Sergiu Hart eds., 2002).

[77] *See* Vernon L. Smith, Rationality in Economics: Constructivist and Ecological Forms 260-80 (2008).

[78] *See* Martin A. Nowak, *Five Rules for the Evolution of Cooperation*, *in* Evolution, Games, and God: the Principles of Cooperation 99, 107-10 (Martin A. Nowak & Sarah Coakley eds., 2013).

[79] *See* Nigel Gilbert, *Modeling Sociality: the View From Europe*, *in* Dynamics in Human and Primate Societies: Agent-based Modeling of Social and Spatial Processes 355, 364-5 (Timothy A. Kohler & George J. Gumerman eds., 2000).

doi:10.6342/NTU201601682

highly social sights of interactions. [80][450] Similarly, iterated prisoner's dilemma interactions based on reciprocity of strategies were widely applied. [81][385]

This thesis found human reciprocal behaviors in friendships or social coalitions, but in other species the altruism behaviors became less apparent in the evolution processes in the long run. [82][549] Strong reciprocity expedited the public good, whereas this type of reciprocity behaviors cannot be categorized in evolutionary theories of cooperation due to its differentiations of indirect reciprocity or reciprocal altruism. [83][489]

In social systems, behaviors of retaliation were necessary for social justice and orders, while behaviors of positive or negative, direct or indirect reciprocity were complementary strategic attitudes for pursuing equilibria of interactions of social agents. [84][395] Recognizing power of reputation in intricate social networks had expanded the web of indirect reciprocity and facilitated the evolution of cooperation flows. [85][520] To illustrate this point, it was supposed better that any social scopes of reciprocity would not deviate from the ways the social reciprocitarian behaviors

[80] *See* Edward O. Wilson, Sociobiology: the New Synthesis 120 (Harv. Univ. Press 2000) (1975) ("Human behavior abounds with reciprocal altruism consistent with genetic theory, but animal behavior seems to be almost devoid of it. Perhaps the reason is that in animals relationships are not sufficiently enduring, or memories of personal behavior reliable enough, to permit highly personal contracts associated with the more human forms of reciprocal altruism.").

[81] *See* Robert Axelrod, The Evolution of Cooperation 190 (1984) ("Many of these problems take the form of an iterated Prisoner's Dilemma. Examples can include arm races, nuclear proliferation, crisis bargaining, and military escalation.").

[82] *See generally* James F. Wittenberger, Animal Social Behavior 76-109 (1981).

[83] *See* Flaminio Squazzoni, Agent-based Computational Sociology 42-9 (2012).

[84] *See generally* Vincy Fon & Francesco Parisi, *Revenge and Retaliation*, *in* The Law and Economics of Irrational Behavior 141 (Francesco Parisi & Vernon L. Smith eds., 2005).

[85] *See* Martin A. Nowak & Roger Highfied, Supercooperators: Altruism, Evolution, and Why We Need Each Other to Succeed 51-63 (2012).

doi:10.6342/NTU201601682

motivated reciprocal fairness. [86][271]

In legal systems, methodology of functional law and economics for lawmakers was pertained by restrictions of choice of law and the reciprocity for legislations. [87][280] Reciprocity requirements for enforcing foreign judgments in civil litigation processes were frustrated with the political abstraction. [88][105]

2.3.4 Uncertainty in Bargaining Processes

Though methodological and philosophical spheres arouse controversy on identically regarding of *Droit* and *Loi*, this theory escalated its influence in legal practices in 1850s. [89][228] This presented an useful concept on the theory-building issues. Judicial decisions were made to approach justice or reproductive judgements that consisted in legal rules or the law (*loi*), where existed the *Epokhé* of the rules. [90][235]

Uncertainty in Dynamical Processes

Resolving uncertainty of decision-making processes under asymmetric information was studied by the statistical models with Bayesian sets or the Markovian models

[86] *See* Serge-Christophe Kolm, Reciprocity: An Economics of Social Relations 145-9 (2008).

[87] *See* Jonathan Klick & Francesco Parisi, *Functional Law and Economics*, *in* Theoretical Foundations of Law and Economics 41, 46-53 (Mark D. White ed., 2009).

[88] *See* Richard W. Hulbert, *Some Thoughts on Judgments, Reciprocity, and the Seeming Paradox of International Commercial Arbitration*, 29 U. Pa. J. Int'l L. 641, 653-6 (2008).

[89] *See* Carl Schmitt, Über die Drei Arten des Rechtswissenschaftlichen Denkens 25 (3d ed. 2006) ("In Frankreich fand die positivistische Nichtunterscheidung von Recht und Gesetz, die Identität von *Droit* und *Loi*, ihren rechtswissenschaftlichen Ausdruck in der *Ecole de l'exégése*, die ein halbes Jahrhundert–etwa von 1830 bis 1880–unbestritten geherrscht hat und trotz methodologischer und philosophischer Kritik prakitisch auch heute keineswegs beseitigt ist.").

[90] *See* Jacques Derrida, Force de loi: Le "Fondement mystique de l'autorité" 251 (1994).

doi:10.6342/NTU201601682

for the dynamical decision processes. [91][275] If taking the game-theoretical models as implements to make macro-micro linkages of economic activities and market mechanisms, there were generalized with three key concepts for the definitions and the design of mechanisms: an adjustment process, informational decentralization, desirability criterion. [92][274]

It is worth to start at this point that a dynamic conception of competition arose out of the disturbed equilibria that shown abundance meaning in competition processes such as a discovery procedure or a process of creative destruction. [93][269] In global political economy, centre-periphery analytics in dynamic dimensions is rather than macro- power domination but micro- dynamical processes. [94][282]

2.3.5 Court-facilitated Settlements

As mentioned before, reciprocity can be taken as a good strategy for Tit-for-Tat games applied in observations of social evolution. [95][269] When it comes to the court-facilitated settlements, settlement bargaining models of behavioral decision theory provided insights to set distinct aspiration levels of litigation settlements or settlement negotiations bargaining processes. [96][163] In addition of that, it was found that impartiality of final-offer arbitrators suggested its significance due to the

[91] *See* Vyacheslav V. Kolbin, Decision Making and Programming 469-508 (V. M. Donets trans., 2003).

[92] *See* Leonid Hurwicz & Stanley Reiter, Design Economic Mechanisms 24 (2006).

[93] *See* Ejan Mackaay, Law and Economics for Civil Law Systems 140-6 (2013).

[94] *See* David Kennedy, *Law and the Political Economy of the World*, 26 L.J.I.L., no. 1, 2013, at 7, 21-5.

[95] *See* Ejan Mackaay, Law and Economics for Civil Law Systems 90-3 (2013).

[96] *See generally* Russell Korobkin, *Aspirations and Settlement*, 88 Cornell L. Rev. 1 (2002).

doi:10.6342/NTU201601682

union preferences. [97][141] Thus, final-offer arbitrations enhanced the commitments of the parties to resolve disputes and showed effectiveness in descriptive-normative process or decision control of third party processes. [98][168] Sometimes conventional arbitrations will be embedded in decompositions of negotiation processes to make final offer or additional embellishments by the neutral third party to reach the agreements. [99][152]

Pretrial Discovery and Settlement Negotiations

In legal practices, if the parties would like to set the pretrial discovery or settlement negotiations, firstly, settlement agreements in legal changes used to underestimate the potential impacts on the adjudication of settlements. [100][157] However, the settlements out of courts as reactive institutions without accomplishing the justice for parties were against acknowledgements by social values. [101][169] Renegotiation treatments of mechanisms would reduce additional scopes of arbitrations to avoid unsettled situations in bargaining procedures. [102][127]

Ensuring strong renegotiation proofness for a setting pleading mechanisms of

---

[97] *See* Orley Ashenfelter & David E. Bloom, *Models of Arbitrator Behavior: Theory and Evidence*, 74 The American Economic Review, no. 1, 1984, at 111, 116-23.

[98] *See* Roy J. Lewicki et al., *Models of Conflict, Negotiation and Third Party Intervention: A Review and Synthesis*, 13 Journal of Organizational Behavior, no. 3, 1992, at 209, 233, 237-8.

[99] *See* Howard Raiffa, Negotiation Analysis: The Science and Art of Collaborative Decision Making 335-42 (2002).

[100] *See* Ben Depoorter, *Law in the Shadow of Bargaining: the Feedback Effect of Civil Settlements*, 95 Cornell L. Rev. 957, 979-83 (2010).

[101] *See* Owen M. Fiss, *Against Settlement*, 93 Yale L.J. 1073, 1085 (1984).

[102] *See generally* Paul Pecorino & Mark van Boening, *Bargaining and Information: An Empirical Analysis of A Multistage Arbitration Game*, 19 Journal of Labor Economics, no. 4, 2001, at 922.

doi:10.6342/NTU201601682

dispute resolutions was taken as one way for judicial management efficiency. [103][161] Nevertheless, to some extent, restrictions on settlements were implements on cutting back the chilling of legitimate activities. [104][160]

2.3.6 Minding the Costs of Bargaining Proceedings

The task at hand is to reflect that bargaining positions often change with the risks of tolerances and litigation costs in settlement processes pervading extra-judicial alternative dispute resolution spheres in pretrial bargaining proceedings determined by risks or preferences of settlements. [105][250] Logically, it follows that the costs of unpredictable arbitral bargaining plans and contract interpretations for attending the extraterritorial litigation processes in public courts might swayed the incentives of the parties with respect to their choices to resolve disputes. [106][255] However, accessing justice through litigation processes was found difficult for weak consumers in free markets. [107][43]

Financial commitments from insurance regulations would be a good solution

---

[103] *See* Alon Klement & Zvika Neeman, *Against Compromise: A Mechanism Design Approach*, 21 J.L. Econ. & Org., no. 2, 2005, at 285, 300-3 ("Our results indicate that, contrary to the common wisdom that guides recent procedural reforms, courts should not take an active role in facilitating settlements and should not encourage parties to use alternative means for resolving their disputes.").

[104] *See* Ezra Friedman & Abraham L. Wickelgren, *Chilling, Settlement, and the Accuracy of the Legal Process*, 26 J.L. Econ. & Org., no. 1, 2008, at 144, 152 ("Our model suggests that restrictions on settlement in medical malpractice cases might be one way to reduce the chilling of good doctors without reducing the deterrent effect of malpractice claims on bad doctors.").

[105] *See* Jonathan T. Molot, *Litigation Finance: A Market Solution to A Procedural Problem*, 99 Geo. L.J. 65, 75-6 (2010).

[106] *See* Jens Dammann & Henry Hansmann, *Globalizing Commercial Litigation*, 94 Cornell L. Rev. 1, 34-8 (2008).

[107] *See* Omri Ben-Shahar, *Arbitration and Access to Courts: Economic Analysis*, *in* Regulatory Competition in Contract Law and Dispute Resolution 447, 466 (Horst Eidenmüller ed., 2013).

doi:10.6342/NTU201601682

to litigation-risk problems. [108][253] Organizational litigants would apparently hold higher settlement rate than individual litigants due to the repeat-play incentives with regards of risks. [109][257] Bargaining processes in litigations were often two-side incomplete information games that would ended up generating multiple equilibria with variations of litigation costs. [110][166]

Hence, the pretrial settlement negotiations would make the litigants vacillate between forsaking their incentives to litigations or enhancing their determination on trials. [111][258] In as much as the deterrence concerns by laws, it was shown a much more effective motivation than dispute resolution expenses when it comes to the incentives for arbitrations. [112][124] Pretrial bargaining processes aimed at seeking for common interests of parties which differed from bilateral negotiations and thus ended up with revaluing the need of litigations by the lawyers and their clients. [113][167] Yet in another cases, bargaining and decision-making processes in multi-party negotiations would fail when impairing the equilibria of the interests or misleading the consensus of values. [114][162] Post-arbitration processes would sometimes increase financial risks for foiling the risk-neutral timing advances with

---

[108] *See* Jonathan T. Molot, *A Market in Litigation Risk*, 76 U. Chi. L. Rev. 367, 432 (2009).

[109] *See* Gillian K. Hadfield, *Exploring Economic and Democratic Theories of Civil Litigation: Differences Between Individual and Organizational Litigants in the Disposition of Federal Civil Cases*, 57 Stan. L. Rev. 1275, 1319 (2005).

[110] *See* Alison Watts, *Bargaining Through An Expert Attorney*, 10 J.L. Econ. & Org., no. 1, 1994, at 168, 181.

[111] *See generally* Peter H. Huang, *Lawsuit Abandonment Options in Possibly Frivolous Litigation Games*, 23 Rev. Litig. 47 (2004).

[112] *See* Christopher R. Drahozal & Keith N. Hylton, *The Economics of Litigation and Arbitration: An Application to Franchise Contracts*, 32 J. Legal Stud. 549, 581 (2003).

[113] *See generally* Kathryn E. Spier, *The Dynamics of Pretrial Negotiation*, 59 Review of Economics Studies, 1992, at 93.

[114] *See* Robert H. Mnookin, *Strategic Barriers to Dispute Resolution: A Comparison of Bilateral and Multilateral Negotiations*, 8 Harv. Negot. L. Rev. 1, 14-9 (2003).

doi:10.6342/NTU201601682

unbalanced bargaining power due to the distributions of information during the arbitration hearings. [115][137]

2.4 Strategic Behaviors in Bargaining Dynamics

2.4.1 Evolving Nature of Bargaining Dynamics

Taken as a whole, adequate procedural flexibility and sufficient preparation are key elements for individuals or the parties who are fully committed to take the non-adjudicative alternative dispute resolutions as approaches to reach agreements. [116][146] Equally important is that conflicts of interests and the mechanisms regarding communications determined the effectiveness and the optimum of the functions of mediations and negotiations. [117][158] Mapping bargaining plans starting through predispute processes would help find the equilibria of interests of the parties and make efficient and accurate enforcements of settlement agreements. [118][153]

In spite of negotiations, mediations as extra-judicial functions played evolving roles in court-based proceedings; the desirability of the judges for being mediators could reverberate the procedural efficacy for mediated settlements and enhanced the international enforceability of settlement agreements for the parties. [119][147]

---

[115] *See* Lisa Bernstein, *Understanding the Limits of Court-connected ADR: A Critique of Federal Court-annexed Arbitration Programs*, 141 U. Pa. L. Rev. 2169, 2234-7 (1993).

[116] *See* Susan Blake et al., A Practical Approach to Alternative Dispute Resolution 24-31 (2d ed. 2012).

[117] *See generally* Maria Goltsman et al., *Mediation, Arbitration and Negotiation*, 144 Journal of Economic Theory, 2009, at 1397.

[118] *See* Gerhard Wagner, *Dispute Resolution As A Product: Competition Between Civil Justice Systems*, *in* Regulatory Competition in Contract Law and Dispute Resolution 347, 378-9 (Horst Eidenmüller ed., 2013).

[119] *See* Nadja Alexander, International and Comparative Mediation: Legal Per-

doi:10.6342/NTU201601682

Considered from the arbitration perspectives, some studies suggested that final-offer arbitrations caused higher dispute rate and eradicated the chilling conditions in bargaining processes. [120][138] Compared with the hybrid (over two methods in the sequence) and the mixed (multiple methods) approaches in the bargaining of international dispute resolutions, the mixed approach takes more advantages than the hybrid method. [121][156] While this may be true that arbitration clauses adhered to commercial contracts aiming at protecting innovation commercial information will reflect the market pressures of international transactions. [122][42]

So far, it is clear that pragmatics in bargaining proceedings would not apparently increase its potential efficiency in arbitration or negotiation procedures. [123][159] Uncertainty becomes a thorough problem for distributions of power in negotiation processes with asymmetrical bargaining frameworks. [124][150] Although it may be true that the more information the parties get from their cases or from the neutral outsiders in alternative dispute resolution processes, the more possibility of reducing the client-lawyer agency problems, [125][165] game-theoretical normatively analysis approaches which were prescriptively used for dispute resolutions will not result

---

SPECTIVES 147-8 (2009).

[120] *See generally* Orley Ashenfelter et al., *An Experimental Comparison of Dispute Rates in Alternative Arbitration Systems*, 60 ECONOMETRICA, no. 6, 1992, at 1407.

[121] *See* Anna Spain, *Integrating Matters: Rethinking the Architecture of International Dispute Resolution*, 32 U. PA. J. INT'L L. 1 (2010).

[122] *See* Erin O'Hara O'Connor, *Jurisdictional Competition for Dispute Resolution: Courts Versus Arbitration*, *in* REGULATORY COMPETITION IN CONTRACT LAW AND DISPUTE RESOLUTION 427, 437-41 (Horst Eidenmüller ed., 2013).

[123] *See generally* María de las Mercedes Adamuz & Clara Ponsatí, *Arbitration Systems and Negotiations*, 13 REV. ECON. DESIGN, 2009, at 279.

[124] *See* KLAUS WINKLER, NEGOTIATIONS WITH ASYMMETRICAL DISTRIBUTION OF POWER: CONCLUSIONS FROM DISPUTE RESOLUTION IN NETWORK INDUSTRIES 24-51 (2006).

[125] *See* Steven Shavell, *Alternative Dispute Resolution: An Economic Analysis*, 24 J. LEGAL STUD. 1 (1995).

doi:10.6342/NTU201601682

in exuberant scholarship trends. [126][154] Agent's desires would vibrate negotiation goals and changed the dynamical processes of negotiations. [127][401]

2.4.2 Strategic Behaviors in Decision-makings

Negotiating Rule-makings

While this may be true, negotiation rule-makings imperatively make sense for any strategic movement of conventional or regulatory negotiations where the agencies in the alternative dispute resolutions have to enhance the administrative legitimacy of negotiation rule-making procedures as the institutional design. [128][164] It is worth notice that the key elements of decision-makings in strategic behaviors in negotiation dilemma were as follows: individual, interactive, joint decision-making perspectives; the value claiming and creating decision-makings. [129][152]

Equally relevant to the issues of negotiating rule-makings, macro-micro linkages of modeling negotiation processes were distributed by self-interested agent's general behaviors or the rational strategically decision-making processes. [130][155]

The liability for negotiations contrary to good faith on the grounds with no intention of reaching an agreement can be found in the Principles of European

---

[126] *See* Howard Raiffa, *Contributions of Applied Systems Analysis to International Negotiation*, *in* International Negotiation: Analysis, Approaches, Issues 5, 12-3 (Victor A. Kremenyuk ed., 2d ed. 2002).

[127] *See generally* Mehdi Dastani et al., *Dynamic Desires*, *in* Game Theory and Decision Theory in Agent-based Systems 65 (Simon Parsons et al. eds., 2002).

[128] *See generally* Jody Freeman, *Regulatory Negotiation and the Legitimacy Benefit*, 9 N.Y.U. Envtl. L.J. 60 (2000).

[129] *See* Howard Raiffa, Negotiation Analysis: The Science and Art of Collaborative Decision Making 84-6 (2002).

[130] *See* Julita Vassileva & Chhaya Mudgal, *Bilateral Negotiation With Incomplete and Uncertain Information: Trading Help in A Distributed Peer Help Environment*, *in* Game Theory and Decision Theory in Agent-based Systems 337, 350-2 (Simon Parsons et al. eds., 2002).

doi:10.6342/NTU201601682

Contract Law. [131][6] In bad faith negotiations, when a party interference deliberately all of the chances to reach an agreement, the other party is liable for the expenses out of the negotiations. [132][4]

2.4.3 Multilateral Dispute Resolution Procedures

Equilibrium Strategies and the Coalitions

Power of coalitions constructed main mechanisms of the multilateral bargaining which relied on the incentives of players to reach agreements rather than on the characteristics of equilibrium strategies in bargaining processes. [133][411]

This is consistent with the way of finding equilibrium strategies by following that bilateral negotiations with fixed bargaining costs or fixed discounting factors to reach contractual agreements and then finished the negotiation processes at disparate interests or values; finding the perfect equilibrium preferences of the contracts would be the crucial step of bilateral bargaining. [134][417] To conclude with, elements of bargaining games are generally categorized with players, actions, information,

[131] *See* The Principles of European Contract Law (revised, 2002) ("Article 2:301: (1) A party is free to negotiate and is not liable for failure to reach an agreement. (2) However, a party who has negotiated or broken off negotiations contrary to good faith and fair dealing is liable for the losses caused to the other party. (3) It is contrary to good faith and fair dealing, in particular, for a party to enter into or continue negotiations with no real intention of reaching an agreement with the other party.").

[132] *See* UNIDROIT Principles of International Commercial Contracts (revised, 2010) ("Article 2.1.15: (1) A party is free to negotiate and is not liable for failure to reach an agreement. (2) However, a party who negotiates or breaks off negotiations in bad faith is liable for the losses caused to the other party. (3) It is bad faith, in particular, for a party to enter into or continue negotiations when intending not to reach an agreement with the other party.").

[133] *See generally* Roberto Serrano, *Multilateral Bargaining*, 63 Rev. of Econ. Studies, 1996, at 61.

[134] *See generally* Ariel Rubinstein, *Perfect Equilibrium in A Bargaining Model*, 50 Econometrica, no. 1, 1982, at 97.

doi:10.6342/NTU201601682

strategies, payoffs, outcomes, equilibria, whereas most extensive forms of games were tactful for reasoning about the strategic bargaining of negotiation processes which based on the Rubinstein bargaining theory. [135][506]

Definition of Game

The strategies of a bargaining game of alternating offers with perfect information in negotiation processes was defined as the subgame perfect equilibrium if and only if without any deviation of actions of players in negotiating processes. [136][378]

A concise definition of a bargaining problem by mathematical game theory is quoted as follows: [137][359]

Definition 1. *An n-player bargaining problem with set of players N is a pair (F, d) whose elements are the following:*

Feasible set F is the comprehensive hull of compact and convex subset of $\mathbb{R}^N$.

Disagreement point d is an allocation in F. It is assumed that there is $x \in F$ *such that* $x > d$.

Rubinstein Bargaining Model

Considering the multilateral bargaining processes of game-theoretical models based on the Rubinstein bargaining model, for the proposition of modeling non-repeated alternating offers games the infinite time horizon, was mathematically illustrated

[135] *See* Sarit Kraus, Strategic Negotiation in Multiagent Environments 11-27 (2001).

[136] *See* Martin J. Osborne & Ariel Rubinstein, A Course in Game Theory 117-23 (1994).

[137] *See* Julio González-Díaz et al., An Introductory Course on Mathematical Game Theory 206 (2010).

doi:10.6342/NTU201601682

and quoted as follows: [138][366]

Rubinstein Bargaining Model. *Let players Smith and Jones have discount factors of δ_s and δ_j which are not necessarily equal but are strictly positive and no greater than one.*

In the discounted infinite game, the unique perfect equilibrium outcome is $\theta_s =$

$$\frac{(1-\delta_j)}{1-\delta_s\delta_j}$$

, where Smith is the first mover.

By the way, it is worth to note that the Rubinstein's negotiation model is the basic and classical form at the beginning stage of the multi-period non-cooperative game theory. [139][374]

2.4.4 Hawk-Dove Model

Rivalry Model

Generally analyzing the basic rivalry model, at the beginning of the introduction, consider two different kinds of behaviors: aggressive behaviors (*Hawk*) and peaceful behaviors (*Dove*). The rules for the Hawk-Dove model are quoted as follows: [140][421]

1. When two doves meet, they fairly share the resource R.

[138] *See* Eric Rasmusen, Games and Information: An Introduction to Game Theory 363-4 (4d ed. 2007) ("This model from Rubinstein (1982) is widely used because of the way it explains why two players with the same discount rated to split the surplus equally (the limiting case in the model as the discount rate goes to zero and δ goes to one). Unfortunately, as with the Nash bargaining solution, there is no obvious best way to extend the model to three or more players–no best way to specify how they make and accept offers.").

[139] *See* Ferenc Forgó et al., Introduction to the Theory of Games: Concepts, Methods, Applications 308 (1999).

[140] *See* Jacques Istas, Mathematical Modeling for the Life Sciences 62 (2005).

doi:10.6342/NTU201601682

2. When a hawk and a dove meet, the hawk brings the resource R without fight.

3. When two hawks meet, they fight together. This induces damages P and each hawk bring only half of the resource R minus the damages P.

H denotes the strategy of the *Hawk*, *D* denotes the strategy of the *Dove*, V denotes the fitness values, and C denotes the defeated costs, then the payoff matrix of the Hawk-Dove model is quoted as follows: [141][371][423]

$$\mathbf{A} = \begin{pmatrix} \frac{V-C}{2} & V \\ 0 & \frac{V}{2} \end{pmatrix} \tag{2.4.1}$$

, where $C > \frac{V}{2} > 0$.

The interpretations of the payoffs in the Hawk-Dove model were summarized and quoted as follows: [142][371]

(1) If both individuals adopt strategy *H* (they fight together), then they have the same possibility to overcome the other or being defeated.

(2) If both individuals adopt strategy *D*, then they both have the same possibility to obtain resources.

(3) If one adopt *H* and the other adopt *D*, they either obtain the resources at no cost or does not incur any cost.

Further analyzing the games under each strategy, the possible results are: (1) as $V > C$, the state is trivial; (2) as $V < C$, no pure-strategy Nash equilibrium exists,

[141] *See* Fernanado Vega-Redondo, Economics and the Theory of Games 361 (2003). *See also* Ross Cressman, Evolutionary Dynamics and Extensive Form Games 25 (2003).

[142] *See* Fernanado Vega-Redondo, Economics and the Theory of Games 361 (2003).

doi:10.6342/NTU201601682

but there exists a unique evolutionarily stable strategy of the Hawk-Dove model, quoted as follows: [143][371]

$$\sigma = (\sigma_H, \sigma_D) = (\frac{V}{C}, 1 - \frac{V}{C}) \tag{2.4.2}$$

And then, consider the population of the *Hawk* and the *Dove*. The payoff matrix of (2.4.1) could be quoted as follows: [144][371]

$$\dot{y}(t) = y(t)(1 - y(t))[\frac{V - C}{2}y(t) + V(1 - y(t)) - \frac{V}{2}(1 - y(t))] \tag{2.4.3}$$

$$\dot{y}(t) = \frac{1}{2}y(t)(1 - y(t))[Vy(t) - Cy(t)] \tag{2.4.4}$$

and,

$$y(t) < \frac{V}{C} \Rightarrow \dot{y}(t) > 0 \tag{2.4.5}$$

$$y(t) = \frac{V}{C} \Rightarrow \dot{y}(t) = 0 \tag{2.4.6}$$

$$y(t) > \frac{V}{C} \Rightarrow \dot{y}(t) < 0 \tag{2.4.7}$$

It shows that the evolutionarily stable strategy of the Hawk-Dove model is *global stable* at $(\frac{V}{C}, 1 - \frac{V}{C})$. [145][371]

---

[143] *See* Fernanado Vega-Redondo, Economics and the Theory of Games 362 (2003).

[144] *See* Fernanado Vega-Redondo, Economics and the Theory of Games 370 (2003).

[145] *See* Fernanado Vega-Redondo, Economics and the Theory of Games 371 (2003).

doi:10.6342/NTU201601682

2.4.5 Rock-Scissors-Paper Model

Evolutionary Dynamics

From theories-building perspectives on continuous games, replicator dynamics as new strategies to analyze the existing strategies would rely on the settings of adaptive dynamics of uniformly actions of agents in a very large population. [146][422]

The definition of evolutionarily stable strategy is given by Maynard Smith (1974), quoted as follows: [147][420]

> An evolutionarily stable strategy is a strategy such that, if all members of a population adopt it, then no mutant strategy could invade the population under the influence of natural selection.

Evolutionary Stable Mixed Strategy

In addition, checking the state of the mixed Nash equilibria evolutionary stable could be the key for finding evolutionarily stable strategies of games, and so, in order to precisely understand the evolutionarily stable mixed strategies, the definition is quoted as follows: [148][522]

Definition 2. *In the general symmetric game, p is an evolutionary stable mixed strategy if there is a (small) positive number y such that, when any other mixed strategy q invades p at any level $x < y$, the fitness of an organism playing p is*

[146] *See* Sean H. Rice, Evolutionary Theory: Mathematical and Conceptual Foundations 282-3 (2004).

[147] *See* Thomas L. Vincent & Joel S. Brown, Evolutionary Game Theory, Natural Selection, and Darwinian Dynamics 151 (2005).

[148] *See* David Easley & Jon Kleinberg, Networks, Crowds, and Markets: Reasoning About A Highly Connected World 200 (2010).

doi:10.6342/NTU201601682

strictly greater than the fitness of an organism playing q.

Rock-Scissors-Paper Game

The rules of the Rock-Scissors-Paper game are: R beats S, S beats P, and P beats R. The game is zero sum, where the payoffs are: winning yields 1, losing yields -1, a tie yields 0. And then consider the corresponding payoff matrix, quoted as follows: [149][424][419]

$$\mathbf{A} = \begin{pmatrix} 0 & 1 & -1 \\ -1 & 0 & 1 \\ 1 & -1 & 0 \end{pmatrix}$$

, where the first row and column is associated with *Rock*, and the second row and column is associated with *Scissors*, and the third row and column is associated with *Paper*. This Rock-Scissors-Paper game has a unique Nash equilibrium, which adopts the mixed strategy $\sigma = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$, where σ is not evolutionarily stable strategy. [150][424]

Monotone Selection Dynamics

Further if replace the payoff 1 to ϵ, it shows the monotone selection dynamics of the Rock-Scissors-Paper game. The payoff matrix is quoted as follows: [151][424]

---

[149] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 74 (1998). *See also* Karl Sigmund, The Calculus of Selfishness 41-3 (2010).

[150] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 71 (1998).

[151] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 89 (1998).

doi:10.6342/NTU201601682

$$\mathbf{A} = \begin{pmatrix} 0 & -1 & \epsilon \\ \epsilon & 0 & -1 \\ -1 & \epsilon & 0 \end{pmatrix}$$

It is extended to show that the replicator dynamics such as different types of the Rock-Scissors-Paper games is payoff monotonic; as $\epsilon > 0$, the payoff matrix converges into the boundary. [152][424]

General Rock-Scissor-Paper Game

Consider the general Rock-Scissor-Paper game, quoted as follows: [153][424][429]

$$\mathbf{A} = \begin{pmatrix} 0 & -b & a \\ a & 0 & -b \\ -b & a & 0 \end{pmatrix}$$

with $a, b > 0$.

It illustrates that the function $V := x_1 x_2 x_3$, x_1, x_2, x_3 are the interior points, the best response dynamics for the Rock-Scissor-Paper game shows that all interior points converge into the unique Nash equilibrium $E = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$. [154][424][429]

It follows that, quoted as follows: [155][430]

---

[152] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 88 (1998).

[153] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 94 (1998). *See also* Karl Sigmund, *Introduction to Evolutionary Game Theory*, *in* 69 Proceedings of Symposia in Applied Mathematics 1, 14 (Karl Sigmund ed., 2011).

[154] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 96 (1998). *See also* Karl Sigmund, *Introduction to Evolutionary Game Theory*, *in* 69 Proceedings of Symposia in Applied Mathematics 1, 14 (Karl Sigmund ed., 2011).

[155] *See* Josef Hofbauer, *Deterministic Evolutionary Game Dynamics*, *in* 69 Proceedings of Symposia in Applied Mathematics 61, 62 (Karl Sigmund ed., 2011).

doi:10.6342/NTU201601682

For $\beta \in \mathbb{R}$, $\beta_1 + \beta_2 + \beta_3 = 0$,

$$\beta \cdot A = (a-b)(\beta_1\beta_2 + \beta_2\beta_3 + \beta_3\beta_1) = \frac{b-a}{2}[\beta_1^2 + \beta_2^2 + \beta_3^2] \quad (2.4.8)$$

, as $0 < b < a$, the game is negative definite, A is evolutionarily stable strategy; as $0 < a < b$, the game is positive definite, quoted as follows: [156][430]

$$\beta \cdot A\beta > 0, \forall \beta \in \mathbb{R}\backslash 0.$$

, where the equilibrium A is not evolutionarily stable.

Further consider the generalized Rock-Scissor-Paper game, quoted as follows: [157][426]

$$\mathbf{A} = \begin{pmatrix} 1 & x+a & 0 \\ 0 & 1 & x+a \\ x+a & 0 & 1 \end{pmatrix}$$

, where a $\in \mathbb{R}$.

It shows that for any a, $\mu = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$ is the unique Nash equilibrium strategy, and so the replicator dynamics is quoted as follows: [158][426]

$$\dot{x_1} = [x_1 + (x+a)x_2 - x \cdot Ax]x_1 \quad (2.4.9)$$

$$\dot{x_2} = [x_2 + (x+a)x_3 - x \cdot Ax]x_2 \quad (2.4.10)$$

$$\dot{x_3} = [x_3 + (x+a)x_1 - x \cdot Ax]x_3 \quad (2.4.11)$$

[156] *See* Josef Hofbauer, *Deterministic Evolutionary Game Dynamics*, *in* 69 Proceedings of Symposia in Applied Mathematics 61, 62 (Karl Sigmund ed., 2011).

[157] *See* Jörgen W. Weibull, Evolutionary Game Theory 77 (1995).

[158] *See* Jörgen W. Weibull, Evolutionary Game Theory 77 (1995).

doi:10.6342/NTU201601682

The results of analyzing the replicator dynamics above showed that, quoted as follows: [159][426]

(1) For any $a > 0$, the unique Nash equilibrium strategy μ is asymptotically stable.

(2) For any $a = 0$, the unique Nash equilibrium strategy μ is Lyapunov stable but not asymptotically stable.

(3) For any $a < 0$, the unique Nash equilibrium strategy μ is unstable.

Generally summarizing, the interior evolutionarily stable strategies the replicator dynamics for the generalized Rock-Paper-Scissors games are globally asymptotically stable. [160][430] Rock-Scissor-Paper games adopted in the ecological phenomena were called 'competitively intransitive networks' with no static equilibria and determined the time-varying results by the invasion rates. [161][519] Irrational thinking in strategic reasoning or adjustment processes with different preferences or beliefs governing the game made evolutionary game theories diverge from traditional nonstrategic economic theories. [162][425] Evolutionary game theory applied in natural selections or social science involved with a very large population where the equilibrium strategies progressed with a uniformly action in various stages of the games. [163][422]

---

[159] *See* Jörgen W. Weibull, Evolutionary Game Theory 78 (1995).

[160] *See* Josef Hofbauer, *Deterministic Evolutionary Game Dynamics*, *in* 69 Proceedings of Symposia in Applied Mathematics 61, 62-3 (Karl Sigmund ed., 2011).

[161] *See* David O'Sullivan & George L. W. Perry, Spatial Simulation: Exploring Pattern and Process 76-8 (2013).

[162] *See* Larry Samuelson, Evolutionary Games and Equilibrium Selection 15 (1997) ("Evolutionary game theory similarly assumes that the behavior driving the process by which agents adjust their strategies may not be perfectly rational, even though it may lead to "rational" equilibrium behavior.").

[163] *See* Sean H. Rice, Evolutionary Theory: Mathematical and Conceptual Foun-

doi:10.6342/NTU201601682

2.4.6 Post-award Review Bargaining Model

Definitions

Let I(t) denotes the interests of the parties in post-awards review bargaining, P(t) denotes the power of the courts in post-award judicial reviews.

Methods: Lyapunov Functions

Consider a Lyapunov function, quoted as follows: [164][570]

$$\dot{I(t)} = -I + P^2 \tag{2.4.12}$$

$$\dot{P(t)} = I^2 - P \tag{2.4.13}$$

, and the Lyapunov function E is defined by

$$E(x, y) = x^2 + y^2 \tag{2.4.14}$$

Results

Follow the calculation of the Lyapunov function, quoted as follows: [165][570]

The function

$$E(I(t), P(t)) = I^2 + P^2$$

, which is positive definite in every domain containing (0,0), and,

---

DATIONS 290 (2004) ("There is one more major assumptions of evolutionary game theory that we need to address. We have thus far assumed that all evolution is response to selection; in other words, we tacitly assumed infinite population size. One important consequences of this assumption is that a strategy that is not favored by selection has zero probability of increasing in frequency.").

[164] *See* SHEPLEY L. ROSS, DIFFERENTIAL EQUATIONS 688 (3d ed. 1984).

[165] *See* SHEPLEY L. ROSS, DIFFERENTIAL EQUATIONS 688 (3d ed. 1984).

doi:10.6342/NTU201601682

$$\dot{E}(I,P) = -2(I^2 + P^2) + 2(I^2P + P^2I)$$

, where $\dot{E}$ is negative definite in every domain containing (0,0). Thus it follows that E is a Lyapunov function of the system in every domain. And so, the critical point (0,0) is asymptotically stable. Take the critical point (0,0) as a rest point, then it follows that (0,0) is not evolutionarily stable for the replicator dynamics of the post-awards review bargaining model. [166][424]

Phase Planes

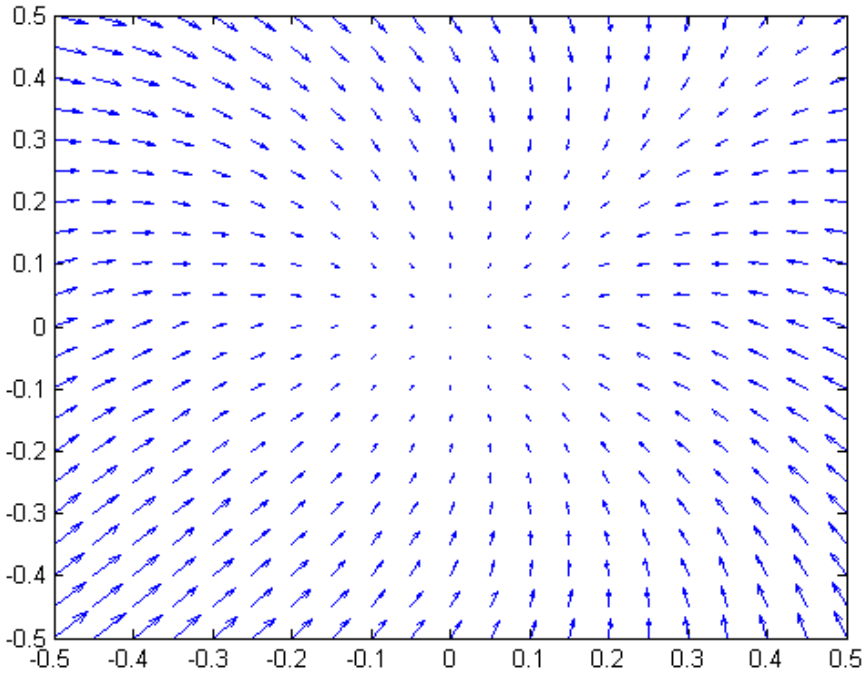


Figure 2.1: Post-award Review Bargaining Model

[166] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 70-1, 79-82 (1998).

doi:10.6342/NTU201601682

2.5 Concluding Remarks

In this chapter, this thesis created the post-award review bargaining model. The results show that the interests of the parties do not always oscillate with the power of the courts in post-award judicial review bargaining.

It depends on the preferences of the parties, the incentives of the courts, the stability of the strategic decision-makings, as well as the agent behaviors of being selfish or reciprocal. In post-award settlement bargaining processes, equilibrium strategies and the coalitions of the mutual interest-based parties bring about the Nash bargaining solution. Analogous to decision-making methods, evolutionary game theory provide an insightful remark on the competitive interactions of agents in the bargaining processes.

doi:10.6342/NTU201601682

Chapter 3

Modeling Judicial Behaviors in Post-award Procedural Dynamics

3.1 Introduction

In this chapter, this thesis tried in effort to approach an ideal post-award arbitral proceeding where international enforceability of arbitral awards will be ensured. Based on the New York Convention, constructing international enforceable awards becomes an special issue in national legislative implements, focusing on the domestic grounds for recognition and enforcement of foreign arbitral awards, which diverged from the nations. International or national public policy defence is commonly seen in the vacatur grounds for arbitral awards. In the meantime, this thesis explored the impacts of transnational legal orders on arbitrations. Developing mechanisms for the international enforceability in international legitimacy was related to the legislative design in multilevel hierarchy of orders. This thesis introduced behavioral principles, systems thinking, evolutionary analysis of law as the methodological basis for the

doi:10.6342/NTU201601682

approaches of mathematical sociological simulation of modeling judicial behaviors in post-award procedural dynamics.

3.2 Constructing International Enforceable Awards

3.2.1 International Enforceability of Arbitral Awards

At the outset of approaching the topics of international enforceability of arbitral awards, there was little agreement on how to ensure an international enforceable arbitral awards both in international and domestic categories of arbitration forums. Elaborating arbitral legislative mechanisms to ensure the international enforceability was an ideal but deviates from reality. Therefore, this section started with collecting the key factors of legislative design on the issues of recognition and enforcement of foreign arbitral awards in international commercial arbitration and applying the systematic analysis in order to moving closely to the aim.

International Enforceable Awards

This thesis wanted to approach ways of generating international enforceable awards guaranteed by the national or international legislative design. The task at hand is to make sure one thing that neutrality is the centrality of enforceability of any kind of arbitral awards. The neutrality and effectiveness of international commercial arbitration was bounded and evaluated by whether the costs and fees for raising the assertion that arbitral awards were misconducted in enforcements of arbitral awards

doi:10.6342/NTU201601682

would assess the standard or not. [1][120]

International enforceability of commercial arbitration in the contexts of the New York Convention was manifested as various indications of autonomous arbitrations in a very divergent way of legal interpretations on the finality tests of international arbitrations. [2][78] The applications of the doctrines of *forum non conveniens* as the dismissals of actions would employ the assets against the international enforceability of the foreign arbitral awards in the opposite direction of the New York Convention. [3][116] Under the circumstances of the international post-award judicial reviews, global economic approaches suggested that the parties could expand the scope of the enforceability of annulled arbitral awards, whereas comity approaches narrowed the grounds of vacating arbitral awards to under the very limited conditions of declining the previous judgments of annulment of arbitral awards for recognizing the vacated arbitral awards enforceable. [4][130]

Role of Courts in Supervising Arbitrations

As optimized dispute resolution measures, the ADR processes would be changed to arbitrations when mediations fail; however, the extents judicial control of the procedural dynamics involved would make the interests of arbitral efficacy labile.

[1] *See* Catherine A. Rogers, *Context and Institutional Structure in Attorney Regulation: Constructing an Enforcement Regime for International Arbitration*, 39 Stan. J. Int'l L. 1, 32-4 (2003).

[2] *See* Stefan Kröll, *The Non-enforceability of Decisions Rendered in Summary Arbitral Proceedings Pursuant to the NAI Rules Under the New York Convention*, 23 Am. Rev. Int'l Arb. 75, 94-6 (2012).

[3] *See* The International Commercial Disputes Committee of the Association of the Bar of the City of New York, *Lack of Jurisdiction and Forum Non Conventions as Defenses to the Enforcement of Foreign Arbitral Awards*, 15 Am. Rev. Int'l Arb. 407, 431-4 (2004).

[4] *See generally* Christopher R. Drahozal, *Enforcing Vacated International Arbitration Awards: An Economic Approach*, 11 Am. Rev. Int'l Arb. 451 (2000).

doi:10.6342/NTU201601682

[5][34] Proceedings of annulling arbitral awards in the arbitral seat if contractually accepted by the parties should be given effect. [6][21] For fairness and efficiency of international enforceability assessments, reflecting on the ancillary nature 'judgment upon judgment' of the foreign arbitral awards and legal principles purported the case-by-case consequences of the capability of producing the extra-territorial effects. [7][70] For procedural issues in order to meet the efficacy of post-award annulment proceedings, taking actions for setting aside arbitral awards has its time limits. [8][46]

For transnational transactions, to recognize arbitral awards by national courts by the *res judicata* effect but without the enforcements of awards could happen when the postponing motion for justifying jurisdictions, whereas the domestic procedural laws governed the enforcement of arbitral awards rather than the substantial laws, that the confirmation time of the enforcements of awards in the United States would be three years based on the FAA. [9][109] In comparison, in England arbitral jurisdictions, challenging awards by a party may only work in arbitral procedural review systems and be narrowed to the domains of serious procedural irregularity or arbitral award's jurisdictions due to some arbitral efficacy reasons; the power of courts for challenging arbitral awards is limited under 1996 English Arbitration Act. [10][27]

---

[5] *See* Alan Redfern et al., Law and Practice of International Commercial Arbitration 44-6 (4d ed. 2004).

[6] *See* 2 Gary B. Born, International Commercial Arbitration 2698 (2009).

[7] *See* Maxi Scherer, *Effects of Foreign Judgments Relating to International Arbitral Awards: Is the 'Judgment Route' the Wrong Road?*, 4 J. Int'l Disp. Settlement, no. 3, 2013, at 587, 605-11.

[8] *See* Vladimir Pavic, *Annulment of Arbitral Awards in International Commercial Arbitration*, *in* Investment and Commercial Arbitration: Similarities and Divergences 131, 146-7 (Christina Knahr et al. eds., 2010).

[9] *See* William W. Park & Alexander A. Yanos, *Treaty Obligations and National Law: Emerging Conflicts in International Arbitration*, 58 Hastings. L.J. 251, 260-2 (2006).

[10] *See* William W. Park, Arbitration of International Business Disputes Studies

doi:10.6342/NTU201601682

The emanation test of legal theory demonstrated in French courts reluctantly took the enforcement of foreign commercial arbitral awards regarding the equilibrium of the interests and sovereign of the state entity. [11][54] A perspective of arbitral award debtor was once created for resolving the conflicts of personal jurisdictions between the parties and the courts, in order to secure the non-enforcement of foreign arbitral awards contrary to the constitutional concerns where the propositions were not based on the seven grounds for defence in the New York Convention, the judiciary or the legislature of the arbitral award creditors of the national judicial power. [12][22] Ideal arbitral design for international commercial arbitrations was proceeded beyond the judicial control of national courts that reformed a-national or delocalized arbitral procedural functions. [13][20]

3.2.2 New York Convention

Legislative implementing foundations extended from the New York Convention on the domestic statutory mechanisms for annulling and recognizing non-domestic or international commercial arbitral awards should be well-designed and conducted in national arbitration legislations. [14][21]

Foreign arbitral awards will be refused to enforce on the national legal grounds of

---

IN LAW AND PRACTICE 214-20 (2006).

[11] *See generally* Sarah François-Poncet, *Enforcement of Arbitral Awards Against Sovereign States or State Entities–France*, *in* ENFORCEMENT OF ARBITRAL AWARDS AGAINST SOVEREIGNS 355 (R. Doak Bishop ed., 2009).

[12] *See* PEDRO J. MARTINEZ-FRAGA, THE AMERICAN INFLUENCE ON INTERNATIONAL COMMERCIAL ARBITRATION: DOCTRINAL DEVELOPMENTS AND DISCOVERY METHODS 160-1 (2009).

[13] *See* 1 GARY B. BORN, INTERNATIONAL COMMERCIAL ARBITRATION 1299-304 (2009).

[14] *See* 2 GARY B. BORN, INTERNATIONAL COMMERCIAL ARBITRATION 2380-8 (2009).

doi:10.6342/NTU201601682

setting aside according to the New York Convention by the domestic courts. [15][33] The definition of domesticity for the categories of arbitrations was based on the New York Convention §V (1)(e), to be summarized, when arbitral awards being annulled by the national laws of the seat of arbitration, the award would categorized into a domestic arbitral award. [16][26]

Procedures and rules for amending, correcting, interpreting without rewriting the arbitral awards was demonstrated in England, France and Germany arbitration laws. While recognizing or enforcing national arbitral awards and foreign awards, there were domestic procedural discrepancy by national arbitration laws on the correctly applications of New York Convention or not; the French arbitration laws presented more autonomousness than German arbitration laws, which narrowed the scope into international public policy. [17][48][49][50]

---

[15] *See* Klaus Lionnet & Annette Lionnet, Handbuch der internationalen und nationalen Schiedsgerichtsbarkeit: Systematische Darstellung der privaten Handelsschiedsgerichtsbarkeit für die Praxis der Parteien einschließlich CD-ROM mit einschlägigen Normen und Regelwerken 112 (3d ed. 2005) ("Trotzdem leitete Chromalloy das Vollstreckungsverfahren in den USA (wie auch in Frankreich) ein. Der US District Court von Columbia erteilte dem aufgehobenen Schiedsspruch das Exequatur. Das US-Gericht urteilte, dass es nach Art. V Abs. 1 lit. e der NYC zwar befugt sei, die Vollstreckung zu versagen, dass jedoch für diesen Fall das US-Verfahrensrecht eine Vollstreckung vorsehe und gemäßArt. VII NYC zur Anwendung komme.").

[16] *See* Tibor Várady et al., International Commercial Arbitration: A Transnational Perspective 707 (3d ed. 2006).

[17] *See* Miranda Karali & Jane Ballantyne, *England*, *in* Practitioner's Handbook on International Commercial Arbitration 351, 404-14 (Frank Bernd Weigand ed., 2d ed. 2009). *See also* Emmanuel Gaillard, *France*, *in* Practitioner's Handbook on International Commercial Arbitration 423, 466-70 (Frank Bernd Weigand ed., 2d ed. 2009). *See also* Inka Hanefeld, *Germany*, *in* Practitioner's Handbook on International Commercial Arbitration 475, 534-9 (Frank Bernd Weigand ed., 2d ed. 2009).

doi:10.6342/NTU201601682

Public Policy Defence

Public policy defence of international commercial arbitration was in the New York Convention §V (2) (b). [18][10] According to the New York Convention §V, judicial control under transnational public policies expanded the original legal basis of public policy defence for the consistency of the interests of international communities rather than a state. [19][58] International public policy defence embodying in the New York Convention on the exceptional grounds of the enforceability of arbitral awards was inapplicable to issues of binding the arbitrability of arbitral agreements but extended to rationale favouring enforceability of foreign arbitral awards. [20][132][16]

3.2.3 UNCITRAL Model Law

The grounds for the enforcement of the annulled foreign arbitral awards in the New York Convention and the UNCITRAL Model Law could be found similar in

[18] *See* New York Convention (1958) ("§V (2) (b): Recognition and enforcement of an arbitral award may also be refused if the competent authority in the country where recognition and enforcement is sought finds that: (b.) The recognition or enforcement of the award be contrary to the public policy of that country.").

[19] *See* Bernard Hanotiau & Olivier Caprasse, *Public Policy in International Commercial Arbitration*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 787, 794-801 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

[20] *See* Ray Y. Chan, *The Enforceability of Annulled Foreign Arbitral Awards in the United States: A Critique of Chromalloy*, 17 B.U. Int'l L.J. 141, 168-181 (1999). *See also* Chromalloy Aeroservices v. The Arab Republic of Egypt, 939 F. Supp. 907 (D.D.C. 1996) ("As the Court stated earlier, this is a case of first impression. There are no reported cases in which a court of the United States has faced a situation, under the Convention, in which the court of a foreign nation has nullified an otherwise valid arbitral award. This does not mean, however, that the Court is without guidance in this case. ... The Court concludes that the award of the arbitral panel is valid as a matter of U.S. law. The Court further concludes that it need not grant res judicata effect to the decision of the Egyptian Court of Appeal at Cairo. Accordingly, the Court grants Chromalloy Aeroservices' Petition to Recognize and Enforce the Arbitral Award, and denies Egypt's Motion to Dismiss that Petition.").

doi:10.6342/NTU201601682

Hilmarton and *Chromalloy* cases. [21][32][5] What is more, in comparison, the Sec. 47 English Arbitration Act 1996 provided a clear statute for the finality of interim and partial awards and the timing of bifurcating the arbitral proceedings that addressed the content of arbitral awards and the issues of a default provision as a better solution than the equivocal rules in the UNCITRAL Model Law. [22][114][7]

3.2.4 Enforceability of Nullified Foreign Arbitral Awards

This section would like to explore from the grounds for annulment of national arbitral awards or refusing to recognize the foreign judicial decisions to the enforceability of nullified foreign arbitral awards. The first aspect to point out is that to review the nullified arbitral awards is case by case in international commercial arbitration. For instance, arbitral awards set aside in the country of origin could be re-examined by the Paris courts. [23][33] Double or multiple judicial control of arbitrations would be risen at times as the challenging arbitral awards procedure was proceeded, especially for the foreign arbitral awards set aside in the country of origin but to be considered

[21] *See* Peter Binder, International Commercial Arbitration and Conciliation in UNCITRAL Model Law Jurisdictions 289 (2d ed., 2005). *See also* UNCITRAL Model Law (amended, 2006) ("Article 36. (1) (b) if the court finds that: (i) the subject-matter of the dispute is not capable of settlement by arbitration under the law of this State; or (ii) the recognition or enforcement of the award would be contrary to the public policy of this State.").

[22] *See* James M. Gaitis, *The Federal Arbitration Act: Risks and Incongruities Relating to the Issuance of Interim and Partial Awards in Domestic and International Arbitrations*, 16 Am. Rev. Int'l Arb. 1, 22-7 (2005). *See also* Arbitration Act (U.K.) (1996) ("Sec. 47 (1) Unless otherwise agreed by the parties, the tribunal may make more than one awardat different times on different aspects of the matters to be determined. (2) The tribunal may, in particular, make an award relating (a) to an issue affecting the whole claim, or (b) to a part only of the claims or cross-claims submitted to it for decision. (3) If the tribunal does so, it shall specify in its award the issue, or the claim or part of aclaim, which is the subject matter of the award.").

[23] *See* Klaus Lionnet & Annette Lionnet, Handbuch der internationalen und nationalen Schiedsgerichtsbarkeit: Systematische Darstellung der privaten Handelsschiedsgerichtsbarkeit für die Praxis der Parteien einschließlich CD-ROM mit einschlägigen Normen und Regelwerken 111-2 (3d ed. 2005).

doi:10.6342/NTU201601682

valid by other various countries, like the case *Hilmarton*, it would be somewhat enigmatic in legal practices but in fact rarely happened in international commercial arbitration if the parties could identify the efficacy problems in advance and choose the arbitration law adequately in their arbitral agreements. [24][59]

Some scholars considered the *Hilmarton* jurisprudence unjust in granting the *res judicata* effect of foreign arbitral awards and lacking the annulling forum of foreign jurisdictions, by indicating that in that case French courts should set a compensating mechanism for the party who initially won the enforceability of the arbitral awards at the country of origin. [25][134] The cases *Chromalloy* and *Hilmarton* kept away from post-award international cooperative efficacy created by the New York Convention and from the *res judicata* effect of post-award judicial review systems. [26][67]

Manifest disregard of the law was as the main standard of grounds for vacatur of arbitral awards in the provisions of FAA, this manifest disregard test on the statutory laws or public policies on foreign arbitral awards would deduce similar grounds between the non-enforcement and the vacatur of arbitral awards in the United States. [27][126] As the clear errors in fact-findings or manifest disregard of law were found in international arbitral proceedings, post-award judicial reviews

[24] *See* Albert Jan Van Den Berg, *The Efficacy of Awards in International Commercial Arbitration*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 115, 121-31 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[25] *See* Georgios C. Petrochilos, *Enforcing Awards Annulled in Their State of Origin under the New York Convention*, 48 Int'l L. & Comp. L.Q., no. 4, 1999, at 856, 870, 884.

[26] *See* Andrea Giardina, *The International Recognition and Enforcement of Arbitral Awards Nullified in the Country of Origin*, *in* Law of International Business and Dispute Settlement in the 21th Century 205, 212-7 (Robert Briner et al. eds., 2001).

[27] *See* Kenneth R. Davis, *Unconventional Wisdom: A New Look at Articles V and VII of the Convention on the Recognition and Enforcement of Foreign Arbitral Awards*, 37 Tex. Int'l L.J. 43, 70-4 (2002).

doi:10.6342/NTU201601682

used to expand the scope of examining foreign arbitral awards but narrowed the public policy defence of national arbitration law, not taking the public interests as the prior stage of judicial reviews. [28][64]

Res judicata effect would not be guaranteed when national courts applying the confirmations of arbitral awards annulled at the country of origin in post-award judicial reviews, as the arbitral awards were annulled for misapplying substantial laws, or violating the grounds of public policy defence. [29][53]

3.2.5 Public Policy Defence

The first thing that needs to be considered is the *Mitsubishi*'s footnote nineteen, quoted as follows: [30][18]

> We therefore have no occasion to speculate on this matter at this stage in the proceedings, when Mitsubishi seeks to enforce the agreement to arbitrate, not to enforce an award. Nor need we consider now the effect of an arbitral tribunal's failure to take cognizance of the statutory cause of action on the claimant capacity to re-initiate suit in federal court. We merely note that, in the event the choice-of-forum and choice-of-law clauses operated in tandem as a prospective waiver of a party's right to pursue statutory remedies for antitrust violations, we would have little

[28] *See* Richard E. Speidel, *International Commercial Arbitration: Implementing the New York Convention*, *in* Arbitration Law in America: A Critical Assessment 185, 299-302 (Edward Brunet et al. eds., 2006).

[29] *See* Edward G. Kehoe, *The Enforcement of Arbitral Awards Against Foreign Sovereigns–the United States*, *in* Enforcement of Arbitral Awards Against Sovereigns 241, 264 (R. Doak Bishop ed., 2009).

[30] *See* Mitsubishi v. Soler Chrysler-Plymouth, 473 U.S. 614, Fn. 19 (1985).

doi:10.6342/NTU201601682

hesitation in condemning the agreement as against public policy.

The scope of the prospective waiver doctrine, refusing to enforce contractual provisions as the waivers of the legal statutory frameworks, due to the basis of the arbitration clauses provided by the New York Convention was expanded in *Mitsubishi* case. [31][93]

Substantive Issues

International commercial arbitrations as private international justice are still in the close linkages of national legal fields that are in control of the grounds of public policies and procedural regularities of national arbitration laws. [32][151] As matter of facts, building up international post-award review systems need to be traced back to its a-national reasons. [33][33]

International enforceability of arbitral awards was endorsed in transnational legal frameworks of globalized dispute settlements for private commercial actors, hence international enforceability should be concerned with the impact of globalization on public policy defense which was not narrowed to a domestic notion but as a international mandatory legal rule. [34][103] However, distributions of power between

[31] *See* Joseph R. Brubaker & Michael P. Daly, *Twenty-Five Years of the "Prospective Waiver" Doctrine in International Dispute Resolution: Mitsubishi's Footnote Nineteen Comes to Life in the Eleventh Circuit*, 64 U. Miami L. Rev. 1233, 1272-7 (2010).

[32] *See* Simon Roberts & Michael Palmer, Dispute Processes: ADR and the Primary Forms of Decision-making 264-75 (2d ed. 2005).

[33] *See* Klaus Lionnet & Annette Lionnet, Handbuch der internationalen und nationalen Schiedsgerichtsbarkeit: Systematische Darstellung der privaten Handelsschiedsgerichtsbarkeit für die Praxis der Parteien einschließlich CD-ROM mit einschlägigen Normen und Regelwerken 113 (3d ed. 2005) ("Die Auffassung, welche den Vollstreckung Entscheidungen in den beiden Fällen *Hilmarton* und *Chrommalloy* zustimmt, muss aus rechtslogischen Gründen von der völligen Denationalisierung der internationalen Schiedsgerichtsbarkeit ausgehen.").

[34] *See* Christopher S. Gibson, *Arbitration, Civilization and Public Policy: Seeking Counterpoise*

doi:10.6342/NTU201601682

arbitral tribunals and national courts could not possibly display the panoramic view of consolidating the international enforceability of aritral awards for public policy defence and the sophisticated but feasible mechanisms of international enforceable arbitral awards hid in the contractual silence and ambiguity. [35][101]

After the *Hilmarton* case, French courts still held strong international public policy orders of favouring enforcement of foreign arbitral awards. [36][57] In France the arbitral awards would be set aside according to the violation of international public policy, such as finding the fact of fraud in arbitral proceedings. [37][26] The case of recognition of foreign arbitral award annulled at the country of origin in French courts was based on §1502 Code de Procédure Civile, the international public policy defense was taken as the grounds of recognition of foreign annulled arbitral award in Société Hilmarton Ltd. v. Société OTV, 1997. [38][55][17][15]

Between Arbitral Autonomy and the Public Policy Defense in View of Foreign Mandatory Public Law, 113 Penn. St. L. Rev. 1227, 1238-43, 1263-5 (2009).

[35] *See* S.I. Strong, *The Sounds of Silence: Are U.S. Arbitrators Creating Internationally Enforceable Awards When Ordering Class Arbitration in Cases of Contractual Silence or Ambiguity?*, 30 Mich. J. Int'l L. 1017, 1092-4 (2009) ("While public policy will not overcome the parties' express wishes, the better default position in cases where there is silence or ambiguity is to allow the arbitrator construe the contract in accordance with traditional legal principles. ... However, the novelty of the procedure and the disfavor with which representative proceedings are held in many nations will doubtless lead to challenges at the international enforcement stage.").

[36] *See* Dana Freyer, *The Enforcement of Awards Affected by Judicial Orders of Annulment at the Place of Arbitration*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 757, 771-3 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

[37] *See* Tibor Várady et al., International Commercial Arbitration: A Transnational Perspective 755 (3d ed. 2006).

[38] *See* Emmanuel Gaillard, *The Relationship of the New York Convention With Other Treaties and With Domestic Law*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 69, 77-9 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009). *See also* Société Hilmarton Ltd. v. Société Omnium de Traitement et de Valorisation (OTV), Cour de cassation [Cass.] [supreme court for judicial matters] 1e civ., 23 March 1994, No. 92-15.137 (Fr.) ("Attendu, enfin, que la sentence rendue en Suisse était une sentence internationale qui n'était pas integree dans l'ordre juridique de cet etat, de sorte que son existence demeurait etablie malgré son annulation et que sa reconnaissance en France n'était pas

doi:10.6342/NTU201601682

Public Policy and Violation of the EU Laws

Contrary to the arbitration jurisdictions of most EU or East Asia countries, in the United States, public policy defenses was not so utilitarian in grounds for the refusal of enforcements. [39][45] In general, the EU legal norms does not constitute the EU public policy defense for the annulment of international arbitral awards, while the potentiality of the EU competence based on national procedural autonomy will generate the adaptability of the EU public policy defense in competition law and consumer protection legal regimes. [40][82]

3.2.6 Arbitrations in Transnational Legal Orders

When it comes to the collective actions of international commercial arbitration, the evolution of international public policy defence in agent behaviors of arbitrations, the transnational mass claims to large-scale dispute resolutions, they are still not very clearly defined in global private orders. [41][171] As the issues mentioned before, from the aspects of demonstrating international enforceability of arbitral awards,

---

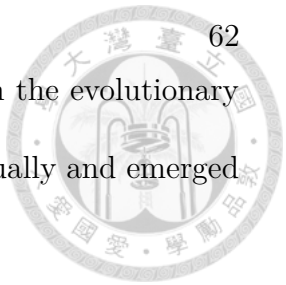
contraire á l'ordre public international."). *See also* Société Hilmarton Ltd. v. Société Omnium de Traitement et de Valorisation (OTV), Cour de cassation [Cass.] [supreme court for judicial matters] 1e civ., 10 June, 1997, No. Q 95-18.402, R 95-18.403 (Fr.) ("déclaré exécutoire en France la sentence rendue le 10 avrril 1992.").

[39] *See* Peter L. Murray, *The Role of American Courts in International Arbitration*, *in* International Contract Litigation, Arbitration and Judicial Responsibility in Transnational Disputes 69, 75 (Rolf Stürner & Masanori Kawano eds., 2011).

[40] *See* George A. Bermann, *Reconciling European Union Law Demands With the Demands of International Arbitration*, 34 Fordham Int'l L. J. 1193, 1206-16 (2011).

[41] *See* Deborah Hensler, *How Economic Globalisation is Helping to Construct A Private Transnational Legal Order*, *in* The Law of the Future and the Future of Law 249, 256-259 (Sam Muller et al. eds., 2011) ("As a result, I suspect that national courts will be slow to embrace the notion of transnational coordination of mass claims. Multi-national corporations might play an important role in this context, by nudging domestic courts towards cooperation and consolidation.").

doi:10.6342/NTU201601682



configurational webs of institutional-based systems were based on the evolutionary legal rules though the transnational configurations increased mutually and emerged from public and private international law formations. [42][172]

Consistent with this point of view, transnational legal orders and global legal pluralism were increased in academic discussions on the functional accountability of non-state standard setters to consolidate the enforceability of decisions that made by them. [43][178] Broadening the scopes on the rise of new global private legal orders in which principles of transnational mass claims to arbitration, it requires deliberations on the collective actions of large-scale disputes in multiple jurisdictions to resolve uncertainty in evolution of public policies in response. [44][171]

Constructing international legitimacy that attracts political science attentions by appealing to establishments of international rights to political communities, beliefs in distributions of power to political systems, it would not project universalistic images of international authorities. [45][173] Protecting international tribunals against national legislatures, the judiciary is far more crucial in contemporary democratic legislation systems. [46][175] Competitions between fundamental principles were in

---

[42] *See* Poul F. Kjaer, *Law and Order Within and Beyond National Configurations*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 395, 420-24 (Poul F. Kjaer et al. eds., 2011).

[43] *See generally* Anna Peters et al., *Towards Non-state Actors as Effective, Legitimate, and Accountable Standard Setters*, *in* Non-state Actors as Standard Setters 492 (Anna Peters et al. eds., 2009).

[44] *See generally* Deborah Hensler, *How Economic Globalisation is Helping to Construct A Private Transnational Legal Order*, *in* The Law of the Future and the Future of Law 249 (Sam Muller et al. eds., 2011).

[45] *See generally* Jean-Marc Coicaud, *Deconstructing International Legitimacy*, *in* Fault Lines of International Legitimacy 29 (Hilary Charlesworth & Jean-Marc Coicaud eds., 2010).

[46] *See* Geir Ulfstein, *The International Judiciary*, *in* The Constitutionalization of International Law 147-152 (2009) ("Unlike the situation in national law, individual national lawmakers are not in a position to change the law if they disagree with the decisions of international

doi:10.6342/NTU201601682

the echoes of hierarchy and the spheres of international legitimacy. [47][173]

The mixed-jurisdiction courts exist inherent harmonized legislative jurisprudence power when judges import legal principles into different legal systems and reflect mixed nature of the distinct legal procedures. [48][179] Non-state and state actors were both inquired into the implications for legitimacy and accountability identified with the intergovernmental and contemporary standard settings. [49][176]

Empirical researches applying non-state actors into the polycentric regulatory theory are rare. [50][177] By contrast, some studies applied the economic-utilitarian principles or the utilitarian theory into the analysis of jurisdictions, or some applied the prisoner's dilemma games, chicken games, coordination games in explaining the preferences of jurisdictions in empirical cases, or making legal interpretations or predictions on them.[51][180] In tradition of science, reasoning the rationality of the international legislatures by decision-making methods to contend with risks variables has emerged a new avenue of the transdisciplinary studies focusing on risk and uncertainty. [52][170]

---

tribunals.").

[47] *See* Jean-Marc Coicaud, *Deconstructing International Legitimacy*, *in* Fault Lines of International Legitimacy 29, 49-70 (Hilary Charlesworth & Jean-Marc Coicaud eds., 2010).

[48] *See* Vernon Valentine Palmer, *Introduction to the Mixed Jurisdictions*, *in* Mixed Jurisdictions Worldwide: the Third Legal Family 3, 35-40 (Vernon Valentine Palmer ed., 2001).

[49] *See* Anne Peters et al., *Non-state Actors as Standard Setters: Framing the Issue in An Interdisciplinary Fashion*, *in* Non-state Actors as Standard Setters 1, 11-14 (Anna Peters et al. eds., 2009) ("'Non-state actor' is a term of political science and sociology, but no legal term of art.").

[50] *See generally* Julia Black, *Legitimacy, Accountability and Polycentric Regulation: Dilemmas, Trilemmas and Organisational Response*, *in* Non-state Actors as Standard Setters 241 (Anna Peters et al. eds., 2009).

[51] *See generally* Michael Whincop, *Three Positive Theories of International Jurisdiction*, 24 Melb. U. L. Rev. 379 (2000).

[52] *See generally* Jacqueline Peel, Science and Risk Regulation in International Law 58-110 (2010).

doi:10.6342/NTU201601682

Normative legitimacy is theoretically above the social orders whereas democratic legitimacy have the implications with the state sovereignty. [53][178] Considering the stability and plasticity of the international legitimacy, taken the socialized instability into accounts, would generate the systemic changes of the a-national environment in multilateralism of transnational legal orders. [54][174] Evolutionary configurational webs are similar to the institutionalised coordination mechanisms and impaired the autonomy of agents in legal systems. [55][172]

3.3 Evolutionary Multilevel Hierarchy of Orders

3.3.1 Evolutionary Theories and the Law

Interdisciplinarity of Mathematical Social Science

Some original or unadulterated economic and mathematical social science concepts are too abstruse to be directly applicable in legal contexts or settings thus the laws are sometimes destituted by repeat behaviors of social agents. [56][254] However, it

[53] *See* Anna Peters et al., *Towards Non-state Actors as Effective, Legitimate, and Accountable Standard Setters*, *in* Non-state Actors as Standard Setters 492, 511-513 (Anna Peters et al. eds., 2009) ("The basic legitimatory norm of traditional international law (notably international treaties and customary international law) has not been democracy, but state sovereignty.").

[54] *See* Jean-Marc Coicaud, *The Evolution of International Order and Fault Lines of International Legitimacy*, *in* Fault Lines of International Legitimacy 87, 88-96 (Hilary Charlesworth & Jean-Marc Coicaud eds., 2010).

[55] *See* Poul F. Kjaer, *Law and Order Within and Beyond National Configurations*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 395, 408-413 (Poul F. Kjaer et al. eds., 2011) ("One central aspect of configurational webs is mutual stabilisation through the emergence of dense institutional links, in form of, for example, (neo-) corporatist structures of the kind which emerged in the wake of increased differentiation between the economic and the political systems.").

[56] *See* Robin Feldman, *Law's Misguided Love Affair With Science*, 10 Minn. J.L. Sci. & Tech. 95, 115-6 (2009) ("Other examples include legal tests imported into law from economic or social science research that are then far too complex to operate in a legal setting. ..... The

doi:10.6342/NTU201601682

is hard to define what science really is, but borrowing the rationality of science for the adaptation of the legal science is usually used or misused in some social translations of the laws. [57][226] Interdisciplinary studies in some ways are radical with disciplinary professions that counter with the horizons of them. [58][236]

At the outset of the applications, interdisciplinary legal studies examined the evolution of international legal norms with the ways how legal institutions interacted with other exogenous factors in various explorations of legal changes; these studies focused on similar intellectual traditions with political science factors that explained the evolving nature of legal institutions in international relations, where existed two crucial elements of forming the legal evolutions: power and interests. [59][247]

Some scholar indicated that interdisciplinary legal studies when constructing atypical legal theories conversing with doctrinal scholarships came out of the external perspectives of the innovation empiricism. [60][259] Some pessimistic viewpoints of the empirical legal studies on the evidence-based law think it undermining the influence

---

repeated behavior is revealing in that it reflects both our vision of law and our vision of science in relation to law. We so often despair of law's inability to resolve legal issues to our satisfaction and view science as a source of rescue from our discontent.").

[57] *See* Robin Feldman, The Role of Science in Law 94, 104 (2009) ("As described above, law is constantly driven to adapt to changing circumstances within existing frameworks as tested and refined through various spheres of acceptance. Science rules are particularly ill suited to this process of adaptation. ..... Science begins with observations and theories that are rationally acceptable and well supported, which is something far less than certain and infallible. Ignoring these qualifications, law tries to translate science into social and legal conclusions without understanding the perils of that translation.").

[58] *See* Stanley Fish, There's No Such Thing as Free Speech 231-42 (1994) ("Being interdisciplinary is more than hard to do; it is impossible to do. ..... Some of those who find magic in the word interdisciplinary come very close to making this point but shy away from it at the last moment.").

[59] *See* Emilie M. Hafner-Burton et al., *Political Science Research on International Law: the State of the Field*, 106 Am. J. Int'l L. 47, 82-88 (2012) ("Power and interests shape the interpretation and development of legal institutions in important ways.").

[60] *See generally* Richard A. Posner, *Legal Scholarship Today*, 115 Harv. L. Rev. 1314 (2002).

doi:10.6342/NTU201601682

of the true phenomena constituent of legislative purposes. [61][248]

Adopting Theories of Science on Policies

What science and technologies can do to the laws tends to take sluggishly vigorous paces towards the epistemological legal scholarships in the past decades. [62][242] On the exploration of "from legal science to scientific law (Wissenschaftliche Recht)," the methodological dimensions conceptualized scientific approaches to the laws were contended with danger and far from the original insights of legal values, while the laws were widely accepted as a historical science. [63][230]

Trends of cross-national differences on the science and technological policies were gradually converged into a similar ideology of scientific entrepreneurs, which cannot be regulated by a singular contract of the laws. [64][229] As artificial intelligence approaches with its ontology to study legal proofs in crossing disciplinary boundaries, the simplicity of elements cannot be ignored. [65][243]

Legal policy applications of happiness studies turned to hedonic adaptations

---

[61] *See generally* Jeffrey J. Rachlinski, *Evidence-based Law*, 96 Cornell L. Rev. 901 (2011).

[62] *See* Sheila Jasanoff, *Making Order: Law and Science in Action*, *in* The Handbook of Science and Technology Studies 761, 780-1 (Edward J. Hackett et al. eds., 3d ed. 2008) ("Relentlessly, concerned with the law's epistemic authority, STS students of science, technology, and the law have been on the whole less attentive to the law's magisterial role in constructing and maintaining justice, legitimacy, and constitutional order – and, of course, in holding at bay the disruptive forces of injustice, illegitimacy, and disorder.").

[63] *See* Roger Berkowitz, The Gift of Science: Leibniz and the Modern Legal Tradition 117- 21 (2005).

[64] *See* Sheila Jasanoff, Designs on Nature: Science and Democracy in Europe and the United States 244-46 (2005).

[65] *See* Marilyn MacCrimmon, *What Is "Common" About Common Sense? Cautionary Tales for Travelers Crossing Disciplinary Boundaries*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 55, 74-5 (Marilyn MacCrimmon & Peter Tillers eds., 2002) ("Thus, AI research indicates that we should be cautious about adopting an ontology that is too simple and, taking into account that context gives meaning to actions, should incorporate a context that recognizes all relevant relationships.").

doi:10.6342/NTU201601682

of individual's choices for settlements or litigations. [66][251] Empirical happiness researches in policy evaluation and judicial decision-making processes pointed out that long-term behaviors very often changed with individual's social preferences and choices. [67][249] Legal policies can help social individuals pursue authentic happiness by legal policy-makers facilitating the policy efficacy. [68][308] In addition, hedonic adaptation behaviors in social phenomena or legal proceedings were significant on the adaptation from injury or preinjury behaviors. [69][252]

Modeling Social Influence

Legal norms as parts of social norms were institutionally distributions of power in adjudicatory functions of legal systems. [70][231] At the very least, this thesis gave a brief overview on that social influence in multidimensional decision spaces used to be performed though methodological differences of the theoretically analysis of biological dynamical phenomena. In artificial systems, the collective behaviors of social systems and decision-making methods of social agents formed social behaviors. Social influence should be better considered from a dynamical systematic view. Social influence was concretized as macro-level collective behaviors by information

---

[66] *See* Peter H. Huang, *Happiness Studies and Legal Policy*, 6 Annu. Rev. Law Soc. Sci., no. 21, 2010, at 1, 10-11 ("In particular, litigants may sue to seek justice, revenge, and other emotions besides happiness, emotions in tort litigation can be cultural evaluations, and plaintiffs are often motivated by seeking identity and meaning. If plaintiffs fear losing litigation options, they are less likely to settle and will settle for more than if their lawsuits proceeded faster.").

[67] *See* Peter H. Huang, *Happiness in Business or Law*, 12 Transactions: Tenn. J. Bus. L. 153, 157, 169 (2011).

[68] *See generally* Peter H. Huang, *Authentic Happiness, Self-knowledge and Legal Policy*, 9 Minn. J.L. Sci. & Tech. 755 (2008).

[69] *See* Rick Swedloff & Peter H. Huang, *Tort Damages and the New Science of Happiness*, 85 Ind. L.J. 553, 567-73 (2010).

[70] *See* Hamish Ross, Law as A Social Institution 138-48 (2001) ("The relationship between legal norms and institutional social action is of primary importance to the sociology of law.").

doi:10.6342/NTU201601682

spreading, opinion formations, the spatial voting in a topological way, or regulatory legislations. [71][232]

Modeling Uncertainty in the Law

Lawyer played significant agents to negotiated settlements in judicial processes and the effects sometimes changed the litigation original structures. [72][237] By many accounts, legal objectivity is important in legitimization specially emphasizing the judge's decision-making methods. [73][246] Out-of-court bargaining settlements in judicial processes or political decision-makings were studies by the approaches of decision theory under uncertainty and decision game theory in early time. [74][238] For instance, judges make fallacious decisions not due to their egocentric biases but to the way they deliberate. [75][263]

There is no mainstream science for the courts to rely on. [76][234] The evolutionary analysis of law concerning human cognitive processes was an approach for studying

---

[71] *See* Paul Weirich, Decision Space: Multidimensional Utility Analysis 239-41 (2001) ("This judicial principle yields different safety standards than my principles of trustee decision making. The preferences of a representative worker are an average of the preferences of workers, but they are not a power-weighted average. .....Multidimensional utility analysis makes trustee decisions tractable. ..... Multidimensional utility analysis requires a decision space in which to locate and separate reasons for options. Given the idealizations about agents and their decision problems, the finest-grained reason is a chance for realization of a person's basic intrinsic attitude.").

[72] *See* Donald Black, Sociological Justice 13-14 (1989).

[73] *See generally* P. W. Brouwer, *On the Objectivity of Judicial Decisions*, *in* Conflicts in Social Science 123 (Anton van Harskamp ed., 1996).

[74] *See* Stuart S. Nagel & Marian G. Neef, Decision Theory and the Legal Process 155-57 (1979) ("Closely related to the two-person bargaining in contract law is the multiple-person bargaining associated with coalition formation within collegial courts. This is one area of decision game theory that has been well developed in the political science literature.").

[75] *See* Chris Guthrie et al., *Inside the Judicial Mind*, 86 Cornell L. Rev. 777 (2001).

[76] *See* Sheila Jasanoff, Science at the Bar: Law, Science, and Technology in America 207 (1995) ("Historically, sociologically, and politically, the proposal that courts should increase their reliance on a value-neutral mainstream science is therefore extremely problematic.").

doi:10.6342/NTU201601682

human behaviors by behavioral decision theory which was argued short for rigorous empirical analysis. [77][262]

Evolutionary currents in legal philosophy constructed synthesis foundations of theoretical hermeneutical interpretations of the laws, in that normative concept of evolution which was defined by descriptive theories and transformed by the evolution of legal institutions and norms; the natural selections and reciprocal altruism are in early stages of general evolutionary theories. [78][227] Dispute resolution processes are integrated by isolating the institutional judiciary from a larger political point of view.[79][266] Legal meta-norms would become inconsistent in models of behaviors when they were underlying teleology. [80][265] Explaining preference-shaping purposes of legal theories in criminal laws segregated the economic and social disciplines in methodological concerns. [81][264]

The laws varied with time and organizations which represented the business aspects of social institutions, whereas the laws were also as the social control by

---

[77] *See generally* Jeffrey J. Rachlinski, *Comment: Is Evolutionary Analysis of Law Science or Storytelling?*, 41 Jurimetrics J. 365 (2001) ("The difficulty this creates for evolutionary analysis of law is that we do not (and cannot) know the environmental conditions that produced human cognitive processes with any rigor or precision. ..... Without the ability to identify the environmental pressures that produced human cognition or the ability to compare human cognition to that of similar species, evolutionary analysis of law inevitably will lack precision and empirical support.").

[78] *See* Wojciech Zaluski, Evolutionary Theory and Legal Philosophy 16-23, 130-40 (2009).

[79] *See* Owen M. Fiss, *The Social and Political Foundations of Adjudication*, 6 Law and Human Behavior, no. 2, 1982, at 121, 124-5 ("The judiciary's competence and thus its legitimacy depends upon adherence to these two qualities of processes–dialogue and independence–not on the willingness of the people to consent to particular outcomes or on people's capacity to appoint or remove the individuals who hold the public office.").

[80] *See* Hannu Tapani Klami, *Legal Argument and Decision Theory*, 37 Am. J. Juris. 171, 174-75 (1992).

[81] *See* Kenneth G. Dau-Schmidt, *Economics and Sociology: the Prospects for an Interdisciplinary Discourse on Law*, 1997 Wis. L. Rev. 389, 414-19 (1997) ("The law is part of the process for internalizing norms of behavior.").

doi:10.6342/NTU201601682

Black (1976),[82][239] the variations or elements for modeling the behaviors of the laws remained crucial to legal scholarships. [83][267] Time-oriented models were designed to predict legal processes and provided insights to ponder better legal empirical practices for legal agents such as lawyers, judges, and legal scholars. [84][268]

Social selections of behaviors consistent with the social environments showed the co-evolutions of legal systems and human behaviors; this approach helped make out the functions of legal designs. [85][261] Evolutionary science beyond Darwinian nature selections historically transformed with divergent aspects of societal dimensions such as cultural or creative evolutions, etc. [86][233] Theory of human decision-making of evolutionary psychology indicated that the human mind to make choices was also in the consequences of nature selection. [87][260]

Systemic boundaries of legal systems were based on the communications of agents and the differentiations of societal events. [88][241] Legal dissonances characterized by the way how people think about legal rules or doctrines being dominated by

---

[82] *See* Donald Black, The Behavior of Law (special ed. 2010) 105-21 (1976).

[83] *See* Michael R. Gottfredson & Michael J. Hindelang, *A Study of the Behavior of Law*, 44 Am. Sociological Rev., 1979, at 3, 13-17.

[84] *See* Stuart S. Nagel & Marian Neef, *Time-Oriented Models and the Legal Process: Reducing Delay and Forecasting the Future*, 1978 Wash. U. L. Q. 467, 518 (1978) ("They need not become professional modelers, but they should develop a better understanding of the potentialities and limitations of modeling approaches in order to more constructively apply them in their work.").

[85] *See* Katherine J. Kaminsky & Matthrew W. Kirkhart, *A Step Beyond: Adding Behavior Analysis to the Discussion of Evolution, Natural Selection, and the Law*, 53 Fla. L. Rev. 947, 956-64 (2001).

[86] *See* Bela H. Banathy, Guided Evolution of Society: A Systems View 9-49 (2000).

[87] *See* Thomas S. Ulen, *Evolution, Human Behavior, and Law: A Response to Owen Jones's Dunwody Lecture*, 53 Fla. L. Rev. 931, 936-8 (2001).

[88] *See* Marc Amstutz, *Eroding Boundaries: On Financial Crisis and an Evolutionary Concept of Regulatory Reform*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 223, 240-6 (Poul F. Kjaer et al. eds., 2011).

doi:10.6342/NTU201601682

'time-shifted rationalities' from long-term evolutionary perspectives. [89][240]

Mathematical modeling uncertainty was one of the theories of uncertainty for scientific fact-findings due to errors of calculating time or incorrect mathematical formulas. [90][244] This thesis summarized the results by connecting with the history of the applications of biological games on animal contest behaviors or co-evolutionary models was bountifully introduced. [91][403]

The processes of nature selection and finding out evolutionarily stable strategies were the most significant differences between classic game theory and evolutionary game theory. [92][427] Neutrally stable strategies can not replace evolutionarily stable strategies in replicator dynamics because Liapunov stability do not imply neutrally stable strategies while the converse exists. [93][428]

---

[89] *See* Morris B. Hoffman, *Evolutionary Jurisprudence: the End of the Naturalistic Fallacy and the Beginning of Nature Reform*, *in* Law and Neuroscience: Current Legal Issues 2010 483, 492-501 (Michael Freeman ed., 2011) ("When we are confident that a human behaviors has an evolutionary core, and that a legal doctrine conflicts with that core, we need to ask ourselves whether the legal doctrine reflects a cultural judgement that the core is one of those time-shifted rationalities that once made evolutionary sense but no longer does.").

[90] *See* Vern R. Walker, *Theories of Uncertainty: Explaining the Possible Sources Error in Inferences*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 197, 221-2 (Marilyn MacCrimmon & Peter Tillers eds., 2002).

[91] *See generally* Peter Hammerstein & Reinhard Selten, *Game Theory and Evolutionary Biology*, *in* 2 Handbook of Game Theory with Economic Applications 929 (Robert J. Aumann & Sergiu Hart eds., 1994).

[92] *See* Peter Hammerstein, *Towards A Darwinian Theory of Decision Making: Games and the Biological Roots of Behavior*, *in* Evolution and Rationality: Decisions, Co-operation and Strategic Behaviour 7, 12-6 (Samir Okasha & Ken Binmore eds., 2012).

[93] *See* Simon M. Huttegger & Kevin J. S. Zollman, *Evolution, Dynamics and Rationality: the Limits of ESS Methodology*, *in* Evolution and Rationality: Decisions, Co-operation and Strategic Behaviour 67, 81 (Samir Okasha & Ken Binmore eds., 2012).

doi:10.6342/NTU201601682

3.3.2 System Theory and the Laws

To begin with the purposes of applications of system theories, global legal systems from system theories perspectives, making by the deductive methods of dynamical legal reasoning in decision-making processes of legal autopoiesis, it generated that autonomous legal systems beyond the state were derived from domestic political competitions for sovereign reasons and would acquire more efficacy for empirical practices of transnational commerces under the contexts of global interdependence. [94][219] It follows that laws as autopoietic systems, the systematization was bounded with differentiation, where reciprocal behaviors evolved with social norms in legal sociology fostered the equilibria of informal expectations for contractual parties. [95][211] Metaphysical statements generated from correspondent assumptions formed a logistical basis of the legal systems. [96][225]

Organizational Theories of Systems Thinking

On the decision-making programs (Entscheidungsverfahren) of legislators and the courts, the assumption for the reconstructions of classical judicial decision-making procedures was that the legislation was simply a differentiation and technical overall

[94] *See* Gralf-Peter Calliess, *Reflexive Transnational Law: the Privatisation of Civil Law and the Civilisation of Private Law*, *in* Zeitschrift für Rechtssoziologie 23, Heft 2, 2002, at 185, 1-3, 24-6.

[95] *See* Gunther Teubner, Law as An Autopoietic System 100-22 (Zenon Bankowski ed., Anne Bankowska et al. trans., 1993) ("In a legal system, characterized by a high degree of differentiation, integration through concepts or values is no longer possible. ..... Complementarity and reciprocity of expectations and the demand for consistency in behaviour are essential mechanisms for the formation of norms which influence the legal definition of contractual obligations.").

[96] *See* Thomas D. Barton, *The Structure of Legal Systems*, 37 Am. J. Juris. 291, 310-2 (1992).

doi:10.6342/NTU201601682

perspectively centralization on the legal formulations. [97][209] Role of courts in legal systems was discussed in early developing literatures of system theory of the laws: differences between legislations and jurisdictions in legal systems were the laws' self-description nature, whereas in global legal orders demonstrated the centre and periphery of the laws. [98][210]

System of regulation rooted in self-referential systems performs the aspects of intersystemic exchange in communicative procedures. [99][218] As far as this thesis interpreted the results that the function system of law established its communicative domains in rules of procedures, where the function system crisis emerged when function system of law was discomposed. [100][217] Biological concepts of co-evolution were once applied in law and business, discursively on changes of contracting and business organizational structures. [101][224]

Intuitions of biological connections with social life were not universally adopted

---

[97] *See* Niklas Luhmann, Rechtssoziologie 235 (4d ed. 2008) ("Dann liegt die Annahme nahe, daßGesetzgebung nichts weiter sei als eine Ausdifferenzierung und technische Zentralisierung eines Teils der richterlichen Entscheidungsleistung, eine Art Pauschalentscheidung über einige Entscheidungsprämissen, die sich besonders zu summarischer Behandlung und rechtssatzmäßiger Formulierung eignen.").

[98] *See* Niklas Luhmann, Das Recht der Gesellschaft 302-4 (1995) ("Alles spricht dafür, daßEinteilungen der Weltgesellschaft nach Zentren und Peripherien durch die primordiale Form der funktionalen Differenzierung regiert werden und ihr folgen. ..... Komplexitätsprobleme können durch Rückgang auf eine, wie es scheint, 'primitivere' Differenzierungsform gelöst werden: durch Anerkennung der Differenz von Zentrum und Peripherie.").

[99] *See* Alberto Febbrajo, *The Failure of Regulatory Institutions–A Conceptual Framework*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 269, 275-7 (Poul F. Kjaer et al. eds., 2011).

[100] *See generally* Rudolf Stichweh, *Towards A General Theory of Function System Crises*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 43 (Poul F. Kjaer et al. eds., 2011).

[101] *See* Thomas Earl Geu, *Chaos, Complexity, and Coevolution: the Web of Law, Management Theory, and Law Related Services at the Millennium*, 66 Tenn. L. Rev. 137, 221-35 (1998).

doi:10.6342/NTU201601682

in social systems of interactions. [102][220] To the extent, political occurrences were defined as political behaviors which were linear additive to macro-behaviors but making puzzles in nonlinear micro-events. [103][544] The public policy-makings related to the approaches of nonlinear dynamic systems or complexity theories for policy deliberations of public health were case-by-case applicable. [104][221]

Multilevel Systems Thinking

The hierarchical structures of legal systems presented by the constitution of a single nation could reveal the distinguishes of legal norms and legal systems. [105][212] Legal change by the jurisprudence and legislations used to be analyzed from a purely rational perspective on institutional change. [106][216] Beyond the case it followed that evolutionary economics and system theory of law in the study of legal institutional change were generalized into gene-culture co-evolutionary theory. [107][215]

Propositions of legal behaviors were affected by legal cultures of the times and

---

[102] *See* Thomas S. Smith, *Nonlinear Dynamics and the Micro-Macro Bridge*, *in* Chaos, Complexity, and Sociology: Myths, Models, and Theories 52, 62 (Raymond A. Eve et al. eds., 1997) ("A fair fraction of the micro-macro problem in social theory thus appears to reduce to the study of how global effects arise from local dynamics in systems of interaction.").

[103] *See* Claudio Cioffi-Revilla, Politics and Uncertainty: Theory, Models and Applications 280-2 (1998).

[104] *See* Euel Elliott & L. Douglas Kiel, *Nonlinear Dynamics, Complexity, and Public Policy: Use, Misuse, and Applicability*, *in* Chaos, Complexity, and Sociology: Myths, Models, and Theories 64, 68-70 (Raymond A. Eve et al. eds., 1997).

[105] *See* Hans Kelsen, Introduction to the Problems of Legal Theory 63-5 (Bonnie Litschewski Paulson & Stanley L. Paulson trans., 1992).

[106] *See* Wolfgang Kerber, *Transnational Commercial Law, Multi-level Legal Systems, and Evolutionary Economics*, *in* Law, Economics and Evolutionary Theory 297, 298-304 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011) ("Legal change is driven both by legislation and by the jurisprudence of courts. Especially the legal evolution that emerges through the ongoing decisions of courts has been the focus of ex- or implicit evolutionary approaches.").

[107] *See* Bart Du Laing, *Gene-Culture Co-evolution Theory and the Evolution of Legal Behavior and Institutions*, *in* Law, Economics and Evolutionary Theory 248 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

doi:10.6342/NTU201601682

from macro-view the legal system of one nation could reflect power distributions of social systems where it also could be interpreted as an allocative system. [108][213] The function or context methodology of law constructed a comparing normative ground for the conceptualization of the legal comparisons. [109][223]

Binary social preference functions in analysis of voting rules were applicable in spatial models of legislative decision-making and bargaining. [110][525] Theory of legal evolution within system theory of law interpreted the law as a complex and self-referential system of communication. [111][214] But it is not abstruse that any of social systems have the autopoietic features on their life cycles. [112][222]

3.3.3 Postmodernist Interdisciplinarity

To begin with, science and the law was constructed for studying the boundaries between the scientific innovation and its impacts on the legal systems. But since the rising of postmodernist studies, they faced some challenge on the interdisciplinarity of nonlinear dynamical systems and social science.

---

[108] *See* Lawrence M. Friedman, The Legal System: A Social Science Perspective 16-24 (1975).

[109] *See* David J. Gerber, *System Dynamics: Toward A Language of Comparative Law?*, 46 Am. J. Comp. L. 719, 722-4 (1998).

[110] *See* Norman Schofield, The Spatial Model of Politics 126-32, 266 (2008).

[111] *See* Simon Deakin & Fabio Carvalho, *System and Evolution in Corporate Governance*, *in* Law, Economics and Evolutionary Theory 111, 120-9 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[112] *See* Milan Zeleny, *On the Social Nature of Autopoietic Systems*, *in* Evolution, Order and Complexity 122, 126 (Elias L. Khalil & Kenneth E. Boulding eds., 1996) ("Life of social system, and thus life itself, is based on a dynamic and autopoietic harmony between birth and death processes.").

doi:10.6342/NTU201601682

Mathematical Definitions of Chaos

Despite of the higher dimensional dynamical mappings of attractors, consider a chaotic dynamical system, with a very concisely and the most popular mathematical definition of chaos and a very clear illustration as in the footnote (Devaney, 1986), were both quoted as follows: [113][565]

Definition 3. *Let V be a set. F: V → V is said to be chaotic on V if*

1. *f has sensitive dependence on initial conditions.*
2. *f is topologically transitive.*
3. *periodic points are dense in V.*

, and the illustration in the footnote, quoted as follows: [114][569]

> To summarize, a chaotic map possesses three ingredients: unpredictability, indecomposability, and an element of regularity. A chaotic system is unpredictable because of the sensitive dependence on initial conditions. It cannot be broken down or decomposed into two subsystems (two invariant open subsets) which do not interact under f because of topological transitivity. And, in the midst of this random behavior, we nevertheless have an element of regularity, namely the periodic points which are dense.

And so, the Lorenz set of nonlinear differential equations was quoted as follows: [115][567]

---

[113] *See* John Banks et al., Chaos: A Mathematical Introduction 168 (2003).

[114] *See also* Robert L. Devaney, An Introduction to Chaotic Dynamical Systems 50 (1986).

[115] *See* Neil Gershenfeld, The Nature of Mathematical Modeling 208 (1998).

doi:10.6342/NTU201601682

$$\begin{aligned} \dot{x} &= 10(y - x) \\ \dot{y} &= -xz + \frac{8}{3}x - y \\ \dot{z} &= xy - 28z \end{aligned} \tag{3.3.1}$$

Furthermore, it follows that there are three requirements for chaotic behaviors in three or more state space dimensions, quoted as follows: [116][566]

1. no intersection of different trajectories;
2. bounded trajectories;
3. exponenital divergence of nearby trajectories.

Mathematical Definitions of Nonlinearity

The mathematical definitions of linear/nonlinear ordinary differential equation are quoted as follows: [117][570]

Definition 4. *A linear ordinary differential equation of order n, in the dependent variable y and the independent variable x, is an equation that is in, or can be expressed in, the form*

$$a_0(x)\frac{d^n y}{dx^n} + a_1(x)\frac{d^{n-1}y}{dx^{n-1}} + ... + a_{n-1}(x)\frac{y}{x} + a_n(x)y = b(x)$$

, where a_0 is not identically zero.

A nonlinear ordinary differential equation is an ordinary differential equation that is not linear.

---

[116] *See* Robert C. Hilbert, Chaos and Nonlinear Dynamics 119 (2d ed. 2000).

[117] *See* Shepley L. Ross, Differential Equations 5 (3d ed. 1984).

doi:10.6342/NTU201601682

Postmodernist Viewpoints of Interdisciplinarity

At the outset of the postmodern studies, they constructed the sociological theories in the subdomains of legal studies or the criminology without any exigent proofs of mathematical theorems, simply with semiotics discussions based on the nonlinearity of human societies and social movements. [118][190][204][189] For instance, the studies was that orderly disorder in far-from-equilibrium conditions of nonlinear systems, nonlinearity, dissipative structures were from quantum chaos theory concepts with imaginary implications on empowered democracy phenomena or institutional social structures. [119][196], and so, they concluded that bifurcations and chaos theory applying in the forms of lawyering and legal discourses were also connected with the criminal justice studies. [120][197][194] To make it further, there were some studies indicated that the Foucault's argumentations for human science or mathematical formalization were distinct with mainstream understandings on the mathematical concepts beyond formal logics. [121][192][199] In the same directions of studies, the postmodernist studies showed that psychoanalytic semiotics was integrated with the chaos theory and contingent universalities which might be over-expanded into the

---

[118] *See* Christopher R. Williams & Bruce A. Arrigo, Law, Psychology, and Justice: Chaos Theory and the New (Dis)order 28-50 (2002). *See* Dragan Milovanovic, *Inscribing the Body With A Sign: Semiotics and Punishment*, *in* Legality and Illegality: Semiotics, Postmodernism, and Law 47, 62-4 (W. Richard Janikowski & Dragan Milovanovic eds., 1995). *See also* Bruce A. Arrigo & Dragan Milovanovic, The French Connection in Criminology: Rediscovering Crime, Law, and Social Change 115-31 (2005).

[119] *See* Dragan Milovanovic, Postmodern Law and Disorder: Psychoanalytic Semiotics, Chaos and Juridic Exegeses 236-7 (1992).

[120] *See* Dragan Milovanovic, *Psychoanalytic Semiotics, Chaos, and Rebellious Lawyering*, *in* Lacan: Topologically Speaking 174, 177-83 (Ellie Ragland & Dragan Milovanovic eds., 2004). *See also* Dragan Milovanovic, Postmodern Criminology (1997).

[121] *See* Vladimir Tasić, Mathematics and the Roots of Postmodern Thought 92-3 (2001). *See also* Jason Glynos & Yannis Stavrakakis, *Postures and Impostures: on Lacan's Style and Use of Mathematical Science*, *in* Lacan & Science 207 (2002).

doi:10.6342/NTU201601682

notions of the critical legal studies. [122][203][202][205][191]

Sokal Hoax

After the trends of postmodernist applications of nonlinear dynamical systems, Alan Sokal, as a physics professor in New York then, published an article intentionally obscuring the constructions as postmodernists did for their sociological theories in *Social Text* 1996. [123][208]

Sokal's works firstly critically examined most postmodern sciences and drew his conclusions on the misusing theories with respect to the confusions caused by the postmodernists and what the true theoretical implications of the nonlinear theories should be. [124] But he then turned into a more modest way for explaining the hoax after the tempest. [125][193][200][188]

After the Sokal hoax, a great amount of the examining the postmodernists' works were risen to verify their statements. [126][195] Though the debates in Sokal Hoax were not overall argued with the plausible sociological or criminological theories,

---

[122] *See* Dragan Milovanovic, *Visions of the Emerging Orderly (Dis)order*, *in* Chaos, Criminology, and Social Justice: the New Orderly (Dis)order 195, 202-4 (Dragan Milovanovic ed., 1997). *See* Caren Schulman, *Chaos, Law, and Critical Legal Studies: Mapping the Terrain*, *in* Chaos, Criminology, and Social Justice: the New Orderly (Dis)order 123, 128-32 (Dragan Milovanovic ed., 1997). *See also* Michael I. Meyerson, *Mathematics and the Legal Imagination: A Response to Paul Edelman*, 19 Const. Comment. 477 (2002). *See also* Michael I. Meyerson, Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution (2002).

[123] *See* Alan Sokal, *Transgressing the Boundaries: Towards A Transformative Hermeneutics of Quantum Gravity*, 46/47 Social Text 217 (1996).

[124] *See* Alan Sokal & Jean Bricmont, Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science 134-46 (1998).

[125] *See* Alan D. Sokal, *What the Social Text Affair Does and Does Not Prove*, *in* A House Built on Sand: Exposing Postmodernist Myths About Science 9 (Noretta Koertge ed., 1998). *See also* Alan Sokal, Beyond the Hoax: Science, Philosophy and Culture (2008).

[126] *See* Paul R. Gross & Norman Levitt, Higher Superstition: the Academic Left and Its Quarrels With Science 92-106 (1994).

doi:10.6342/NTU201601682

the relevant issues and the criticisms corrected the deviated trends of postmodernist studies since then. [127][198] For instance, there were some studies pointed out that the postmodern mathematics was self-criticism inspected for the problems of scientific literacy and education. [128][201][207][206]

3.3.4 Behavioral Analysis of Law

Beyond Evidence-based Laws

In approaching the issues, it began with the facts that evolutionary adaptation was presented in complex mappings of impersonal agent interactions and exchange states of agents as well, which determined whether to achieve cooperation or not. [129][331] Cooperative actions of agents caused mutual gains than self-interested ones that activated cooperation mechanisms of social situations. [130][330] Furthermore, to illustrate, bounded rationality, will-power or self-interest elements rooting for debiasing through substantive laws or regulating subjective judicial behaviors of the judges would be reexamined by individual's hindsights on bargaining hybrid

[127] *See* Noam Chomsky et al., *The Limitations of Rationality and Science?*, *in* David Detmer, Challenging Postmodernism: Philosophy and the Politics of Truth 305, 322-29 (2003).

[128] *See* Noretta Koertge, *Postmodernisms and the Problem of Scientific Literacy*, *in* A House Built on Sand: Exposing Postmodernist Myths About Science 257, 260-4 (Noretta Koertge ed., 1998). *See also* David Lucy, Book Review, 1 Law, Probability & Risk 185 (2002) (reviewing Michael I. Meyerson, Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution (2002)). *See also* Paul H. Edelman, *The Law and Large Numbers*, 19 Const. Comment. 459 (2002) (reviewing Michael I. Meyerson, Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution (2002).

[129] *See* Elizabeth Hoffman et al., *What Makes Trade Possible?*, *in* The Law and Economics of Irrational Behavior 169, 184 (Francesco Parisi & Vernon L. Smith eds., 2005) ("Cooperation through trust is almost impossible in such an environment because no individual has the opportunity to build a reputation for trust.").

[130] *See* Kevin McCabe et al., *Lessons From Neuroeconomics for the Law*, *in* The Law and Economics of Irrational Behavior 68, 77-8 (Francesco Parisi & Vernon L. Smith eds., 2005).

doi:10.6342/NTU201601682

bias in adjudicative decision-making processes. [131][322] In order to avoid mistakes that ordinary bargaining conditions may cause, the second-order decision strategies are adopted to the third parties as political agents or administrative institutions. [132][335] While in comparisons of the convergence of taxonomy of behavioral laws and system theory, the assumptions of rational choice theory on self-interested social agents that premised underlying the decision-makings of heuristics and biases in preferences, where the availability heuristic would show acutely policy implications of professional experiences rather than the practice guidelines in regulatory regimes and legal systems. [133][352]

Heuristics Decision-makings and the Law

Heuristics in preferences wielded influence on the challenge of losing autonomy of boundedly rational decision-makers in the policy-making community. [134][337] Most decision-makings were based on heuristic functions synergic with social environments and informational or reputational influence, especially the heuristics of reciprocal behaviors. [135][333] Heuristic as the laws or the facts for the laws was monotonously in legal decisions or interpretations but relatively momentous for making the laws.

---

[131] *See* Christine Jolls, Behavioral Economics and the Law 23-8 (2011).

[132] *See generally* Cass R. Sunstein & Edna Ullmann-Margalit, *Second-Order Decisions*, *in* Behavioral Law and Economics 187 (Cass R. Sustain ed., 2000).

[133] *See* Russell B. Korobkin & Thomas S. Ulen, *Law and Behavioral Science: Removing the Rationality Assumption From Law and Economics*, 88 Cal. L. Rev. 1051, 1086-90, 1139-44 (2000).

[134] *See* Russell Korobkin, *What Comes After Victory for Behavioral Law and Economics?*, 2011 U. Ill. L. Rev. 1653, 1659-62 (2011) ("In new world of law and economics, individuals are understood not as ruthless optimizers, but as boundedly rational human beings who have a limited supply to cognitive energy and attention and rely on a cacophony of heuristic cues.").

[135] *See* Cass R. Sunstein, *Toward Behavioral Law and Economics*, *in* Judgments, Decisions, and Public Policy 218, 228 (Rajeev Gowda & Jeffrey C. Fox eds., 2002).

doi:10.6342/NTU201601682

[136][328] Political heuristics would be relied on when making political decisions by the governments, in the meanwhile, by the social agents making evaluations on public policies though fragile in response to public opinions. [137][336] Campaign finance compared with availability heuristics and confirmation biases could be more powerful to change the political outcomes. [138][340]

Mathematical rigorous models undoubtedly hold a higher status of hierarchy in interdisciplinary studies, as well as economics and the laws. [139][324] Despite of this, the game-theoretical models of the processes of bargaining and the phenomena of power in the heart of political theories in the explanations of political reasoning were found in very early studies. [140][356]

Reliance on heuristics would cause deviation in rational judgments from the perspectives of ecological rationality. [141][338] In addition, applications of heuristics to legal studies should take the logically systematic wrong opinions into accounts. [142][342]

---

[136] *See* Christoph Engel & Gerd Gigerenzer, *Law and Heuristics: An Interdisciplinary Venture*, *in* Heuristics and the Law 1, 4-8 (G. Gigerenzer & C. Engel eds., 2006).

[137] *See* Jeffrey J. Rachlinski, *Selling Heuristics*, 64 Ala. L. Rev. 389, 406-15 (2012).

[138] *See generally* Molly J. Walker Wilson, *Behavioral Decision Theory and Implications for the Supreme Court's Campaign Finance Jurisprudence*, 31 Cardozo L. Rev. 3 (2010).

[139] *See* Peter H. Huang, *Emotional Reactions to Law and Economics, Market Metaphors, and Rationality Rhetoric*, *in* Theoretical Foundations of Law and Economics 163, 163 (Mark D. White ed., 2009) ("[D]ifferences in how most academic and professional economists perceive law and economics versus how most academic and professional lawyers perceive law and economics are due to primarily to differences in how familiar they are with microeconomics presented in a mathematically rigorous fashion.").

[140] *See* Herbert A. Simon, *Theories of Decision-Making in Economics and Behavioral Science*, 49 The Am. Econ. Rev., no.3, 1959, at 253, 266-7.

[141] *See* Jeffrey J. Rachlinski, *The Psychological Foundations of Behavioral Law and Economics*, 2011 U. Ill. L. Rev. 1675, 1684-7 (2011).

[142] *See* Jeffrey J. Rachlinski, *Heuristics, Biases, and Philosophy*, 43 Tulsa L. Rev. 865, 873-5 (2008).

doi:10.6342/NTU201601682

Refraining from the costs of group-based judgment errors and reducing debiasing actors in legal proceedings had revoked a sequential theoretical progress of behavioral law and economics. [143][327] Group polarization worked with the legislature mainly due to the social influence. [144][353]

Social norm compliance with macroview of individuals that could be transformed from mixed motive games into coordination games except reciprocity conditions. [145][325] Empirical questions of macro-economic controls on bankruptcy problems often revealed the consistency of legislation. [146][344] For instance, redistributive legal rules would possibly do less harm to work incentives than taxes. [147][354] Rational agent's behaviors would better take care on the perceptions of the judicial efficient incentives provided by corresponding legal systems. [148][332]

The nature of uncertainty would be discord with traditional economics and the laws approaches when facing the risks in legal systems being ergodic in reasoning about pattern structures. [149][329] Preferences are in the heart of bargaining theory, where there were two classical types of prescriptions studying the agent behaviors

[143] *See generally* Christine Jolls, *Behavioral Law and Economics*, *in* Behavioral Economics and its Applications 115 (Peter Diamond & Hannu Vartiainen eds., 2007).

[144] *See* Cass R. Sunstein, *Deliberative Trouble? Why Groups Go to Extremes*, 110 Yale L.J. 71, 104-5 (2000).

[145] *See* Marco Faillo & Lorenzo Sacconi, *Norm Compliance: the Contribution of Behavioural Economics Models*, *in* Games, Rationality and Behaviour: Essays in Behavioural Game Theory and Experiments 101, 116-21 (Alessandro Innocenti & Patrizia Sbriglia eds., 2008).

[146] *See* Joshua D. Wright, *Behavioral Law and Economics, Paternalism, and Consumer Contracts: An Empirical Perspective*, 2 N.Y.U. J. L. & Liberty 470, 484-9 (2007).

[147] *See* Christine Jolls, *Behavioral Economic Analysis of Redistributive Legal Rules*, 51 Vand. L. Rev. 1653, 1675-7 (1998).

[148] *See* Eric A. Posner, *Probability Errors: Some Positive and Normative Implications for Tort and Contract Law*, *in* The Law and Economics of Irrational Behavior 456, 465-7 (Francesco Parisi & Vernon L. Smith eds., 2005).

[149] *See generally* Douglass C. North, *Cognitive Science and the Study of the "Rules of the Game" in the World of Uncertainty*, *in* Norms and the Law 48 (John N. Drobak ed., 2006).

doi:10.6342/NTU201601682

of intrapersonal or interpersonal dynamics would generate entirely different results. [150][343] To conclude with, predicting the environment of evolutionary adaptiveness in the emergence of legal institutions was perplexing in finding the effective paths to institutional mechanisms. [151][341]

Decision Theory and the Law

Deviations of judicial decision-makings based on rational assumptions would be overturned by multivariant adaptive constraints of legal policies or insights of general legal principles that made it more modest towards legal reasoning of behavioral decision theory. [152][323] Behavioral decision theory phenomena generated cognitive insights of changing risk preferences for the agents in empirical legal systems. [153][351]

Legal decision theory approached the complex nature of rationality as well as the behavioral tendencies of agents in legal systems. [154][347] Legal decision theory included the cognitive limitations and assumed that people would deliberate reasons before they made decisions but ended up with failure in predictions with respect to the prospect theory. [155][348] Beyond this situations, the decision-making processes in contract bargaining negotiations of commercial transactions would be reorganized

---

[150] *See* Grant M. Hayden & Stephen E. Ellis, *Law and Economics After Behavioral Economics*, 55 U. Kan. L. Rev. 629, 645-6 (2007).

[151] *See generally* Oliver R. Goodenough, *Institutions, Emotions, and Laws: A Goldilocks Problem for Mechanism Design*, 33 Vt. L. Rev. 395 (2009).

[152] *See* Larry A. DiMatteo et al., Visions of Contract Theory: Rationality, Bargaining, and Interpretation 18-23 (2007).

[153] *See* Jeffrey J. Rachlinski, *The "New" Law and Psychology: A Reply to Critics, Skeptics, and Cautious Supporters*, 85 Cornell L. Rev. 739, 743-4 (2000).

[154] *See generally* Gregory Mitchell, *Tendencies Versus Boundaries: Levels of Generality in Behavioral Law and Economics*, 56 Vand. L. Rev. 1781 (2003).

[155] *See* Robert A. Prentice, *Chicago Man, K-T Man, and the Future of Behavioral Law and Economics*, 56 Vand. L. Rev. 1663, 1768-71 (2003).

doi:10.6342/NTU201601682

by behavioral theories of inertia and network benefits. [156][334] Nevertheless, legal decision theory failed in predictive norms of rationality with empirical boundaries of legal behaviors. [157][350]

3.3.5 Rational Choice Theory

At the outset, the rational bargaining behaviors in reality situations tended not to always match the optimal predictions of rational choice theory models, where the outcomes estimated under uncertainty made more impreciseness on real-world problems due to dynamical individual's preferences and social environmental risks. [158][298] Adaptive rationality argued the self-restraint behaviors of individual's will rooting on completely self-interested incentives or social potential impact. [159][297] Agent-based social simulation and evolutionary game theory as approaches were not only gradually, but specifically, used in social sciences of strategically decision-makings and the organization theories. [160][296]

---

[156] *See* Russell Korobkin, *Behavioral Economics, Contract Formation, and Contract Law*, *in* Behavioral Law and Economics 116, 125-9 (Cass R. Sustain ed., 2000).

[157] *See* Gregory Mitchell, *Why Law and Economics' Perfect Rationality Should Not Be Traded for Behavioral Law and Economics' Equal Incompetence*, 91 Geo. L.J. 67, 137-9 (2002).

[158] *See* Thomas S. Ulen, *Rational Choice Theory in Law and Economics*, *in* Encyclopedia of Law and Economics 790, 801-6 (Boudwijn Bockaert & Gerrit De Geest eds., 1999).

[159] *See* Robert H. Frank, *Departures From Rational Choice: With and Without Regret*, *in* The Law and Economics of Irrational Behavior 13, 30-1 (Francesco Parisi & Vernon L. Smith eds., 2005).

[160] *See* Sun-Ki Chai, *Rational Choice Theory: A Forum for Exchange of Ideas between the Hard and Social Sciences in Predictive Behavioral Modeling*, *in* Social Computing, Behavioral Modeling, and Prediction 1, 2-3 (Huan Liu et al. eds., 2008).

doi:10.6342/NTU201601682

Rational Choice of Legal Behaviors

Legal behaviors are defined on rational preferences that courts call upon judges to do legal reasoning unanimously with legal precedents or policies preferences, just like human computers. [161][293] Universalizability deviated from publicity principles when extracting from the derivation of its relevance to the moral law. [162][301]

Judicial behaviors adopted legal orders without the dependence of the value of markets would restrict the predictability of rational choice theory on evaluating the applications of legal principles. [163][273] However, on the other hand, legislative participation or design will generate more powerful effects on the enforcements of international treaties, where the legislature's consents manifested domestic policy preferences in law-making processes. [164][306]

To interpreting collective behaviors provided rational policy-makers or legislature scenarios and encouraged rationality in finding the legal implications from traditional economical models. [165][307] For instance, in analyzing post-award judicial decisions in correspondence with the ways of predicting the choices that tribunals may make, negotiating games of the parties would show that the independence of tribunals costs less effectiveness. [166][303] Conventional rational choice theory often generated

---

[161] *See* Lee Epstein et al., The Behavior of Federal Judges: A Theoretical and Empirical Study of Rational Choice 50 (2013).

[162] *See* David Luban, *The Publicity Principle*, *in* The Theory of Institutional Design 154, 180-2 (Robert E. Goodin ed., 1996).

[163] *See* Ernst-Joachim Mestemäcker, A Legal Theory Without Law: Posner v. Hayek on Economic Analysis of Law 46-9 (2007).

[164] *See* Jack L. Goldsmith & Eric A. Posner, *International Agreements: A Rational Choice Approach*, 44 Va. J. Int'l L. 113, 122-7 (2003).

[165] *See generally* Matthew D. Adler et al., *Preferences and Rational Choice: New Perspectives and Legal Implications: Introduction*, 151 U. Pa. L. Rev. 707 (2003).

[166] *See* Andrew T. Guzman, *International Tribunals: A Rational Choice Analysis*, 157 U. Pa.

doi:10.6342/NTU201601682

its outcomes which were empirically matchable to behavioral predictions, whereas it showed weakness in some social dilemma cases with asymmetric information. [167][296] Therefore, modeling non-rational individual decision-makings was under the assumptions of eschewing traditional corrective legislations but as an appraisal for the rational choice model, it presented the empirical prelude to explaining behaviors of individuals. [168][269]

This decade the attitudinal models emerged in political science theoretically based on the ideology of empirical legal studies in describing judicial behaviors from microview perspectives. [169][302] Policy implications of emotional reactions for international actors were affiliated with their belief-dependent preferences which sometimes reflected on the compliance with legal orders. [170][308]

Institutional Design and Game Theory

Rational choice institutionalism focused on unitary and interest-based incentives of states provided a new avenue for evaluating how much the domestic actors would influence the international rule-makings. [171][304] For adding up the rational choices

---

L. Rev. 171, 208-12 (2008).

[167] *See generally* Sun-Ki Chai, *Rational Choice Theory: A Forum for Exchange of Ideas between the Hard and Social Sciences in Predictive Behavioral Modeling*, *in* Social Computing, Behavioral Modeling, and Prediction 1, 4-5 (Huan Liu et al. eds., 2008).

[168] *See* Ejan Mackaay, Law and Economics for Civil Law Systems 40-6 (2013).

[169] *See generally* Lawrence B. Solum, *The Positive Foundations of Formalism: False Necessity and American Legal Realism*, 127 Harv. L. Rev. 2464 (2014) (reviewing Lee Epstein et al., The Behavior of Federal Judges: A Theoretical and Empirical Study of Rational Choice (2013)).

[170] *See generally* Peter H. Huang, *International Environmental Law and Emotional Rational Choice*, 31 J. Legal Stud. 237 (2002).

[171] *See* Kenneth W. Abbott, *Enriching Rational Choice Institutionalism for the Study of International Law*, 2008 U. Ill. L. Rev. 5, 35-42 (2008).

doi:10.6342/NTU201601682

of collective actors in non-state paradigms, rational choice institutionalism theory would underestimate the complexity of the dynamical individual preference changes. [172][305] However, the generalized deliberation dynamics simplified in rational choice theory as determinate individual's preferences or desires was often ignored in theories on decision-making behavioral analysis of rational agents. [173][295]

Institutional design theory was not adopted in the disparate social structures but the collective behaviors of individuals. [174][299] Institutional reshaping often became transient phenomena or unorthodox ideas when involving in processes of political innovations. [175][300] Besides, the inclusive fitness of human beings based on bounded willpower, self-interest and rationality was partially revealed to altruism behaviors from long-term interest perspectives. [176][309] It follows that game-theoretical models simplified factual rationality with computational or predictive functions with respect to the globalization of the adaptive mechanisms for the organism. [177][310]

---

[172] *See* Anne van Aaken, Comment, *Towards Behavioral International Law and Economics: A Comment on Enriching Rational Choice Institutionalism for the Study of International Law*, 2008 U. Ill. L. Rev. 47, 53-5 (2008).

[173] *See* Robert Grafstein, Choice-free Rationality: A Positive Theory of Political Behavior 34-9 (1999).

[174] *See* Philip Pettit, *Institutional Design and Rational Choice*, *in* The Theory of Institutional Design 54, 55 (Robert E. Goodin ed., 1996).

[175] *See* John S. Dryzek, *The Informal Logic of Institutional Design*, *in* The Theory of Institutional Design 103, 120-3 (Robert E. Goodin ed., 1996).

[176] *See generally* Richard A. Posner, *Rational Choice, Behavioral Economics, and the Law*, 50 Stan. L. Rev. 1551 (1998).

[177] *See generally* Herbert A. Simon, *A Behavioral Model of Rational Choice*, 69 The Quarterly Journal of Economics, no. 1, 1955, at 99.

doi:10.6342/NTU201601682

3.3.6 Bounded Rationality

Sociobiology with respect to the evolutionary theory on biology or ecology that was interpreted with interactions of social agents, which would also be speculated with normative implications of behavioralism, where the taxonomy was divided into three fundamentals: bounded rationality, bounded willpower, bounded self-interest. [178][349] Bounded rationality interfaced with arbitral jurisdictions from behavioral laws and economics perspectives was deduced that the tendency of arbitrators on the basis of availability heuristics could be concerned with the arbitrator's independent rationality and national post-award legal systems. [179][339]

In general what this means is that bounded rationality was proposed by Herbert A. Simon, mainly in political science studies with the assumptions of interests-group perceptions concerned with fairness and risks where destabilized the independence of legislator's decision-makings. [180][355] Social behaviors of the boundedly rational individuals, such as the addictions, were taken as decision-process malfunctions which involved the counterparts of social incentives and temptation preferences.

---

[178] *See* Richard A. Posner, *Behavioral Law and Economics: A Critique*, Econ. Educ. Bull., no. 8, 2002, at 1, 3, 13-21.

[179] *See* Giacomo Rojas Elgueta, *Understanding Discovery in International Commercial Arbitration Through Behavioral Law and Economics: A Journey Inside the Minds of Parties and Arbitrators*, 16 Harv. Negot. L. Rev. 165, 186-7 (2011) ("The availability heuristic not only offers a possible explanation for the abuse of discovery in international arbitration, but also builds a strong case against arbitral discretion as an essential measure to develop appropriate procedural rules corresponding to the needs of each disputes.").

[180] *See* Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 Stan. L. Rev. 1471, 1508-10 (1998) ("Legislators interested in their own reelection will be responsive to the preferences and judgments of their constituents and those of powerful interest groups. ... Mobilized groups may also attempt to manage exploit the public's views, including views influenced by bounded self-interest and bounded rationality, to bolster their own efforts; a prime example discussed below is the "availability entrepreneur," who seeks to publicize an event in order to make it more "available" to the general public, and thus to increase the public's demand for regulation.").

doi:10.6342/NTU201601682

[181][326] Unbounded rationality was taken as reasons for unstable behaviors of actors that changing their situations by using incentives under the debiasing of bounded rational actors. [182][345]

Beyond Rationalizability

Rationalizability can not be isolated from noncooperative iterated games. [183][382] People's actions are constrained by the rationalizability, therefore in order to define rationalizability with the profiles of rationalizable actions Z_j, there was a concise definition, quoted as follows: [184][378]

Definition 5. *An action $a_i \in A_i$ is rationalizable in the strategic game (N, (A_i), (u_i)), if for each $j \in N$, there is a set $Z_j \subseteq A_j$ such that*

1. $a_i \in Z_i$,

2. every action $a_j \in Z_j$ is a best response to a belief $\mu_j(a_j)$ of player j whose support is a subset of Z_j.

Ecological Rationality and Adaptive Behaviors

Heuristic thinking in adaptive decision-makings would consist in higher parts of mathematical thinking where social situations or real-world problems are hard to be

---

[181] *See* B. Douglas Bernheim & Antonio Rangel, *Behavioral Public Economics: Welfare and Policy Analysis With Nonstandard Decision-Makers*, *in* Behavioral Economics and its Applications 7, 49-53 (Peter Diamond & Hannu Vartiainen eds., 2007).

[182] *See* Christine Jolls & Cass R. Sunstein, *Debiasing Through Law*, 35 J. Legal Stud. 199, 443 (2006).

[183] *See* James W. Friedman, Game Theory With Applications to Economics 196-7 (2d ed. 1991).

[184] *See* Martin J. Osborne & Ariel Rubinstein, A Course in Game Theory 55 (1994).

doi:10.6342/NTU201601682

solved by mathematical logics. [185][318] Models of bounded rationality often relied on the specific defined rules with constraints of environments where adaptive agent's behaviors could be operated with heuristics and be functionalized by mathematical optimization analysis on real-world problems. [186][320] Bounded agents that evolved with aspirations to make choices in traditional prescriptive legal scholarships would become a significant gap. [187][317]

Aspiration-based adaptations broadened bounded rationality theoretical basis by studying the complexity of people's choice or activated representations. [188][311] How to build up mathematical models for analyzing boundedly rational behaviors and strategic interactions was the initial contribution of economists, while studying the boundedly rational votings became a branch of political science prominently formulated by Herbert A. Simon. [189][312]

Modeling bounded rationality to study the interactive agents both the market systems and individuals was based on demonstrating the reasoning procedures by making complexity considerations in repeated games on equilibrium paths. [190][316] Assuming courts are irrational thus adjusting the rules of decision-makings with bounded rational incentives, behavioral economic analysis transcend the traditional

---

[185] *See* Gerd Gigerenzer, *Is the Mind Irrational or Ecologically Rational?*, *in* The Law and Economics of Irrational Behavior 37, 40-1 (Francesco Parisi & Vernon L. Smith eds., 2005).

[186] *See* Gerd Gigerenzer & Reinhard Selten, *Rethinking Rationality*, *in* Bounded Rationality: the Adaptive Toolbox 1, 8-11 (G. Gigerenzer & R. Selten eds., 2002).

[187] *See* Matthew D. Adler, *Bounded Rationality and Legal Scholarship*, *in* Theoretical Foundations of Law and Economics 137, 151-62 (Mark D. White ed., 2009) ("Bounded rationality may not be a gap in the foundations of such scholarship, but it is a large and unresolved gap in our understanding of how prescriptive legal scholars should conduct their activities.").

[188] *See* Jonathan Bendor et al., A Behavioral Theory of Elections 12-5 (2011).

[189] *See* Jonathan Bendor, Bounded Rationality and Politics 11-47 (2010).

[190] *See* Ariel Rubinstein, Modeling Bounded Rationality 137-64 (1998).

doi:10.6342/NTU201601682

economic predictions in public law enforcement contexts. [191][319]

Bounded rationality from cognitive restraints interpreted by measurement and incoherence was essentially conflict with individual's self-controlling behaviors of rational choice theory in economics. [192][313] For instance, institutional judges might inevitably encounter the problems of the boundedly rational manipulations of legal interpretations and the empirical uncertainty of factor or information gathering in making choices, etc. [193][315]

3.4 Mathematical Sociological Modeling Methods

3.4.1 Agent-based Computing and Social Simulation

Real-world Socio-environmental Scenarios

Social embeddedness was based on social intelligence hypothesis and the social trends obviated by rational decision-making processes of individuals. [194][492] In that case, mathematics of complex adaptive social systems was hard when it comes to transforming generality for simple explanations of complex interacting agents.

---

[191] *See* Christine Jolls, *On Law Enforcement with Boundedly Rational Actors*, *in* The Law and Economics of Irrational Behavior 268, 272-81 (Francesco Parisi & Vernon L. Smith eds., 2005).

[192] *See* Alistair Munro, Bounded Rationality and Public Policy: A Perspective from Behavioural Economics 13-6, 136 (2009).

[193] *See* Adrian Vermeule, Judging Under Uncertainty: An Institutional Theory of Legal Interpretation 153-62 (2006).

[194] *See* Bruce Edmonds, *Agent-based Social Simulation and Its Necessity for Understanding Socially Embedded Phenomena*, *in* Minding Norms: Mechanisms and Dynamics of Social Order in Agent Societies 34, 37 (Rosaria Conte et al. eds., 2014) ("[S]ocial embedding implies that there are many aspects of human life that can not be satisfactorily modeled if one omits either the individual and her decision-making or the system of groups and interactions that the individual is embedded in.").

doi:10.6342/NTU201601682

[195][444] One cannot deny that adaptive decision patterns for alternative traits with additional heuristics in transforming adaptive traits of ecological models into social collective decision-making behaviors of the laws were defined as a threshold value of the ways of how social groups making decisions but not as the optimal value. [196][488] Furthermore, it is tempting to characterize that decision-makers as social agents in artificial societies to approximate realistic situations with social policies or law-making and litigation procedures in rigorous analysis are constructed by bounded rationality of discovering agents behaviors. [197][490]

Simulation of Social Agent Behaviors

Modeling cooperative interactions in social dilemma, without loss of generality, needs to adopt bounded rationality theories on decision-makings for simulating the social agents. [198][499] In view of this, the spatial distributing properties of autonomous individuals locally behaviors resulted in bounded rationality due to the bounded

---

[195] *See* John H. Miller & Scott E. Page, Complex Adaptive Systems: An Introduction to Computational Models of Social Life 234-5 (2007) ("[T]he only way to predict the future behavior of the system is to let it run out, the obvious hope is that there are other opportunities to uncover more compact descriptions of complex behavior.").

[196] *See* Steven F. Railsback & Volker Grimm, Agent-Based and Individual-Based Modeling: A Practical Introduction 143-55, 243-54 (2012).

[197] *See* Michael J. North & Charles M. Macal, Managing Business Complexity: Discovering Strategic Solutions With Agent-based Modeling and Simulation 97-101 (2007) ("The main weakness of rational choice theory is that research strongly indicates that people rarely make purely rational decisions. ..... Bounded rationality refined rational choice theory by including decision-makers that have limited knowledge and finite cognitive abilities. ..... Bounded rationality is a good fit for many kinds of human, and nonhuman, decision-making.").

[198] *See* Peter J. Deadman & Edella Schlager, *Models of Individual Decision Making in Agent-based Simulation of Common-Pool-Resource Management Institutions*, *in* Integrating Geographic Information Systems and Agent-based Modeling Techniques for Simulating Social and Ecological Processes 137, 143 (H. Randy Gimblett ed., 2002) ("Bounded rational individuals develop shared norms of trust and reciprocity that encourage cooperation and that allow individuals to achieve outcomes that make themselves better off.").

doi:10.6342/NTU201601682

information and bounded computing capacity of agents. [199][503] Simulating social interaction processes of large-scale groups in social networks needs to connect with the studies of effects on decision-makings of individuals. [200][497] For instance, some studies draw a clear-cut conclusion for the evolving theories of their history from computational sociology to mathematical sociology (eg. "computational sociology: from artificial life to agent-based modeling" and "mathematical sociology: from the social network to the meta-network"), and pointed out that for social co-evolution, the synthesis of agent-based modeling and dynamic network analysis to construct agent-based dynamic network simulation models as a better tool to study social behaviors of intelligent adaptive agents by taking environment as a meta-network. [201][494] Mutation and selection drove human societal evolution mechanisms but gave up the optimal strategies due to bounded rationality of interacting agents; repeated games would be a good way for studying small-scale societies. [202][553]

Generally speaking, simulating the distribution of power and its interactions with organizations in areas of institutional changes would volatile in simulating evolving institutional networks. [203][486] Macroscopic patterns in agent-based modeling could

---

[199] *See* Joshua M. Epstein, *Agent-Based Computational Models and Generative Social Science*, 4 Complexity, no. 5, 1999, at 41, 42.

[200] *See* Andreas Pyka & Thomas Grebel, *Agent-based Modelling—A Methodology for the Analysis of Qualitative Development Processes*, *in* Agent-based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences 17, 28-9 (Francesco C. Billari et al. eds., 2006).

[201] *See* Terrill L. Frantz & Kathleen M. Carley, *Agent-based Modeling Within A Dynamic Network*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 475, 477-95 (Stephen J. Guastello et al. eds., 2009).

[202] *See* Johan Almenberg & Anna Dreber, *Economics and Evolution: Complementary Perspectives on Cooperation*, *in* Evolution, Games, and God: the Principles of Cooperation 132, 141-3 (Martin A. Nowak & Sarah Coakley eds., 2013).

[203] *See* Manuel Wäckerle, The Foundations of Evolutionary Institutional Economics: Generic Institutionalism 229-56 (2014).

doi:10.6342/NTU201601682

be excluded with the considerations of micro-foundations for the refinement of agent-based models. [204][493]

By many accounts of models, adapting to environments and current states showed tenable evolution theories of adaptive traits for myriad species to find their fitness; it addressed the purposes and reasons why modeling behavioral traits and especially with agent-based modeling approach. [205][498] Specifically, for instance, simulating decentralized cooperative behaviors of agents in multi-agent models would reveal the social dynamics in spatially distributed population models and the predictions of social norms. [206][495]

Agent-based Computing and Societal Researches

Legislative organizations considered as social organizations, where people are defined as the agents of the decision-making or bargaining systems in political spheres, and so taking the scope of agent-based modeling could be connected with the study of complexity. [207][546] Connecting with the dispute resolution bargaining, autonomous agents of negotiations are often designed as cooperation schemes applied in game theory, agent-based modeling, social networks modeling, etc. [208][523] Modeling

---

[204] *See* Brian Epstein, *Agent-based Modeling and the Fallacies of Individualism*, *in* Models, Simulations, and Representations 115, 133 (Paul Humphreys & Cyrille Imbert eds., 2012).

[205] *See* Volker Grimm & Steven F. Railsback, *Agent-based Models in Ecology: Patterns and Alternative Theories of Adaptive Behaviour*, *in* Agent-based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences 139, 150 (Francesco C. Billari et al. eds., 2006).

[206] *See generally* Miklos N. Szilagyi, *Agent-Based Simulation of the N-Person Chicken Game*, *in* Advances in Dynamic Game Theory: Numerical Methods, Algorithms, and Applications to Ecology and Economics 695 (Steffen Jϕrgensen et al. eds., 2007).

[207] *See* John H. Holland, Emergence: From Chaos to Order 116-8 (1998).

[208] *See* John A. Sokolowski & Catherine M. Banks, Modeling and Simulation for Analyzing Global Events 63-78 (2009) ("These agent encounters could be thought of as games,

doi:10.6342/NTU201601682

processes of complex cultural systems by using cross-cultural approaches would be prevalent between the agent-based modeling and the concepts of artificial complex societies. [209][502] From that standpoint, modeling complex adaptive systems with agent-based approaches would be both adopted in germane socioeconomic systems and population processes to help develop theories of human interactions of complex social networks. [210][496]

Modeling predator-prey models or SIR models differs from agent-based modeling for the latter depending on deterministic automaton was fabricated unforeseeable outcomes in complex systems. [211][487] And so, furthermore, team-forming behaviors of agents is important in designing the scenarios of investigating targets of the agents. [212][500]

---

and therefore formal methods of game theory could be used to implement the negotiation and cooperation functionality. Agent-based models often contain multiple agents that form a network of relationships called social networks.").

[209] *See* Henry T. Wright, *Agent-based Modeling of Small-Scale Societies: State of the Art and Future Prospects*, *in* Dynamics in Human and Primate Societies: Agent-based Modeling of Social and Spatial Processes 373, 380-3 (Timothy A. Kohler & George J. Gumerman eds., 2000).

[210] *See generally* Francesco C. Billari et al., *Agent-based Computational Modelling: An Introduction*, *in* Agent-based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences 1 (Francesco C. Billari et al. eds., 2006).

[211] *See* Daniela Calvetti & Erkki Somersalo, Computational Mathematical Modeling: An Integrated Approach Across Scales 199-211 (2013).

[212] *See* Vanessa Teague & Liz Sonenberg, *Investigating Commitment Flexibility in Multi-Agent Contracts*, *in* Game Theory and Decision Theory in Agent-based Systems 267, 288-9 (Simon Parsons et al. eds., 2002).

doi:10.6342/NTU201601682

NetLogo: Agent-based Modeling Examples

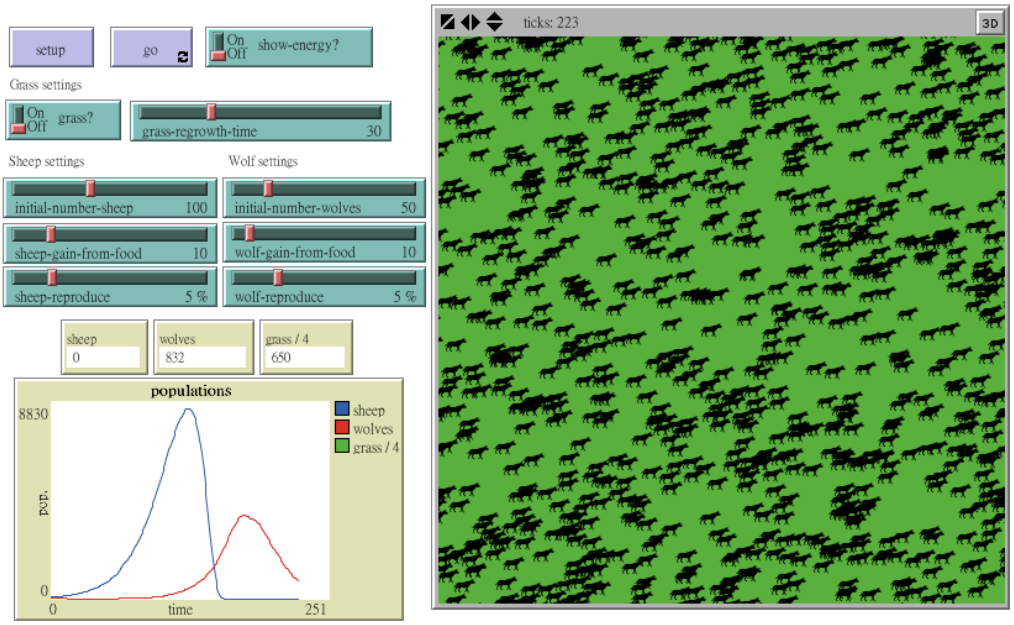


Figure 3.1: Wolf Sheep Predation (1)

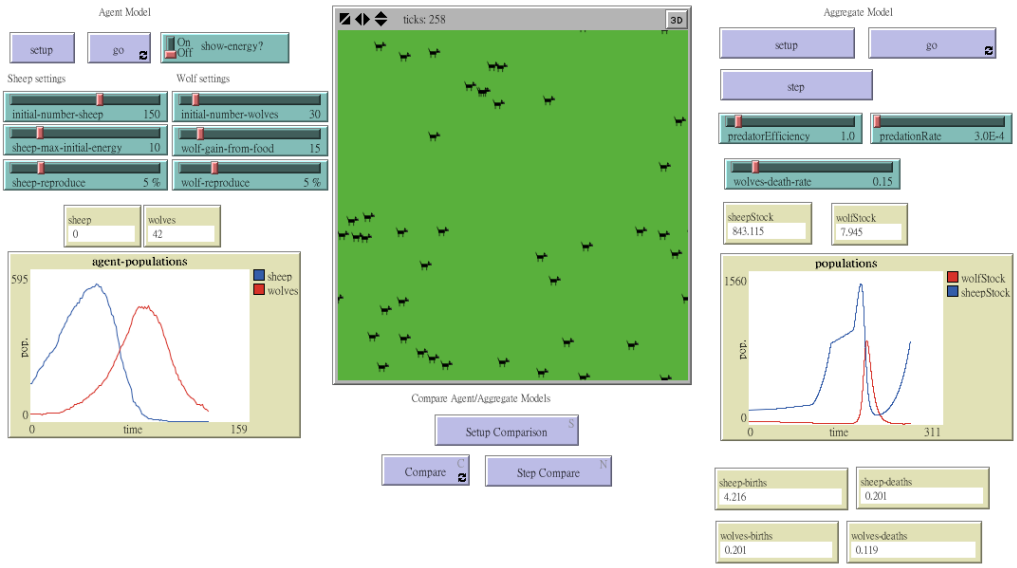


Figure 3.2: Wolf Sheep Predation (2)

doi:10.6342/NTU201601682

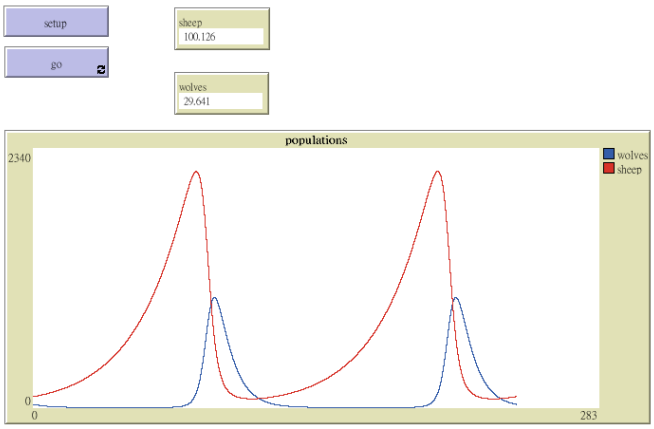


Figure 3.3: Wolf Sheep Predation (3)

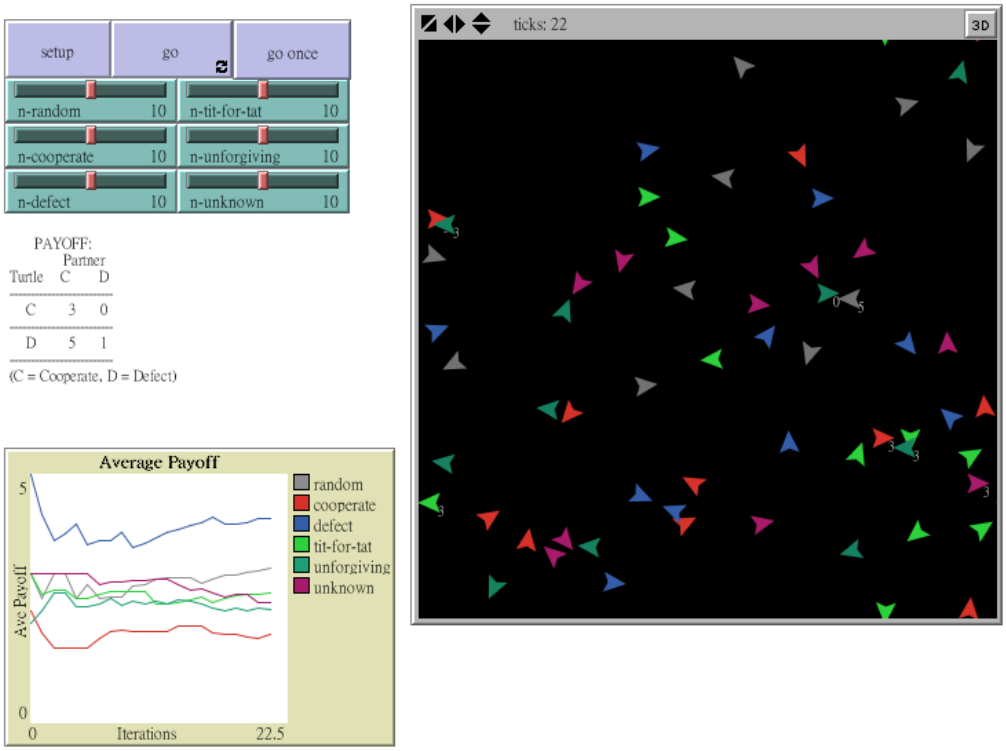


Figure 3.4: Prisoner's Dilemma

doi:10.6342/NTU201601682

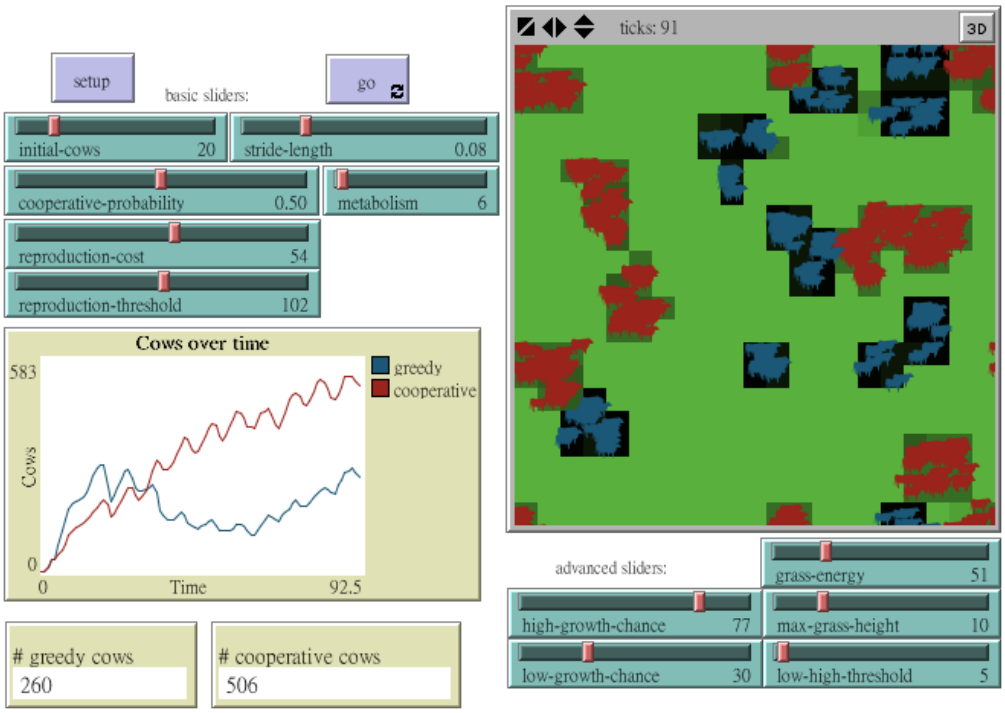


Figure 3.5: Cooperation

3.4.2 Mathematical Sociology

If analyzing the dynamics of distribution of power in the social force, economic power, spatial dominants, could be characterized with two parts: social resources and the relationships in international interactions of agents. [213][432] For instance, in political spheres, the constitutions represented the rules that led the outcomes of social behaviors of social actors. [214][432] Micro-macro linkages of the populations of individuals in social systems were determined by dynamic probabilistic behaviors.

[213] *See* Gordon Burt, Conflict, Complexity and Mathematical Social Science 226-40 (2010).

[214] *See* Gordon Burt, Conflict, Complexity and Mathematical Social Science 188 (2010) ("Some actions may be outside the constitution, the constitution itself may not be well defined, the constitution may changed by individual actions and the constitution may have provision for constitutional change.").

doi:10.6342/NTU201601682

[215][432] If theories being followed by the Coleman's scheme, macro-micro models were reconstructed and simulated in agent-based computational models of different dimensions; macro-conditions and micro-conditions with respect to their outcomes were determined by the preferences of actors and problems of macro-micro models could be sorted with rational choice theory. [216][438]

Recent Emergence of New Avenues

Doubtless, the complex adaptive system would be mainly of importance for its systematic features of self-organization processes. [217][433] Processes models used in studying the social behaviors as well as the political behaviors and legal behaviors with multilevel decision-makings, which can be divided into three types of social simulation models, including the rational choice models, the agent-based models, the artificial society models, demonstrate the micro-macro relations and provide insights for the applicability of sociology with respect to artificial neutral networks. [218][439]

Contemporary Marxist sociology of mathematics was the first mainstream of the mathematical sociology studies; they studied social phenomena by mathematical tools but focusing on their research aims at interpretations of Marxism. [219][434]

---

[215] *See* Gordon Burt, Conflict, Complexity and Mathematical Social Science 120-1 (2010).

[216] *See* Werner Raub et al., *Micro-Macro Links and Microfoundations in Sociology*, *in* Micro-Macro Links and Microfoundations in Sociology 1, 20-21 (Vincent Buskens et al. eds., 2012).

[217] *See* Jürgen Klüver, The Dynamics and Evolution of Social Systems: New Foundations of A Mathematical Sociology 8 (2000).

[218] *See* Vittorio Capecchi, *Mathematics and Sociology: From Lazarsfeld to Artificial Neural Networks*, *in* Applications of Mathematics in Models, Artificial Neutral Networks and Arts: Mathematics and Society 1, 42-62 (Vittorio Capecchi et al. eds., 2010).

[219] *See generally* Sal Restivo, The Social Relations of Physics, Mysticism, and Math-

doi:10.6342/NTU201601682

Quantitative measurement methods applied in sociology were reviewed in theories of social processes, which were found sometimes true, such as social diffusions or telephone traffics, simplified the complexity of the social problems to make trivial solutions; nevertheless, it represented the earlier time progresses of mathematical sociology. [220][437]

Behavioral models account for the human emotions and asymmetric information while the discrete choice analysis assuming that social agents always hold their rational preferences and do not be affected by their societal peers. [221][440] The training of mathematical modeling reflected the costs of mathematical sociology which limited the width of its applications. [222][435] However, in theories-building perspectives the networks of exchanges hold more trust and social stability than market-based societies. [223][431]

Spatial modeling theories concerning the choices of social individuals from a macro-view perspective was indistinct and uncertain for the results of individual incentives. [224][443] Collective rationality played significant effects in social norms

---

ematics: Studies in Social Structure, Interests, and Ideas (1983).

[220] *See* James S. Coleman, Introduction to Mathematical Sociology 515-29 (1964).

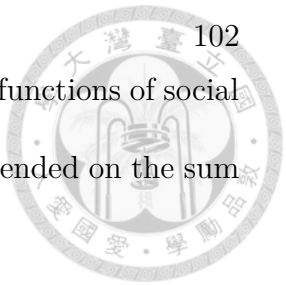
[221] *See* Federico Gallo et al., *Tackling Climate Change Through Energy Efficiency: Mathematical Models to Offer Evidence-based Recommendations for Public Policy*, *in* Applications of Mathematics in Models, Artificial Neutral Networks and Arts: Mathematics and Society 131, 133-7 (Vittorio Capecchi et al. eds., 2010).

[222] *See* Robert K. Leik & B. F. Meeker, Mathematical Sociology 17 (1975) ("It would be inappropriate to give the impression that mathematical work in sociology is all benefit and no cost. One of the obvious costs is that the user must be trained sufficiently to work and, perhaps more difficult, to think creatively in mathematical form.").

[223] *See* Alex Pentland, Social Physics: How Good Ideas Spread–the Lessen From A New Science 199-202 (2014).

[224] *See* Thomas C. Schelling, *Dynamic Models of Segregation*, *in* 1 Computational Social Science 159 (Nigel Gilbert ed., 2010) 162-3 (1971) ("Some of the phenomena of segregation may be similarly complex in relation to the dynamics of individual choices. ..... A special reason for doubting any social efficiency in aggregate segregation is that the range of choice is often so

doi:10.6342/NTU201601682



than individual rationality; this property revealed the basis of the functions of social learning and influence. [225][431] The value of collective actions depended on the sum of power of actors and the interests of the actions. [226][554]

Artificial adaptive systems are compared with the realistic social processes, which are constructed by mathematical methods eg. algebra and evolutionary algorithms. [227][441] Object-oriented programming in sociocultural domains, which was called computational sociology, helps explanations of social theories with empirical data by social simulation models; it became the emerging new avenue of the possible interdisciplinarity of mathematical science and sociology. [228][442] To illustrate, the feedback loops of the phases on the model-building frameworks connected with the study of a real-world problems developed the problem-solving methods in early applications of mathematical sociology; the general use of game theory such as prisoner's dilemma for strategic analysis and the arbitrated solutions that widely spread in early stages of mathematical sociological studies. [229][436]

---

meager.").

[225] *See* Alex Pentland, Social Physics: How Good Ideas Spread–the Lessen From A New Science 58-61 (2014) ("Learning and reinforcing this social contract is what enables a group of people to coordinate their actions effectively.").

[226] *See* James S. Coleman, *Foundations for A Theory of Collective Decisions*, *in* Social Choice 27, 38 (Bernhardt Lieberman ed., 2011) ("Thus, just as the value of an action is the sum over all actors of their power times their interest in that action, the value of one actor's interest in an action is his power times his interests in it.").

[227] *See* Massimo Buscema, *The General Philosophy of the Artificial Adaptive Systems*, *in* Applications of Mathematics in Models, Artificial Neutral Networks and Arts: Mathematics and Society 197 (Vittorio Capecchi et al. eds., 2010).

[228] *See* Norman P. Hummon & Thomas J. Fararo, *The Emergence of Computational Sociology*, *in* 2 Computational Social Science 3 (Nigel Gilbert ed., 2010) (1995).

[229] *See* Thomas J. Fararo, Mathematical Sociology: An Introduction to Fundamentals 1-6, 737-61 (1973).

doi:10.6342/NTU201601682

3.4.3 Modeling Multilevel Hierarchy of Orders

Theorizing complex systems of multi-level hierarchy of ordering in complex social systems needs to take the transcendental realism as its theoretical basis. [230][473] Modern evolutionary economics arose from the system theories which became more applicable in the evolutionary business and some specific social processes reflecting biological populations, competitive selections, replicator dynamics, etc. [231][471] For instance, self-organization processes would play the important parts of nonlinear dynamical modeling stimulating the socio-economics, as well as the relevant areas of path-dependence, emergence, bifurcation, evolution, etc. [232][481]

Computational Legal Studies

To begin with, studies on dynamics of settlements in macro-view of social agents could be analyzed by the collective behaviors of the parties. [233][475] Social reasoning about the macro-micro transitions of collective decision-makings was determined by

---

[230] *See* Drew Wollin, *Commentary: Simplicity in Theories of Complexity–Defining, Knowing and Doing*, *in* Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy 109, 113-18 (John Foster & J. Stanley Metcalfe eds., 2001) ("For practice or decision making in complex systems, complexity theory both constrains and enables. In furthering bounded rationality, complexity suggests inevitable unknownables.").

[231] *See* John Foster & J. Stanley Metcalfe, *Modern Evolutionary Economic Perspectives: An Overview*, *in* Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy 1, 2-9 (John Foster & J. Stanley Metcalfe eds., 2001) ("Replicator dynamics in market processes have a number of novel attributes, ... Replicator dynamics allows us to deal with processes without using equilibrium attractors as devices to postulate convergence to 'long-run' positions.").

[232] *See* Renate Mayntz, *Networks and Self-organization: Dissecting the Model of 'Complex Networks'*, 6 Socio-Economic Rev., 2008, at 750, 752-53.

[233] *See* Hermann Haken, *Synergetics in Sociology and Biology*, *in* Sociobiology and Bioeconomics 199, 215-16 (Peter Koslowski ed., 1999) ("The slight changes in human relationships or general attitudes may cause dramatic qualitative changes of the whole behaviour pattern.").

doi:10.6342/NTU201601682

the strategic actions of social isolated agents adapting their environments. [234][277] In this case, settlement bargaining out of courts involving reciprocal inducements would be found resulting in cooperative solutions to the limitations of enforcing fairness and generated efficiency. [235][270] In addition of that, trial costs and efficient plans of discovery in trials will determine the optimal proceedings of settlement negotiations. [236][341] Also, the imperfect information in contracting formation processes will be inescapable because of the contracting choices of default rules. [237][278] A short time periods for cooling-off in the mediated settlement bargaining would reduce self-controling problems out of the mediation reform by the parties. [238][346]

What is more, interaction-based modeling provides socio-economics an applicable approach to analyze multiple steady states of local or global interactions in nonlinear dynamical environments of social substantive phenomena. [239][470] Cooperative and competitive behaviors of agents in social economic systems are similar with the laws of economy of nature, as well as resemblances of socio-biological and bio-economical theories. [240][476] Following the H. A. Simon' theories of behavioral settings on

---

[234] *See* Cristina Bicchieri, Rationality and Coordination 1-31 (1993).

[235] *See* Robert Cooter & Thomas Ulen, Law & Economics 277-82, 399-401 (6d ed. 2012).

[236] *See* Robert Mnookin & Robert Wilson, *A Model of Efficient Discovery*, 25 Games and Economic Behavior, no. 2, 1998, at 219, 246.

[237] *See* Michael J. Trebilcock, The Limits of Freedom of Contract 120-6 (1993).

[238] *See* Colin Camerer et al., *Regulation for Conservatives: Behavioral Economics and the Case for "Asymmetric Paternalism"*, 151 U. Pa. L. Rev. 1211, 1238-44 (2003).

[239] *See generally* Lawrence E. Blume & Steven N. Durlauf, *The Interactions-based Approach to Socioeconomic Behavior*, *in* Social Dynamics 15 (Steven N. Durlauf & H. Peyton Young eds., 2001).

[240] *See* Peter Koslowski, *The Theory of Evolution as Sociobiology and Bioeconomics: A Critique of Its Claim to Totality*, *in* Sociobiology and Bioeconomics 301, 306-8 (Peter Koslowski ed., 1999) ("The extent of the market determines the scale of the division of labor and specialisation, the density of population on a territory the scale of the competitiveness and of the social differentiation in castes.").

doi:10.6342/NTU201601682

substantively rationality and procedural rationality, second-order complexity was often defined and applied with the non-separability arguments. [241][472]

Interdisciplinarity of Biology and Social Simulation

Definitions of socio-economics remained blurred, however, the basic concepts from competition models in economic theories was as the trust game concepts in the legitimacy of the states, or as the reputation effects in distribution of power in laws, etc., which were all in the spectrum for socio-economics. [242][479]

As the interdisciplinary theory-building processes, the work faced the challenge of deterministic or probabilistic universality of theories and the boundaries of the philosophical implications. [243][272] When different approaches making a great aim of theoretical dominant factors, nevertheless, from a methodology perspective, they must be strictly examined in view of the differences of imaginary metaphors and theorized interpretations, such as the relations of the errors of similarity mixture with theories at times, the stronger theoretical backgrounds formed, the more meaningful interdisciplinarity would be.

Relevant properties between social and biological complex dynamical systems

---

[241] *See* Robert Delorme, *Theorizing Complexity*, *in* Frontiers of Evolutionary Economics: Competition, Self-Organization and Innovation Policy 80, 86-103 (John Foster & J. Stanley Metcalfe eds., 2001) ("Complexity is order-and-disorder. Order alone or disorder alone pertain to non-complexity. ..... Complexity vanishes when separability appears. Non-separability is at the root of cognitive irreducibility. It is thus constitutive of complexity.").

[242] *See* Robert Boyer, *The Quest for Theoretical Foundations of Socio-economics: Epistemology, Methodology or Ontology?*, 6 Socio-Economic Rev., 2008, at 733, 741-46 ("Therefore, socio-economics should mainly follow the first rule, i.e. it should build on its own legacy, clarify its specific domain and develop the more relevant methodologies given its objective: explaining the diversity of governance structures and describing the forces that govern their evolution.").

[243] *See* James R. Hackney Jr., Under Cover of Science: American Legal-Economic Theory and the Quest for Objectivity 15 (2007).

doi:10.6342/NTU201601682

could be found their similarities in the elements described mathematically and the systems reasoned to be reproduced or not. [244][480] For instance, spatiality analysis on the regulatory theory is a significant interdisciplinary studies that revealed in natural and social processes describing in mathematical languages, as well as the self-organizing processes and multilevel analysis of complex systems. [245][483]

Moreover, the convergence of the socio-economics and ecological dimensions was applied in invasive species management areas, regarding disciplinary impediments of ecological-economic modeling, which would generate more integrations of these two disciplinary studies. [246][463]

Multilevel Hierarchy of Orders in Laws

Observations of the early studies on applying evolutionary models into the laws and economics with the corporate structures and bankruptcy problems indicated that for the purposes of changing legal environments and government directives the interdisciplinary approaches of path dependence analysis and evolution-toward-efficiency paradigms should be constructed. [247][284] In addition, policy space or case space models were applied in adjudication of legal rules; the space models were illustrating the individual behaviors such as preferences and choices of judges and

---

[244] *See* Ralph J. Greenspan, *A Biological Perspective on Complex Networks for A New Epistemology*, 6 Socio-Economic Rev., 2008, at 746, 747-48.

[245] *See* Didier Sornette, *Interdisciplinarity in Socio-economics, Mathematical Analysis and Predictability of Complex Systems*, 6 Socio-Economic Rev., 2008, at 759, 759-66.

[246] *See* David C. Finnoff, *Integrating Economics and Biology for Invasive Species Management*, *in* Bioeconomics of Invasive Species: Integrating Ecology, Economics, Policy, and Management 25, 39-42 (Reuben P. Keller et al. eds., 2009).

[247] *See generally* Mark J. Roe, *Chaos and Evolution in Law and Economics*, 109 Harv. L. Rev. 641 (1996).

doi:10.6342/NTU201601682

the policy-makers and their outcomes. [248][279]

Effects, rationale, the desirability of legal rules formed the three levels of the applications of economics and the laws. [249][269] Another example indicates that applying principles of fairness and efficiency without unanimous consents will result in conflicts with the right-based legal rules as protecting the individual's right for the autonomy or self-determination. [250][281] As far as the multilevel hierarchy of orders in rational societies is concerned, irrationality and hyper-rationality in distinctive scenarios can be brought on applications of the strategic analysis and rational-choice models. [251][276]

3.4.4 Lotka-Volterra Model

Traditional predator-prey models were basically divided into four types by Bossel: predator and unlimited prey, predator and limited prey, predator and two prey populations, prey and two predator populations. [252][529]

Judge from the phase plane of the Lotka-Volterra Model and further derive the theorem, quoted as follows: [253][563]

---

[248] *See generally* Lewis A. Kornhauser, *Modeling Courts*, *in* Theoretical Foundations of Law and Economics 1, 20 (Mark D. White ed., 2009) ("[C]ase space provides a common framework in which to compare and evaluate courts as well as legislatures and administrative agencies. Policy space models assimilate adjudication to legislation.").

[249] *See* Ejan Mackaay, Law and Economics for Civil Law Systems 6-17 (2013).

[250] *See* Mark A. Geistfeld, *Efficiency, Fairness, and the Economic Analysis of Tort Law*, *in* Theoretical Foundations of Law and Economics 234, 240-5 (Mark D. White ed., 2009).

[251] *See* Richard A. Posner, Economic Analysis of Law 18-21 (6d ed. 2003).

[252] *See* Hartmut Bossel, Systems and Models: Complexity, Dynamics, Evolution, Sustainability 303 (2007).

[253] *See* Morris W. Hirsch et al., Differential Equations, Dynamical Systems, and an Introduction to Chaos 240 (3d ed. 2013).

doi:10.6342/NTU201601682

Theorem 1. *Every solution of the predator-prey of the predator-prey system is a closed orbit (except the equilibrium point Z and the coordinate axes).*

Generalize the competitive species model, quoted as follows: [254][563]

$$\dot{x(t)} = x(1 - ax - y) \tag{3.4.1}$$

$$\dot{y(t)} = y(b - x - y) + h \tag{3.4.2}$$

, where h $\in \mathbb{R}$, a, b, t ≥ 0. When y(t) is negative, t > 0, the species go extinct, thus assume that x(t), y(t) > 0.

On the spatial dynamics of metapopulation, explore the way of modeling the colonization of species to find the trade-offs, quoted as follows: [255][537]

$$\dot{p(t)} = c_1 p(1 - p) - m_1 p \tag{3.4.3}$$

$$\dot{q(t)} = c_2 q(1 - p - q) - m_2 q - c_1 pq \tag{3.4.4}$$

p, q denote the spatial fraction occupying by species, c_1, c_2 the colonization rate of the populations, m_1, m_2 the mortality rate of the populations.

Concluding with the statements of this model was that the inferior competitive species would end up with a better colonization. [256][537]

Also refer to the diffusion of the Lotka-Volterra competitive model for studying the spatial spread of the populations, quoted as follows: [257][539]

---

[254] *See* Morris W. Hirsch et al., Differential Equations, Dynamical Systems, and an Introduction to Chaos 251 (3d ed. 2013).

[255] *See* William W. Murdoch et al., Consumer-Resource Dynamics 312 (2003).

[256] *See* William W. Murdoch et al., Consumer-Resource Dynamics 313 (2003).

[257] *See* J. D. Murray, Mathematical Biology: II. Spatial Models and Biomedical Applications 13-5 (3d ed. 2003).

doi:10.6342/NTU201601682

$$\frac{\partial S_1}{T} = D_1 \nabla^2 S_1 + a_1 S_1 (1 - b_1 S_1 - c_1 S_2) \tag{3.4.5}$$

$$\frac{\partial S_2}{T} = D_2 \nabla^2 S_2 + a_2 S_2 (1 - b_2 S_2 - c_2 S_1) \tag{3.4.6}$$

, where $a_1, a_2 > 0$, are the birth rates; $\frac{1}{b_1}, \frac{1}{b_2} > 0$, are the carrying capacities; $c_1, c_2 > 0$, are the competitive coefficients; $D_1, D_2 > 0$, are the diffusion coefficients.

This model can be analyzed by numerical solutions of the travelling wavespeeds. [258][539]

Considering two-species models (one predator and one prey) in a closed system, quoted as follows: [259][543]

$$\dot{x_1} = x_1(\alpha - \beta x_2) \tag{3.4.7}$$

$$\dot{x_2} = x_2(-\gamma + \delta x_1) \tag{3.4.8}$$

, where x_1 is the prey population; x_2 is the predator population; α is the birth rate of the prey; γ is the death rate of the predator; β, δ denote the interacting conditions between the prey and the predator.

The system is quoted as follows: [260][420]

$$\frac{dx_1}{dx_2} = \frac{x_2(-\gamma + \delta x_1)}{x_1(\alpha - \beta x_2)}$$

[258] *See* J. D. Murray, Mathematical Biology: II. Spatial Models and Biomedical Applications 16-8 (3d ed. 2003).

[259] *See* Fred Brauer & Carlos Castillo-Chávez, Mathematical Models in Population Biology and Epidemiology 180 (2000).

[260] *See* Thomas L. Vincent & Joel S. Brown, Evolutionary Game Theory, Natural Selection, and Darwinian Dynamics 42 (2005).

doi:10.6342/NTU201601682

Take $\gamma = 1$, $\beta = 1$, then the characteristic equation is quoted as follows: [261][542]

$$\lambda^2 + \alpha\delta = 0 \tag{3.4.9}$$

, and the solutions are the two pure imaginary roots, quoted as follows: [262][542]

$$\lambda = \pm\sqrt{\alpha\delta}i \tag{3.4.10}$$

It shows that the critical point is a center, [263][564] and the classical predator-prey model is structurally unstable surrounded by a family of periodic orbits. [264][542]

Generalized Lotka-Volterra Systems

This results are extended to the N-species (distinctive) Lotka-Volterra Systems, quoted as follows: [265][420]

$$H_1(x) = \frac{r_1}{K_1}\Big(K_1 - \sum_{j=1}^{\infty} a_1 j x_j)$$

...

$$H_n(x) = \frac{r_n}{K_n}\Big(K_n - \sum_{j=1}^{\infty} a_n j x_j)$$

And so, the results are extended to N-dimensional Lotka-Volterra Model, quoted as follows: [266][424]

---

[261] *See* Mark Kot, Elements of Mathematical Ecology 111 (2001).

[262] *See* Mark Kot, Elements of Mathematical Ecology 111 (2001).

[263] *See* William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems 493 (9th ed. 2010).

[264] *See* Mark Kot, Elements of Mathematical Ecology 107-13 (2001).

[265] *See* Thomas L. Vincent & Joel S. Brown, Evolutionary Game Theory, Natural Selection, and Darwinian Dynamics 43 (2005).

[266] *See* Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics 203-9 (1998).

doi:10.6342/NTU201601682

Theorem 2. *Consider a three-dimensional Lotka-Volterra equation:*

$$\dot{x_i} = x_i(r_i + \sum_{j=1}^{3} a_{ij}x_j), i = 1, 2, 3.a_{ij} < 0 \tag{3.4.11}$$

This system is persistent and uniformly bounded, and both properties are robust, if and only if,

(i) there exists an interior rest point $\bar{x}$;

(ii) det(-A) > 0;

(iii) the two species subsystems are uniformly bounded and not bistable.

(iv) if the system admits a heteroclinic cycle.

Or the global bifurcation of the predator-prey model (Freedman & Wolkowicz, 1986), quoted as follows: [267][542]

$$\dot{x_1} = \alpha x_1(1 - \frac{x_1}{K}) - \phi(x_1)x_2 \tag{3.4.12}$$

$$\dot{x_2} = \delta\phi(x_1)x_2 - \gamma x_1 \tag{3.4.13}$$

This system shows that the homoclinic bifurcation of the predator-prey model will be catastrophic for the population of the predator which will suddenly break down after the homoclinic bifurcation where a limit cycle running into a saddle point. [268][542]

The competition model is quoted as follows: [269][540][531]

---

[267] *See* Mark Kot, Elements of Mathematical Ecology 140 (2001).

[268] *See* Mark Kot, Elements of Mathematical Ecology 150-1 (2001).

[269] *See* J. D. Murray, Mathematical Biology: I. An Introduction 94 (3d ed. 2002). *See also* Cristoforo Sergio Bertuglia & Franco Vaio, Nonlinearity, Chaos, and Complexity: the Dynamics of Natural and Social Systems 119 (2005).

doi:10.6342/NTU201601682

$$\dot{x_1} = r_1 x_1[1 - \frac{x_1}{k_1} - \beta\frac{x_2}{k_2}] \tag{3.4.14}$$

$$\dot{x_2} = r_2 x_2[1 - \frac{x_2}{k_2} - \beta\frac{x_1}{k_1}] \tag{3.4.15}$$

To solve this system, let $\dot{x_1}, \dot{x_2} = 0$, and then there showed four fixed points of the phase plane; calculate the eigenvalues of each fixed point, then get the trajectories of this system, which is part of the stable manifold of the saddle. [270][568]

Concluding this reciprocal competitive model was that if the carrying capacities of the two populations were different, then they could coexist for a very long time; but as the carrying capacities of the two populations were identical, then one species could be totally eliminated by the other as the time is sufficient long. [271][531]

Population thinking on communicating populations would really help solve the prisoner's dilemma situations under undetermined concepts of rationality in some empirical social or economic problems. [272][321]

Or simply by changing a sign could be the cooperation models, quoted as follows: [273][540]

---

[270] *See* Steven H. Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering 155-9 (1994).

[271] *See* Cristoforo Sergio Bertuglia & Franco Vaio, Nonlinearity, Chaos, and Complexity: the Dynamics of Natural and Social Systems 119-20 (2005).

[272] *See* Ulrich Witt, *Bounded Rationality, Social Learning, and Viable Moral Conduct in A Prisoner's Dilemma*, *in* Behavioral Norms, Technological Progress, and Economic Dynamics: Studies in Schumpeterian Economics 33, 45-6 (Ernst Helmstädter & Mark Perlman eds., 1996).

[273] *See* J. D. Murray, Mathematical Biology: I. An Introduction 100 (3d ed. 2002).

doi:10.6342/NTU201601682

$$\dot{x_1} = r_1 x_1[1 - \frac{x_1}{k_1} + \beta\frac{x_2}{k_2}] \tag{3.4.16}$$

$$\dot{x_2} = r_2 x_2[1 - \frac{x_2}{k_2} + \beta\frac{x_1}{k_1}] \tag{3.4.17}$$

The rules for the stable analysis of differential systems are quoted as follows: [274][570]

$$\frac{dx}{dt} = f(x,y), \frac{dy}{dt} = g(x,y)$$

Phase trajectories are the solutions, quoted as follows: [275][570]

$$\frac{dx}{dy} = \frac{f(x,y)}{g(x,y)}$$

And then use matrix A to analyze this system, quoted as follows: [276][570]

$$\frac{dx}{dt} = ax + by, \frac{dy}{dt} = cx + dy$$

It follows that the eigenvalues of A, quoted as follows: [277][570]

$$\lambda_{\mathbf{i}} = \begin{pmatrix} a-\lambda & b \\ c & d-\lambda \end{pmatrix}$$

The characteristic equation is quoted as follows: [278][570]

$$\mathbf{v} = c_1\mathbf{v_1}e^{-\lambda_1 t} + c_2\mathbf{v_2}e^{-\lambda_2 t} \tag{3.4.18}$$

[274] *See* Shepley L. Ross, Differential Equations 644-5 (3d ed. 1984).

[275] *See* Shepley L. Ross, Differential Equations 644-5 (3d ed. 1984).

[276] *See* Shepley L. Ross, Differential Equations 644-5 (3d ed. 1984).

[277] *See* Shepley L. Ross, Differential Equations 644-5 (3d ed. 1984).

[278] *See* Shepley L. Ross, Differential Equations 644-5 (3d ed. 1984).

doi:10.6342/NTU201601682

There are five cases of the roots λ_1 and λ_2, quoted as follows: [279][570][564]

(i) λ_1 and λ_2 are real, unequal, of the same sign.

(ii) λ_1 and λ_2 are real, unequal, of the opposite sign.

(iii) λ_1 and λ_2 are real and equal.

(iv) λ_1 and λ_2 are conjugate complex but not pure imaginary.

(v) λ_1 and λ_2 are pure imaginary.

Before drawing the phase planes, define the critical points for each case above, quoted as follows: [280][570][564]

(i) The critical point is a *node*, as the roots λ_1 and λ_2 are real, unequal, of the same sign. The stability of the critical point is asymptotically stable if the roots are negative; unstable as the roots are positive.

(ii) The critical point is a *saddle point*, as the roots λ_1 and λ_2 are real, unequal, of opposite sign. The stability of the critical point is unstable.

(iii) The critical point is a *node*, as the roots λ_1 and λ_2 are real, equal. The stability of the critical point is asymptotically stable if the roots are negative; unstable as the roots are positive.

(iv) The critical point is a *spiral point*, as the roots λ_1 and λ_2 are conjugate complex but not pure imaginary. The stability of the critical point

[279] *See* Shepley L. Ross, Differential Equations 644-5 (3d ed. 1984). *See also* William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems 486-94 (9th ed. 2010).

[280] *See* Shepley L. Ross, Differential Equations 645-54 (3d ed. 1984). *See also* William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems 486-94 (9th ed. 2010).

doi:10.6342/NTU201601682

is asymptotically stable if the real part of the roots is negative; unstable if real part of the roots is positive.

(v) The critical point is a *center*, as the roots λ_1 and λ_2 are pure imaginary. The stability of the critical point is stable but not asymptotically stable.

3.4.5 Harvesting Models

The Gause (1935) Model was on the interference of the resource of two competitive species, quoted as follows: [281][535]

$$\dot{x(t)} = rx(1 - \frac{x}{K}) - \alpha xy \tag{3.4.19}$$

$$\dot{y(t)} = sy(1 - \frac{y}{L}) - \beta xy \tag{3.4.20}$$

, where r, s, K, L, α, $\beta > 0$, constants. Also, x(t), y(t) ≥ 0 will be interested.

The Gause model of interspecific competition was as mentioned above, and the generalized model for the bionomic equilibrium supply of open-access fishery such as the Schaefer model is quoted as follows: [282][535]

$$\dot{x(t)} = rx(1 - \frac{x}{K}) - qEx = 0 \tag{3.4.21}$$

$$R = (pqx - c)E = 0 \tag{3.4.22}$$

---

[281] *See* Colin W. Clark, Mathematical Bioeconomics: the Optimal Management of Renewable Resources 192-4 (2d ed. 2005).

[282] *See* Colin W. Clark, Mathematical Bioeconomics: the Optimal Management of Renewable Resources 131 (2d ed. 2005).

doi:10.6342/NTU201601682

$$rx(1-\frac{x}{K})=qEx \tag{3.4.23}$$

$$pqx=c \tag{3.4.24}$$

, where r, p, q, K, E > 0, constants, so the generalized form is quoted as follows: [283][535]

$$Y=\frac{rc}{pq}(1-\frac{c}{pqK}) \tag{3.4.25}$$

The equilibrium is quoted as follows: [284][535]

$$X_E=K(1-\frac{qE}{r}) \tag{3.4.26}$$

This equation shows the sustainability of the open-access fishery.

3.4.6 Post-award Judicial Review Model

Definitions

For modeling judicial behaviors in post-award procedural dynamics, this thesis takes J(t) as the judicial power in post-award reviews, A(t) as the competence of arbitral tribunals in post-award reviews, V denotes the intensity of the vacatur grounds for foreign arbitral awards, V ∈ ℝ.

[283] *See* Colin W. Clark, Mathematical Bioeconomics: the Optimal Management of Renewable Resources 131 (2d ed. 2005).

[284] *See* Colin W. Clark, Mathematical Bioeconomics: the Optimal Management of Renewable Resources 320 (2d ed. 2005).

doi:10.6342/NTU201601682

Methods: Homogeneous Systems

Consider a homogeneous system as follows: [285][564]

$$\dot{J(t)} = J(t) + A(t) \tag{3.4.27}$$

$$\dot{A(t)} = VJ(t) + A(t) \tag{3.4.28}$$

Results

It follows that the characteristic equation

$$r = 1 \pm 2\sqrt{V}$$

, and the critical point (0,0). Therefore, it follows the results, summarized and quoted as follows: [286][570]

> (1) As V > 0, the roots of the characteristic equation are real, unequal, of opposite sign. Hence, the critical point (0,0) of this homogeneous system is a saddle, which is always unstable.
>
> (2) As V = 0, the characteristic equation r = 1, the roots of it is real and equal. Hence, the critical point (0,0) of this homogeneous system is a node, which is asymptotically stable if the roots are negative; unstable if the roots are positive.
>
> (3) As V < 0, the roots of the characteristic equation are conjugate complex but not pure imaginary. Hence, the critical point (0,0) of this

[285] *See* William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems 391-4 (9th ed. 2010) (generating the ideas).

[286] *See* Shepley L. Ross, Differential Equations 646-50 (3d ed. 1984).

doi:10.6342/NTU201601682

homogeneous system is a spiral, which is asymptotically stable if real part of roots is negative; unstable if real part of roots is positive.

Phase Planes

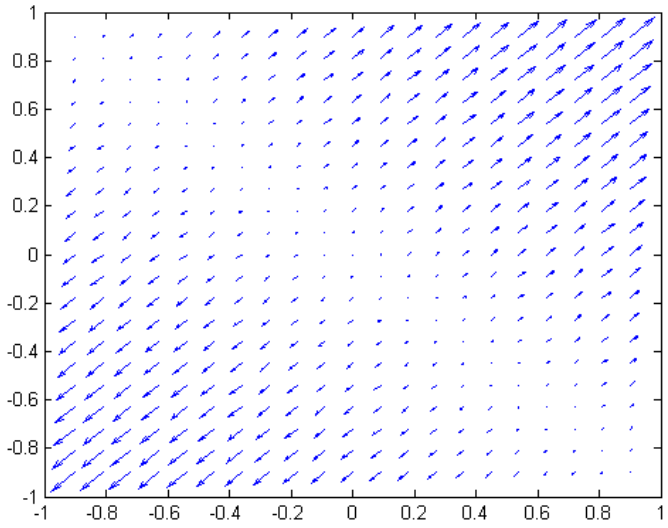


Figure 3.6: Post-award Judicial Review Model (1)

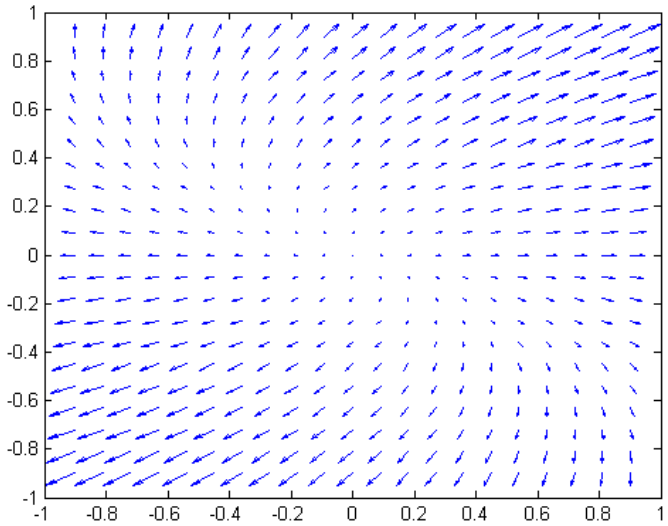


Figure 3.7: Post-award Judicial Review Model (2)

doi:10.6342/NTU201601682

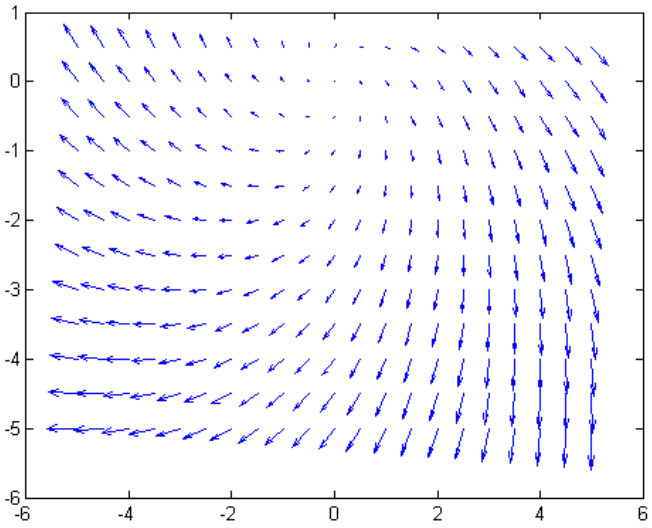


Figure 3.8: Post-award Judicial Review Model (3)

3.5 Concluding Remarks

In this chapter, this thesis modelled the judicial behaviors in evolutionary multilevel hierarchy of orders based on the heuristics in preferences of social agents. And so, this thesis built up the post-award judicial review model to predict scenarios and possible solutions and to explain how the intensity of the vacatur grounds for foreign arbitral awards made great impacts on post-award procedural dynamics. The role of judicial power in post-award review systems was interpreted in the stability analysis of the homogeneous systems. It followed the results that for the harmonized mutual pursuant of ensuring the enforceability of foreign arbitral awards depending on the intensity of the vacatur grounds for foreign arbitral awards, and for constructing international enforceable awards by national arbitral legislative control as well as minding the sustainability of national arbitration laws.

doi:10.6342/NTU201601682

Chapter 4

Legislative Design on International Post-award Review Systems

4.1 Introduction

In this chapter, this thesis firstly schemed procedural delocalized arbitrations for the national legislative management of arbitration laws in trends of harmonization and the restatement of arbitral awards. Secondly, this thesis further made the point often overlooked that *lex arbitri* bring about the procedural autonomy in arbitral proceedings. Thirdly, this thesis added the widely applied transnational norms *lex mercatoria* to the grounds for building up international post-award review systems of a-national arbitrations. In addition of that, for the methodological concerns, as disassembling legislative choices in norm-governed space, this thesis referred to the prisoner's dilemma games and the general cooperative games for coalitions as well. Finally, this thesis took the post-award reviews as self-organized processes in complex adaptive systems. This chapter converged the frameworks of legislative

doi:10.6342/NTU201601682

modeling on post-award reviews and the conceptual policy modeling on artificial societies and show the methodological similarity among them by literature reviews. After that, this thesis concluded with the illustrations of the international legislative control model by analyzing the stability of the autonomous systems.

4.2 Scheming Procedural Delocalized Arbitrations

4.2.1 Legislative Management of Arbitration Laws

Adaptation of Uniform Arbitral Legislation

Proposing the international judicial adoption to national legislative provisions or the promoting the uniformity of legal standards of enforcement in international legal norms, as the New York Convention §II(2), §VII(2), would be the future directions of national arbitral legislation. [1][75]

Innovation ideas of uniform legislation on arbitration laws, generating from the legislative apprehension of nations, came from the amendments of the New York Convention connecting with its basis on §II. [2][60] The national legislative choices of the adopting transnational legal orders in international commercial arbitration could be considered a market-strategy-based legislative design. [3][36]

---

[1] *See generally* S.I. Strong, *What Constitutes An "Agreement in Writing" in International Commercial Arbitration? Conflicts Between the New York Convention and the Federal Arbitration Act*, 48 Stan. J. Int'l L. 47 (2012).

[2] *See* Gerold Herrmann, *Does the World Need Additional Uniform Legislation on Arbitration*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 223, 230-2 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[3] *See* Katherine Lynch, The Forces of Economic Globalization: Challenges to the Regime of International Commercial Arbitration 273 (2003).

doi:10.6342/NTU201601682

Resilience of National Arbitral Design

Legislative bargaining was generally divided into two types: (1) the closed-rule bargaining model for passing a proposal by a legislative body of coalitions, based on the Rubinstein infinite-horizon bargaining game with multiple subgame-perfect equilibria; (2) the open-rule bargaining model for amending the laws in the yes/no voting with approaches of deterring the random outburst of extra amendments in legislative processes. [4][357]

Enacting national arbitral legislations based on domestic or international public policies, clarifying the classifications of the propositions on recognizing the validity of arbitral agreements and contracts for entering arbitrations with respect to the acknowledgement of the procedural delocalization accompanying with the nature of a-national arbitrations and the applications of transnational legal principles are of chief importance among substantive provisions of legislative design. [5][23] It follows that enacting domestic legislative design on legal frameworks of extra-territorial jurisdictions would be recommended to ratify the §34 UNCITRAL Model Law as the basis of annulment standards of national arbitration legislations. [6][106]

The substance of procedural due process that was implemented in resolving the problems of the predispute arbitration clauses of unfair aggregation of imbalance of disparate resources and legitimacy interests contracted by the private parties.

---

[4] *See* Steven Tadelis, Game Theory: An Introduction 229-35 (2013).

[5] *See* Thomas E. Carbonneau, Cases and Materials on Arbitration Law and Practice 43 (5d ed. 2009).

[6] *See* Winston Stromberg, *Avoiding the Full Court Press: International Commercial Arbitration and Other Global Alternative Dispute Resolution Processes*, 40 Loy. L.A. L. Rev. 1337, 1381-3 (2007).

doi:10.6342/NTU201601682

[7][89][11] Some studies asserted that through the lens of creating arbitral precedents by the arbitral tribunals would possibly fill the gaps of national arbitration laws and further mending the functions of legitimacy by reasoning arbitral decisions. [8][94] First-order and second-order effects on tailored post-award judicial reviews would mitigate the externalities of the separative two systems of arbitral jurisdictions and national courts by predispute contracting for the proceedings. [9][85]

4.2.2 Arbitral Legislation in the Trends of Harmonization

Harmonized Post-award Review Mechanisms

To begin with, this decades the domestic/national arbitral legislation in the trends of harmonization was very prosperous all over the world. Accordingly, how to build up harmonized post-award review mechanisms to ensure the international enforceability of national/international arbitral awards becomes more and more important for the national arbitral legislative management.

Uniform arbitration legal forums across different national adoptions of divergent international legislative perspectives on the implementation of judicial reviews in post-award proceedings relied on the revision of the New York Convention as the evolution of arbitral legislations. [10][77] In view of the enforceability of international

---

[7] *See generally* Judith Resnik, Comment, *Fairness in Numbers: A Comment on AT&T v. Conception, Wal-Mart v. Dukes, and Turner v. Rogers*, 125 Harv. L. Rev. 78 (2011). *See also* AT&T Mobility LLC v. Conception, 563 U.S. 321 (2011).

[8] *See generally* W. Mark C. Weidemaier, *Toward A Theory of Precedent in Arbitration*, 51 Wm. & Mary L. Rev. 1895 (2010).

[9] *See* Karen A. Lorang, *Mitigating Arbitration's Externalities: A Call for Tailored Judicial Review*, 59 UCLA L. Rev. 218, 266-8 (2011).

[10] *See* Robert C. Bird, *Enforcement of Annulled Arbitration Awards: A Company Perspective and An Evaluation of A "New" New York Convention*, 37 N.C. J. Int'l L. & Com. Reg. 1013, 1046-54 (2012).

doi:10.6342/NTU201601682

commercial arbitration awards, harmonization of the national arbitration laws would take the evaluation of harmonizing transnational legal systems with respect to the predictable practical consequences of international conventions. [11][24]

One of the most crucial uniform legislation of principles for the applications of international commercial arbitration will be Principles of Transnational Civil Procedure (Grundregeln zum transnationalen Zivilprozeßrecht), programmed by UNIDROIT and American Law Institute in 2004, and manifested the international legal unification (internationale Rechtsvereinheitlichung) which converged with the trends of the harmonization of European private laws. [12][30] And so, Principles of European Contract Law, which played a groundbreaking role for the processes of the harmonization on European contract laws presented as its new complexity growing in transnational legislative paradigms. [13][84]

Efficacy and success of contemporary international adjudication are taken into both academic and legal practices concerns in categories of international commercial arbitration due to the involvements of the state power and international public interests. [14][73] For national uniform legislative design on international commercial arbitration, resolving the incompatibleness of party autonomy and harmonization rules would be of chief importance concerns of transnational adoption of provisions

---

[11] *See* Roy Goode et al., Transnational Commercial Law: Text, Cases, and Materials 631-3 (2007).

[12] *See* Reinhard Zimmermann, Die Europäisierung des Privatrechts und die Rechtsvergleichung 44 (2006).

[13] *See* Nils Jansen & Reinhard Zimmermann, *Contract Formation and Mistake in European Contract Law: A Genetic Comparison of Transnational Model Rules*, 31 Oxford J. Legal Stud. 625, 626-27 (2011).

[14] *See* Gary Born, *A New Generation of International Adjudication*, 61 Duke L.J. 775, 826-57 (2012).

doi:10.6342/NTU201601682

of legal principles for international commercial arbitration. [15][108]

4.2.3 Restatements of Arbitrations

National legislative design on the uniform provisions of the restatements of intrastate or interstate arbitrations, and so international commercial arbitration, should not only contemplate the international enforceability aspects of resolving the conflicts of the multi-jurisdictions, but also the expanded scopes of national judicial reviews and the grounds for recognition and enforcement of foreign judicial judgments. [16][104] Restatements of international principles designed in national legislative enactments are categorically with the mixtures of the intrastate or interstate arbitration laws and the exclusions of the federal common law by the statutory interpretations in restating the governing laws of international commercial arbitration for resolving the inconsistency legislative interfaces. [17][99] Restating the interstate or international commercial arbitration implements the party autonomy doctrine based on public policies and national procedural laws though adopting principles of party autonomy in choice of law is disorderly facilitated at times in legal practice. [18][110]

---

[15] *See* Elizabeth Shackelford, *Party Autonomy and Regional Harmonization of Rules in International Commercial Arbitration*, 67 U. Pitt. L. Rev. 897, 899-90 (2006).

[16] *See* George A. Bermann, *The American Law Institute Goes Global: the Restatement of International Commercial Arbitration*, 16 Willamette J. Int'l L. & Disp. Resol. 300, 315-20 (2008).

[17] *See* George A. Bermann, *Restating the U.S. Law of International Commercial Arbitration*, 42 N.Y.U. J. Int'l L. & Pol. 175, 192-7 (2009) ("In sum, drafters of a Restatement, entering upon the international commercial arbitration fields, find themselves in anything but the juridical vacuum in which the early restaters somehow assumed themselves to be, whether they actually were or not.").

[18] *See* Mo Zhang, *Party Autonomy and Beyond: An International Perspective of Contractual Choice of Law*, 20 Emory Int'l L. Rev. 511, 529-34 (2006).

doi:10.6342/NTU201601682

4.2.4 Procedural Delocalization

The denationalization theory in general situated in pre-dispute settlements of French arbitration jurisdictions which based on this theory to make predictability of the mandatory laws and the *lex fori* doctrine applied in the public policy defence of the enforcement of arbitral awards. [19][36] Delocalized arbitral awards would still be dependent to the legal orders of the country recognized the enforceability of arbitral awards rather than the country of origin. [20][143]

Definitions of procedural delocalization in arbitration proceedings would not manifest the state power of judicial reviews or intervening arbitrations by national procedural legal regimes but detaching from the boundaries of reviewing arbitral awards at the country of origin that enabled international commercial arbitration exempting from the principle *Lex Loci Arbitri*. [21][131] In contrary applications of delocalization of arbitrations, principles of *lex arbitri* broadened the scope of judicial control by local procedural laws intervening the arbitral proceedings, whereas the national legislative design on the adoption of party autonomy doctrines to domestic arbitration statute based on the UNCITRAL Model Law could solve the problems of narrowing the nature of delocalization in national procedural laws at the seat of arbitration. [22][125]

A-national arbitral awards under procedural delocalization or in newly emerged

---

[19] *See* Katherine Lynch, The Forces of Economic Globalization: Challenges to the Regime of International Commercial Arbitration 188 (2003).

[20] *See* Jan Paulsson, *Delocalisation of International Commercial Arbitration: When and Why It Matters*, 32 Int'l L. & Comp. L.Q., no. 1, 1983, at 53, 57.

[21] *See* Pippa Read, *Delocalization of International Commercial Arbitration: Its Relevance in the New Millennium*, 10 Am. Rev. Int'l Arb. 177, 185-7 (1999).

[22] *See* Richard Garnett, *International Arbitration Law: Progress Towards Harmonisation*, 3 Melb. J. Int'l L. 400, 406-7 (2002).

doi:10.6342/NTU201601682

transaction forms were enforced but implicitly autonomous with the international internal procedural principle *lex arbitri*. [23][41] In addition of that, international public orders of public policy requirements with respect to the *lex fori* and the indistinct attitude toward transnational legal orders, such as *lex mercatoria*, would also limit applications of party autonomy in the choice of law in denationalization of national arbitration systems. [24][128]

4.2.5 Lex Arbitri and Arbitral Proceedings

Governing procedural laws and reasoned arbitral awards are the key elements for the practice of international commercial arbitration, which are strongly in connections with the *lex arbitri* and the efficacy costs of arbitration. [25][123] *Lex arbitri* that governed the arbitral proceedings was also designated in the choice of law clause but excluded from the inquiries into the applications of laws in post-award international judicial reviews to the lex arbitri issues. [26][98] It was inevitable that for the trends of transnational legal orders adopting the *lex arbitri* for establishing international commercial contract relationships in a bounded international sphere being subject

---

[23] *See* Loukas A. Mistelis, *Delocalization and its Relevance in Post-award Review*, *in* The UNCITRAL Model Law After Twenty-Five Years: Global Perspectives on International Commercial Arbitration 167, 173-7 (Frédéric Bachand & Fabien Gélinas eds., 2013).

[24] *See* Otto Sandrock, *To Continue Nationalizing or to De-nationalize? That Is Now the Question in International Arbitration*, 12 Am. Rev. Int'l Arb. 301, 321 (2000).

[25] *See* Paul Michael, *Party Autonomy and Implied Choice in International Commercial Arbitration*, 14 Am. Rev. Int'l Arb. 571, 576-80 (2003).

[26] *See* George A. Bermann, *Ascertaining the Parties' Intentions in Arbitral Design*, 113 Penn. St. L. Rev. 1013, 1019-22 (2009) ("In addition, ignoring the lex arbitri in domestic FAA cases introduces a strange dissonance between the interstate and the international cases, for in international cases, courts do generally consider the arbitration law of the arbitral situs as the law providing the legal framework of the arbitration. It is understandable that courts pay closer attention to the distinction between substantive law and the lex arbitri in international cases, but there is no principled reason why they should do.").

doi:10.6342/NTU201601682

to national laws. [27][144]

The principle of procedural autonomy benefiting the international commercial arbitration will be impaired by its divergence of the procedural protocols. [28][61] Coordination problems in international adjudications or international relationships were studied to analyze the a-national utilization of legal institutional functions. [29][117] One cannot deny that from both internal (arbitral tribunals) and external (judicial control) aspects, *lex arbitri* that connected with the seat of arbitration would not only be justifies by principles of party autonomy of choosing the governing procedural law but theories of delocalization. [30][107]

Bounded by the judicial supervisions of the courts for ensuring the enforceability of arbitral awards and the judicial control of the seat of the arbitration, delocalized arbitrations would not be effortless to be recognized under the *lex arbitri* subject to national arbitration legislations. [31][112] Earlier enactments of arbitrations were not disturbed by the frequency with the worldwide modernization of arbitration laws. [32][118] To look at the trends another way, it followed that traditional practical

---

[27] *See* Jan Paulsson, *Arbitration Unbound: Award Detached from the Law of Its Country of Origin*, 30 Int'l L. & Comp. L.Q., no. 2, 1981, at 358, 379-82.

[28] *See* William Park, *Arbitration's Protean Nature: the Value of Rules and the Risks of Discretion*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 331, 334-43 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007) ("The dark side of all this discretion lies in the discomfort that a litigant may feel when arbitrators make up the rules as they go along, divorced from any precise procedural canons set in advance.").

[29] *See generally* Tom Ginsburg & Richard H. McAdams, *Adjudicating in Anarchy: An Expressive Theory of International Dispute Resolution*, 45 Wm. & Mary L. Rev. 1229 (2004).

[30] *See* Loukas Mistelis, *Reality Test: Current State of Affairs in Theory and Practice Relating to "Lex Arbitri"*, 17 Am. Rev. Int'l Arb. 155, 165-70 (2006).

[31] *See* Dejan Janićijević, *Delocalization in International Commercial Arbitration*, 3 Law and Politics, no. 1, 2005, at 63, 67-8.

[32] *See* Christopher R. Drahozal, *Regulatory Competition and the Location of International Arbitration Proceedings*, 24 Int'l Rev. L. & Econ. 371, 378-83 (2004).

doi:10.6342/NTU201601682

trainings on international litigations or dispute resolutions would both not converged methodologically into international commercial arbitration. [33][100]

International market structures were found altering with the parties made their choices for the procedures of arbitrations or litigations to resolve their disputes. [34][135] *Lex loci arbitri* based on the New York Convention was promoted by the neutrality of international commercial arbitration in the United States. [35][113]

4.2.6 Lex Mercatoria and A-national Arbitrations

Lex Mercatoria, a a-national legal norm, it is used in challenging arbitral awards with transnational legal principles such as *Lex Mercatoria* or a-national laws in the national arbitration legal forums or for the public policy defence based on §1051 (2) ZPO and §68 (2) (g) English Arbitration Act 1996. [36][25][2][7]

From the systematic perspectives, the nature of *Lex Mercatoria* reflects several important properties of a-national arbitral jurisdictions but without the universally

---

[33] *See generally* S.I. Strong, *Research in International Commercial Arbitration: Special Skills, Special Sources*, 20 Am. Rev. Int'l Arb. 119 (2009).

[34] *See* Alessandra Casella, *On Market Integration and the Development of Institutions: the Case of International Commercial Arbitration*, 40 European Economic Review, 1996, at 155, 174-80 ("International commercial arbitration is a concrete and important example of the link between economic transactions and the creation of international coalitions of private individuals, the emergence 'from the bottom' of international jurisdictions.").

[35] *See* Catherine A. Giambastiani, *Recent Development: Lex Loci Arbitri and Annulment of Foreign Arbitral Awards in U.S. Court*, 20 Am. U. Int'l L. Rev. 1101, 1111 (2005).

[36] *See* Maren Heidemann, Methodology of Uniform Contract Law: the UNIDROIT Principles in International Legal Doctrine and Practice 172-7, 180-92 (2007). *See also* Zivilprozessordnung [ZPO] [Code of Civil Procedure], Sep. 12, 1950, §1025-66 (Ger.) (amended, 2012) ("§1051 (2) Haben die Parteien die anzuwendenden Rechtsvorschriften nicht bestimmt, so hat das Schiedsgericht das Recht des Staates anzuwenden, mit dem der Gegenstand des Verfahrens die engsten Verbindungen aufweist."). *See also* Arbitration Act (U.K.) (1996) ("Sec. 68 (2) Serious irregularity means an irregularity of one or more of the following kinds whichthe court considers has caused or will cause substantial injustice to the applicant (g) the award being obtained by fraud or the award or the way in which it wasprocured being contrary to public policy.").

doi:10.6342/NTU201601682

acceptable definitions, in this case, *Lex Mercatoria* is considered as the function of efficacy in business communities due to the advantageous legal settings for the international arbitrators based on its autonomous nature. [37][183] Arbitral autonomy in national legal systems compared with the multiple hybrid legal systems would be arranged in resembling features not only as the integration of autonomy theories in central of contemporary legal philosophy but also as the role of reconciling the commercial conflicts by efficiency of contract structures since the new *Lex Mercatoria* emerged. [38][185] The hybrid theory of international commercial arbitration is *lex mercatoria arbitralis*, recognized by the international tribunals and created in the public international law systems, where the arbitrators can adopt it in a-national arbitration, analogous to the applications of *lex loci arbitri* in a-national arbitral awards. [39][140] Some studies enquired into *true Lex Mercatoria* and indicated that new *Lex Mercatoria* was based on the state-based theory, both of these a-national principles were rapidly changed with the global legal systems. [40][184]

A-national and autonomous properties of *Lex Mercatoria* take advantages in legal interpretations of international contracts, in the meantime, *Lex Mercatoria* and the principle of party autonomy are based on the UNIDROIT Principles and English Arbitration Act 1996. [41][183][4][7] In modern transnational commercial conflicts,

---

[37] *See* Paul Freeman, *Lex Mercatoria: A Legal Basis for the Resolution of International Disputes*, *in* International Commercial Arbitration: Developing Rules for the New Millennium 121, 123-26 (Martin Odams de Zylva & Reziya Harrison eds., 2000).

[38] *See generally* Nathan Oman, *Corporations and Autonomy Theories of Contract: A Critique of the New Lex Mercatoria*, 83 Denv. U. L. Rev. 101, 107-10 (2005).

[39] *See* Hans Smit, *A-national Arbitration*, 63 Tul. L. Rev. 629, 632-3 (1988).

[40] *See generally* Ralf Michaels, *The True Lex Mercatoria: Law Beyond the State*, 14 Ind. J. Global Legal Stud. 447 (2007).

[41] *See* Paul Freeman, *Lex Mercatoria: A Legal Basis for the Resolution of International Disputes*, *in* International Commercial Arbitration: Developing Rules for the New Millen-

doi:10.6342/NTU201601682

arbitrators often apply a-national legal rules such as *Lex Mercatoria* as the criterion of decision-makings in the arbitral proceedings. [42][187]

Lex Mercatoria was originally constructed by the constituents of *Law Merchant* applied in the systems of customary laws and in harmony with the interdependence of legal principles, where *Law Merchant*'s jurisdictions were widely accepted in the local fairs. [43][182] *Piepoudre*, in the medieval local fairs, was indicated the market courts ordinary to the merchant courts, where the judges as the market leaders at the same time applied the the medieval *Law Merchant* rules to resolve the conflicts of the commerce. [44][182][182]

In the modern time, though without the general and clear definitions, and so the implications of it vary from the distinctive legal systems, *Lex Mercatoria* still widely used in international commercial trades for its a-national and autonomous properties that make transnational legal rules properly be adopted by the arbitral tribunals. [45][183] To discover the original theories of *Lex Mercatoria* corresponding

---

NIUM 121, 136-37 (Martin Odams de Zylva & Reziya Harrison eds., 2000) ("Moreover, the greater arbitral freedom, and emphasis placed upon the broadest possible understanding of the scope of 'party autonomy' found in the English Arbitration Act 1996, offers encouragement to the would-be lex mercatorist, in London at least."). *See also* UNIDROIT PRINCIPLES OF INTERNATIONAL COMMERCIAL CONTRACTS (revised, 2010). *See also* ARBITRATION ACT (U.K.) (1996).

[42] *See* Emmanuel Gaillard, *Transnational Law: A Legal System or a Method of Decision Making?*, 17 ARB. INT'L 59, 61-62 (2001).

[43] *See generally* Bruce L. Benson, *The Law Merchant's Story: How Romantic Is It?*, *in* LAW, ECONOMICS AND EVOLUTIONARY THEORY 68, 72-85 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[44] *See* Bruce L. Benson, *The Law Merchant's Story: How Romantic Is It?*, *in* LAW, ECONOMICS AND EVOLUTIONARY THEORY 68, 77-79 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011). *See also* Bruce L. Benson, *The Law Merchant's Story: How Romantic Is It?*, *in* LAW, ECONOMICS AND EVOLUTIONARY THEORY 68, 80-82 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[45] *See* Paul Freeman, *Lex Mercatoria: A Legal Basis for the Resolution of International Disputes*, *in* INTERNATIONAL COMMERCIAL ARBITRATION: DEVELOPING RULES FOR THE NEW MILLENNIUM 121, 123-127 (Martin Odams de Zylva & Reziya Harrison eds., 2000).

doi:10.6342/NTU201601682

to the theoretical foundation of it, one can resort to the evolution of national legal systems or the arbitral jurisprudence of the old time. [46][187]

As participating in the international commercial arbitral proceedings, arbitral tribunals will apply the trade practices by the parties' consents for analyzing the commercial norms in the ways of interpreting international commercial contracts to solve the disputes. [47][129] The mandatory rule of laws specified with *lex mercatoria* in conflicts of laws issues can authorize the arbitral tribunals to decide the applicable transnational principles for the international commercial case during the arbitral proceedings. [48][259]

In contemporary contract theory, *Lex Mercatoria* can be an equilibrium solution or as the integrating strategies of autonomy in efficiency theories, apart from this, the commercial interests generated by it will harmonize the bifurcations of the complex business scenarios in the autonomy theories. [49][185]

Domestic courts play an important role in international commercial arbitration by judging the divergent forms of international legitimacy, by distinguishing the judicial and quisi-judicial conflicts, and by balancing the interests of economic power and the state justice. [50][181]

---

[46] *See generally* Emmanuel Gaillard, *Transnational Law: A Legal System or a Method of Decision Making?*, 17 Arb. Int'l 59 (2001).

[47] *See* Christopher R. Drahozal, *Commercial Norms, Commercial Codes, and International Commercial Arbitration*, 33 Vand. J. Transnat'l L. 79, 121-6 (2000).

[48] *See* Andrew Tweeddale & Keren Tweeddale, Arbitration of Commercial Disputes: International and English Law and Practice 203 (2005).

[49] *See generally* Nathan Oman, *Corporations and Autonomy Theories of Contract: A Critique of the New Lex Mercatoria*, 83 Denv. U. L. Rev. 101 (2005) ("A new *Lex Mercatoria* may indeed hold the promise of reconciling the competing approaches to contract, but the promise does not lie in the fact that autonomy theories can be summarily banished from its domain.").

[50] *See* Yves Dezalay & Bryant G. Garth, Dealing in Virtue: International Commercial Arbitration and the Construction of A Transnational Legal Order 126-128,

doi:10.6342/NTU201601682

Arbitration structures make the neutrality crucial for the business disputes, correspondingly, the equilibria of judicial and economic power remain dynamical and ambiguous, [51][181] for the economic power transforming the legal environments asymmetric with the socio-political instabilities. [52][181]

Some studies take the transnational laws as the semi-autonomous legal systems. [53][186] Some studies pointed out the theoretical inadequacy of *Lex Mercatoria* for the shortage of the empirical findings and the basis of the non-state legal norms, and so the institutions beyond the states that orientated the neutral theory of law. [54][184] *Lex Mercatoria* is not bound with the national laws and will dynamically change with the international commercial norms by the contracts of transnational transactions. [55][29] In this case, resorting to the transnational general legal principles will be with no binding in the theoretical frameworks of the contracts. [56][187] *Good Faith*

297-302 (1996).

[51] *See* Yves Dezalay & Bryant G. Garth, Dealing in Virtue: International Commercial Arbitration and the Construction of A Transnational Legal Order 290-291 (1996).

[52] *See* Yves Dezalay & Bryant G. Garth, Dealing in Virtue: International Commercial Arbitration and the Construction of A Transnational Legal Order 291-293 (1996) ("While change is typically gradual, certain sociopolitical conjectures accelerate the process through which positions among the dominant fractions of the elite are redistributed.").

[53] *See* Peer Zumbansen, *Piercing the Legal Veil: Commercial Arbitration and Transnational Law*, 8 European Law Journal, no. 3, 2002, at 400, 429-430 ("Thus the debate over *Lex Mercatoria* is not simply an extension of the way ordinarily accustomed to recognise as law. Instead it is about the social function of law against the background of a largely differentiated world of States and societies.").

[54] *See* Ralf Michaels, *The True Lex Mercatoria: Law Beyond the State*, 14 Ind. J. Global Legal Stud. 447, 460-65 (2007) ("Moreover, if *Lex Mercatoria* is autopoietic, then it must be created neither in the state, nor in commerce, but within the law itself. But it is true for the law in general; it is not specific to *Lex Mercatoria*.").

[55] *See* Gabriël Moens & Peter Gillies, International Trade and Business: Law, Policy and Ethics 102-5 (2d ed. 2006).

[56] *See* Emmanuel Gaillard, *Transnational Law: A Legal System or a Method of Decision Making?*, 17 Arb. Int'l 59, 66 (2001).

doi:10.6342/NTU201601682

interpreting in most factual contracts and applying as the legal rules is coordinated with the functions of *Lex Mercatoria*. [57][187] To concluded with, the concept of restatement on the international contract laws is rooted in UNIDROIT Principles and *Lex Mercatoria*, and both are codified in the discourses of globalization. [58][36] And so, in the trends of finding the gap-filling of CISG, *Lex Mercatoria* was found to be a proper rule to adopt in legal interpretations. [59][47][9]

4.3 Legislative Choices in Norm-governed Space

4.3.1 Norm-governed Societies

Laws, Orders, Norms

In the first place, norms as rules in social dilemma under sequential or simultaneous conditions would be evaluated with choices and settings of multi-players in lab games and the refinements of cooperation behaviors (positive reciprocity), competitions, or punishments synchronized with the norms of distributive justice. [60][287] It follows

[57] *See* Emmanuel Gaillard, *Transnational Law: A Legal System or a Method of Decision Making?*, 17 Arb. Int'l 59, 66-68 (2001).

[58] *See* Katherine Lynch, The Forces of Economic Globalization: Challenges to the Regime of International Commercial Arbitration 309-44 (2003).

[59] *See* Pilar Perales Viscasillas, *The Role of the UNIDROIT Principles and the PECL in the Interpretation and Gap-filling of CISG*, *in* CISG Methodology 287, 310-1 (André Janssen & Olaf Meyer eds., 2009). *See also* United Nations Convention on Contracts for the International Sales of Goods [CISG] (1980) (Article 9 (2): The parties are considered, unless otherwise agreed, to have impliedly made applicable to their contract or its formation a usage of which the parties knew or ought to have known and which in international trade is widely known to, and regularly observed by, parties to contracts of the type involved in the particular trade concerned.).

[60] *See* Raúl López-Pérez, *Introducing Social Norms in Game Theory*, *in* Games, Rationality and Behaviour: Essays in Behavioural Game Theory and Experiments 26, 30-41 (Alessandro Innocenti & Patrizia Sbriglia eds., 2008).

doi:10.6342/NTU201601682

that social dilemma games with other-regarding preferences of many players were distinct with rational choice theory and applied in the emerging literatures of social norms and the laws, which focused on the phenomenon of manipulating emergences of norms to change human collective behaviors, etc. [61][288] Linkages of the social expectations, values, and behaviors formed the social norms which were applied in game theory with social rational actors. [62][289]

Modeling Norms

To look at norms from social simulating perspectives, simulating norms by agent-based modeling or game-theoretical analysis on strategic interactions and interests of agents, which based on individual rationality, was formed by implements with the revamping theories evolving with the replicator dynamics of evolutionary game theory. [63][286] Human behaviors sometimes departed from social norms, which revealed that subtle social factors or situations under multiple social forces made behaviors change. [64][290] Distinctions between behavioral regularities and social norms would be that the latter proffered a rationale for cooperative interactions of social agents which reflects different social values and strategic behaviors in collective

---

[61] *See* Lynn A. Stout, *Social Norms and Other-regarding Preferences*, *in* Norms and the Law 13, 27-9 (John N. Drobak ed., 2006).

[62] *See* Robert Axelrod, *An Evolutionary Approach to Norms*, *in* 3 Computational Social Science 25, 27 (Nigel Gilbert ed., 2010) (1986) ("Norms have been defined in various ways in the different literatures and even within the same literature. The three most common types of definitions are based upon expectations, values, and behavior.").

[63] *See* Martin Neumann, *How Are Norms Brought About? A State of the Art of Current Research*, *in* Minding Norms: Mechanisms and Dynamics of Social Order in Agent Societies 50, 52-6 (Rosaria Conte et al. eds., 2014).

[64] *See* Jeffrey J. Rachlinski, *The Limits of Social Norms*, 74 Chi.-Kent L. Rev. 1537, 1556-66 (2000).

doi:10.6342/NTU201601682

decision-makings. [65][285] Assumptions of individual rationality and self-interest would be forgone when it comes to the conjunctions of contracting behaviors and the relevant contract theories. [66][292] Decentralized lawmaking with internalized social norms would comparatively approach fair and efficient outcomes. [67][291]

4.3.2 Game Theory and the Laws

Cooperative Games and the Laws

Classical game-theoretical models and the laws were introduced and reasoned in the applications of coordination games. [68][409] Imperfect information in contract formation will be common with the bargaining situations offsetting with economic inefficiency problems of contracting costs. [69][415] In general, cooperative games were applied in explaining the evolving nature of legal principles and rule-makings. [70][398] Moreover, for instance, decision-makings of national courts in choices of laws for multistage jurisprudence of dispute resolution processes can be applied in

---

[65] *See* Eric A. Posner, Law and Social Norms 11-35 (2000).

[66] *See* Lisa Bernstein, *Social Norms and Default Rules Analysis*, 3 S. Cal. Interdisc. L.J. 59, 90 (1993).

[67] *See* Peter H. Huang & Ho-Mou Wu, *More Order Without More Law: A Theory of Social Norms and Organization Cultures*, 10 J.L. Econ. & Org., no. 2, 1994, at 390, 404.

[68] *See* Richard H. McAdams, *Beyond the Prisoner's Dilemma: Coordination, Game Theory, and Law*, 82 S. Cal. L. Rev. 209, 230-6, 257 (2009) ("There is much to be learned from elemental coordination games, such as Battle of the Sexes, Hawk-Dove, and Assurance, which collectively model bargaining, constitutional law, democratic stability, international law, standard setting, low-stakes disputes, traffic, property, gender roles, social movements, and even the interaction of prosecutors and their prisoners.").

[69] *See* Avery Katz, *The Strategic Structure of Offer and Acceptance: Game Theory and the Law of Contract Formation*, 89 Mich. L. Rev. 215, 273-78 (1990).

[70] *See generally* Jean-Pierre Benoît & Lewis A. Kornhauser, *Game-Theoretic Analysis of Legal Rules and Institutions*, *in* 3 Handbook of Game Theory with Economic Applications 2229 (Robert J. Aumann & Sergiu Hart eds., 2002).

doi:10.6342/NTU201601682

prisoner's dilemma games with the analysis of the cooperative and self-interested behaviors of the parties. [71][410]

In fact, theory-buildings in an initial stage on the generalized interdisciplinary legal studies of game theory and the laws was found shortcomings including as follows: assumptions of common knowledge, common conjectures, nonuniqueness of equilibria, hyperrationality hypothesis. [72][413] Game theory applying in the laws was studied in logical dynamics or legal informatics, such as the asymmetry information of legal processes and repeated games of the laws. [73][245]

Interdisciplinarity of mathematical game theories and decision-making theories, the interpretations on models with the predictions of the outcomes are the most important parts for the contributions to its theoretical basis, the conversations of the mathematics and most of the communicative stages of societal aspects will not depend too much on mathematical skills. [74][524] For properly illustrating this point, the preferences and the coalitions of political institutions with the strategies of the negotiators indicated the key elements of win-sets in interdisciplinary bargaining

---

[71] *See* Michael Whincop, *The Recognition Scene: Game Theoretic Issues in the Recognition of Foreign Judgments*, 23 Melb. U. L. Rev. 416, 419-20 (1999).

[72] *See* Peter H. Huang, *Strategic Behavior and the Law: A Guide for Legal Scholars to Game Theory and the Law and Other Game Theory Texts*, 36 Jurimetrics J. 99, 106-7 (1995-1996) (reviewing Douglas G. Baird et al., Game Theory and the Law (1994)).

[73] *See* Johan van Benthem, *Action and Procedure in Reasoning*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 243, 252-9 (Marilyn MacCrimmon & Peter Tillers eds., 2002) ("The main claims is rather that it makes sense to analyze legal events as games, as a means of bringing out some salient characteristics – for reasons analogous to those making game-theoretic analysis of logic illuminating.").

[74] *See* T. W. Körner, Naïve Decision Making: Mathematics Applied to the Social World 341-4 (2008) ("[E]ven when mathematics is important in decision making, mathematical skill will only be a small part of what makes a good decision maker. Mathematics has made contributions to our understanding of decision making which could hardly have been arrived at using other modes of thought.").

doi:10.6342/NTU201601682

processes. [75][408]

However, considering with the differential games as the forms of linear quadratic games, in finite or infinite time horizon, it was demonstrated by Riccati differential systems applied in finding the solutions or coordinating the policies of international issues in transnational governmental targets or other multiple policy instrument variables, etc., which was based on the rigid mathematical theories. [76][373] Yet the problems of renegotiation emerged in the incomplete information of contracts between the parties and or incentive contracts in the bargaining processes would result in contrary to efficiency and might cause unstable conditions of finality for dispute resolution processes for the unacceptable variables to renegotiate, instead of as the new contracts were written the parties choose to renegotiate for the interests-based bargaining processes. [77][379]

4.3.3 Prisoner's Dilemma Games

Mathematical Game Theory

The story of prisoner's dilemma game is that two prisoners are arrested and isolated to give testimonies separately. If the two both cooperate with each other, they will both be released and received the awards. If the two both testify against the other, they will both go to prison. If one testify against the other, he will be released and the other will go to prison, in order to properly illustrate, [78][380] where

[75] *See* Robert D. Putnam, *Diplomacy and Domestic Politics: The Logic of Two-Level Games*, *in* International Dispute Resolution 55, 67-76 (Carrie Menkel-Meadow ed., 2012) (1988).

[76] *See* Engelbert J. Dockner et al., Differential Games in Economics and Management Science 170-80 (2000).

[77] *See* Douglas G. Baird et al., Game Theory and the Law 109-18 (1994).

[78] *See* Drew Fudenberg & Jean Tirole, Game Theory 9-10 (1991).

doi:10.6342/NTU201601682

rules were commonly used in studying social behaviors and the evolutionary and adaptive interactions of social agents (R: reward, P: punishment, S: sucker's payoffs, T: temptation to defect) as the tabular. [79][526]

Beyond the traditional paths, prisoner dilemma games played an important role in study of evolution of cooperation, whereas spatial prisoner dilemma scenarios with agent-based modeling showed less significant features on the applications of biological models. [80][552] In Axelrod's study on prisoner's dilemma games, irrational choices of reciprocity such as cooperative actions evolved in competitive agents would yield higher payoffs, and that explained the consistency with evolutionary biological perspectives. [81][545] The importance of prisoner's dilemma in the applications of social simulation is that rationality of individuals at the beginning could end up resulting in the counterparts of collective social behaviors, whereas it could be a metaphor adopted in social institutional design. [82][294]

Prisoner's Dilemma Games with Social Preferences

On the connections with the legal studies, the first example to point out is that prisoner's dilemma models illustrate the judicial activism which will not change the ultimate outcomes but significantly activated the legal changes in societal aspects.

---

[79] *See* Alain Barrat et al., Dynamical Processes on Complex Networks 235-6 (2008).

[80] *See* Christoph Hauert, *Mathematical Models of Cooperation*, *in* Evolution, Games, and God: the Principles of Cooperation 115, 123-8 (Martin A. Nowak & Sarah Coakley eds., 2013).

[81] *See* Duncan J. Watts, Small Worlds: the Dynamics of Networks Between Order and Randomness 200-4 (1998).

[82] *See* Itzhak Gilboa, Rational Choice 97-9 (2010).

doi:10.6342/NTU201601682

[83][414] Yet the theory continued the applications of the prisoner's dilemma games, economic models were based on adaptive social agents learned strategies of games widely used in early studies of economics and the extensions of the population-based evolutionary prisoner's dilemma games. [84][547] Mutual reciprocal cooperation is the fairness equilibrium of the prisoner's dilemma games with social preferences. [85][370]

Existence of the Nash Equilibrium

In studying the existence of the Nash equilibrium in N-person strategic games, three very important fixed point theories are quoted as follows: [86][365]

Banach Fixed Point Theorem. *Let X be a complete metric space. If $\phi \in X^X$ is a contraction, then there exists a unique $x^* \in X$ such that $\phi(x^*) = x^*$.*

Brouwer Fixed Point Theorem. *For any given $n \in \mathbb{N}$, let S be a nonempty, closed, bounded, and convex subset of $\mathbb{R}^n$. If ϕ is a continuous self-map on S, then there exists an $s \in S$ such that $\phi(x) = x$.*

Kakutani's Fixed Point Theorem. *For any given $n \in \mathbb{N}$, let X be a nonempty, closed, bounded, and convex subset of $\mathbb{R}^n$. If Γ is a convex-valued self-correspondence on X that has a closed graph, then Γ has a fixed point, that is, there exists an $x \in X$ with $x \in \Gamma(x)$.*

---

[83] *See* Thomas W. Merrill, *Pluralism, the Prisoner's Dilemma, and the Behavior of the Independent Judiciary*, 88 Nw. U. L. Rev. 396, 406-9 (1993).

[84] *See* John H. Holland, Hidden Order: How Adaptation Builds Complexity 80-7, 152-5 (1996).

[85] *See* Colin F. Camerer, Behavioral Game Theory: Experiments in Strategic Interaction 106 (2003).

[86] *See* Efe A. Ok, Real Analysis with Economic Applications 176, 279, 331 (2007).

doi:10.6342/NTU201601682

In conclusion of this part, applying the theorems above to examine the existence of solutions of infinite-dimensional variational inequalities in differential Nash games, it follows the Fan-Browder fixed point theorem, quoted as follows: [87][360]

Fan-Browder fixed point theorem. *Let X be a nonempty compact convex subset of a topological vector space Y. Let F be a mapping of X into* 2^X. *For each* $x \in X$, *F(x) is a nonempty convex subset of X. Suppose further that for each* $y \in X$, $F^{-1}(y) = x$: $x \in X$, $y = F(x)$ *is open in X. Then there exists* $\bar{x} \in X$ *such that* $\bar{x} \in F(\bar{x})$.

, which combined with the Brouwer Fixed Point Theorem can prove the existence. [88][360]

4.3.4 Reasoning About Cooperation

Bargaining for Coalitions Structures

Bargaining for coalitions structures fluctuated in the communication networks of n-person cooperative games. [89][386] Simulation games of multiple agents and their collective decision-makings was the integration of knowledge which synthesized the agents' preferences. [90][402] Bargaining situations of the laws as the experimental legal science are strongly linked with the game-theoretical analysis, nevertheless, there are little legal studies leaned on the applications. [91][399] Applying dynamic

[87] *See* Terry L. Friesz, Dynamic Optimization and Differential Games 269 (2010).

[88] *See* Terry L. Friesz, Dynamic Optimization and Differential Games 269-70 (2010).

[89] *See* John C. Harsanyi, Rational Behavior and Bargaining Equilibrium in Games and Social Situations 131-2 (1977).

[90] *See* Edward A. Parson, *What Can You Learn From A Game?*, *in* Wise Choices: Decisions, Games, and Negotiations 233, 235-45 (Richard J. Zeckhauser et al. eds., 1996).

[91] *See* Martin Shubik, *Game Theory and Experimental Gaming*, *in* 3 Handbook of Game Theory with Economic Applications 2327, 2345 (Robert J. Aumann & Sergiu Hart eds.,

doi:10.6342/NTU201601682

programming in the experimental legal studies can show the subgame-perfectness of the games to make sure the time consistency with the equilibria of games. [92][407]

In social phenomena, concerning the inner stability of the standard of behaviors in social organizations was once controversial. [93][387] In addition, the processes of rational deliberation evolved with deliberational rules while how common knowledge was formed and the critic consequences of assumptions in deliberating processes revealed the importance. [94][384]

Dynamical complex networks revealed the importance of the analysis of social phenomena in physics community, and so for the study of neural networks, it is extended to the strategic equilibria in dynamic processes of decision space where the conceptual frameworks made the significance to the interdisciplinary studies of social science on the contributions of changing the equilibrium dynamical processes into non-equilibria, which are profiles of strategies self-supporting profiles, but the agents' paths of incentives dominated the outcomes in social systems. [95][376] Furthermore,

---

2002) ("The work on both auctions and public goods is of substantive interest to those interested in mechanism design. But essentially as yet there is no indication that the intersection between law, game theory and experimentation is more than some applied industrial organization where the legal content is negligible beyond a relatively simplistic misinterpretation of the contextual setting of threats.").

[92] *See* Alain Haurie, *From Repeated to Differential Games: How Time and Uncertainty Pervade the Theory of Games*, *in* Frontiers of Game Theory 165, 174-5 (Ken Binmore et al. eds., 1993).

[93] *See* John von Neumann & Oskar Morgenstern, Theory of Games and Economic Behavior (reprint 1972) 40-5 (3d ed. 1953) ("We think that the procedure of the mathematical theory of games of strategy gains definitely in plausibility by the correspondence which exists between its concepts and those of social organizations.").

[94] *See* Brian Skyrms, The Dynamics of Rational Deliberation 159-60 (1990) ("The strong common-knowledge assumptions behind the Nash equilibria concept can be relaxed in a number of different ways, and each opens up a domain of phenomena unknown in classical game theory.").

[95] *See* Paul Weirich, Equilibrium and Rationality: Game Theory Revised by Decision Rules 130-37 (1998) ("A strategic equilibrium is a profile of strategies that are strategically

doi:10.6342/NTU201601682

as the hyperrational agents have no equilibrium expectations, the game theory would rather become thorny in making predictions to game-theoretical situation modeling. [96][383] Paths of coalition incentives are regulated by rationality. [97][361]

Referring to the Binmore's models, constructing mechanisms for social agents was concluded with five elements: objective, regulation, incentives, equilibrium, optimization. [98][369] Providing insights into economic models will also need strategic frameworks to explaining factors and equilibrium selections on theoretical settings of the laws. [99][396] For instance, a jury-selection game can be designed with the assumptions contrary to the optimal thresholds with rational strategies. [100][358]

Yet another point to make is that the justifications on rational procedures will be scrutinized as the rational players making mistakes on the common knowledge of rationality. [101][367] Multi-agents in games that making choices in scenarios were assumed self-interested in preferences to meet their dominant strategies. [102][400]

---

self-supporting given the profile. ..... In general, there are important differences between paths of relative and nonrelative incentives. In a path of relative incentives, a strategy may appear in one profile followed by one relative response, and then appear in another profile followed by a different relative response.This cannot happen in a path of nonrelative incentives.").

[96] *See* David M. Kreps, Game Theory and Economic Modelling 177-9 (1990).

[97] *See* Paul Weirich, Collective Rationality: Equilibrium in Cooperative Games 169-75 (2010) ("Agents in games with empty cores cannot pursue all incentives, but rationality is still attainable.").

[98] *See* Ken Binmore, Natural Justice 192-5 (2005).

[99] *See generally* Avner Greif, *Economic History and Game Theory*, *in* 3 Handbook of Game Theory with Economic Applications 1989 (Robert J. Aumann & Sergiu Hart eds., 2002).

[100] *See* Steven J. Brams, Game Theory and the Humanities: Bridging Two Worlds 146-52 (2011).

[101] *See* Ken Binmore, Does Game Theory Work? The Bargaining Challenge 320-3 (2007).

[102] *See* Simon Parsons & Michael Wooldridge, *An Introduction to Game Theory and Decision Theory*, *in* Game Theory and Decision Theory in Agent-based Systems 1, 10-6 (Simon Parsons et al. eds., 2002).

doi:10.6342/NTU201601682

4.3.5 Political Choices in Decision Space

Decision-makings in Policy Analysis

To start with, cross-disciplinary studies on administrative laws emerged new avenues for the separation of power and the agency policies control as a legislative-executive game by public choice analysis contributing to the institutional design. [103][377] It follows that the individual interests of the interest groups in political spheres can be simulated as common interests. [104][269] Large or small intensity of interest groups shows inconspicuous influence or differences between the transaction costs either of insulted political lawmaking or intrusive judicial reviews. [105][139] For instance, some studies used mathematical interpretations on analyzing the public policies by constructing game-theoretical models which could be concluded with two effects on legal systems: (1) optimizing the negligence rules with concerns of costs of the injuries; (2) modeling fluctuating actions of public policies on education. [106][532]

The legislation models cannot account for public choice theory because of the irrationality of voting behaviors and the self-interest agents in political processes. [107][381] Seeking or preventing legal changes by judges and legislators would be more

---

[103] *See* Jerry L. Mashaw, Greed, Chaos, and Governance: Using Public Choice to Improve Public Law 191-8 (1997).

[104] *See* Ejan Mackaay, Law and Economics for Civil Law Systems 178-9 (2013).

[105] *See* Einer R. Elhauge, *Does Interest Group Theory Justify More Intrusive Judicial Review?*, 101 Yale L.J. 31, 80-9 (1991).

[106] *See* Nicholas L. Georgakopoulos, Principles and Methods of Law and Economics: Basic Tools for Normative Reasoning 140-8 (2005).

[107] *See* Daniel A. Farber & Philip P. Frickey, Law and Public Choice: A Critical Introduction 21-33 (1991) ("So even a model of legislators' behavior must incorporate a non-public choice model of voting in order to predict legislative events. ..... Our best picture of the political process, then, is a mixed model in which constituent interest, special interest groups, and ideology all help determine legislative conduct.").

doi:10.6342/NTU201601682

or less affected by interest group pressures in litigations and legislative processes. [108][363] To concluded with, judicial review games for the policy-makings by public choice analysis provided insights for problems of legislative control but remained indeterminate open-minded conclusions. [109][377]

4.3.6 Legislative Choices in Decision Space

Interactions of Institutional Behaviors

Social choice theory could be taken as a part of jurisprudence and a powerful skill of legal decision-makings. [110][412] Designs of legislative choices with concerns of agenda controls and strategic votings could help enhance the protections of private rights in legislative decision processes. [111][416] Sophisticated votings with the game-theoretic analysis of the non-cooperative behaviors under complete information were concluded in dominance-solvable game forms. [112][405]

Assuming the perfect information and coalitions for legislators, the legislative voting procedure was a cooperation game. [113][393] The analysis of preferences of

[108] *See* Maxwell L. Stearns & Todd J. Zywicki, Public Choice Concepts and Applications in Law 471-3 (2009).

[109] *See* Jerry L. Mashaw, Greed, Chaos, and Governance: Using Public Choice to Improve Public Law 172-80 (1997) ("A public choice or game-theoretic approach to the question of judicial review of administrative rulemaking hardly leads in a single or a conclusive direction. Note, however, that here strategic rational actor models do seem to provide some purchase on pressing policy problems and to lead in directions that have tended to be ignored by legal reformers.").

[110] *See* David Luban, *Social Choice Theory as Jurisprudence*, 69 S. Cal. L. Rev. 521, 577 (1996).

[111] *See* William H. Riker & Barry R. Weingast, *Constitutional Regulation of Legislative Choice: the Political Consequences of Judicial Deference to Legislatures*, 74 Va. L. Rev. 373, 393-401 (1988).

[112] *See* Hervé Moulin, *Social Choice*, *in* 2 Handbook of Game Theory with Economic Applications 1091, 1105-8 (Robert J. Aumann & Sergiu Hart eds., 1994).

[113] *See* Robert Wilson, *A Game-Theoretic Analysis of Social Choice*, *in* Social Choice 393,

doi:10.6342/NTU201601682

individuals to be interrelated with social group choices which especially manifested in voting rules was highly mathematical concerns. [114][368] Some studies rethought the instability of multidimensional social choice processes in the chaotic dynamics, which constituted by the preferences of voters in a multidimensional policy space that actuated the political stability. [115][559]

Summarizing the definition of social preferences in the social choice function was that social preferences in preference orders represented social decisions in the social choice function would assign to preference profiles of non-dictatorship individual preferences and social preferences in preference/indifference relationships. [116][364] For policy evaluations with two or multiple parties, competition behaviors formed a social choice to search an equilibrium policy, where the multiple parties had to seek coalitions due to the unstable social choice. [117][392]

396-7 (Bernhardt Lieberman ed., 2011).

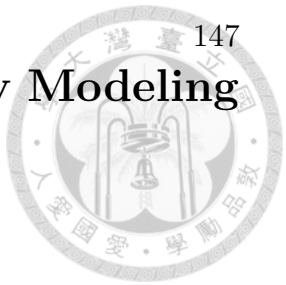
[114] *See* Alan D. Taylor, Social Choice and the Mathematics of Manipulation 20-9, 102-17 (2005).

[115] *See generally* Diana Richards, *From Individuals to Groups: the Aggregation of Votes and Chaotic Dynamics*, *in* Chaos Theory in the Social Sciences: Foundations and Applications 89 (L. Douglas Kiel & Euel Elliott eds., 1996).

[116] *See* Ein-Ya Gura & Michael Maschler, Insights Into Game Theory: An Alternative Mathematical Experience 67-80 (2008).

[117] *See* David Chapman, *Some Types of Party Competition and Their Function in Social Choice*, *in* Social Choice 349 (Bernhardt Lieberman ed., 2011).

doi:10.6342/NTU201601682



4.4 Legislations and Conceptual Policy Modeling

4.4.1 Self-organization in Complex Systems

Generalization of Self-organization

In human societies, conversations started with the self-organizing bio-psycho-social approach, where the individuals could determine interpersonal adaptive regulatory functions of communicating social emergent relationships. [118][464] Self-organizing processes existed in the complex systems formed with the complex webs of nonlinear dynamical interactions of agents in the emergent orders of functions. [119][474]

Self-organizing processes, transformability, adaptations of systems, and resilient reactions toward the disturbance of complex adaptive systems of society have the profound implications for the economic evalution and policy-makings. [120][484] Social-ecological resilience basically differs from the ecological or engineering resilience. [121][451]

Social-ecological systems in the resilience analysis categorize in the superordinate systems which will co-evolve with the internal rules of their corresponding adaptive

---

[118] *See* David Pincus, *Coherence, Complexity, and Information Flow: Self-organizing Processes in Psychotherapy*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 335, 360-2 (Stephen J. Guastello et al. eds., 2009).

[119] *See generally* Jan Walleczek, *The Frontiers and challenges of Biodynamics Research*, *in* Self-organized Biological Dynamics & Nonlinear Control: Toward Understanding Complexity, Chaos, and Emergent Function in Living Systems 1 (Jan Walleczek ed., 2000).

[120] *See* Carl Folke, *Resilience: the Emergence of A Perspective for Social-ecological Systems Analyses*, 16 Global Environmental Change, 2006, at 253, 260-3.

[121] *See* Ahjond S. Garmestani et al., *Introduction: Social-ecological Resilience and Law*, *in* Social-ecological Resilience and Law 1, 6 (Ahjond S. Garmestani & Craig R. Allen eds., 2014) ("With respect to social-ecological system, resilience is the amount of disturbance a linked social-ecological system can absorb before reorganizing into a new state characterized by a different set of processes and structures.").

doi:10.6342/NTU201601682

cycles. [122][455] Understanding globalization with the self-organizational logics will help find the orders of systems and the way uniformly evolving in complex dynamical systems. [123][465]

Basically it was the competitions that formed the evolutionary processes and selection mechanisms for populations. [124][449] Behavioral economics and artificial societies became prominent and influential by the refinement of game theory. [125][482]

It is noticeable that anti-competitive and competitive hehaviors in decentralized control paradigms will become much more adaptive than in the centralized one, which properties dominated the biological systems and so hold advantages on higher benefits in a narrow communicative network. [126][485] The linkages between the self-organization in artificial systems and the neutral theory of natural selection in complex dynamical systems addressed the explanations of evolutionary theory and the real-world functions of evolution. [127][446]

Modeling perspectives on agent-based social simulations or complex adaptive systems provided useful and practical insights into the dimensions of management,

---

[122] *See* Thomas Kirchhoff et al., *From Cultural Landscapes to Resilient Social-ecological Systems: Transformation of A Classical Paradigm or A Novel Approach?*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 49, 50-2 (Tobias Plieninger & Claudia Bieling eds., 2012).

[123] *See generally* Joachim Karl Rennstich, *Is Globalization Self-organizing?*, *in* Globalization as Evolutionary Process: Modeling Global Change 87 (George Modelski et al. eds., 2008).

[124] *See* J. Stanley Metcalfe, Evolutionary Economics and Creative Destruction 21-6 (1998).

[125] *See* Helga Nowotny, *Bargaining, Not Borrowing: on Problem Choice and Problem Space*, 6 Socio-Economic Rev., 2008, at 754, 757.

[126] *See* Thomas D. Seeley, *When Is Self-organization Used in Biological Systems?*, 202 Biol. Bull., 2002, at 314, 316.

[127] *See* Pierre-Yves Oudeyer, Self-organization in the Evolution of Speech 38-44 (James R. Hurford trans., 2006).

doi:10.6342/NTU201601682

policy design and analysis. [128][477] Resilience researches on systems thinkings of management included the metaphor of the adaptiveness of social-ecological systems. [129][454]

Definitions of self-organization in biological systems emphasized that properties of emergence in complex systems for finding the rules governing agent behaviors in nonlinear dynamical systems. [130][448] On the spatial self-organizating processes in two-species Lotka-Volterra models, interpreting the results of predator-prey models from the spatial pattern formation to their interacting processes would see more details in the consequences of the models. [131][445]

New avenues of the studies of adapting institutions, adaptive governance and complexity would related to global sustainability from long-term ecosystem-based perspectives of the social-ecological resilience. [132][458] Multi-level complex social-ecological governance systems governed by state or non-state actors are embedded in the co-evolutionary interdependence of social and ecological complex systems in

---

[128] *See generally* Simon Levin et al., *Socio-ecological Systems as Complex Adaptive Systems: Modeling and Policy Implications*, 18 Environment and Development Economics, 2012, at 111.

[129] *See* Tobias Plieninger & Claudia Bieling, *Connecting Cultural Landscapes to Resilience*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 3, 15-21 (Tobias Plieninger & Claudia Bieling eds., 2012).

[130] *See* Scott Camazine et al., Self-organization in Biological Systems 7-13 (2001) ("Self-organization is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system's components are executed using only local information, without references to the global pattern.").

[131] *See* Richard V. Solé & Jordi Bascompte, Self-organization in Complex Ecosystems 75-9 (2006).

[132] *See* Emily Boyd & Carl Folke, *Adapting Institutions, Adaptive Governance and Complexity: An Introduction*, *in* Adapting Institutions: Governance, Complexity, and Socio-ecological Resilience 1, 3-4 (Emily Boyd & Carl Folke eds., 2012).

doi:10.6342/NTU201601682

the inter-connectedness of social-ecological resilience. [133][459]

Sustainability of social-ecological systems could be managed by the interplay between functional diversity and systems disturbance in cross-scale dynamics and the learning processes of building resilience. [134][469] Convergence of humanity and animality shows the divergence in ontological concerns of resilience thinking. [135][456] The interconnectedness of reciprocated behaviors of cooperative agents in social-spatial structures will change with the Darwin natural selection theory. [136][466]

Resilience of Legal Systems

Resilience of legal systems in adaptive law emphasized the internal functions of law and the adaptation of the legal principles on the external disturbances of society and the natural world. [137][452] Restrict or adaptive contracts can be systematically investigated by complex networks under the independent risk-spreading hypothesis governing by legal agreements. [138][462]

---

[133] *See* Emily Boyd & Carl Folke, *Conclusions: Adapting Institutions and Resilience*, *in* Adapting Institutions: Governance, Complexity, and Socio-ecological Resilience 264, 272-7 (Emily Boyd & Carl Folke eds., 2012) ("Self-organisation–the ability to construct flexible/transparent networks that can evaluate and absorb new ideas and prepare for unknown unknowns (generalised resilience).").

[134] *See* Carl Folke et al., *Synthesis: Building Resilience and Adaptive Capacity in Social-ecological Systems*, *in* Navigating Social-ecological Systems: Building Resilience for Complexity and Change 352, 357-82 (Fikret Berkes et al. eds., 2003).

[135] *See* Lesley Head, *Conceptualising the Human in Cultural Landscapes and Resilience Thinking*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 65, 73-6 (Tobias Plieninger & Claudia Bieling eds., 2012).

[136] *See* Charlotte K. Hemelrijk, *A Process-oriented Approach to the Social Behaviour of Primates*, *in* Self-organisation and Evolution of Social Systems 81, 87-91 (Charlotte K. Hemelrijk ed., 2005).

[137] *See* Craig Anthony (Tony) Arnold & Lance H. Gunderson, *Adaptive Law*, *in* Social-ecological Resilience and Law 317, 317-9 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

[138] *See generally* Simon A. Andrew, *Adaptive versus Restrictive Contracts: Can They Resolve Different Risk Problems?*, *in* Self-organizing Federalism: Collaborative Mechanisms

doi:10.6342/NTU201601682

Improving adaptive governance processes of legal system dynamics will reform the administrative law with the interconnections of law and natural science. [139][453] Conflicts in either interest systems or role systems which are subsystems of legal systems could be mediated, where the processes were defined as the self-organization of legal systems. [140][447]

Adaptiveness of Policy-makings

Economic self-organization in the context of socio-economics emphasized on the asymmetric information or systematic complexity rather than biological domains. [141][467] Political economy was derived from political ecology, where the complexity of policy-making processes demonstrated in adaptive cycles of the interrelationships of elements: disturbance, diversity, ecological knowledge, self-organization. [142][468] The scales differed in spatiality from sociocultural to economical perspectives on the studies of socioeconomic policy. [143][457]

TO MITIGATE INSTITUTIONAL COLLECTIVE ACTION DILEMMAS 91 (Richard C. Feiock & John T. Scholz eds., 2010).

[139] *See* Ahjond S. Garmestani et al., *The Integration of Social-ecological Resilience and Law*, *in* SOCIAL-ECOLOGICAL RESILIENCE AND LAW 365, 370-3 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

[140] *See* KAZUKO HIROSE KAWAGUCHI, A SOCIAL THEORY OF INTERNATIONAL LAW: INTERNATIONAL RELATIONS AS A COMPLEX SYSTEM 87-119 (2003).

[141] *See* John Foster, *The Self-organizational Perspective on Economic Evolution: A Unifying Paradigm*, *in* THE EVOLUTIONARY FOUNDATIONS OF ECONOMICS 367, 387-8 (2005) ("Subscription to such mechanisms, in itself, is a form of socially embedded mutualism that has self-organized in society to replace predator-prey-style power hierarchies as the means to achieve economic coordination.").

[142] *See* Fikret Berkes et al., *Introduction*, *in* NAVIGATING SOCIAL-ECOLOGICAL SYSTEMS: BUILDING RESILIENCE FOR COMPLEXITY AND CHANGE 1, 14-23 (Fikret Berkes et al. eds., 2003) ("Thus, resilience in concerned with the magnitude of disturbance that can be absorbed or buffed without the system undergoing fundamental changes in its functional characteristics.").

[143] *See* Alejandro J. Rescia et al., *Cultural Landscapes as Complex Adaptive Systems: the Cases of Northern Spain and Northern Argentina*, *in* RESILIENCE AND THE CULTURAL LANDSCAPE: UN-

doi:10.6342/NTU201601682

Adaptiveness of legislative or policy-analysis institutions that resolved emerging dilemmas in mechanism dynamics was in the centrality of self-organizing governance of policy network developments. [144][460] Analysis of policy-making in decentralized systems in a self-organizing approach discussed the policy scenarios of balancing divergent interests of bargaining among state or non-state actors. [145][461]

4.4.2 Conceptual Policy Modeling on Artificial Societies

To begin with conceptual mappings, in general, the convergence of taxonomy on artificial intelligence and the laws fit together in logics languages for legal reasoning, specially for the common sense reasoning of contexts. [146][513]

It is a complicated conceptual framework of artificial societies and the law. In approaching this issues of illustrations, just consider conceptual business processes modeling [147][509] and conceptual policy modeling for the development process of long-term behaviors of systems. [148][516]

---

derstanding and Managing Change in Human-shaped Environments 126, 137-40 (Tobias Plieninger & Claudia Bieling eds., 2012).

[144] *See* Richard C. Feiock & John T. Scholz, *Self-organizing Governance of Institutional Collective Action Dilemmas: An Overview*, *in* Self-organizing Federalism: Collaborative Mechanisms to Mitigate Institutional Collective Action Dilemmas 3, 17-29 (Richard C. Feiock & John T. Scholz eds., 2010).

[145] *See* Bryan D. Jones, *Conflicts, Power, and Irreconcilable Preferences: Some Limits to Self-organizing Mechanisms*, *in* Self-organizing Federalism: Collaborative Mechanisms to Mitigate Institutional Collective Action Dilemmas 73, 86-7 (Richard C. Feiock & John T. Scholz eds., 2010).

[146] *See* John A. Barnden & Donald M. Peterson, *Artificial Intelligence, Mindreading, and Reasoning in Law*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 21, 30-31 (Marilyn MacCrimmon & Peter Tillers eds., 2002).

[147] *See generally* Brian Henderson-Sellers, *Random Thoughts on Multi-level Conceptual Modelling*, *in* The Evolution of Conceptual Modeling: From A Historical Perspective Towards the Future of Conceptual Modeling 93 (Roland Kaschek & Lois Delcambre eds., 2011).

[148] *See generally* Sabrina Scherer et al., *Bridging Narrative Scenario Texts and Formal Policy*

doi:10.6342/NTU201601682

To start with the point that, individual-based (agent-based) models displayed applications of multiagent systems which provided broad insights into the artificial societies that autonomous agents simulated the behaviors of entities in real-world social systems; there were many differences between linear and nonlinear systems of macro simulations of macro-level observable variables in mathematical control theory. [149][512] Artificial sociality between agents and groups plays the central part of the concept of emergence. [150][514]

New avenues were emerged and created by the mathematical game theory with respect to the influence of communities, such as artificial intelligence and the laws, applied to social network analysis and formulating legal theories by modeling the legal knowledge or reasoning methods. [151][517] What is more, the properties of rational actors in artificial intelligence modeling included as follows: autonomy in making independent decisions, pro-activeness in making goal-directed behaviors, reactivity in deliberating to change with environments and social ability in existing social interactions. [152][507]

For instance, recent emerging agent-based computational economics which was

---

Modeling Through Conceptual Policy Modeling, 21 Artificial Intelligence and Law, 2013, at 455.

[149] *See generally* R. Keith Sawyer, *Artificial Societies: Multiagent Systems and the Micro-Macro Link in Sociological Theory*, *in* 3 Computational Social Science 133 (Nigel Gilbert ed., 2010) (2003).

[150] *See* Rosaria Conte & Nigel Gilbert, *Introduction: Computer Simulation for Social Theory*, *in* Artificial Societies: the Computer Simulation of Social Life 1, 8-12 (Nigel Gilbert & Rosaria Conte eds., 1995) ("Agent should not be seen as a twofold, individual and societal, phenomenon, but as a multi-level one, where individual and societal levels are integrated because of the special make up of the agents - their social characterization.").

[151] *See generally* Kevin D. Ashley & Will Bridewell, *Emerging AI & Law Approaches to Automating Analysis and Retrieval of Electronically Stored Information in Discovery Proceedings*, 18 Artificial Intelligence and Law, 2010, at 311.

[152] *See* Michael Wooldridge, Reasoning About Rational Agents 2-5 (2000).

doi:10.6342/NTU201601682

rooted in artificial intelligence with virtually serious games was taken as a powerful approach for business simulations, also for mathematical biology and evolutionary game theory, as an access to study complex dynamical systems corresponding to self-organized social systems. [153][510]

Interactions of political actors in political organizations were reflected the issues of international affairs. [154][515] Policy modeling or norm design in social laws of the agent society was focused on controlling and predicting the decision-making processes of agents depended on the multiagent scenarios of bargaining. [155][505] For instance, automated contracting by two self-interested agents which the second party determines rules after the first party is known as the principle-agent paradigm. [156][506] This is a well-known model universally used in political science studies.

4.4.3 Public Policy Analysis and Legislative Modeling

The key aspect of the arguments mentioned above was, altogether, legal experience knowledge-based systems applied in rule-based or case-based analysis sometimes omitting the real legal functions and the regarding intrinsic adaptive mechanisms

---

[153] *See* Wilbert Grevers & Anne van der Veen, *Serious Games for Economists*, *in* Complexity and Artificial Markets 159, (Klaus Schredelseker & Florian Hauser eds., 2008) ("Population games seem to offer a solution for the both the system interpretation of complex dynamical systems and the interpretation of individual beliefs in decision making. ..... AI in serious games might serve as a common language for agent-based models in economic theory.").

[154] *See* Robert Axelrod, *A Model of the Emergence of New Political Actors*, *in* Artificial Societies: the Computer Simulation of Social Life 19, 34-38 (Nigel Gilbert & Rosaria Conte eds., 1995).

[155] *See* Michael Wooldridge, An Introduction to Multiagent Systems 173-7, 245-9 (2d ed. 2009).

[156] *See* Sarit Kraus, Strategic Negotiation in Multiagent Environments 227-29 (2001).

doi:10.6342/NTU201601682

of legal reasoning demonstrated in legislations. [157][508] Simplifying scenarios of legal knowledge-based systems to program or design by regulation systems without much consistency of governmental power but concordant with insurance policies, legislative actions, non-governmental enforcement power methods. [158][511]

Accordingly, in order to analyze legal languages and understand judicial settings AI represented the approaches or ontological bridges in conceptualization of judicial decision-makings and fundamental legal theories, but it explicitly differed from the processes of sociological modeling. [159][504] More consideration needs to be analyzed from aspects of petitioners and respondents, boundaries of experience/science and non-science functions for engineering legal knowledge were implicit. [160][518]

4.4.4 Romeo-Juliet Model

The Romeo-Juliet Model is quoted as follows: [161][534][562]

$$\dot{R} = \alpha R + \beta J \tag{4.4.1}$$

$$\dot{J} = \gamma R + \delta J \tag{4.4.2}$$

---

[157] *See* A. Valente, Legal Knowledge Engineering: A Modelling Approach 19-20, 39-41 (1995).

[158] *See* Tom M. van Engers, *Legal Engineering: A Structural Approach to Improving Legal Quality*, *in* Applications and Innovations in Intelligent Systems XIII 3, 8-9 (Ann Macintosh et al. eds., 2006).

[159] *See* Núria Casellas, Legal Ontology Engineering: Methodologies, Modelling Trends, and the Ontology of Professional Judicial Knowledge 250-3 (2011).

[160] *See* Gary Edmond, *Legal Engineering: Contested Representations of Law, Science (and Non-science) and Society*, 32 Social Studies of Science, no. 3, 2002, at 371, 382-7.

[161] *See* John M. Gottman et al., The Mathematics of Marriage Dynamic Nonlinear Models 112 (2005). *See also* J. C. Sprott, *Dynamical Models of Love*, 8 Nonlinear Dynamics, Psychology, and Life Sciences, no. 3, 2004, at 303, 304.

doi:10.6342/NTU201601682

, where $\alpha, \beta, \gamma, \delta > 0$ or < 0 forms four types of romantic styles.

For the extensions of the Romeo-Juliet Model, take $\omega = 1$, $\beta > 0$, the rate of collapse of the relationships, it follows that the happiness reacting model of Romeo and Juliet is quoted as follows: [162][561]

$$\frac{d^2R}{dt^2} + \beta + \omega^2 R = 0$$

, and so the extensions of the original model is quoted as follows: [163][560]

$$\dot{R} = \alpha R + \beta J + F \tag{4.4.3}$$

$$\dot{J} = \gamma R + \delta J + G \tag{4.4.4}$$

, where F denotes the R appeals to J, and G expresses how J appeals to R, when the $\alpha = 0$, $\beta < 0$, F =0, $\gamma > 0$, $\delta = 0$, G = 0, the romance of Romeo and Juliet would break down. This is an undamped oscillating system, which contains a life cycle of the status of love and hate that change periodically with time.

Explore the Gottman-Murray Model of Marital Interactions, quoted as follows: [164][527]

$$P_{t+1} = r_p P_t + a, r_p > 1, a \neq 0, a \in \mathbb{R}. \tag{4.4.5}$$

, where r_p is a constant, representing the tone of conversation.

---

[162] *See* J. C. Sprott, *Dynamical Models of Happiness*, 9 Nonlinear Dynamics, Psychology, and Life Sciences, no. 1, 2005, at 23, 24-5.

[163] *See* J. Wauer et al., *Dynamical Models of Love With Time-varying Fluctuations*, 188 Applied Mathematics and Computation, 2007, at 1535, 1536.

[164] *See* Earl Hunt, The Mathematics of Behavior 96-101 (2007).

doi:10.6342/NTU201601682

And then differentiate P_{t+1} and P_t, quoted as follows: [165][527]

$$\frac{P_{t+1}}{P_t} = 1 \tag{4.4.6}$$

$$P_t = \frac{a}{1 - r_p} \tag{4.4.7}$$

And then they are quoted as follows: [166][527]

$$W = \frac{a}{1 - r_w} \tag{4.4.8}$$

$$H = \frac{a}{1 - r_h} \tag{4.4.9}$$

And then the marriage model is quoted as follows: [167][540]

$$W_{t+1} = I_{HW}(H_t) + r_1 W_t + P \tag{4.4.10}$$

$$H_{t+1} = I_{WH}(W_{t+1}) + r_2 H_t + Q \tag{4.4.11}$$

, where P, Q are constants representing the wife's and husband's affection to each other, which determine the states of marital interactions.

---

[165] *See* Earl Hunt, The Mathematics of Behavior 96-101 (2007).

[166] *See* Earl Hunt, The Mathematics of Behavior 96-101 (2007).

[167] *See* J. D. Murray, Mathematical Biology: I. An Introduction 155 (3d ed. 2002).

doi:10.6342/NTU201601682

4.4.5 Susceptible-Infected-Recovery Model

SI Model

Start modeling the disease-spreading processes with the fully susceptible-infected model (SI model), quoted as follows: [168][521]

$$\dot{X} = \beta \frac{SX}{n} \tag{4.4.12}$$

$$\dot{S} = -\beta \frac{SX}{n} \tag{4.4.13}$$

, where S denotes the number of people who are susceptible, X denotes the number of people who are infected, β denotes the rate of contacting with others on average, n denotes the total population; the possibility of being susceptible is $\frac{S}{n}$, thus the possibility of the infected people X contacting with susceptible people is $\beta \mathrm{S} \frac{X}{n}$.

Take s, x replace $\frac{S}{n}$ and $\frac{X}{n}$, the differential system is quoted as follows: [169][521]

$$\dot{x} = \beta s x \tag{4.4.14}$$

$$\dot{s} = -\beta s x \tag{4.4.15}$$

The solution of this system is quoted as follows: [170][521]

$$x(t) = \frac{x_0 e^{\beta t}}{1 - x_0 + x_0 e^{\beta t}} \tag{4.4.16}$$

[168] *See* M. E. J. Newman, Networks: An Introduction 628-31 (2010).

[169] *See* M. E. J. Newman, Networks: An Introduction 628-31 (2010).

[170] *See* M. E. J. Newman, Networks: An Introduction 628-31 (2010).

doi:10.6342/NTU201601682

, where the equation showed in graphs is a logistic curve, increasing exponentially with time.

SIR Model

Continue with the SI model's settings, further consider the average rate γ that infected people will recover or die, and the time τ of remaining infected, the SIR model is quoted as follows:[171][521]

$$\dot{x} = \beta s x \tag{4.4.17}$$

$$\dot{s} = -\beta s x \tag{4.4.18}$$

$$\dot{r} = \gamma x \tag{4.4.19}$$

It concluded the SIR model with population settings, quoted as follows: [172][548]

1. An epidemic will occur only if the number of the susceptible in a population exceeds the threshold value $\sigma = \frac{\gamma}{\beta}$.

2. The spread of the disease does not stop for lack of a susceptible population; it stops only for lack of infectives. In particular, some individuals will escape the disease altogether.

The infection rate β was the threshold value. S_0 is the number of the susceptible. Conclude with the Threshold Theorem of Epidemiology (Kermack & McKendrick, 1927), quoted as follows: [173][548]

[171] *See* M. E. J. Newman, Networks: An Introduction 613-36 (2010).

[172] *See* Martin Braun, Differential Equations and Their Applications 460 (4d ed. 1993).

[173] *See* Martin Braun, Differential Equations and Their Applications 461 (4d ed. 1993).

doi:10.6342/NTU201601682

Threshold Theorem of Epidemiology. *Let $S_0 = \sigma + \nu$ and assume that $\frac{\nu}{\sigma}$ is very small compared to one. Assume moreover, that the number of initial infectives I_0 is very small. Then, the number of individuals who ultimately contract the disease is 2ν. In other words, the level of susceptibles is reduced to a point as far below the threshold as it originally was above it.*

SIS Model

If considering the reinfection of the diseases in the endemic disease state, the SIS model is quoted as follows: [174][521]

$$\dot{x} = \beta s x - \gamma x \tag{4.4.20}$$

$$\dot{s} = \gamma x - \beta s x \tag{4.4.21}$$

with

$$s + x = 1 \tag{4.4.22}$$

After calculations, the solution to this differential system is quoted as follows: [175][521]

$$x(t) = x_0 \frac{(\beta - \gamma)e^{(\beta-\gamma)t}}{\beta - \gamma + \beta x_0 e^{(\beta-\gamma)t}} \tag{4.4.23}$$

, where the equation shows in graphs a logistic curve, as $\beta > \gamma$; the disease will be eradicated, as $\beta < \gamma$.

---

[174] *See* M. E. J. Newman, Networks: An Introduction 636-7 (2010).

[175] *See* M. E. J. Newman, Networks: An Introduction 636-7 (2010).

doi:10.6342/NTU201601682

SIRS Model

If adding up the elements of getting temporary immunity of the disease after recovery in the SI model, also δ denoting the average rate of losing immunity, then the SIRS model is quoted as follows: [176][521]

$$\dot{x} = \beta s x - \delta x \tag{4.4.24}$$

$$\dot{s} = \delta r - \beta s x \tag{4.4.25}$$

$$\dot{r} = \gamma x - \delta r \tag{4.4.26}$$

with

$$s + x + r = 1 \tag{4.4.27}$$

It is not possible to solve this system directly, but taking the numerical analysis to approach the solutions is possible.

SEIR Model

If adding up the density of the exposed population E, which divides the agents by their infected status, then the model (Anderson & May, 1991) is quoted as follows: [177][536]

---

[176] *See* M. E. J. Newman, Networks: An Introduction 637-9 (2010).

[177] *See* Peter Turchin, Complex Population Dynamics: A Theoretical/Empirical Synthesis 129 (2003).

doi:10.6342/NTU201601682

$$\dot{S} = \mu N - \beta SI - \mu S \tag{4.4.28}$$

$$\dot{E} = \beta SI - \sigma E - \mu E \tag{4.4.29}$$

$$\dot{I} = \sigma E - \gamma I - \mu I \tag{4.4.30}$$

, where $N = S + E + I + R$; σ is the speed of the exposed becoming the infective; γ is the speed of the infective becoming the recovered; μ is the parameter of birth and death rates; βSI is the rate of the susceptible becoming the infective.

If eliminating E, the model is quoted as follows: [178][536]

$$\dot{S} = \mu(N - S) - \beta SI \tag{4.4.31}$$

$$\dot{I} = \beta SI - (\gamma + \mu)I \tag{4.4.32}$$

, where let $N = S + E + I + R$ become $N - S = I + R$, and take $\mu I = 0$ to reinterpret μ as the birth and death rate of the susceptible; γ as the death rate of the infective, then the model is quoted as follows: [179][536]

$$\dot{S} = \mu R - \beta SI \tag{4.4.33}$$

$$\dot{I} = \beta SI - \gamma I \tag{4.4.34}$$

This oscillatory dynamical system has the same structure as the Lotka-Volterra model: taking the susceptible as the prey, the infective as the predator. [180][536]

[178] *See* Peter Turchin, Complex Population Dynamics: A Theoretical/Empirical Synthesis 129 (2003).

[179] *See* Peter Turchin, Complex Population Dynamics: A Theoretical/Empirical Synthesis 130 (2003).

[180] *See* Peter Turchin, Complex Population Dynamics: A Theoretical/Empirical

doi:10.6342/NTU201601682

4.4.6 International Legislative Control Model

Definitions

X denotes the political control of the enforceability of foreign arbitral awards. Y denotes the legislative control of enforceability of foreign arbitral awards. They both do not depend on the variable time t but simply on the dependent variables X and Y in this international legislative control model.

Methods: Autonomous Systems

Consider two autonomous systems, quoted as follows: [181][564][570]

Type 1: Positive Effects of the Political Control

$$\dot{X} = Y \tag{4.4.35}$$

$$\dot{Y} = X \tag{4.4.36}$$

Results

The solutions of the Type 1 system are given by

$$H(X, Y) = Y^2 - X^2 = C$$

, C is a constant, and the trajectories of the Type 1 system are hyperbolas and the critical point (0,0) is a saddle point. [182][564]

Synthesis 130 (2003).

[181] *See* William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems 504-5 (9th ed. 2010). *See also* Shepley L. Ross, Differential Equations 635-6 (3d ed. 1984).

[182] *See* William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems 504-5 (9th ed. 2010).

doi:10.6342/NTU201601682

Phase Planes

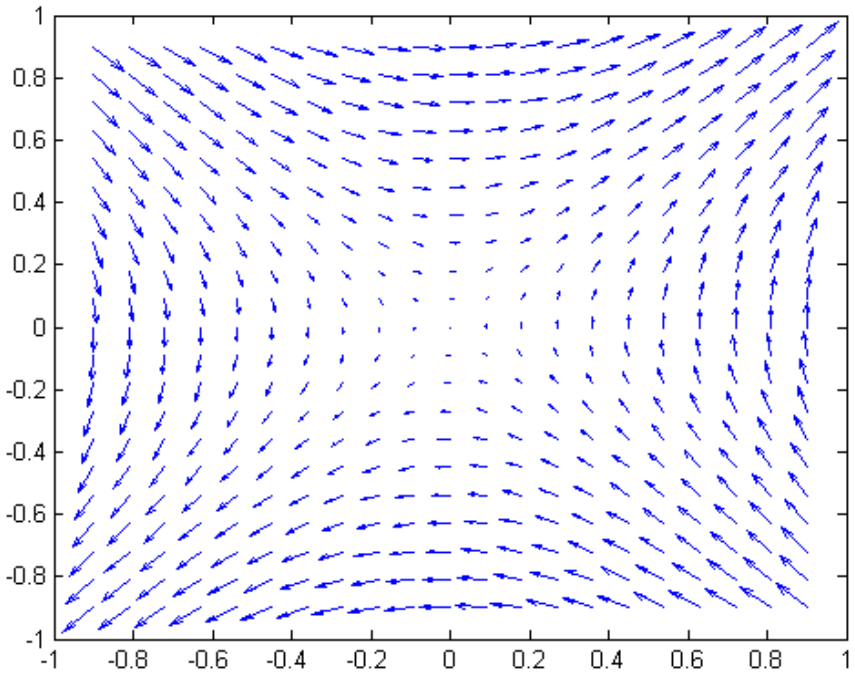


Figure 4.1: Positive Effects of the Political Control

Type 2: Negative Effects of the Political Control

$$\dot{X} = Y \tag{4.4.37}$$

$$\dot{Y} = -X \tag{4.4.38}$$

Results

The results of the Type 2 system show that (0,0) is the only one critical point, and the paths of the Type 2 system is a circle in the clockwise direction based on the solution of the one-parameter family

$$H(X, Y) = X^2 + Y^2 = C$$

doi:10.6342/NTU201601682

, C is a constant. [183][570]

Phase Planes

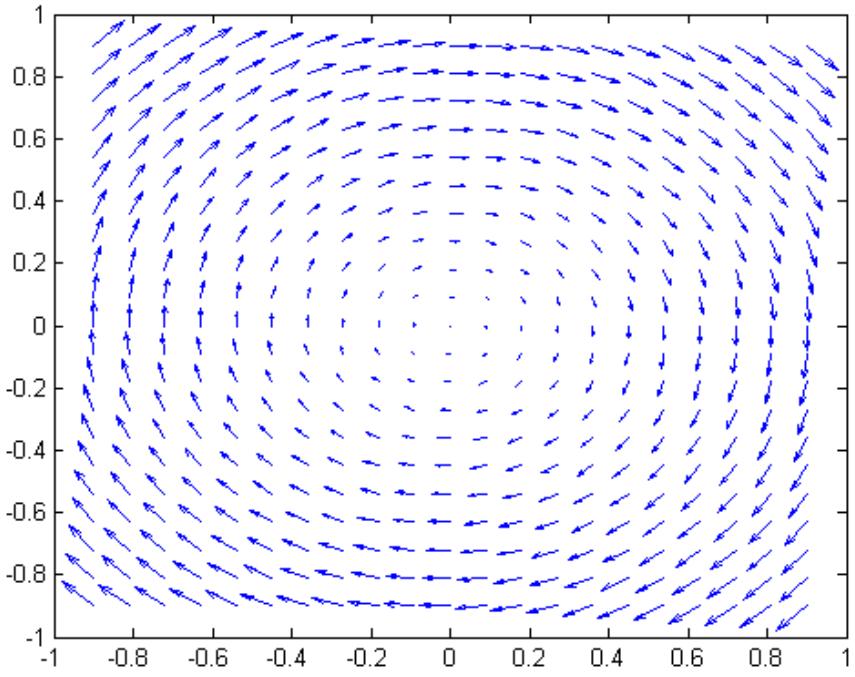


Figure 4.2: Negative Effects of the Political Control

4.5 Concluding Remarks

In this chapter, this thesis built the international legislative control model. The results of the model showed that less involvements of the political control of the enforceability of foreign arbitral awards brought about the stability of international post-award review systems. This thesis learned about the discrepancy between the outcomes of modeling political control and legislative control of the international enforceability of the foreign arbitral awards evolving in the international legislative

[183] *See* Shepley L. Ross, Differential Equations 635-6 (3d ed. 1984).

doi:10.6342/NTU201601682

control model. This thesis found that constructing the national legislative control of the international post-award review systems in the life cycles of political control in the dynamical complex networks was difficult, however, this thesis emphasized that legislative modeling as a theory-building research could be applicable for reasoning about the international post-award review systems. Legislative modeling is based on the oscillation of positive and negative effects on the political control dependent with the legislative control of the enforceability of foreign arbitral awards in autonomous systems governed by norms.

doi:10.6342/NTU201601682

Chapter 5

Conclusion

5.1 Conclusion

In the first part of this thesis, this thesis started with analyzing strategic behaviors in dispute resolution bargaining processes and made the extensions on distribution of power in the post-award review bargaining model. This thesis concluded that finding the strategic equilibria of choices in decision space as well as the perfect equilibrium preferences of the contracts in dynamic processes of settlement bargaining dominated the efficacy of the post-award review bargaining.

In the second part of this thesis, this thesis modelled the judicial behaviors in the evolutionary multilevel hierarchy of orders based on the heuristics decision-makings with the preferences of social agents. In this part, this thesis concluded that for the sustainability of the national interest-based arbitration systems or of the post-award judicial reviews in the international commercial arbitration spheres, the reciprocity between the judicial power and the arbitral competence in post-award procedural dynamics showed the significance of the international enforceability in

doi:10.6342/NTU201601682

foreign arbitral awards.

In the third part of this thesis, this thesis investigated the commercial and social norms of bargaining for coalitions structures for governing the legislative choices as conceptual policy modeling on the theoretical basis of scheming the structures for procedural delocalized arbitrations. This thesis concluded that constructing the legislative control of international post-award review systems was based on legal implementation of the dynamical complex networks of the transnational political organizations and the corresponding non-state actors.

5.2 Legislative Control of Post-award Procedures

5.2.1 Legislative Modeling: Control, Predict, Analyze

Legislative modeling as a theory-building research approach applied in this thesis is for the purposes of controlling the post-award procedural dynamics, predicting the sustainability of national arbitration laws, analyzing the grounds for ensuring the international enforceability of arbitral awards.

5.2.2 Long-term Behaviors of Post-award Review Systems

The three models constructed in this thesis include: Post-award Review Bargaining Model, Post-award Judicial Review Model, International Legislative Control Model. This thesis was interested in the long-term behaviors of post-award review systems displaying in the stability analysis of phase planes and critical points of systems.

In the Post-award Review Bargaining Model, the results show that the interests of the parties do not always oscillate with the power of the courts in post-award

doi:10.6342/NTU201601682

judicial review bargaining. In the Post-award Judicial Review Model, the results show that how the intensity of the vacatur grounds for foreign arbitral awards makes great impacts on post-award procedural dynamics. In the International Legislative Control Model, the results show that less involvements of the political control of the enforceability of foreign arbitral awards brings about the stability of international post-award review systems.

5.2.3 Recommendations for Taiwan Arbitration Laws

Ratifying the New York Convention

This section as follows introduced the latest amendment on Taiwan Arbitration Law in 2015 on the issues of recognition and enforcement of foreign arbitral awards: [1][1]

> Article 47
>
> A foreign arbitral award is an arbitral award which is issued outside the territory of the Republic of China or issued pursuant to foreign laws within the territory of the Republic of China.
>
> A foreign arbitral award, after an application for recognition has been granted by the court, shall be binding on the parties and have the same force as a final judgment of a court, and is enforceable.

This thesis compared the amendments of the Taiwan Arbitration Law with the holding of the Judicial Yuan Interpretation of Taiwan No. 591, which declined the propositions of the party alleging that there was obvious reasoning contradictions

[1] *See* Chungtsai Fa [The Arbitration Law of R.O.C.] (amended, 2015).

doi:10.6342/NTU201601682

in the disputed national arbitral award, quoted as follows: [2][14]

> The Arbitration Act as amended and promulgated on June 24, 1998, provides that, "where an arbitral award shall state the reasons upon which it is based but fails to do so," one party may bring an action against the other to set aside the arbitral award (See Articles 40-I (i) and 1st half of 38 (ii) thereof). Although the said Act does not list contradiction in reasoning of an arbitral award as a ground for bringing such an action, it may well be a systemic design made by the legislature for purposes of developing a healthy environment necessary to preserve the arbitration system after considering the characteristics of arbitration, as well as consulting the common practices of international commercial arbitration. Therefore, it has not gone beyond the bounds of legislative liberty and thus does not contravene the intent of Article 16 of the Constitution to protect the people's right of instituting legal proceedings.

This thesis suggested to ratify the New York Convention in Taiwan Arbitration Law as legislative grounds for applying principles of the international commercial arbitration in Taiwan commercial arbitrations, for the purposes of scheming the features of procedural delocalization for creating a-national arbitral awards by the Taiwan arbitral tribunals, and to keep up with the trends of harmonization of arbitral legislations governed by transnational commercial norms. Ensuring the international enforceability of arbitral awards is important for national legislative systems to gain more incentives for functioning international commercial arbitrations in Taiwan.

---

[2] *See* J. Y. Interpretation, No. 591 (Taiwan) (2005).

doi:10.6342/NTU201601682

Adding the Grounds for Modifications or Corrections

The grounds for modifications or corrections of arbitral awards accredited by the Federal Arbitration Act allow the arbitral tribunals to correct or reinterpret the arbitral awards, nevertheless, making the adjustments of arbitral awards is forbidden under this circumstances. [3][51]

This thesis suggested to add the grounds for modifications or corrections on the evident material miscalculation or mistakes and reinterpretations of arbitral awards to Taiwan Arbitration Law for eliminating the efficacy costs of arbitrations. [4][8]

5.3 Future Work and Additional Topics

In future developments of this thesis, the extensions of arbitral legislation beyond the state will be the first place. For national legislative design on arbitration laws, constructing renegotiation mechanisms before post-award reviews becomes crucial for solving the efficacy costs problems. In addition, the court-facilitated mediations in post-award judicial review procedures is also important for consolidating the legitimacy interests.

---

[3] *See* Peter Bowman Rutledge et al., *United States*, *in* Practitioner's Handbook on International Commercial Arbitration 877, 928-30 (Frank Bernd Weigand ed., 2d ed. 2009).

[4] *See* Federal Arbitration Act [FAA], 9 U.S.C. §11 (amended, 1990) ("In either of the following cases the United States court in and for the district wherein the award was made may make an order modifying or correcting the award upon the application of any party to the arbitration (a) Where there was an evident material miscalculation of figures or an evident material mistake in the description of any person, thing, or property referred to in the award. (b) Where the arbitrators have awarded upon a matter not submitted to them, unless it is a matter not affecting the merits of the decision upon the matter submitted. (c) Where the award is imperfect in matter of form not affecting the merits of the controversy. The order may modify and correct the award, so as to effect the intent thereof and promote justice between the parties.").

doi:10.6342/NTU201601682

Online Dispute Resolution

UNCITRAL online dispute resolution negotiations in cross-border online commerces depend on a uniform legal system to provide justice where governmental paternalism of public policy choices creates an impact on principles of party autonomy in the online dispute resolution processes. [5][81] Online dispute resolution processes are unique compared with traditional approaches of conflict resolutions. Studying the role of arbitrations in online dispute resolutions is a good topic for the future work.

Multi-party Arbitrations

Multi-party arbitrations (Mehrparteien-Schiedsgerichtsbarkeit) will lead the trends of the forms of conflict resolutions in the future development of arbitral legislations. [6][33] To analyze the spectrum of possible solutions of the post-award judicial reviews on multi-party arbitrations and their international enforceability of arbitral awards will become a new avenue of researches.

---

[5] *See* Ronald A. Brand, *Party Autonomy and Access to Justice in the UNCITRAL Online Dispute Resolution Project*, 10 Loy. U. Chi. Int'l L. Rev. 11, 31-4 (2012).

[6] *See* Klaus Lionnet & Annette Lionnet, Handbuch der internationalen und nationalen Schiedsgerichtsbarkeit: Systematische Darstellung der privaten Handelsschiedsgerichtsbarkeit für die Praxis der Parteien einschließlich CD-ROM mit einschlägigen Normen und Regelwerken 430-46 (3d ed. 2005).

doi:10.6342/NTU201601682

Bibliography

Laws

[1] Chungtsai Fa [The Arbitration Law of R.O.C.] (amended, 2015).

[2] Zivilprozessordnung [ZPO] [Code of Civil Procedure], Sep. 12, 1950, §1025-66 (Ger.) (amended, 2012).

[3] Code de Procédure Civile [C.P.C.] [Code of Civil Procedure] art. 1442-1527 (Fr.) (amended, 2011).

[4] UNIDROIT Principles of International Commercial Contracts (revised, 2010).

[5] UNCITRAL Model Law (amended, 2006).

[6] The Principles of European Contract Law (revised, 2002).

[7] Arbitration Act (U.K.) (1996).

[8] Federal Arbitration Act [FAA], 9 U.S.C. §1-16, §201-8, §301-7 (amended, 1990).

[9] United Nations Convention on Contracts for the International Sales of Goods [CISG] (1980).

[10] New York Convention (1958).

Cases

[11] AT&T Mobility LLC v. Conception, 563 U.S. 321 (2011).

[12] Dallah Real Estate v. Pakistan [2010] UKSC 46.

[13] Hall Street Associates, L.L.C. v. Mattel, Inc., 552 U.S. 576 (2008).

[14] J. Y. Interpretation, No. 591 (Taiwan) (2005).

[15] Société Hilmarton Ltd. v. Société Omnium de Traitement et de Valorisation (OTV), Cour de cassation [Cass.] [supreme court for judicial matters] 1e civ., 10 June, 1997, No. Q 95-18.402, R 95-18.403 (Fr.).

[16] Chromalloy Aeroservices v. The Arab Republic of Egypt, 939 F. Supp. 907 (D.D.C. 1996).

doi:10.6342/NTU201601682

[17] Société Hilmarton Ltd. v. Société Omnium de Traitement et de Valorisation (OTV), Cour de cassation [Cass.] [supreme court for judicial matters] 1e civ., 23 March 1994, No. 92-15.137 (Fr.).

[18] Mitsubishi v. Soler Chrysler-Plymouth, 473 U.S. 614 (1985).

International Commercial Arbitration

Books

[19] Peter B. Rutledge, Arbitration and the Constitution (2013).

[20] 1 Gary B. Born, International Commercial Arbitration (2009).

[21] 2 Gary B. Born, International Commercial Arbitration (2009).

[22] Pedro J. Martinez-Fraga, The American Influence on International Commercial Arbitration: Doctrinal Developments and Discovery Methods (2009).

[23] Thomas E. Carbonneau, Cases and Materials on Arbitration Law and Practice (5d ed. 2009).

[24] Roy Goode et al., Transnational Commercial Law: Text, Cases, and Materials (2007).

[25] Maren Heidemann, Methodology of Uniform Contract Law: the UNIDROIT Principles in International Legal Doctrine and Practice (2007).

[26] Tibor Várady et al., International Commercial Arbitration: A Transnational Perspective (3d ed. 2006).

[27] William W. Park, Arbitration of International Business Disputes Studies in Law and Practice (2006).

[28] Jane Jenkins & Simon Stebbings, International Construction Arbitration Law (2006).

[29] Gabriël Moens & Peter Gillies, International Trade and Business: Law, Policy and Ethics (2d ed. 2006).

[30] Reinhard Zimmermann, Die Europäisierung des Privatrechts und die Rechtsvergleichung (2006).

[31] Andrew Tweeddale & Keren Tweeddale, Arbitration of Commercial Disputes: International and English Law and Practice (2005).

[32] Peter Binder, International Commercial Arbitration and Conciliation in UNCITRAL Model Law Jurisdictions (2d ed., 2005).

[33] Klaus Lionnet & Annette Lionnet, Handbuch der internationalen und nationalen Schiedsgerichtsbarkeit: Systematische Darstellung der privaten Handelsschiedsgerichtsbarkeit für die Praxis der Parteien einschließlich CD-ROM mit einschlägigen Normen und Regelwerken (3d ed. 2005).

doi:10.6342/NTU201601682

[34] Alan Redfern et al., Law and Practice of International Commercial Arbitration (4d ed. 2004).

[35] Menno Aden, Internationale Handelsschiedsgerichtsbarkeit: Kommentar zu den Schiedsverfahrensordnungen ICC-DIS-Wiener Regeln-UNCITRAL-LCIA (2d ed. 2003).

[36] Katherine Lynch, The Forces of Economic Globalization: Challenges to the Regime of International Commercial Arbitration (2003).

[37] Gary B. Born, International Commercial Arbitration: Commentary and Materials (2d ed. 2001).

[38] Mahmood Bagheri, International Contracts and National Economic Regulation: Dispute Resolution Through International Commercial Arbitration (2000).

[39] August Reinisch, International Organizations Before National Courts (2000).

[40] Isaak I. Dore, Theory and Practice of Multiparty Commercial Arbitration With Special Reference to the UNCITRAL Framework (1990).

Articles

[41] Loukas A. Mistelis, *Delocalization and its Relevance in Post-award Review*, *in* The UNCITRAL Model Law After Twenty-Five Years: Global Perspectives on International Commercial Arbitration 167 (Frédéric Bachand & Fabien Gélinas eds., 2013).

[42] Erin O'Hara O'Connor, *Jurisdictional Competition for Dispute Resolution: Courts Versus Arbitration*, *in* Regulatory Competition in Contract Law and Dispute Resolution 427 (Horst Eidenmüller ed., 2013).

[43] Omri Ben-Shahar, *Arbitration and Access to Courts: Economic Analysis*, *in* Regulatory Competition in Contract Law and Dispute Resolution 447 (Horst Eidenmüller ed., 2013).

[44] Peter L. Murray, *The Role of American Courts in International Arbitration*, *in* International Contract Litigation, Arbitration and Judicial Responsibility in Transnational Disputes 69 (Rolf Stürner & Masanori Kawano eds., 2011).

[45] Peter L. Murray, *The Role of American Judges in Alternative Dispute Resolution*, *in* International Contract Litigation, Arbitration and Judicial Responsibility in Transnational Disputes 305 (Rolf Stürner & Masanori Kawano eds., 2011).

[46] Vladimir Pavic, *Annulment of Arbitral Awards in International Commercial Arbitration*, *in* Investment and Commercial Arbitration: Similarities and Divergences 131 (Christina Knahr et al. eds., 2010).

doi:10.6342/NTU201601682

[47] Pilar Perales Viscasillas, *The Role of the UNIDROIT Principles and the PECL in the Interpretation and Gap-filling of CISG*, *in* CISG Methodology 287 (André Janssen & Olaf Meyer eds., 2009).

[48] Miranda Karali & Jane Ballantyne, *England*, *in* Practitioner's Handbook on International Commercial Arbitration 351 (Frank Bernd Weigand ed., 2d ed. 2009).

[49] Emmanuel Gaillard, *France*, *in* Practitioner's Handbook on International Commercial Arbitration 423 (Frank Bernd Weigand ed., 2d ed. 2009).

[50] Inka Hanefeld, *Germany*, *in* Practitioner's Handbook on International Commercial Arbitration 475 (Frank Bernd Weigand ed., 2d ed. 2009).

[51] Peter Bowman Rutledge et al., *United States*, *in* Practitioner's Handbook on International Commercial Arbitration 877 (Frank Bernd Weigand ed., 2d ed. 2009).

[52] Marianne Roth, *UNCITRAL Model Law on International Commercial Arbitration*, *in* Practitioner's Handbook on International Commercial Arbitration 953 (Frank Bernd Weigand ed., 2d ed. 2009).

[53] Edward G. Kehoe, *The Enforcement of Arbitral Awards Against Foreign Sovereigns–the United States*, *in* Enforcement of Arbitral Awards Against Sovereigns 241 (R. Doak Bishop ed., 2009).

[54] Sarah François-Poncet, *Enforcement of Arbitral Awards Against Sovereign States or State Entities–France*, *in* Enforcement of Arbitral Awards Against Sovereigns 355 (R. Doak Bishop ed., 2009).

[55] Emmanuel Gaillard, *The Relationship of the New York Convention With Other Treaties and With Domestic Law*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 69 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

[56] Emmanuel Gaillard & Yas Banifatemi, *Negative Effect of Competence-competence: the Role of Priority in Favour of the Arbitrators*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 257 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

[57] Dana Freyer, *The Enforcement of Awards Affected by Judicial Orders of Annulment at the Place of Arbitration*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 757 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

[58] Bernard Hanotiau & Olivier Caprasse, *Public Policy in International Commercial Arbitration*, *in* Enforcement of Arbitration Agreements and International Arbitral Awards: the New York Convention in Practice 787 (Emmanuel Gaillard & Domenico Di Pietro eds., 2009).

doi:10.6342/NTU201601682

[59] Albert Jan Van Den Berg, *The Efficacy of Awards in International Commercial Arbitration*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 115 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[60] Gerold Herrmann, *Does the World Need Additional Uniform Legislation on Arbitration*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 223 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[61] William Park, *Arbitration's Protean Nature: the Value of Rules and the Risks of Discretion*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 331 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[62] Julian D.M. Lew, *Achieving the Dream: Autonomous Arbitration?*, *in* Arbitration Insights: Twenty Years of the Annual Lecture of the School of International Arbitration 455 (Julian D.M. Lew & Loukas A. Mistelis eds., 2007).

[63] Richard E. Speidel, *Common Legal Issues in American Arbitration Law*, *in* Arbitration Law in America: A Critical Assessment 29 (Edward Brunet et al. eds., 2006).

[64] Richard E. Speidel, *International Commercial Arbitration: Implementing the New York Convention*, *in* Arbitration Law in America: A Critical Assessment 185 (Edward Brunet et al. eds., 2006).

[65] Ronald A. Brand, *Balancing Sovereignty and Party Autonomy in Private International Law*, *in* Liber Memorialis Petar Šarčević: Universalism, Tradition, and the Individual 35 (J. Erauw et al. eds., 2006).

[66] L. Yves Fortier, *The Never-ending Struggle Between Arbitrators and Judges in International Commercial Arbitration*, *in* Law of International Business and Dispute Settlement in the 21th Century 177 (Robert Briner et al. eds., 2001).

[67] Andrea Giardina, *The International Recognition and Enforcement of Arbitral Awards Nullified in the Country of Origin*, *in* Law of International Business and Dispute Settlement in the 21th Century 205 (Robert Briner et al. eds., 2001).

Journals

[68] George A. Bermann, Book Review, 24 Am. Rev. Int'l Arb. 197 (2013) (reviewing Peter B. Rutledge, Arbitration and the Constitution (2013)).

[69] S.I. Strong, *Constitutional Conundrums in Arbitration*, 15 Cardozo J. Conflict Resol. 41 (2013) (reviewing Peter B. Rutledge, Arbitration and the Constitution (2013)).

doi:10.6342/NTU201601682

[70] Maxi Scherer, *Effects of Foreign Judgments Relating to International Arbitral Awards: Is the 'Judgment Route' the Wrong Road?*, 4 J. Int'l Disp. Settlement, no. 3, 2013, at 587.

[71] George A. Bermann, *The "Gateway" Problem in International Commercial Arbitration*, 37 Yale J. Int'l L. 1 (2012).

[72] George A. Bermann, *Arbitrability Trouble*, 23 Am. Rev. Int'l Arb. 367 (2012).

[73] Gary Born, *A New Generation of International Adjudication*, 61 Duke L.J. 775 (2012).

[74] Thomas Clay, *Liberté, Égalité, Efficacité: La devise du nouveau droit français de l'arbitrage Commentaire article par article*, 139 Journal du Droit International, no.2, 2012, at 443.

[75] S.I. Strong, *What Constitutes An "Agreement in Writing" in International Commercial Arbitration? Conflicts Between the New York Convention and the Federal Arbitration Act*, 48 Stan. J. Int'l L. 47 (2012).

[76] S.I. Strong, *Does Class Arbitration "Change the Nature" of Arbitration? Stolt-Nielsen, AT&T, and A Return to First Principles*, 17 Harv. Negot. L. Rev. 201 (2012).

[77] Robert C. Bird, *Enforcement of Annulled Arbitration Awards: A Company Perspective and An Evaluation of A "New" New York Convention*, 37 N.C. J. Int'l L. & Com. Reg. 1013 (2012).

[78] Stefan Kröll, *The Non-enforceability of Decisions Rendered in Summary Arbitral Proceedings Pursuant to the NAI Rules Under the New York Convention*, 23 Am. Rev. Int'l Arb. 75 (2012).

[79] Lawrence A. Cunningham, *Rhetoric Versus Reality in Arbitration Jurisprudence: How the Supreme Court Flaunts and Flunks Contracts*, 75 Law & Contemp. Probs. 129 (2012).

[80] Michael P. Van Alstine, *Stare Decisis and Foreign Affairs*, 61 Duke L.J. 941 (2012).

[81] Ronald A. Brand, *Party Autonomy and Access to Justice in the UNCITRAL Online Dispute Resolution Project*, 10 Loy. U. Chi. Int'l L. Rev. 11 (2012).

[82] George A. Bermann, *Reconciling European Union Law Demands With the Demands of International Arbitration*, 34 Fordham Int'l L. J. 1193 (2011).

[83] George A. Bermann, *The UK Supreme Court Speaks to International Arbitration: Learning From the Dallah Case*, 22 Am. Rev. Int'l Arb. 1 (2011).

[84] Nils Jansen & Reinhard Zimmermann, *Contract Formation and Mistake in European Contract Law: A Genetic Comparison of Transnational Model Rules*, 31 Oxford J. Legal Stud. 625 (2011).

[85] Karen A. Lorang, *Mitigating Arbitration's Externalities: A Call for Tailored Judicial Review*, 59 UCLA L. Rev. 218 (2011).

doi:10.6342/NTU201601682

[86] Fabien Gélinas, *The Independence of International Arbitrators and Judges: Tampered With or Well Tempered?*, 24 N.Y. Int'l L. Rev. 1 (2011).

[87] David Horton, *Arbitration as Delegation*, 86 N.Y.U. L. Rev. 437 (2011).

[88] Renata Brazil-David, *International Commercial Arbitration Involving A State Party and the Defense of State Immunity*, 22 Am. Rev. Int'l Arb. 241 (2011).

[89] Judith Resnik, Comment, *Fairness in Numbers: A Comment on AT&T v. Conception, Wal-Mart v. Dukes, and Turner v. Rogers*, 125 Harv. L. Rev. 78 (2011).

[90] Jack M. Graves, *Arbitration as Contract: the Need for A Fully Developed and Comprehensive Set of Statutory Default Legal Rules*, 2 Wm. & Mary Bus. L. Rev. 227 (2011).

[91] Christopher A. Whytock & Cassandra Burke Robertson, *Forum Non Conventions and the Enforcement of Foreign Judgments*, 111 Colum. L. Rev. 1444 (2011).

[92] Markus A. Petsche, *International Commercial Arbitration and the Transformation of the Conflict of Laws Theory*, 18 Mich. St. J. Int'l L. 453 (2010).

[93] Joseph R. Brubaker & Michael P. Daly, *Twenty-Five Years of the "Prospective Waiver" Doctrine in International Dispute Resolution: Mitsubishi's Footnote Nineteen Comes to Life in the Eleventh Circuit*, 64 U. Miami L. Rev. 1233 (2010).

[94] W. Mark C. Weidemaier, *Toward A Theory of Precedent in Arbitration*, 51 Wm. & Mary L. Rev. 1895 (2010).

[95] Catherine Walsh, *The Uses and Abuses of Party Autonomy in International Contracts*, 60 U.N.B. L.J. 12 (2010).

[96] W. Michael Reisman & Heide Iravani, *The Changing Relation of National Courts and International Commercial Arbitration*, 21 Am. Rev. Int'l Arb. 5 (2010).

[97] Joshua D. H. Karton, *Party Autonomy and Choice of Law: Is International Arbitration Leading the Way or Marching to the Beat of Its Own Drummer?*, 60 U.N.B. L.J. 32 (2010).

[98] George A. Bermann, *Ascertaining the Parties' Intentions in Arbitral Design*, 113 Penn. St. L. Rev. 1013 (2009).

[99] George A. Bermann, *Restating the U.S. Law of International Commercial Arbitration*, 42 N.Y.U. J. Int'l L. & Pol. 175 (2009).

[100] S.I. Strong, *Research in International Commercial Arbitration: Special Skills, Special Sources*, 20 Am. Rev. Int'l Arb. 119 (2009).

[101] S.I. Strong, *The Sounds of Silence: Are U.S. Arbitrators Creating Internationally Enforceable Awards When Ordering Class Arbitration in Cases of Contractual Silence or Ambiguity?*, 30 Mich. J. Int'l L. 1017 (2009).

doi:10.6342/NTU201601682

[102] Julian D.M. Lew, *Does National Court Involvement Undermine the International Arbitration Process?* 24 Am. U. Int'l L. Rev. 489 (2009).

[103] Christopher S. Gibson, *Arbitration, Civilization and Public Policy: Seeking Counterpoise Between Arbitral Autonomy and the Public Policy Defense in View of Foreign Mandatory Public Law*, 113 Penn. St. L. Rev. 1227 (2009).

[104] George A. Bermann, *The American Law Institute Goes Global: the Restatement of International Commercial Arbitration*, 16 Willamette J. Int'l L. & Disp. Resol. 300 (2008).

[105] Richard W. Hulbert, *Some Thoughts on Judgments, Reciprocity, and the Seeming Paradox of International Commercial Arbitration*, 29 U. Pa. J. Int'l L. 641 (2008).

[106] Winston Stromberg, *Avoiding the Full Court Press: International Commercial Arbitration and Other Global Alternative Dispute Resolution Processes*, 40 Loy. L.A. L. Rev. 1337 (2007).

[107] Loukas Mistelis, *Reality Test: Current State of Affairs in Theory and Practice Relating to "Lex Arbitri"*, 17 Am. Rev. Int'l Arb. 155 (2006).

[108] Elizabeth Shackelford, *Party Autonomy and Regional Harmonization of Rules in International Commercial Arbitration*, 67 U. Pitt. L. Rev. 897 (2006).

[109] William W. Park & Alexander A. Yanos, *Treaty Obligations and National Law: Emerging Conflicts in International Arbitration*, 58 Hastings. L.J. 251 (2006).

[110] Mo Zhang, *Party Autonomy and Beyond: An International Perspective of Contractual Choice of Law*, 20 Emory Int'l L. Rev. 511 (2006).

[111] David W. Rivkin & Eric P. Tuchmann, *Protecting Both the FAA and Party Autonomy: the Hall Street Decision*, 17 Am. Rev. Int'l Arb. 537 (2006).

[112] Dejan Janićijević, *Delocalization in International Commercial Arbitration*, 3 Law and Politics, no. 1, 2005, at 63.

[113] Catherine A. Giambastiani, *Recent Development: Lex Loci Arbitri and Annulment of Foreign Arbitral Awards in U.S. Court*, 20 Am. U. Int'l L. Rev. 1101 (2005).

[114] James M. Gaitis, *The Federal Arbitration Act: Risks and Incongruities Relating to the Issuance of Interim and Partial Awards in Domestic and International Arbitrations*, 16 Am. Rev. Int'l Arb. 1 (2005).

[115] Eric A. Posner & John C. Yoo, *Judicial Independence in International Tribunals*, 93 Cal. L. Rev. 1 (2005).

[116] The International Commercial Disputes Committee of the Association of the Bar of the City of New York, *Lack of Jurisdiction and Forum Non Conventions as Defenses to the Enforcement of Foreign Arbitral Awards*, 15 Am. Rev. Int'l Arb. 407 (2004).

doi:10.6342/NTU201601682

[117] Tom Ginsburg & Richard H. McAdams, *Adjudicating in Anarchy: An Expressive Theory of International Dispute Resolution*, 45 Wm. & Mary L. Rev. 1229 (2004).

[118] Christopher R. Drahozal, *Regulatory Competition and the Location of International Arbitration Proceedings*, 24 Int'l Rev. L. & Econ. 371 (2004).

[119] Robert B. Ahdieh, *Between Dialogue and Degree: International Review of National Courts*, 79 N.Y.U. L. Rev. 2029 (2004).

[120] Catherine A. Rogers, *Context and Institutional Structure in Attorney Regulation: Constructing an Enforcement Regime for International Arbitration*, 39 Stan. J. Int'l L. 1 (2003).

[121] C. Chatterjee, *The Reality of the Party Autonomy Rule in International Arbitration*, 20 J. Int'l Arb. 539 (2003).

[122] Okuma Kazutake, *Party Autonomy in International Commercial Arbitration: Consolidation of Multiparty and Classwide Arbitration*, 9 Ann. Surv. Int'l & Comp. L. 189 (2003).

[123] Paul Michael, *Party Autonomy and Implied Choice in International Commercial Arbitration*, 14 Am. Rev. Int'l Arb. 571 (2003).

[124] Christopher R. Drahozal & Keith N. Hylton, *The Economics of Litigation and Arbitration: An Application to Franchise Contracts*, 32 J. Legal Stud. 549 (2003).

[125] Richard Garnett, *International Arbitration Law: Progress Towards Harmonisation*, 3 Melb. J. Int'l L. 400 (2002).

[126] Kenneth R. Davis, *Unconventional Wisdom: A New Look at Articles V and VII of the Convention on the Recognition and Enforcement of Foreign Arbitral Awards*, 37 Tex. Int'l L.J. 43 (2002).

[127] Paul Pecorino & Mark van Boening, *Bargaining and Information: An Empirical Analysis of A Multistage Arbitration Game*, 19 Journal of Labor Economics, no. 4, 2001, at 922.

[128] Otto Sandrock, *To Continue Nationalizing or to De-nationalize? That Is Now the Question in International Arbitration*, 12 Am. Rev. Int'l Arb. 301 (2000).

[129] Christopher R. Drahozal, *Commercial Norms, Commercial Codes, and International Commercial Arbitration*, 33 Vand. J. Transnat'l L. 79 (2000).

[130] Christopher R. Drahozal, *Enforcing Vacated International Arbitration Awards: An Economic Approach*, 11 Am. Rev. Int'l Arb. 451 (2000).

[131] Pippa Read, *Delocalization of International Commercial Arbitration: Its Relevance in the New Millennium*, 10 Am. Rev. Int'l Arb. 177 (1999).

[132] Ray Y. Chan, *The Enforceability of Annulled Foreign Arbitral Awards in the United States: A Critique of Chromalloy*, 17 B.U. Int'l L.J. 141 (1999).

doi:10.6342/NTU201601682

[133] Philip J. McConnaughay, *The Risks and Virtues of Lawlessness: A "Second Look" at International Commercial Arbitration*, 93 Nw. U. L. Rev. 453 (1999).

[134] Georgios C. Petrochilos, *Enforcing Awards Annulled in Their State of Origin under the New York Convention*, 48 Int'l L. & Comp. L.Q., no. 4, 1999, at 856.

[135] Alessandra Casella, *On Market Integration and the Development of Institutions: the Case of International Commercial Arbitration*, 40 European Economic Review, 1996, at 155.

[136] Bruce L. Benson, *An Exploration of the Impact of Modern Arbitration Statutes on the Development of Arbitration in the United States*, 11 J.L. Econ. & Org., no. 2, 1995, at 479.

[137] Lisa Bernstein, *Understanding the Limits of Court-connected ADR: A Critique of Federal Court-annexed Arbitration Programs*, 141 U. Pa. L. Rev. 2169 (1993).

[138] Orley Ashenfelter et al., *An Experimental Comparison of Dispute Rates in Alternative Arbitration Systems*, 60 Econometrica, no. 6, 1992, at 1407.

[139] Einer R. Elhauge, *Does Interest Group Theory Justify More Intrusive Judicial Review?*, 101 Yale L.J. 31 (1991).

[140] Hans Smit, *A-national Arbitration*, 63 Tul. L. Rev. 629 (1988).

[141] Orley Ashenfelter & David E. Bloom, *Models of Arbitrator Behavior: Theory and Evidence*, 74 The American Economic Review, no. 1, 1984, at 111.

[142] William W. Park, *The Lex Loci Arbitri and International Commercial Arbitration*, 32 Int'l L. & Comp. L.Q., no. 1, 1983, at 21.

[143] Jan Paulsson, *Delocalisation of International Commercial Arbitration: When and Why It Matters*, 32 Int'l L. & Comp. L.Q., no. 1, 1983, at 53.

[144] Jan Paulsson, *Arbitration Unbound: Award Detached from the Law of Its Country of Origin*, 30 Int'l L. & Comp. L.Q., no. 2, 1981, at 358.

[145] Soia Mentschikoff, *Commercial Arbitration*, 61 Colum. L. Rev. 846 (1961).

Dispute Settlements

Books

[146] Susan Blake et al., A Practical Approach to Alternative Dispute Resolution (2d ed. 2012).

[147] Nadja Alexander, International and Comparative Mediation: Legal Perspectives (2009).

[148] Gérardine Meishan Goh, Dispute Settlement in International Space Law: A Multi-Door Courthouse for Outer Space (2007).

[149] Mary Ellen O'Connell, International Dispute Resolution: Cases and Materials (2006).

doi:10.6342/NTU201601682

[150] Klaus Winkler, Negotiations With Asymmetrical Distribution of Power: Conclusions From Dispute Resolution in Network Industries (2006).

[151] Simon Roberts & Michael Palmer, Dispute Processes: ADR and the Primary Forms of Decision-making (2d ed. 2005).

[152] Howard Raiffa, Negotiation Analysis: The Science and Art of Collaborative Decision Making (2002).

Articles

[153] Gerhard Wagner, *Dispute Resolution As A Product: Competition Between Civil Justice Systems*, *in* Regulatory Competition in Contract Law and Dispute Resolution 347 (Horst Eidenmüller ed., 2013).

[154] Howard Raiffa, *Contributions of Applied Systems Analysis to International Negotiation*, *in* International Negotiation: Analysis, Approaches, Issues 5 (Victor A. Kremenyuk ed., 2d ed. 2002).

[155] Julita Vassileva & Chhaya Mudgal, *Bilateral Negotiation With Incomplete and Uncertain Information: Trading Help in A Distributed Peer Help Environment*, *in* Game Theory and Decision Theory in Agent-based Systems 337 (Simon Parsons et al. eds., 2002).

Journals

[156] Anna Spain, *Integrating Matters: Rethinking the Architecture of International Dispute Resolution*, 32 U. Pa. J. Int'l L. 1 (2010).

[157] Ben Depoorter, *Law in the Shadow of Bargaining: the Feedback Effect of Civil Settlements*, 95 Cornell L. Rev. 957 (2010).

[158] Maria Goltsman et al., *Mediation, Arbitration and Negotiation*, 144 Journal of Economic Theory, 2009, at 1397.

[159] María de las Mercedes Adamuz & Clara Ponsatí, *Arbitration Systems and Negotiations*, 13 Rev. Econ. Design, 2009, at 279.

[160] Ezra Friedman & Abraham L. Wickelgren, *Chilling, Settlement, and the Accuracy of the Legal Process*, 26 J.L. Econ. & Org., no. 1, 2008, at 144.

[161] Alon Klement & Zvika Neeman, *Against Compromise: A Mechanism Design Approach*, 21 J.L. Econ. & Org., no. 2, 2005, at 285.

[162] Robert H. Mnookin, *Strategic Barriers to Dispute Resolution: A Comparison of Bilateral and Multilateral Negotiations*, 8 Harv. Negot. L. Rev. 1 (2003).

[163] Russell Korobkin, *Aspirations and Settlement*, 88 Cornell L. Rev. 1 (2002).

[164] Jody Freeman, *Regulatory Negotiation and the Legitimacy Benefit*, 9 N.Y.U. Envtl. L.J. 60 (2000).

[165] Steven Shavell, *Alternative Dispute Resolution: An Economic Analysis*, 24 J. Legal Stud. 1 (1995).

doi:10.6342/NTU201601682

[166] Alison Watts, *Bargaining Through An Expert Attorney*, 10 J.L. Econ. & Org., no. 1, 1994, at 168.

[167] Kathryn E. Spier, *The Dynamics of Pretrial Negotiation*, 59 Review of Economics Studies, 1992, at 93.

[168] Roy J. Lewicki et al., *Models of Conflict, Negotiation and Third Party Intervention: A Review and Synthesis*, 13 Journal of Organizational Behavior, no. 3, 1992, at 209.

[169] Owen M. Fiss, *Against Settlement*, 93 Yale L.J. 1073 (1984).

Transnational Legal Order

Books

[170] Jacqueline Peel, Science and Risk Regulation in International Law (2010).

Articles

[171] Deborah Hensler, *How Economic Globalisation is Helping to Construct A Private Transnational Legal Order*, *in* The Law of the Future and the Future of Law 249 (Sam Muller et al. eds., 2011).

[172] Poul F. Kjaer, *Law and Order Within and Beyond National Configurations*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 395 (Poul F. Kjaer et al. eds., 2011).

[173] Jean-Marc Coicaud, *Deconstructing International Legitimacy*, *in* Fault Lines of International Legitimacy 29 (Hilary Charlesworth & Jean-Marc Coicaud eds., 2010).

[174] Jean-Marc Coicaud, *The Evolution of International Order and Fault Lines of International Legitimacy*, *in* Fault Lines of International Legitimacy 87 (Hilary Charlesworth & Jean-Marc Coicaud eds., 2010).

[175] Geir Ulfstein, *The International Judiciary*, *in* The Constitutionalization of International Law (2009).

[176] Anne Peters et al., *Non-state Actors as Standard Setters: Framing the Issue in An Interdisciplinary Fashion*, *in* Non-state Actors as Standard Setters 1 (Anna Peters et al. eds., 2009).

[177] Julia Black, *Legitimacy, Accountability and Polycentric Regulation: Dilemmas, Trilemmas and Organisational Response*, *in* Non-state Actors as Standard Setters 241 (Anna Peters et al. eds., 2009).

[178] Anna Peters et al., *Towards Non-state Actors as Effective, Legitimate, and Accountable Standard Setters*, *in* Non-state Actors as Standard Setters 492 (Anna Peters et al. eds., 2009).

[179] Vernon Valentine Palmer, *Introduction to the Mixed Jurisdictions*, *in* Mixed Jurisdictions Worldwide: the Third Legal Family 3 (Vernon Valentine Palmer ed., 2001).

doi:10.6342/NTU201601682

Journals

[180] Michael Whincop, *Three Positive Theories of International Jurisdiction*, 24 Melb. U. L. Rev. 379 (2000).

Lex Mercatoria

Books

[181] Yves Dezalay & Bryant G. Garth, Dealing in Virtue: International Commercial Arbitration and the Construction of A Transnational Legal Order (1996).

Articles

[182] Bruce L. Benson, *The Law Merchant's Story: How Romantic Is It?*, *in* Law, Economics and Evolutionary Theory 68 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[183] Paul Freeman, *Lex Mercatoria: A Legal Basis for the Resolution of International Disputes*, *in* International Commercial Arbitration: Developing Rules for the New Millennium 121 (Martin Odams de Zylva & Reziya Harrison eds., 2000).

Journals

[184] Ralf Michaels, *The True Lex Mercatoria: Law Beyond the State*, 14 Ind. J. Global Legal Stud. 447 (2007).

[185] Nathan Oman, *Corporations and Autonomy Theories of Contract: A Critique of the New Lex Mercatoria*, 83 Denv. U. L. Rev. 101 (2005).

[186] Peer Zumbansen, *Piercing the Legal Veil: Commercial Arbitration and Transnational Law*, 8 European Law Journal, no. 3, 2002, at 400.

[187] Emmanuel Gaillard, *Transnational Law: A Legal System or a Method of Decision Making?*, 17 Arb. Int'l 59 (2001).

Postmodern Thoughts

Books

[188] Alan Sokal, Beyond the Hoax: Science, Philosophy and Culture (2008).

[189] Bruce A. Arrigo & Dragan Milovanovic, The French Connection in Criminology: Rediscovering Crime, Law, and Social Change (2005).

[190] Christopher R. Williams & Bruce A. Arrigo, Law, Psychology, and Justice: Chaos Theory and the New (Dis)order (2002).

[191] Michael I. Meyerson, Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution (2002).

[192] Vladimir Tasić, Mathematics and the Roots of Postmodern Thought (2001).

doi:10.6342/NTU201601682

[193] Alan Sokal & Jean Bricmont, Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science (1998).

[194] Dragan Milovanovic, Postmodern Criminology (1997).

[195] Paul R. Gross & Norman Levitt, Higher Superstition: the Academic Left and Its Quarrels With Science (1994).

[196] Dragan Milovanovic, Postmodern Law and Disorder: Psychoanalytic Semiotics, Chaos and Juridic Exegeses (1992).

Articles

[197] Dragan Milovanovic, *Psychoanalytic Semiotics, Chaos, and Rebellious Lawyering*, *in* Lacan: Topologically Speaking 174 (Ellie Ragland & Dragan Milovanovic eds., 2004).

[198] Noam Chomsky et al., *The Limitations of Rationality and Science?*, *in* David Detmer, Challenging Postmodernism: Philosophy and the Politics of Truth 305 (2003).

[199] Jason Glynos & Yannis Stavrakakis, *Postures and Impostures: on Lacan's Style and Use of Mathematical Science*, *in* Lacan & Science 207 (2002).

[200] Alan D. Sokal, *What the Social Text Affair Does and Does Not Prove*, *in* A House Built on Sand: Exposing Postmodernist Myths About Science 9 (Noretta Koertge ed., 1998).

[201] Noretta Koertge, *Postmodernisms and the Problem of Scientific Literacy*, *in* A House Built on Sand: Exposing Postmodernist Myths About Science 257 (Noretta Koertge ed., 1998).

[202] Caren Schulman, *Chaos, Law, and Critical Legal Studies: Mapping the Terrain*, *in* Chaos, Criminology, and Social Justice: the New Orderly (Dis)order 123 (Dragan Milovanovic ed., 1997).

[203] Dragan Milovanovic, *Visions of the Emerging Orderly (Dis)order*, *in* Chaos, Criminology, and Social Justice: the New Orderly (Dis)order 195 (Dragan Milovanovic ed., 1997).

[204] Dragan Milovanovic, *Inscribing the Body With A Sign: Semiotics and Punishment*, *in* Legality and Illegality: Semiotics, Postmodernism, and Law 47 (W. Richard Janikowski & Dragan Milovanovic eds., 1995).

Journals

[205] Michael I. Meyerson, *Mathematics and the Legal Imagination: A Response to Paul Edelman*, 19 Const. Comment. 477 (2002).

[206] Paul H. Edelman, *The Law and Large Numbers*, 19 Const. Comment. 459 (2002) (reviewing Michael I. Meyerson, Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution (2002)).

doi:10.6342/NTU201601682

[207] David Lucy, Book Review, 1 Law, Probability & Risk 185 (2002) (reviewing Michael I. Meyerson, Political Numeracy: Mathematical Perspectives on Our Chaotic Constitution (2002)).

[208] Alan Sokal, *Transgressing the Boundaries: Towards A Transformative Hermeneutics of Quantum Gravity*, 46/47 Social Text 217 (1996).

System Theory

Books

[209] Niklas Luhmann, Rechtssoziologie (4d ed. 2008).

[210] Niklas Luhmann, Das Recht der Gesellschaft (1995).

[211] Gunther Teubner, Law as An Autopoietic System (Zenon Bankowski ed., Anne Bankowska et al. trans., 1993).

[212] Hans Kelsen, Introduction to the Problems of Legal Theory (Bonnie Litschewski Paulson & Stanley L. Paulson trans., 1992).

[213] Lawrence M. Friedman, The Legal System: A Social Science Perspective (1975).

Articles

[214] Simon Deakin & Fabio Carvalho, *System and Evolution in Corporate Governance*, *in* Law, Economics and Evolutionary Theory 111 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[215] Bart Du Laing, *Gene-Culture Co-evolution Theory and the Evolution of Legal Behavior and Institutions*, *in* Law, Economics and Evolutionary Theory 248 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[216] Wolfgang Kerber, *Transnational Commercial Law, Multi-level Legal Systems, and Evolutionary Economics*, *in* Law, Economics and Evolutionary Theory 297 (Peer Zumbansen & Gralf-Peter Calliess eds., 2011).

[217] Rudolf Stichweh, *Towards A General Theory of Function System Crises*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 43 (Poul F. Kjaer et al. eds., 2011).

[218] Alberto Febbrajo, *The Failure of Regulatory Institutions–A Conceptual Framework*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 269 (Poul F. Kjaer et al. eds., 2011).

[219] Gralf-Peter Calliess, *Reflexive Transnational Law: the Privatisation of Civil Law and the Civilisation of Private Law*, *in* Zeitschrift für Rechtssoziologie 23, Heft 2, 2002, at 185.

[220] Thomas S. Smith, *Nonlinear Dynamics and the Micro-Macro Bridge*, *in* Chaos, Complexity, and Sociology: Myths, Models, and Theories 52 (Raymond A. Eve et al. eds., 1997).

doi:10.6342/NTU201601682

[221] Euel Elliott & L. Douglas Kiel, *Nonlinear Dynamics, Complexity, and Public Policy: Use, Misuse, and Applicability*, *in* Chaos, Complexity, and Sociology: Myths, Models, and Theories 64 (Raymond A. Eve et al. eds., 1997).

[222] Milan Zeleny, *On the Social Nature of Autopoietic Systems*, *in* Evolution, Order and Complexity 122 (Elias L. Khalil & Kenneth E. Boulding eds., 1996).

Journals

[223] David J. Gerber, *System Dynamics: Toward A Language of Comparative Law?*, 46 Am. J. Comp. L. 719 (1998).

[224] Thomas Earl Geu, *Chaos, Complexity, and Coevolution: the Web of Law, Management Theory, and Law Related Services at the Millennium*, 66 Tenn. L. Rev. 137 (1998).

[225] Thomas D. Barton, *The Structure of Legal Systems*, 37 Am. J. Juris. 291 (1992).

Legal Studies

Books

[226] Robin Feldman, The Role of Science in Law (2009).

[227] Wojciech Zaluski, Evolutionary Theory and Legal Philosophy (2009).

[228] Carl Schmitt, Über die Drei Arten des Rechtswissenschaftlichen Denkens (3d ed. 2006).

[229] Sheila Jasanoff, Designs on Nature: Science and Democracy in Europe and the United States (2005).

[230] Roger Berkowitz, The Gift of Science: Leibniz and the Modern Legal Tradition (2005).

[231] Hamish Ross, Law as A Social Institution (2001).

[232] Paul Weirich, Decision Space: Multidimensional Utility Analysis (2001).

[233] Bela H. Banathy, Guided Evolution of Society: A Systems View (2000).

[234] Sheila Jasanoff, Science at the Bar: Law, Science, and Technology in America (1995).

[235] Jacques Derrida, Force de loi: Le "Fondement mystique de l'autorité" (1994).

[236] Stanley Fish, There's No Such Thing as Free Speech (1994).

[237] Donald Black, Sociological Justice (1989).

doi:10.6342/NTU201601682

[238] Stuart S. Nagel & Marian G. Neef, Decision Theory and the Legal Process (1979).

[239] Donald Black, The Behavior of Law (special ed. 2010) (1976).

Articles

[240] Morris B. Hoffman, *Evolutionary Jurisprudence: the End of the Naturalistic Fallacy and the Beginning of Nature Reform*, *in* Law and Neuroscience: Current Legal Issues 2010 483 (Michael Freeman ed., 2011).

[241] Marc Amstutz, *Eroding Boundaries: On Financial Crisis and an Evolutionary Concept of Regulatory Reform*, *in* The Financial Crisis in Constitutional Perspective: the Dark Side of Functional Differentiation 223 (Poul F. Kjaer et al. eds., 2011).

[242] Sheila Jasanoff, *Making Order: Law and Science in Action*, *in* The Handbook of Science and Technology Studies 761 (Edward J. Hackett et al. eds., 3d ed. 2008).

[243] Marilyn MacCrimmon, *What Is "Common" About Common Sense? Cautionary Tales for Travelers Crossing Disciplinary Boundaries*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 55 (Marilyn MacCrimmon & Peter Tillers eds., 2002).

[244] Vern R. Walker, *Theories of Uncertainty: Explaining the Possible Sources Error in Inferences*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 197 (Marilyn MacCrimmon & Peter Tillers eds., 2002).

[245] Johan van Benthem, *Action and Procedure in Reasoning*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 243 (Marilyn MacCrimmon & Peter Tillers eds., 2002).

[246] P. W. Brouwer, *On the Objectivity of Judicial Decisions*, *in* Conflicts in Social Science 123 (Anton van Harskamp ed., 1996).

Journals

[247] Emilie M. Hafner-Burton et al., *Political Science Research on International Law: the State of the Field*, 106 Am. J. Int'l L. 47 (2012).

[248] Jeffrey J. Rachlinski, *Evidence-based Law*, 96 Cornell L. Rev. 901 (2011).

[249] Peter H. Huang, *Happiness in Business or Law*, 12 Transactions: Tenn. J. Bus. L. 153 (2011).

[250] Jonathan T. Molot, *Litigation Finance: A Market Solution to A Procedural Problem*, 99 Geo. L.J. 65 (2010).

[251] Peter H. Huang, *Happiness Studies and Legal Policy*, 6 Annu. Rev. Law Soc. Sci., no. 21, 2010, at 1.

[252] Rick Swedloff & Peter H. Huang, *Tort Damages and the New Science of Happiness*, 85 Ind. L.J. 553 (2010).

doi:10.6342/NTU201601682

[253] Jonathan T. Molot, *A Market in Litigation Risk*, 76 U. Chi. L. Rev. 367 (2009).

[254] Robin Feldman, *Law's Misguided Love Affair With Science*, 10 Minn. J.L. Sci. & Tech. 95 (2009).

[255] Jens Dammann & Henry Hansmann, *Globalizing Commercial Litigation*, 94 Cornell L. Rev. 1 (2008).

[256] Peter H. Huang, *Authentic Happiness, Self-knowledge and Legal Policy*, 9 Minn. J.L. Sci. & Tech. 755 (2008).

[257] Gillian K. Hadfield, *Exploring Economic and Democratic Theories of Civil Litigation: Differences Between Individual and Organizational Litigants in the Disposition of Federal Civil Cases*, 57 Stan. L. Rev. 1275 (2005).

[258] Peter H. Huang, *Lawsuit Abandonment Options in Possibly Frivolous Litigation Games*, 23 Rev. Litig. 47 (2004).

[259] Richard A. Posner, *Legal Scholarship Today*, 115 Harv. L. Rev. 1314 (2002).

[260] Thomas S. Ulen, *Evolution, Human Behavior, and Law: A Response to Owen Jones's Dunwody Lecture*, 53 Fla. L. Rev. 931 (2001).

[261] Katherine J. Kaminsky & Matthrew W. Kirkhart, *A Step Beyond: Adding Behavior Analysis to the Discussion of Evolution, Natural Selection, and the Law*, 53 Fla. L. Rev. 947 (2001).

[262] Jeffrey J. Rachlinski, *Comment: Is Evolutionary Analysis of Law Science or Storytelling?*, 41 Jurimetrics J. 365 (2001).

[263] Chris Guthrie et al., *Inside the Judicial Mind*, 86 Cornell L. Rev. 777 (2001).

[264] Kenneth G. Dau-Schmidt, *Economics and Sociology: the Prospects for An Interdisciplinary Discourse on Law*, 1997 Wis. L. Rev. 389 (1997).

[265] Hannu Tapani Klami, *Legal Argument and Decision Theory*, 37 Am. J. Juris. 171 (1992).

[266] Owen M. Fiss, *The Social and Political Foundations of Adjudication*, 6 Law and Human Behavior, no. 2, 1982, at 121.

[267] Michael R. Gottfredson & Michael J. Hindelang, *A Study of the Behavior of Law*, 44 Am. Sociological Rev., 1979, at 3.

[268] Stuart S. Nagel & Marian Neef, *Time-Oriented Models and the Legal Process: Reducing Delay and Forecasting the Future*, 1978 Wash. U. L. Q. 467 (1978).

Economics

Books

[269] Ejan Mackaay, Law and Economics for Civil Law Systems (2013).

[270] Robert Cooter & Thomas Ulen, Law & Economics (6d ed. 2012).

doi:10.6342/NTU201601682

[271] Serge-Christophe Kolm, Reciprocity: An Economics of Social Relations (2008).

[272] James R. Hackney Jr., Under Cover of Science: American Legal-Economic Theory and the Quest for Objectivity (2007).

[273] Ernst-Joachim Mestemäcker, A Legal Theory Without Law: Posner v. Hayek on Economic Analysis of Law (2007).

[274] Leonid Hurwicz & Stanley Reiter, Design Economic Mechanisms (2006).

[275] Vyacheslav V. Kolbin, Decision Making and Programming (V. M. Donets trans., 2003).

[276] Richard A. Posner, Economic Analysis of Law (6d ed. 2003).

[277] Cristina Bicchieri, Rationality and Coordination (1993).

[278] Michael J. Trebilcock, The Limits of Freedom of Contract (1993).

Articles

[279] Lewis A. Kornhauser, *Modeling Courts*, *in* Theoretical Foundations of Law and Economics 1 (Mark D. White ed., 2009).

[280] Jonathan Klick & Francesco Parisi, *Functional Law and Economics*, *in* Theoretical Foundations of Law and Economics 41 (Mark D. White ed., 2009).

[281] Mark A. Geistfeld, *Efficiency, Fairness, and the Economic Analysis of Tort Law*, *in* Theoretical Foundations of Law and Economics 234 (Mark D. White ed., 2009).

Journals

[282] David Kennedy, *Law and the Political Economy of the World*, 26 L.J.I.L., no. 1, 2013, at 7.

[283] Robert Mnookin & Robert Wilson, *A Model of Efficient Discovery*, 25 Games and Economic Behavior, no. 2, 1998, at 219.

[284] Mark J. Roe, *Chaos and Evolution in Law and Economics*, 109 Harv. L. Rev. 641 (1996).

Social Norms

Books

[285] Eric A. Posner, Law and Social Norms (2000).

Articles

[286] Martin Neumann, *How Are Norms Brought About? A State of the Art of Current Research*, *in* Minding Norms: Mechanisms and Dynamics of Social Order in Agent Societies 50 (Rosaria Conte et al. eds., 2014).

doi:10.6342/NTU201601682

[287] Raúl López-Pérez, *Introducing Social Norms in Game Theory*, *in* Games, Rationality and Behaviour: Essays in Behavioural Game Theory and Experiments 26 (Alessandro Innocenti & Patrizia Sbriglia eds., 2008).

[288] Lynn A. Stout, *Social Norms and Other-regarding Preferences*, *in* Norms and the Law 13 (John N. Drobak ed., 2006).

[289] Robert Axelrod, *An Evolutionary Approach to Norms*, *in* 3 Computational Social Science 25 (Nigel Gilbert ed., 2010) (1986).

Journals

[290] Jeffrey J. Rachlinski, *The Limits of Social Norms*, 74 Chi.-Kent L. Rev. 1537 (2000).

[291] Peter H. Huang & Ho-Mou Wu, *More Order Without More Law: A Theory of Social Norms and Organization Cultures*, 10 J.L. Econ. & Org., no. 2, 1994, at 390.

[292] Lisa Bernstein, *Social Norms and Default Rules Analysis*, 3 S. Cal. Interdisc. L.J. 59 (1993).

Rational Choice Theory

Books

[293] Lee Epstein et al., The Behavior of Federal Judges: A Theoretical and Empirical Study of Rational Choice (2013).

[294] Itzhak Gilboa, Rational Choice (2010).

[295] Robert Grafstein, Choice-free Rationality: A Positive Theory of Political Behavior (1999).

Articles

[296] Sun-Ki Chai, *Rational Choice Theory: A Forum for Exchange of Ideas between the Hard and Social Sciences in Predictive Behavioral Modeling*, *in* Social Computing, Behavioral Modeling, and Prediction 1 (Huan Liu et al. eds., 2008).

[297] Robert H. Frank, *Departures From Rational Choice: With and Without Regret*, *in* The Law and Economics of Irrational Behavior 13 (Francesco Parisi & Vernon L. Smith eds., 2005).

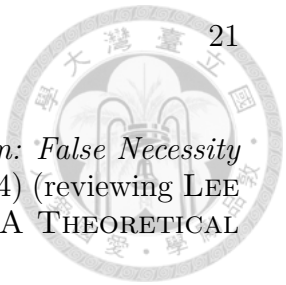
[298] Thomas S. Ulen, *Rational Choice Theory in Law and Economics*, *in* Encyclopedia of Law and Economics 790 (Boudwijn Bockaert & Gerrit De Geest eds., 1999).

[299] Philip Pettit, *Institutional Design and Rational Choice*, *in* The Theory of Institutional Design 54 (Robert E. Goodin ed., 1996).

[300] John S. Dryzek, *The Informal Logic of Institutional Design*, *in* The Theory of Institutional Design 103 (Robert E. Goodin ed., 1996).

[301] David Luban, *The Publicity Principle*, *in* The Theory of Institutional Design 154 (Robert E. Goodin ed., 1996).

doi:10.6342/NTU201601682



Journals

[302] Lawrence B. Solum, *The Positive Foundations of Formalism: False Necessity and American Legal Realism*, 127 Harv. L. Rev. 2464 (2014) (reviewing Lee Epstein et al., The Behavior of Federal Judges: A Theoretical and Empirical Study of Rational Choice (2013)).

[303] Andrew T. Guzman, *International Tribunals: A Rational Choice Analysis*, 157 U. Pa. L. Rev. 171 (2008).

[304] Kenneth W. Abbott, *Enriching Rational Choice Institutionalism for the Study of International Law*, 2008 U. Ill. L. Rev. 5 (2008).

[305] Anne van Aaken, Comment, *Towards Behavioral International Law and Economics: A Comment on Enriching Rational Choice Institutionalism for the Study of International Law*, 2008 U. Ill. L. Rev. 47 (2008).

[306] Jack L. Goldsmith & Eric A. Posner, *International Agreements: A Rational Choice Approach*, 44 Va. J. Int'l L. 113 (2003).

[307] Matthew D. Adler et al., *Preferences and Rational Choice: New Perspectives and Legal Implications: Introduction*, 151 U. Pa. L. Rev. 707 (2003).

[308] Peter H. Huang, *International Environmental Law and Emotional Rational Choice*, 31 J. Legal Stud. 237 (2002).

[309] Richard A. Posner, *Rational Choice, Behavioral Economics, and the Law*, 50 Stan. L. Rev. 1551 (1998).

[310] Herbert A. Simon, *A Behavioral Model of Rational Choice*, 69 The Quarterly Journal of Economics, no. 1, 1955, at 99.

Bounded Rationality

Books

[311] Jonathan Bendor et al., A Behavioral Theory of Elections (2011).

[312] Jonathan Bendor, Bounded Rationality and Politics (2010).

[313] Alistair Munro, Bounded Rationality and Public Policy: A Perspective from Behavioural Economics (2009).

[314] Vernon L. Smith, Rationality in Economics: Constructivist and Ecological Forms (2008).

[315] Adrian Vermeule, Judging Under Uncertainty: An Institutional Theory of Legal Interpretation (2006).

[316] Ariel Rubinstein, Modeling Bounded Rationality (1998).

Articles

[317] Matthew D. Adler, *Bounded Rationality and Legal Scholarship*, *in* Theoretical Foundations of Law and Economics 137 (Mark D. White ed., 2009).

doi:10.6342/NTU201601682

[318] Gerd Gigerenzer, *Is the Mind Irrational or Ecologically Rational?*, *in* The Law and Economics of Irrational Behavior 37 (Francesco Parisi & Vernon L. Smith eds., 2005).

[319] Christine Jolls, *On Law Enforcement with Boundedly Rational Actors*, *in* The Law and Economics of Irrational Behavior 268 (Francesco Parisi & Vernon L. Smith eds., 2005).

[320] Gerd Gigerenzer & Reinhard Selten, *Rethinking Rationality*, *in* Bounded Rationality: the Adaptive Toolbox 1 (G. Gigerenzer & R. Selten eds., 2002).

[321] Ulrich Witt, *Bounded Rationality, Social Learning, and Viable Moral Conduct in A Prisoner's Dilemma*, *in* Behavioral Norms, Technological Progress, and Economic Dynamics: Studies in Schumpeterian Economics 33 (Ernst Helmstädter & Mark Perlman eds., 1996).

Behavioral Economics

Books

[322] Christine Jolls, Behavioral Economics and the Law (2011).

[323] Larry A. DiMatteo et al., Visions of Contract Theory: Rationality, Bargaining, and Interpretation (2007).

Articles

[324] Peter H. Huang, *Emotional Reactions to Law and Economics, Market Metaphors, and Rationality Rhetoric*, *in* Theoretical Foundations of Law and Economics 163 (Mark D. White ed., 2009).

[325] Marco Faillo & Lorenzo Sacconi, *Norm Compliance: the Contribution of Behavioural Economics Models*, *in* Games, Rationality and Behaviour: Essays in Behavioural Game Theory and Experiments 101 (Alessandro Innocenti & Patrizia Sbriglia eds., 2008).

[326] B. Douglas Bernheim & Antonio Rangel, *Behavioral Public Economics: Welfare and Policy Analysis With Nonstandard Decision-Makers*, *in* Behavioral Economics and its Applications 7 (Peter Diamond & Hannu Vartiainen eds., 2007).

[327] Christine Jolls, *Behavioral Law and Economics*, *in* Behavioral Economics and its Applications 115 (Peter Diamond & Hannu Vartiainen eds., 2007).

[328] Christoph Engel & Gerd Gigerenzer, *Law and Heuristics: An Interdisciplinary Venture*, *in* Heuristics and the Law 1 (G. Gigerenzer & C. Engel eds., 2006).

[329] Douglass C. North, *Cognitive Science and the Study of the "Rules of the Game" in the World of Uncertainty*, *in* Norms and the Law 48 (John N. Drobak ed., 2006).

[330] Kevin McCabe et al., *Lessons From Neuroeconomics for the Law*, *in* The Law and Economics of Irrational Behavior 68 (Francesco Parisi & Vernon L. Smith eds., 2005).

doi:10.6342/NTU201601682

[331] Elizabeth Hoffman et al., *What Makes Trade Possible?*, *in* The Law and Economics of Irrational Behavior 169 (Francesco Parisi & Vernon L. Smith eds., 2005).

[332] Eric A. Posner, *Probability Errors: Some Positive and Normative Implications for Tort and Contract Law*, *in* The Law and Economics of Irrational Behavior 456 (Francesco Parisi & Vernon L. Smith eds., 2005).

[333] Cass R. Sunstein, *Toward Behavioral Law and Economics*, *in* Judgments, Decisions, and Public Policy 218 (Rajeev Gowda & Jeffrey C. Fox eds., 2002).

[334] Russell Korobkin, *Behavioral Economics, Contract Formation, and Contract Law*, *in* Behavioral Law and Economics 116 (Cass R. Sustain ed., 2000).

[335] Cass R. Sunstein & Edna Ullmann-Margalit, *Second-Order Decisions*, *in* Behavioral Law and Economics 187 (Cass R. Sustain ed., 2000).

Journals

[336] Jeffrey J. Rachlinski, *Selling Heuristics*, 64 Ala. L. Rev. 389 (2012).

[337] Russell Korobkin, *What Comes After Victory for Behavioral Law and Economics?*, 2011 U. Ill. L. Rev. 1653 (2011).

[338] Jeffrey J. Rachlinski, *The Psychological Foundations of Behavioral Law and Economics*, 2011 U. Ill. L. Rev. 1675 (2011).

[339] Giacomo Rojas Elgueta, *Understanding Discovery in International Commercial Arbitration Through Behavioral Law and Economics: A Journey Inside the Minds of Parties and Arbitrators*, 16 Harv. Negot. L. Rev. 165 (2011).

[340] Molly J. Walker Wilson, *Behavioral Decision Theory and Implications for the Supreme Court's Campaign Finance Jurisprudence*, 31 Cardozo L. Rev. 3 (2010).

[341] Oliver R. Goodenough, *Institutions, Emotions, and Laws: A Goldilocks Problem for Mechanism Design*, 33 Vt. L. Rev. 395 (2009).

[342] Jeffrey J. Rachlinski, *Heuristics, Biases, and Philosophy*, 43 Tulsa L. Rev. 865 (2008).

[343] Grant M. Hayden & Stephen E. Ellis, *Law and Economics After Behavioral Economics*, 55 U. Kan. L. Rev. 629 (2007).

[344] Joshua D. Wright, *Behavioral Law and Economics, Paternalism, and Consumer Contracts: An Empirical Perspective*, 2 N.Y.U. J. L. & Liberty 470 (2007).

[345] Christine Jolls & Cass R. Sunstein, *Debiasing Through Law*, 35 J. Legal Stud. 199 (2006).

[346] Colin Camerer et al., *Regulation for Conservatives: Behavioral Economics and the Case for "Asymmetric Paternalism"*, 151 U. Pa. L. Rev. 1211 (2003).

doi:10.6342/NTU201601682

[347] Gregory Mitchell, *Tendencies Versus Boundaries: Levels of Generality in Behavioral Law and Economics*, 56 Vand. L. Rev. 1781 (2003).

[348] Robert A. Prentice, *Chicago Man, K-T Man, and the Future of Behavioral Law and Economics*, 56 Vand. L. Rev. 1663 (2003).

[349] Richard A. Posner, *Behavioral Law and Economics: A Critique*, Econ. Educ. Bull., no. 8, 2002, at 1.

[350] Gregory Mitchell, *Why Law and Economics' Perfect Rationality Should Not Be Traded for Behavioral Law and Economics' Equal Incompetence*, 91 Geo. L.J. 67 (2002).

[351] Jeffrey J. Rachlinski, *The "New" Law and Psychology: A Reply to Critics, Skeptics, and Cautious Supporters*, 85 Cornell L. Rev. 739 (2000).

[352] Russell B. Korobkin & Thomas S. Ulen, *Law and Behavioral Science: Removing the Rationality Assumption From Law and Economics*, 88 Cal. L. Rev. 1051 (2000).

[353] Cass R. Sunstein, *Deliberative Trouble? Why Groups Go to Extremes*, 110 Yale L.J. 71 (2000).

[354] Christine Jolls, *Behavioral Economic Analysis of Redistributive Legal Rules*, 51 Vand. L. Rev. 1653 (1998).

[355] Christine Jolls et al., *A Behavioral Approach to Law and Economics*, 50 Stan. L. Rev. 1471 (1998).

[356] Herbert A. Simon, *Theories of Decision-Making in Economics and Behavioral Science*, 49 The Am. Econ. Rev., no.3, 1959, at 253.

Game Theory

Books

[357] Steven Tadelis, Game Theory: An Introduction (2013).

[358] Steven J. Brams, Game Theory and the Humanities: Bridging Two Worlds (2011).

[359] Julio González-Díaz et al., An Introductory Course on Mathematical Game Theory (2010).

[360] Terry L. Friesz, Dynamic Optimization and Differential Games (2010).

[361] Paul Weirich, Collective Rationality: Equilibrium in Cooperative Games (2010).

[362] Nicola F. Maaser, Decision-making in Committees: Game-theoretic Analysis (2010).

[363] Maxwell L. Stearns & Todd J. Zywicki, Public Choice Concepts and Applications in Law (2009).

doi:10.6342/NTU201601682

[364] Ein-Ya Gura & Michael Maschler, Insights Into Game Theory: An Alternative Mathematical Experience (2008).

[365] Efe A. Ok, Real Analysis with Economic Applications (2007).

[366] Eric Rasmusen, Games and Information: An Introduction to Game Theory (4d ed. 2007).

[367] Ken Binmore, Does Game Theory Work? The Bargaining Challenge (2007).

[368] Alan D. Taylor, Social Choice and the Mathematics of Manipulation (2005).

[369] Ken Binmore, Natural Justice (2005).

[370] Colin F. Camerer, Behavioral Game Theory: Experiments in Strategic Interaction (2003).

[371] Fernanado Vega-Redondo, Economics and the Theory of Games (2003).

[372] Steven J. Brams, Negotiation Games: Applying Game Theory to Bargaining and Arbitration (2d ed. 2003).

[373] Engelbert J. Dockner et al., Differential Games in Economics and Management Science (2000).

[374] Ferenc Forgó et al., Introduction to the Theory of Games: Concepts, Methods, Applications (1999).

[375] Drew Fudenberg & David K. Levine, The Theory of Learning in Games (1998).

[376] Paul Weirich, Equilibrium and Rationality: Game Theory Revised by Decision Rules (1998).

[377] Jerry L. Mashaw, Greed, Chaos, and Governance: Using Public Choice to Improve Public Law (1997).

[378] Martin J. Osborne & Ariel Rubinstein, A Course in Game Theory (1994).

[379] Douglas G. Baird et al., Game Theory and the Law (1994).

[380] Drew Fudenberg & Jean Tirole, Game Theory (1991).

[381] Daniel A. Farber & Philip P. Frickey, Law and Public Choice: A Critical Introduction (1991).

[382] James W. Friedman, Game Theory With Applications to Economics (2d ed. 1991).

[383] David M. Kreps, Game Theory and Economic Modelling (1990).

[384] Brian Skyrms, The Dynamics of Rational Deliberation (1990).

[385] Robert Axelrod, The Evolution of Cooperation (1984).

doi:10.6342/NTU201601682

[386] John C. Harsanyi, Rational Behavior and Bargaining Equilibrium in Games and Social Situations (1977).

[387] John von Neumann & Oskar Morgenstern, Theory of Games and Economic Behavior (reprint 1972) (3d ed. 1953).

Articles

[388] Lorenzo Sacconi, *A Rawlsian View of CSR and the Game Theory of Its Implementation (Part I): the Multi-Stakeholder Model of Corporate Governance*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 157 (Lorenzo Sacconi et al. eds., 2011).

[389] Lorenzo Sacconi, *A Rawlsian View of CSR and the Game Theory of Its Implementation (Part II): Fairness and Equilibrium*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 194 (Lorenzo Sacconi et al. eds., 2011).

[390] Luciano Andreozzi, *When Reputation Is Not Enough: Justifying Corporate Social Responsibility*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 253 (Lorenzo Sacconi et al. eds., 2011).

[391] Leonardo Becchetti & Noemi Pace, *Corporate Trust Games in Modern Knowledge Economies*, *in* Corporate Social Responsibility and Corporate Governance: the Contribution of Economic Theory and Related Disciplines 353 (Lorenzo Sacconi et al. eds., 2011).

[392] David Chapman, *Some Types of Party Competition and Their Function in Social Choice*, *in* Social Choice 349 (Bernhardt Lieberman ed., 2011).

[393] Robert Wilson, *A Game-Theoretic Analysis of Social Choice*, *in* Social Choice 393 (Bernhardt Lieberman ed., 2011).

[394] Eric Friedman et al., *Manipulation-Resistant Reputation Systems*, *in* Algorithmic Game Theory 677 (Noam Nisan et al. eds., 2007).

[395] Vincy Fon & Francesco Parisi, *Revenge and Retaliation*, *in* The Law and Economics of Irrational Behavior 141 (Francesco Parisi & Vernon L. Smith eds., 2005).

[396] Avner Greif, *Economic History and Game Theory*, *in* 3 Handbook of Game Theory with Economic Applications 1989 (Robert J. Aumann & Sergiu Hart eds., 2002).

[397] Jeffrey S. Banks, *Strategic Aspects of Political Systems*, *in* 3 Handbook of Game Theory with Economic Applications 2203 (Robert J. Aumann & Sergiu Hart eds., 2002).

[398] Jean-Pierre Benoît & Lewis A. Kornhauser, *Game-Theoretic Analysis of Legal Rules and Institutions*, *in* 3 Handbook of Game Theory with Economic Applications 2229 (Robert J. Aumann & Sergiu Hart eds., 2002).

doi:10.6342/NTU201601682

[399] Martin Shubik, *Game Theory and Experimental Gaming*, *in* 3 Handbook of Game Theory with Economic Applications 2327 (Robert J. Aumann & Sergiu Hart eds., 2002).

[400] Simon Parsons & Michael Wooldridge, *An Introduction to Game Theory and Decision Theory*, *in* Game Theory and Decision Theory in Agent-based Systems 1 (Simon Parsons et al. eds., 2002).

[401] Mehdi Dastani et al., *Dynamic Desires*, *in* Game Theory and Decision Theory in Agent-based Systems 65 (Simon Parsons et al. eds., 2002).

[402] Edward A. Parson, *What Can You Learn From A Game?*, *in* Wise Choices: Decisions, Games, and Negotiations 233 (Richard J. Zeckhauser et al. eds., 1996).

[403] Peter Hammerstein & Reinhard Selten, *Game Theory and Evolutionary Biology*, *in* 2 Handbook of Game Theory with Economic Applications 929 (Robert J. Aumann & Sergiu Hart eds., 1994).

[404] Mordecai Kurz, *Game Theory and Public Economics*, *in* 2 Handbook of Game Theory with Economic Applications 1153 (Robert J. Aumann & Sergiu Hart eds., 1994).

[405] Hervé Moulin, *Social Choice*, *in* 2 Handbook of Game Theory with Economic Applications 1091 (Robert J. Aumann & Sergiu Hart eds., 1994).

[406] Françoise Forges, *Some Thoughts on Efficiency and Information*, *in* Frontiers of Game Theory 133 (Ken Binmore et al. eds., 1993).

[407] Alain Haurie, *From Repeated to Differential Games: How Time and Uncertainty Pervade the Theory of Games*, *in* Frontiers of Game Theory 165 (Ken Binmore et al. eds., 1993).

[408] Robert D. Putnam, *Diplomacy and Domestic Politics: The Logic of Two-Level Games*, *in* International Dispute Resolution 55 (Carrie Menkel-Meadow ed., 2012) (1988).

Journals

[409] Richard H. McAdams, *Beyond the Prisoner's Dilemma: Coordination, Game Theory, and Law*, 82 S. Cal. L. Rev. 209 (2009).

[410] Michael Whincop, *The Recognition Scene: Game Theoretic Issues in the Recognition of Foreign Judgments*, 23 Melb. U. L. Rev. 416 (1999).

[411] Roberto Serrano, *Multilateral Bargaining*, 63 Rev. of Econ. Studies, 1996, at 61.

[412] David Luban, *Social Choice Theory as Jurisprudence*, 69 S. Cal. L. Rev. 521 (1996).

[413] Peter H. Huang, *Strategic Behavior and the Law: A Guide for Legal Scholars to Game Theory and the Law and Other Game Theory Texts*, 36 Jurimetrics J. 99 (1995-1996) (reviewing Douglas G. Baird et al., Game Theory and the Law (1994)).

doi:10.6342/NTU201601682

[414] Thomas W. Merrill, *Pluralism, the Prisoner's Dilemma, and the Behavior of the Independent Judiciary*, 88 Nw. U. L. Rev. 396 (1993).

[415] Avery Katz, *The Strategic Structure of Offer and Acceptance: Game Theory and the Law of Contract Formation*, 89 Mich. L. Rev. 215 (1990).

[416] William H. Riker & Barry R. Weingast, *Constitutional Regulation of Legislative Choice: the Political Consequences of Judicial Deference to Legislatures*, 74 Va. L. Rev. 373 (1988).

[417] Ariel Rubinstein, *Perfect Equilibrium in A Bargaining Model*, 50 Econometrica, no. 1, 1982, at 97.

Evolutionary Game Theory

Books

[418] Toshio Yamagishi, Trust: the Evolutionary Game of Mind and Society (2011).

[419] Karl Sigmund, The Calculus of Selfishness (2010).

[420] Thomas L. Vincent & Joel S. Brown, Evolutionary Game Theory, Natural Selection, and Darwinian Dynamics (2005).

[421] Jacques Istas, Mathematical Modeling for the Life Sciences (2005).

[422] Sean H. Rice, Evolutionary Theory: Mathematical and Conceptual Foundations (2004).

[423] Ross Cressman, Evolutionary Dynamics and Extensive Form Games (2003).

[424] Josef Hofbauer & Karl Sigmund, Evolutionary Games and Population Dynamics (1998).

[425] Larry Samuelson, Evolutionary Games and Equilibrium Selection (1997).

[426] Jörgen W. Weibull, Evolutionary Game Theory (1995).

Articles

[427] Peter Hammerstein, *Towards A Darwinian Theory of Decision Making: Games and the Biological Roots of Behavior*, *in* Evolution and Rationality: Decisions, Co-operation and Strategic Behaviour 7 (Samir Okasha & Ken Binmore eds., 2012).

[428] Simon M. Huttegger & Kevin J. S. Zollman, *Evolution, Dynamics and Rationality: the Limits of ESS Methodology*, *in* Evolution and Rationality: Decisions, Co-operation and Strategic Behaviour 67 (Samir Okasha & Ken Binmore eds., 2012).

[429] Karl Sigmund, *Introduction to Evolutionary Game Theory*, *in* 69 Proceedings of Symposia in Applied Mathematics 1 (Karl Sigmund ed., 2011).

doi:10.6342/NTU201601682

[430] Josef Hofbauer, *Deterministic Evolutionary Game Dynamics*, *in* 69 Proceedings of Symposia in Applied Mathematics 61 (Karl Sigmund ed., 2011).

Mathematical Sociology

Books

[431] Alex Pentland, Social Physics: How Good Ideas Spread–the Lessen From A New Science (2014).

[432] Gordon Burt, Conflict, Complexity and Mathematical Social Science (2010).

[433] Jürgen Klüver, The Dynamics and Evolution of Social Systems: New Foundations of A Mathematical Sociology (2000).

[434] Sal Restivo, The Social Relations of Physics, Mysticism, and Mathematics: Studies in Social Structure, Interests, and Ideas (1983).

[435] Robert K. Leik & B. F. Meeker, Mathematical Sociology (1975).

[436] Thomas J. Fararo, Mathematical Sociology: An Introduction to Fundamentals (1973).

[437] James S. Coleman, Introduction to Mathematical Sociology (1964).

Articles

[438] Werner Raub et al., *Micro-Macro Links and Microfoundations in Sociology*, *in* Micro-Macro Links and Microfoundations in Sociology 1 (Vincent Buskens et al. eds., 2012).

[439] Vittorio Capecchi, *Mathematics and Sociology: From Lazarsfeld to Artificial Neural Networks*, *in* Applications of Mathematics in Models, Artificial Neutral Networks and Arts: Mathematics and Society 1 (Vittorio Capecchi et al. eds., 2010).

[440] Federico Gallo et al., *Tackling Climate Change Through Energy Efficiency: Mathematical Models to Offer Evidence-based Recommendations for Public Policy*, *in* Applications of Mathematics in Models, Artificial Neutral Networks and Arts: Mathematics and Society 131 (Vittorio Capecchi et al. eds., 2010).

[441] Massimo Buscema, *The General Philosophy of the Artificial Adaptive Systems*, *in* Applications of Mathematics in Models, Artificial Neutral Networks and Arts: Mathematics and Society 197 (Vittorio Capecchi et al. eds., 2010).

[442] Norman P. Hummon & Thomas J. Fararo, *The Emergence of Computational Sociology*, *in* 2 Computational Social Science 3 (Nigel Gilbert ed., 2010) (1995).

[443] Thomas C. Schelling, *Dynamic Models of Segregation*, *in* 1 Computational Social Science 159 (Nigel Gilbert ed., 2010) (1971).

doi:10.6342/NTU201601682

Complex Adaptive Systems

Books

[444] John H. Miller & Scott E. Page, Complex Adaptive Systems: An Introduction to Computational Models of Social Life (2007).

[445] Richard V. Solé & Jordi Bascompte, Self-organization in Complex Ecosystems (2006).

[446] Pierre-Yves Oudeyer, Self-organization in the Evolution of Speech (James R. Hurford trans., 2006).

[447] Kazuko Hirose Kawaguchi, A Social Theory of International Law: International Relations As A Complex System (2003).

[448] Scott Camazine et al., Self-organization in Biological Systems (2001).

[449] J. Stanley Metcalfe, Evolutionary Economics and Creative Destruction (1998).

[450] Edward O. Wilson, Sociobiology: the New Synthesis (Harv. Univ. Press 2000) (1975).

Articles

[451] Ahjond S. Garmestani et al., *Introduction: Social-ecological Resilience and Law*, *in* Social-ecological Resilience and Law 1 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

[452] Craig Anthony (Tony) Arnold & Lance H. Gunderson, *Adaptive Law*, *in* Social-ecological Resilience and Law 317 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

[453] Ahjond S. Garmestani et al., *The Integration of Social-ecological Resilience and Law*, *in* Social-ecological Resilience and Law 365 (Ahjond S. Garmestani & Craig R. Allen eds., 2014).

[454] Tobias Plieninger & Claudia Bieling, *Connecting Cultural Landscapes to Resilience*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 3 (Tobias Plieninger & Claudia Bieling eds., 2012).

[455] Thomas Kirchhoff et al., *From Cultural Landscapes to Resilient Social-ecological Systems: Transformation of A Classical Paradigm or A Novel Approach?*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 49 (Tobias Plieninger & Claudia Bieling eds., 2012).

[456] Lesley Head, *Conceptualising the Human in Cultural Landscapes and Resilience Thinking*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 65 (Tobias Plieninger & Claudia Bieling eds., 2012).

doi:10.6342/NTU201601682

[457] Alejandro J. Rescia et al., *Cultural Landscapes as Complex Adaptive Systems: the Cases of Northern Spain and Northern Argentina*, *in* Resilience and the Cultural Landscape: Understanding and Managing Change in Human-shaped Environments 126 (Tobias Plieninger & Claudia Bieling eds., 2012).

[458] Emily Boyd & Carl Folke, *Adapting Institutions, Adaptive Governance and Complexity: An Introduction*, *in* Adapting Institutions: Governance, Complexity, and Socio-ecological Resilience 1 (Emily Boyd & Carl Folke eds., 2012).

[459] Emily Boyd & Carl Folke, *Conclusions: Adapting Institutions and Resilience*, *in* Adapting Institutions: Governance, Complexity, and Socio-ecological Resilience 264 (Emily Boyd & Carl Folke eds., 2012).

[460] Richard C. Feiock & John T. Scholz, *Self-organizing Governance of Institutional Collective Action Dilemmas: An Overview*, *in* Self-organizing Federalism: Collaborative Mechanisms to Mitigate Institutional Collective Action Dilemmas 3 (Richard C. Feiock & John T. Scholz eds., 2010).

[461] Bryan D. Jones, *Conflicts, Power, and Irreconcilable Preferences: Some Limits to Self-organizing Mechanisms*, *in* Self-organizing Federalism: Collaborative Mechanisms to Mitigate Institutional Collective Action Dilemmas 73 (Richard C. Feiock & John T. Scholz eds., 2010).

[462] Simon A. Andrew, *Adaptive versus Restrictive Contracts: Can They Resolve Different Risk Problems?*, *in* Self-organizing Federalism: Collaborative Mechanisms to Mitigate Institutional Collective Action Dilemmas 91 (Richard C. Feiock & John T. Scholz eds., 2010).

[463] David C. Finnoff, *Integrating Economics and Biology for Invasive Species Management*, *in* Bioeconomics of Invasive Species: Integrating Ecology, Economics, Policy, and Management 25 (Reuben P. Keller et al. eds., 2009).

[464] David Pincus, *Coherence, Complexity, and Information Flow: Self-organizing Processes in Psychotherapy*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 335 (Stephen J. Guastello et al. eds., 2009).

[465] Joachim Karl Rennstich, *Is Globalization Self-organizing?*, *in* Globalization as Evolutionary Process: Modeling Global Change 87 (George Modelski et al. eds., 2008).

[466] Charlotte K. Hemelrijk, *A Process-oriented Approach to the Social Behaviour of Primates*, *in* Self-organisation and Evolution of Social Systems 81 (Charlotte K. Hemelrijk ed., 2005).

[467] John Foster, *The Self-organizational Perspective on Economic Evolution: A Unifying Paradigm*, *in* The Evolutionary Foundations of Economics 367 (2005).

doi:10.6342/NTU201601682

[468] Fikret Berkes et al., *Introduction*, *in* Navigating Social-ecological Systems: Building Resilience for Complexity and Change 1 (Fikret Berkes et al. eds., 2003).

[469] Carl Folke et al., *Synthesis: Building Resilience and Adaptive Capacity in Social-ecological Systems*, *in* Navigating Social-ecological Systems: Building Resilience for Complexity and Change 352 (Fikret Berkes et al. eds., 2003).

[470] Lawrence E. Blume & Steven N. Durlauf, *The Interactions-based Approach to Socioeconomic Behavior*, *in* Social Dynamics 15 (Steven N. Durlauf & H. Peyton Young eds., 2001).

[471] John Foster & J. Stanley Metcalfe, *Modern Evolutionary Economic Perspectives: An Overview*, *in* Frontiers of Evolutionary Economics: Competition, Self-organization and Innovation Policy 1 (John Foster & J. Stanley Metcalfe eds., 2001).

[472] Robert Delorme, *Theorizing Complexity*, *in* Frontiers of Evolutionary Economics: Competition, Self-organization and Innovation Policy 80 (John Foster & J. Stanley Metcalfe eds., 2001).

[473] Drew Wollin, *Commentary: Simplicity in Theories of Complexity–Defining, Knowing and Doing*, *in* Frontiers of Evolutionary Economics: Competition, Self-organization and Innovation Policy 109 (John Foster & J. Stanley Metcalfe eds., 2001).

[474] Jan Walleczek, *The Frontiers and challenges of Biodynamics Research*, *in* Self-organized Biological Dynamics & Nonlinear Control: Toward Understanding Complexity, Chaos, and Emergent Function in Living Systems 1 (Jan Walleczek ed., 2000).

[475] Hermann Haken, *Synergetics in Sociology and Biology*, *in* Sociobiology and Bioeconomics 199 (Peter Koslowski ed., 1999).

[476] Peter Koslowski, *The Theory of Evolution as Sociobiology and Bioeconomics: A Critique of Its Claim to Totality*, *in* Sociobiology and Bioeconomics 301 (Peter Koslowski ed., 1999).

Journals

[477] Simon Levin et al., *Socio-ecological Systems as Complex Adaptive Systems: Modeling and Policy Implications*, 18 Environment and Development Economics, 2012, at 111.

[478] Andrew Halliday & Marison Glaser, *A Management Perspective on Social Ecological Systems: A Generic System Model and Its Application to A Case Study From Peru*, 18 Human Ecology Review, no. 1, 2011, at 1.

[479] Robert Boyer, *The Quest for Theoretical Foundations of Socio-economics: Epistemology, Methodology or Ontology?*, 6 Socio-economic Rev., 2008, at 733.

[480] Ralph J. Greenspan, *A Biological Perspective on Complex Networks for A New Epistemology*, 6 Socio-economic Rev., 2008, at 746.

doi:10.6342/NTU201601682

[481] Renate Mayntz, *Networks and Self-organization: Dissecting the Model of 'Complex Networks'*, 6 Socio-economic Rev., 2008, at 750.

[482] Helga Nowotny, *Bargaining, Not Borrowing: on Problem Choice and Problem Space*, 6 Socio-economic Rev., 2008, at 754.

[483] Didier Sornette, *Interdisciplinarity in Socio-economics, Mathematical Analysis and Predictability of Complex Systems*, 6 Socio-economic Rev., 2008, at 759.

[484] Carl Folke, *Resilience: the Emergence of A Perspective for Social-ecological Systems Analyses*, 16 Global Environmental Change, 2006, at 253.

[485] Thomas D. Seeley, *When Is Self-organization Used in Biological Systems?*, 202 Biol. Bull., 2002, at 314.

Agent-based Modeling

Books

[486] Manuel Wäckerle, The Foundations of Evolutionary Institutional Economics: Generic Institutionalism (2014).

[487] Daniela Calvetti & Erkki Somersalo, Computational Mathematical Modeling: An Integrated Approach Across Scales (2013).

[488] Steven F. Railsback & Volker Grimm, Agent-Based and Individual-Based Modeling: A Practical Introduction (2012).

[489] Flaminio Squazzoni, Agent-based Computational Sociology (2012).

[490] Michael J. North & Charles M. Macal, Managing Business Complexity: Discovering Strategic Solutions With Agent-based Modeling and Simulation (2007).

[491] Volker Grimm & Steven F. Railsback, Individual-based Modeling and Ecology (2005).

Articles

[492] Bruce Edmonds, *Agent-based Social Simulation and Its Necessity for Understanding Socially Embedded Phenomena*, *in* Minding Norms: Mechanisms and Dynamics of Social Order in Agent Societies 34 (Rosaria Conte et al. eds., 2014).

[493] Brian Epstein, *Agent-based Modeling and the Fallacies of Individualism*, *in* Models, Simulations, and Representations 115 (Paul Humphreys & Cyrille Imbert eds., 2012).

[494] Terrill L. Frantz & Kathleen M. Carley, *Agent-based Modeling Within A Dynamic Network*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 475 (Stephen J. Guastello et al. eds., 2009).

doi:10.6342/NTU201601682

[495] Miklos N. Szilagyi, *Agent-Based Simulation of the N-Person Chicken Game*, *in* Advances in Dynamic Game Theory: Numerical Methods, Algorithms, and Applications to Ecology and Economics 695 (Steffen Jϕrgensen et al. eds., 2007).

[496] Francesco C. Billari et al., *Agent-based Computational Modelling: An Introduction*, *in* Agent-based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences 1 (Francesco C. Billari et al. eds., 2006).

[497] Andreas Pyka & Thomas Grebel, *Agent-based Modelling—A Methodology for the Analysis of Qualitative Development Processes*, *in* Agent-based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences 17 (Francesco C. Billari et al. eds., 2006).

[498] Volker Grimm & Steven F. Railsback, *Agent-based Models in Ecology: Patterns and Alternative Theories of Adaptive Behaviour*, *in* Agent-based Computational Modelling: Applications in Demography, Social, Economic and Environmental Sciences 139 (Francesco C. Billari et al. eds., 2006).

[499] Peter J. Deadman & Edella Schlager, *Models of Individual Decision Making in Agent-based Simulation of Common-Pool-Resource Management Institutions*, *in* Integrating Geographic Information Systems and Agent-based Modeling Techniques for Simulating Social and Ecological Processes 137 (H. Randy Gimblett ed., 2002).

[500] Vanessa Teague & Liz Sonenberg, *Investigating Commitment Flexibility in Multi-Agent Contracts*, *in* Game Theory and Decision Theory in Agent-based Systems 267 (Simon Parsons et al. eds., 2002).

[501] Nigel Gilbert, *Modeling Sociality: the View From Europe*, *in* Dynamics in Human and Primate Societies: Agent-based Modeling of Social and Spatial Processes 355 (Timothy A. Kohler & George J. Gumerman eds., 2000).

[502] Henry T. Wright, *Agent-based Modeling of Small-Scale Societies: State of the Art and Future Prospects*, *in* Dynamics in Human and Primate Societies: Agent-based Modeling of Social and Spatial Processes 373 (Timothy A. Kohler & George J. Gumerman eds., 2000).

Journals

[503] Joshua M. Epstein, *Agent-Based Computational Models and Generative Social Science*, 4 Complexity, no. 5, 1999, at 41.

Artificial Societies

Books

[504] Núria Casellas, Legal Ontology Engineering: Methodologies, Modelling Trends, and the Ontology of Professional Judicial Knowledge (2011).

doi:10.6342/NTU201601682

[505] Michael Wooldridge, An Introduction to Multiagent Systems (2d ed. 2009).

[506] Sarit Kraus, Strategic Negotiation in Multiagent Environments (2001).

[507] Michael Wooldridge, Reasoning About Rational Agents (2000).

[508] A. Valente, Legal Knowledge Engineering: A Modelling Approach (1995).

Articles

[509] Brian Henderson-Sellers, *Random Thoughts on Multi-level Conceptual Modelling*, *in* The Evolution of Conceptual Modeling: From A Historical Perspective Towards the Future of Conceptual Modeling 93 (Roland Kaschek & Lois Delcambre eds., 2011).

[510] Wilbert Grevers & Anne van der Veen, *Serious Games for Economists*, *in* Complexity and Artificial Markets 159 (Klaus Schredelseker & Florian Hauser eds., 2008).

[511] Tom M. van Engers, *Legal Engineering: A Structural Approach to Improving Legal Quality*, *in* Applications and Innovations in Intelligent Systems XIII 3 (Ann Macintosh et al. eds., 2006).

[512] R. Keith Sawyer, *Artificial Societies: Multiagent Systems and the Micro-Macro Link in Sociological Theory*, *in* 3 Computational Social Science 133 (Nigel Gilbert ed., 2010) (2003).

[513] John A. Barnden & Donald M. Peterson, *Artificial Intelligence, Mindreading, and Reasoning in Law*, *in* The Dynamics of Judicial Proof: Computation, Logic, and Common Sense 21 (Marilyn MacCrimmon & Peter Tillers eds., 2002).

[514] Rosaria Conte & Nigel Gilbert, *Introduction: Computer Simulation for Social Theory*, *in* Artificial Societies: the Computer Simulation of Social Life 1 (Nigel Gilbert & Rosaria Conte eds., 1995).

[515] Robert Axelrod, *A Model of the Emergence of New Political Actors*, *in* Artificial Societies: the Computer Simulation of Social Life 19 (Nigel Gilbert & Rosaria Conte eds., 1995).

Journals

[516] Sabrina Scherer et al., *Bridging Narrative Scenario Texts and Formal Policy Modeling Through Conceptual Policy Modeling*, 21 Artificial Intelligence and Law, 2013, at 455.

[517] Kevin D. Ashley & Will Bridewell, *Emerging AI & Law Approaches to Automating Analysis and Retrieval of Electronically Stored Information in Discovery Proceedings*, 18 Artificial Intelligence and Law, 2010, at 311.

[518] Gary Edmond, *Legal Engineering: Contested Representations of Law, Science (and Non-science) and Society*, 32 Social Studies of Science, no. 3, 2002, at 371.

doi:10.6342/NTU201601682

Modeling Behaviors

Books

[519] David O'Sullivan & George L. W. Perry, Spatial Simulation: Exploring Pattern and Process (2013).

[520] Martin A. Nowak & Roger Highfied, Supercooperators: Altruism, Evolution, and Why We Need Each Other to Succeed (2012).

[521] M. E. J. Newman, Networks: An Introduction (2010).

[522] David Easley & Jon Kleinberg, Networks, Crowds, and Markets: Reasoning About A Highly Connected World (2010).

[523] John A. Sokolowski & Catherine M. Banks, Modeling and Simulation for Analyzing Global Events (2009).

[524] T. W. Körner, Naïve Decision Making: Mathematics Applied to the Social World (2008).

[525] Norman Schofield, The Spatial Model of Politics (2008).

[526] Alain Barrat et al., Dynamical Processes on Complex Networks (2008).

[527] Earl Hunt, The Mathematics of Behavior (2007).

[528] Norman Jackson & Pippa Carter, Rethinking Organisational Behaviour: A Poststructuralist Framework (2d ed. 2007).

[529] Hartmut Bossel, Systems and Models: Complexity, Dynamics, Evolution, Sustainability (2007).

[530] Rem G. Khlebopros et al., Catastrophes in Nature and Society: Mathematical Modeling of Complex Systems (2007).

[531] Cristoforo Sergio Bertuglia & Franco Vaio, Nonlinearity, Chaos, and Complexity: the Dynamics of Natural and Social Systems (2005).

[532] Nicholas L. Georgakopoulos, Principles and Methods of Law and Economics: Basic Tools for Normative Reasoning (2005).

[533] Reinhard Illner et al., Mathematical Modelling: A Case Studies Approach (2005).

[534] John M. Gottman et al., The Mathematics of Marriage Dynamic Nonlinear Models (2005).

[535] Colin W. Clark, Mathematical Bioeconomics: the Optimal Management of Renewable Resources (2d ed. 2005).

[536] Peter Turchin, Complex Population Dynamics: A Theoretical/Empirical Synthesis (2003).

[537] William W. Murdoch et al., Consumer-Resource Dynamics (2003).

doi:10.6342/NTU201601682

[538] Horst R. Thieme, Mathematics in Population Biology (2003).

[539] J. D. Murray, Mathematical Biology: II. Spatial Models and Biomedical Applications (3d ed. 2003).

[540] J. D. Murray, Mathematical Biology: I. An Introduction (3d ed. 2002).

[541] A. A. Samarskii & A. P. Mikhailov, Principles of Mathematical Modeling: Ideas, Methods, Examples (2002).

[542] Mark Kot, Elements of Mathematical Ecology (2001).

[543] Fred Brauer & Carlos Castillo-Chávez, Mathematical Models in Population Biology and Epidemiology (2000).

[544] Claudio Cioffi-Revilla, Politics and Uncertainty: Theory, Models and Applications (1998).

[545] Duncan J. Watts, Small Worlds: the Dynamics of Networks Between Order and Randomness (1998).

[546] John H. Holland, Emergence: From Chaos to Order (1998).

[547] John H. Holland, Hidden Order: How Adaptation Builds Complexity (1996).

[548] Martin Braun, Differential Equations and Their Applications (4d ed. 1993).

[549] James F. Wittenberger, Animal Social Behavior (1981).

[550] Tim Poston & Ian Stewart, Catastrophe Theory and its Applications (1978).

Articles

[551] Martin A. Nowak, *Five Rules for the Evolution of Cooperation*, *in* Evolution, Games, and God: the Principles of Cooperation 99 (Martin A. Nowak & Sarah Coakley eds., 2013).

[552] Christoph Hauert, *Mathematical Models of Cooperation*, *in* Evolution, Games, and God: the Principles of Cooperation 115 (Martin A. Nowak & Sarah Coakley eds., 2013).

[553] Johan Almenberg & Anna Dreber, *Economics and Evolution: Complementary Perspectives on Cooperation*, *in* Evolution, Games, and God: the Principles of Cooperation 132 (Martin A. Nowak & Sarah Coakley eds., 2013).

[554] James S. Coleman, *Foundations for A Theory of Collective Decisions*, *in* Social Choice 27 (Bernhardt Lieberman ed., 2011).

[555] Stephen J. Guastello & Larry S. Liebovitch, *Introduction to Nonlinear Dynamics and Complexity*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 1 (Stephen J. Guastello et al. eds., 2009).

doi:10.6342/NTU201601682

[556] Paul van Geert, *Nonlinear Complex Dynamical Systems in Developmental Psychology*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 242 (Stephen J. Guastello et al. eds., 2009).

[557] Peter Allen, *Complexity, Evolution, and Organizational Behavior*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 452 (Stephen J. Guastello et al. eds., 2009).

[558] Matthijs Koopmans, *Epilogue: Psychology at the Edge of Chaos*, *in* Chaos and Complexity in Psychology: the Theory of Nonlinear Dynamical Systems 506 (Stephen J. Guastello et al. eds., 2009).

[559] Diana Richards, *From Individuals to Groups: the Aggregation of Votes and Chaotic Dynamics*, *in* Chaos Theory in the Social Sciences: Foundations and Applications 89 (L. Douglas Kiel & Euel Elliott eds., 1996).

Journals

[560] J. Wauer et al., *Dynamical Models of Love With Time-varying Fluctuations*, 188 Applied Mathematics and Computation, 2007, at 1535.

[561] J. C. Sprott, *Dynamical Models of Happiness*, 9 Nonlinear Dynamics, Psychology, and Life Sciences, no. 1, 2005, at 23.

[562] J. C. Sprott, *Dynamical Models of Love*, 8 Nonlinear Dynamics, Psychology, and Life Sciences, no. 3, 2004, at 303.

Mathematical Modeling

Books

[563] Morris W. Hirsch et al., Differential Equations, Dynamical Systems, and an Introduction to Chaos (3d ed. 2013).

[564] William E. Boyce & Richard C. DiPrima, Elementary Differential Equations and Boundary Value Problems (9th ed. 2010).

[565] John Banks et al., Chaos: A Mathematical Introduction (2003).

[566] Robert C. Hilbert, Chaos and Nonlinear Dynamics (2d ed. 2000).

[567] Neil Gershenfeld, The Nature of Mathematical Modeling (1998).

[568] Steven H. Strogatz, Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering (1994).

[569] Robert L. Devaney, An Introduction to Chaotic Dynamical Systems (1986).

[570] Shepley L. Ross, Differential Equations (3d ed. 1984).

Software

[571] Matlab R2014a.

[572] NetLogo.

doi:10.6342/NTU201601682