THE TRADE REGIME AS A COMPLEX ADAPTIVE SYSTEM: EXPLORATION AND EXPLOITATION OF ENVIRONMENTAL NORMS IN TRADE AGREEMENTS

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ABSTRACT

While the trade regime is often analyzed under the metaphoric assumptions of Newtonian mechanics, we propose an alternative, more organic representation. We argue that the trade regime seems to evolve as a complex adaptive system, at the edge of order and chaos. Drawing from a dataset of 280 different types of environmental provisions found in 680 trade agreements, we show how both the trade regime and the norms contained therein unfold by remaining stable (but not static) and dynamic (but not chaotic). Trade negotiators simultaneously explore new grounds by introducing legal innovations and exploiting known territories by adopting existing norms. Our analysis suggests that, even as the regime grows in the number and length of agreements, there are exploratory and exploitative processes at work. These twin processes can explain that the trade regime appears neither more fragmented/heterogeneous nor more centralized/homogenous than it was fifty years ago, despite its substantial expansion. This hypothesis is at the core of the research agenda that this paper lays out.

I. INTRODUCTION

Identifying complex adaptive systems (CAS) within the law is a new frontier in empirical legal research. It promises insight into how law coevolves with other complex social and natural systems as well as how legal systems grow and sustain themselves.[1] In this article, we argue that applying a CAS perspective to the global trade governance regime opens new avenues of research. The objectives of this article are thus programmatic rather than explanatory and we hereby hope to contribute to the foundational work of an emerging research program.

We illustrate the value of a CAS perspective with respect to two dimensions of the trade governance regime. First, we argue that the network of countries' memberships in 680 bilateral, plurilateral, and multilateral trade agreements presents a complex adaptive structure. Second, we argue that patterns of appearance and adoption of norms in these trade agreements—environmental norms, in our example[2]—also suggest a complex adaptive structure. In both, CAS indicate that not only exogenous but also endogenous processes operate.

This second, normative dimension relates most closely to the other contributions in this Special Issue as it relies upon the text of each of the trade treaties. However, in contrast to other contributions (for example, Elsig *et al* and Pelc *et al*), our empirical analysis does not rely on direct, computer-aided text analysis, but instead human coders identified the 280 different environmental norms (including principles, commitments, and exceptions) that today appear in trade agreements. It also relies on human coders to generate a matrix of legal and substantive relationships between these norms. While computers can easily and accurately identify environment-related

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[1] Pauwelyn, Joost. 2014. "At the Edge of Chaos?: Foreign Investment Law as a Complex Adaptive System, How It Emerged and How It Can Be Reformed." *ICSID Review* 29 (2): 372–418. Ruhl, J B, D M Katz, and M J Bommarito. 2017. "Harnessing Legal Complexity." *Science* 355 (6332): 1377–78.

[2] Jean-Frédéric Morin, Andreas Dür and Lisa Lechner, 'Mapping the Trade and Environment Nexus: Insights from a New Dataset'. For an alternative coding of environmental provision in preferential trade agreements, see José-Antonio Monteiro 'Typology of Environment-Related Provisions in Regional Trade Agreements' Wold Trade Organization Working Paper ERSD-2016-13.

provisions within one or more texts, human coding remains more appropriate for identifying and interpreting sometimes ambiguous norms within complex, structured texts and relating them to one another. This is because lexicon based approaches struggle with the many-to-many relationships words and concepts like norms often have that humans, who parse semantics with comparative ease, can distinguish. For example, the precautionary principle can be expressed in various ways depending on context and cannot always be identified by the co-occurrence of certain keywords. In addition, standard computer-driven text analytic approaches do not permit norms that might emerge across sentences or even paragraphs. Humans recognize intra-textual relationships and anaphora that most text-analytic programs miss. For example, a norm promoting market instruments to achieve environmental objectives may emerge only across a number of specific clauses that evidence that purpose. Lastly, even sophisticated computer-based approaches can only infer latent relationships between concepts from the text provided to them, whereas human coders, especially experts, can judiciously draw upon a contemporary, substance-focused corpus. We therefore provided a detailed codebook[3] to a team of coders, who parsed all trade agreements from preamble to annex for norms described within the codebook.

The following section presents our conceptualization of the trade regime as a CAS. One general expectation that derives from this conceptualization is that, once initialized, even a continually expanding trade system grows according to a dual process, explored in greater details in sections III and IV, namely the exploration of novel relationships and the exploitation of known information. The conclusion identifies a number of research questions that derive from this conceptualization.

[3] Jean-Frédéric Morin, 'TREND (TRade & ENvironment Database) Codebook' (July 2016), Canada Research Chair in International Political Economy, www.chaire-epi.ulaval.ca/trend (visited 16 January 2016).

II. THE TRADE REGIME THROUGH THE LENS OF COMPLEXITY THEORY

A. The Trade Governance Regime

We favor a broad definition of the trade governance regime.[4] It includes multilateral trade agreements as well as bilateral and regional trade agreements (hereinafter, preferential trade agreements or PTAs). It also includes actors negotiating trade treaties as well as dispute settlement and committee level activity, rulings and norms under these treaties, with the parties, officials and adjudicators engaged therein. Our definition, however, does not include treaties that may interact with trade but are not 'as such' trade agreements (e.g., bilateral investment treaties or multilateral environmental agreements).

How we conceive of such regimes highlights or obscures certain features of their evolution. Trade governance is often analyzed under a Newtonian lens that atomistically disaggregates the elements of a system and investigates their interaction, if at all, as linear. For example, many commentators separate the World Trade Organization (WTO) from PTAs as if they operate independently. When PTAs are considered, they are also often analyzed independently from other PTAs and the WTO. Even those that explicitly investigate interactions between PTAs and the WTO conceive of coordination and conflict between distinct entities. Common metaphors that follow include 'building blocks', 'stumbling stones', 'parallel tracks', 'ratchet effect', and 'domino theory'.[5] These metaphors lead us to expect stability unless and until an exogenous pressure provokes change. The impact of PTAs on the WTO, for example, is typically pictured as the exogenous pressure of a chaotic "spaghetti bowl" that contradicts and risks undermining the WTO[6]. Otherwise, the trade regime is seen as evolving at a glacial pace between the major rounds of multilateral trade negotiations (e.g., Tokyo Round, Uruguay Round, and the failed Doha Round).

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[4] Our definition is so broad that it might be more appropriate to talk about the trade regime complex instead. However, since this article relies on complexity theory, we prefer to avoid the frequent confusion between complex as a structure (as in a regime complex) and complexity as a property of a system (as a complex adaptive system). A regime complex does not necessarily display complexity.

[5] Sophie Meunier and Jean-Frédéric Morin, 'No Agreement is an Island: Negotiating TTIP in a Dense Regime Complex', in Jean- Frédéric Morin, Tereza Novotná, Frederik Ponjaert and Mario Telò (eds) *The Politics of Transatlantic Trade Negotiations: TTIP in a Globalized World* (Routledge 2016) 196.

[6] Jagdish Bhagwati, *Termites in the Trading System: How Preferential Agreements Undermine Free Trade* (Oxford: Oxford University Press 2008).

B. The Trade Regime as a Complex Adaptive System

A CAS lens promotes a somewhat different view. Melanie Mitchell defines CAS as 'system[s] in which large networks of components with no central control and simple rules of operation gives rise to complex collective behavior, sophisticated information processing and adaptation via learning or evolution'[7] Not every 'complicated' system is 'complex adaptive' though. Complicated systems can be understood by disaggregating the whole into its constituent parts and studying how they interact because the 'various elements that make up the system maintain a degree of independence from one another'.[8] Clocks, for example, are decomposable, linear, inert, predictable, and amenable to Newtonian analysis. CAS, though, can issue recognizable patterns, but the specific details of their evolution remain unpredictable due to complex dependencies and nonlinearities. Most commonly cited examples of CAS include the economy, ant colonies, the immune system, the brain, cities, jazz bands and the galaxy[9].

Some international regimes seem to correspond well to Mitchell's definition of a CAS. The 'international' is one political domain where there is no central hierarchical authority and globalization is the archetypical example of social inter-connectivity. Yet, despite some pioneering works,[10] international studies lags behind other disciplines in seizing the CAS' descriptive and explanatory power. A burgeoning literature advocates CAS,[11] emphasizing its theoretical supremacy, but to date

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[7] Melanie Mitchell, *Complexity: A Guided Tour* (Oxford: Oxford University Press 2009) 13.

[8] John H. Miller and Scott E. Page, *Complex Adaptive System: An Introduction to Conceptual Models of Social Life* (Princeton: Princeton University Press 2007) 9.

[9] Mitchell, above n 7, 3-12.

[10] James N. Rosenau, 'Foreign Policy as Adaptive Behavior: Some Preliminary Notes for a Theoretical Model', 2(3) Comparative Politics 365 (1970); Robert Axelrod and William D. Hamilton, 'The Evolution of Cooperation', 211 (4489) Science 1390 (1981); George Modelski, 'Is the World Politics Evolutionary Learning?', 44(1) International Organization 1 (1990); Robert Jervis, *System Effects: Complexity in Political and Social Life* (Princeton: Princeton University Press 1997).

[11] John Urry, 'The Complexity of the Global', 22(5) Theory, Culture & Society 235 (2005); Emilian Kavalski, 'The Fifth Debate and the Emergence of Complex International Relations Theory: Notes on the Application of Complexity Theory to the Study of International Life', 20(3) Cambridge Review of International Affairs 435 (2007); Neil E. Harrison, *Complexity in World Politics: Concepts and Methods of a New Paradigm* (New York: State University of New York Press 2006); Shu-Yun Ma, 'Political Science at the Edge of Chaos? The Paradigmatic Implications of Historical Institutionalism', 28(1) International Political Science Review 57 (2007); Armando Geller and Scott Moss, 'Growing Qawm: An Evidence-Driven Declarative Model of Afghan Power Structures', 11(2) Advances in Complex Systems 321 (2008); Karen J. Alter and Sophie Meunier, 'The Politics of International Regime Complexity', 7(1) Perspectives on Politics 13 (2009); Robert Deuchars, 'Deleuze, DeLanda and Social Complexity: Implications for the 'International', 6(2) Journal of International Political Theory 161 (2010); Antoine Bousquet and Simon Curtis, 'Beyond Models and

scholars have only conducted a few empirical investigations on environmental treaties[12] or foreign investment law[13]. This article is the first attempt to explicitly conceptualize the trade regime as a CAS.

While many criteria appear in the literature, six common criteria of a CAS are: 1) multiple heterogeneous elements, 2) no central coordination, 3) interdependency, 4) simple rules of operation, 5) a multiscale structure, and 6) openness.[14] The trade governance regime has all these characteristics.

First, the trade governance regime is made of several constituent elements like any system or structure. It is composed of thousands of agents, including trade negotiators and adjudicators as well as hundreds of institutional artifacts such as trade agreements, regional organizations, customary rules and social norms.[15] Not only are there many and many different types of actors and institutions, but they also have diverse interests and preferences, including with respect to which (if any) environmental norms should be included in trade agreements.[16]

Metaphors: Complexity Theory. Systems Thinking and International Relations', 24(1) Cambridge Review of International Affairs 43 (2011); Erika Cudworth and Stephen Hobden, *Posthuman International Relations: Complexity, Ecologism and Global Politics* (Zed Books 2011); Armando Geller, 'The Use of Complexity-Based Models in International Relations: A Technical Overview and Discussion of Prospects and Challenges', 24(2) Cambridge Review of International Affairs 63 (2011); Robert Gayer and Steve Pickering, 'Applying the Tools of Complexity to International Realm: From Fitness Landscapes to Complexity Cascades', 24(1) Cambridge Review of International Affairs 5 (2011); Emilian Kavalski, 'Waking IR up from its "deep Newtonian slumber"', 41(1) Journal of International Studies 137 (2012); Seva Gunitsky, 'Complexity and Theories of Change in International Politics', 5(1) International Theory 35 (2013).

[12] Rakhyun E. Kim, 'The Emergent Network Structure of the Multilateral Environmental Agreement System', 23(5) Global Environment Change 980 (2013).

[13] Joost Pauwelyn, 'At the Edge of Chaos? Foreign Investment Law as a Complex Adaptive System: How It Emerged and How It Can Be Reformed', ICSID Review 1 (2014); Sergio Puig, 'International Regime Complexity and Economic Law Enforcement', 17(3) Journal of International Economic Law 491 (2014).

[14] Le Prestre, Philippe, 'The Meaning of Complex Governance' (on file with the author at Université Laval, Canada). Philippe Le Prestre makes a useful distinction between CAS characteristics (what they are) and their properties (what they do). For a conceptual discussion of these properties, see Miller and Page, above n 7; Mitchel, above n 6. For its application to International Studies, see Emilian Kavalski, *World Politics at the Edge of Chaos: Reflection on Complexity and Global Life* (New York: State University of New York Press 2016); Neil E. Harrison, *Complexity in World Politics: Concepts and Methods of a New Paradigm* (New York: State University of New York Press 2006).

[15] Andreas Dür, Leonardo Baccini and Manfred Elsig, 'The Design of International Trade Agreements: Introducing a New Dataset', 9(3) The Review of International Organizations 353 (2014) at 354.

[16] Henrik Horn, Petros C. Mavroidis and André Sapir, 'Beyond the WTO? An Anatomy of EU and US Preferential Trade Agreements', 33(11) The World Economy 1565 (2010) at 1566.

Second, these heterogeneous elements are not centrally coordinated. The conclusion of trade agreements does neither require central approval from a multilateral organization nor is there any formal coordination involved. While WTO members have to notify the WTO of their PTAs and must meet certain minimum requirements (e.g., a PTA must liberalize "substantially all" trade), the notification record of WTO members is far from perfect and the WTO rules on PTAs (e.g., GATT Article XXIV) are vague and not effectively enforced.[17]

Third, despite the heterogeneity of constitutive elements and lack of hierarchical arrangement, the trade regime is held together by shared principles and relational dependencies. Trade agreements and dispute settlement awards have avoided blatant incoherencies, as they are negotiated, interpreted, implemented, and adjudicated in the shadow of each other, under the umbrella of a shared liberal credo and guided by WTO minimum rules (as demonstrated by Elsig et al in this Issue).[18] This relative coherence results from dense social, legal and political relations thus linking each element to some other elements of the system and providing some centripetal force.[19]

Fourth, the system operates under relatively simple rules. Only around 200 countries or separate customs territories have the authority to negotiate, adopt, and adjudicate trade agreements, and they do so under well-established rules of international law. Still, boundedly rational actors can learn from their experiences and

[17] Petros C. Mavroidis, 'Always Look at the Bright Side of Non-Delivery: WTO and Preferential Trade Agreements, Yesterday and Today', 10(3) World Trade Review 375 (2011) at 376.

[18] See Valbona Muzaka and Mattew Louis Bishop, 'Doha Stalemate: The End of Trade Multilateralism', 41(2) Review of International Studies 383 (2015); Laura Gomez-Mera and Andrea Molinari, 'Overlapping Institutions, Learning, and Dispute Initiation in Regional Trade Agreements: Evidence from South America', 58(2) International Studies Quarterly 269 (2013) at 269; James Hollway and Johan Koskinen, 'Multilevel Embeddedness: The Case of the Global Fisheries Governance Complex', 44 Social Networks 281 (2016) at 282.

[19] Robert Wolfe, 'See you in Geneva? Legal (Mis)Representations of the Trading System', 11(3) European Journal of International Relations 339 (2005) at 346; Joost Pauwelyn and Wolfgang Alschner, 'Forget about the WTO: The Network of Relations between PTAs and double PTAs', in Andreas Dür and Manfred Elsig (eds), *Trade Cooperation: The Purpose, Design and Effects of Preferential Trade Agreements* (Cambridge: Cambridge University Press 2015) 510. ('The PTA network visualization confirms that, especially in the Americas and South East Asia, PTAs tend to be deep. The EU, the US, Chile, Mexico, Singapore, Australia and New Zealand are central players in this network. The fact that these rules are crafted today by a handful of interconnected hub countries rather than isolated clusters of independent rule makers is likely to facilitate the convergence of views and the emergence of a coherent body of WTO-extra norms.').

the actions of others to update and expand their behavior as well as the rules of operation.[20]

Fifth, the trade system has a multilevel structure with established general principles (e.g. national treatment, tariff commitments and necessity exceptions), gradually evolving norms (e.g., non-tariff barriers) and rapidly mushrooming detailed rules (e.g. the requirement to disclose the origin of genetic resources in patent applications).[21] Different processes operate simultaneously at different scales in an interdependent manner. For example, competition among detailed trade rules[22] is related to the diffusion of certain models of trade agreements.[23]

Lastly, despite being recognizable as a system, the trade regime is also open to its environment like other natural and social systems. As the WTO Appellate Body has provided, it is 'not to be read in clinical isolation from [the rest of] public international law'.[24] The trade governance system is relatively open to influences from domestic law and politics as well as cognate governance regimes. CAS are thus still open to exogenous influences.

Yet a CAS lens differs from a Newtonian lens in important ways. First, it deems the components (e.g., actors and institutions) within the regime as transactive and

[20] Mark S. Copelovitch and Tonya L. Putnam, 'Design in Context: Existing International Agreements and New Cooperation', 68(2) International Organization 471 (2014); Covadonga Meseguer, 'Rational Learning and Bounded Learning in the Diffusion of Policy Innovations', 18(1) Rationality and Society 35 (2006).

[21] John H. Barton, Judith L. Goldstein, Timothy E. Josling and Richard H. Steinberg, *The Evolution of the Trade Regime: Politics, Law and Economics of the GATT and the WTO* (Princeton: Princeton University Press 2006).

[22] See Dür *et al*, above n 13, at 355; Horn *et al*, above n 14, at 1587.

[23] Peter Egger and Mario Larch, 'Interdependent Preferential Trade Agreement Memberships: An Empirical Analysis', 76(2) Journal of International Economics 384 (2008) at 386; Maggie Xiaoyang Chen and Sumit Joshi, 'Third Country effects on the formation of Free Trade Agreements', 82(2) Journal of International Economics 238 (2010) at 239; Richard Baldwin and Dany Jainovich, 'Are Free Trade Agreements contagious?', 88(1) Journal of International Economics 1 (2012) at 10. (Baldwin and Jainovich provide that: 'Basic hypothesis is that much of the spread of regionalism is driven by "defensive" FTAs, i.e., nations sign FTAs to reduce the discrimination created by FTAs signed among their trade partners. FTAs are contagious and the degree of contagion is related to the importance of the partners' markets.')

[24] WTO Appellate Body Report, United States – Standards for Reformulated and Conventional Gasoline (US – Gasoline), WT/DS2ABR, adopted 29 April 1996 at 17; Joost Pauwelyn, Conflict of Norms in Public International Law: How WTO Law Relates to Other Rules of International Law (Cambridge: Cambridge University Press 2003) 29.

adaptive.[25] This in turn leads to the (endogenous) emergence of system features that cannot be reduced to individual components ('the whole is greater than the sum of its parts'). Second, a CAS view suggests the trade governance regime is less 'frozen' than the WTO's negotiating arm. Plenty of 'micro-level innovation' occurs in the dispute settlement system of the WTO and its committee monitoring activities in conjunction with other trade agreements, especially PTAs. At the same time, the trade regime is less 'chaotic' than many PTA observers may believe. Order is brought to the system not only by multilateral agreements, but also by the appearance of similar norms across many PTAs and other centripetal forces discussed earlier.

We do not claim that a CAS lens is necessarily superior to a Newtonian one. Despite Einstein's theory of relativity being accepted as a more accurate physical model, Newtonian physics continues to be useful for most quotidian calculations. In the context of the trade governance regime, a Newtonian lens may be a useful first approximation. However, as each theoretical lens builds on different metaphors and assumptions, they highlight different research questions that we should not ignore but instead explore.

So far, we have argued that the trade regime has all the features of a CAS; the next step is to identify how this change of perspective might result in different expectations about how the trade system evolves.

C. Expected Growth in Complexity: At the Edge of Exploitation and Exploration

A complexity lens leads us to expect a CAS to develop consistent with the six conditions identified above. Stuart Kauffman, a leading complexity theorist, proposes that complex systems expand into the 'adjacent possible' as much as they can without undermining their internal organization.[26] On the face of it, what we witness with the trade regime is consistent with this hypothesis. There are more agreements, issue-

[25] Emirbayer, Mustafa. 1997. "Manifesto for a Relational Sociology." The American Journal of Sociology 103 (2): 281–317.

[26] Stuart Kauffman, *The Origins of Order* (Oxford: Oxford University Press 1993). CASs are constantly changing, which implies that causal processes that are observed at a given time might not be applicable at another time. This makes illusive the search for timeless laws apart from this tendency to grow in complexity.

areas covered, participating countries, and dispute settlement systems and rulings than previously.[27] While several trade agreements concluded in the 1960s have less than 10 pages, some recent trade agreements have more than 1000 pages. This growth, however, has not plunged the regime into chaos. CAS theory expects that the interdependencies connecting the various elements of the system ensure that a system expansion is not realized at the expense of its internal organization.

The fact that elemental units have simple rules of operation does not limit the growth in complexity[28]. On the contrary, the simple rule of natural selection has led to the complex biosphere, and the simple rule of profit-seeking entities has led to a complex economy. As observed by Miller and Page: '[s]imple rules in a stark environment can generate complex aggregate behaviors'.[29] Thus, if trade agreements are increasing in frequency and if trade agreements are getting longer, it is not necessarily because contemporary trade negotiators are more sophisticated individuals than their predecessors; they are largely building on pre-existing elements and following the same "simple rules" as those before them.

Then, where does this complexity come from? While exogenous pressures influence a CAS by virtue of it being open (the sixth condition listed above), complexity theorists also expect it to develop organically and endogenously through processes of 'exploitation' and 'exploration' that keep a system in balance at the edge of order and chaos.[30] 'Exploration' refers to the efforts to create future capabilities by means of 'search, variation, experimentation, and discovery', and implies venturing into the unknown, introducing chaos to a system. 'Exploitation' refers to the leveraging of existing capabilities through activities like 'reproduction, refinement, efficiency selection, and implementation', and means moving incrementally towards known strategies, and the imposition of some order.[31] For an ant colony, the creation of a satellite nest is an exploratory strategy, while nest-mate recruitment for foraging is an exploitation strategy. In business systems, exploration can refer to research and

[27] See Dür *et al*, above n 13, at 355 and Horn *et al*, above, n 14, at 1565.
[28] Ann Florini, 'The Evolution of International Norms' International Studies Quarterly 40 1996, at 369.
[29] See Miller and Page, above n 7, at 231.
[30] Stuart Kauffman and William Macready, 'Technological Evolution and Adaptive Organizations: Ideas from Biology may find Applications in Economics', 1(2) Complexity 26 (1995) at 26.
[31] James G. March, 'Exploration and Exploitation in Organizational Learning', 2(1) Organization Science 71 (1991) at 71.

development activities while exploitation can take the form of a scaled up production to achieve economy of scale. In evolutionary biology, genetic mutation is a type of exploration while the exploitation of the genetic pool takes place with natural selection. For any CAS, exploitation can bring benefits in the short term and exploration can bring more benefits to a system in the long run.[32]

Most systems observe concurrent exploration and exploitation. The challenge is to find an appropriate balance between riskier exploration and safer exploitation at a given time. As March notes, elimination of exploration will make an organization obsolete in a dynamic world: 'Systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria'.[33] In the same manner, continuous exploration, without a sufficient degree of exploitation, will prevent the organization from realizing the potential gains of new discoveries.[34]

In this article, we describe the relationship between exploitation and exploration in the trade governance CAS as one between identifying new contacts or norms and consolidating existing contacts or norms. While innovations may be adopted, innovation and adoption are analytically as distinct as genetic mutation and selection under the theory of evolution or as research and production in business. Nonetheless, innovation and adoption operate jointly to sustain the growth of the trade system.

We discuss below the role of each of these complementary forces as anticipated by CAS theory. We exemplify our arguments by providing empirical illustrations taken from the previously mentioned dataset of trade agreements' environmental provisions. This dataset allows us (i) to detect when a specific type of environmental norm appeared for the first time in a trade agreement and (ii) to measure the extent to

[32] Ibid, at 85. (March provides: 'Thus, the distance in time and space between the locus of learning and the locus for realization of returns is generally greater in the case of exploration than in the case of exploitation, as is the uncertainty.')

[33] Ibid, at 71. See also Piero Formica, 'Why Innovators Should Study the Rise and Fall of the Venetian Empire', Harvard Business Review. Spruyt, Hendrik Spruyt, 'Institutional Selection in International Relations: State Anarchy as Order', 48(4) *International Organization* 527 (1994).

[34] Kauffman describes this as a complexity catastrophe: 'In short, selection becomes too weak a force to hold an adapting population at adaptive peaks. The population flows down the adaptive hillside to the lowlands. This contention of mutational and selective forces leads, as we shall see, to a complexity catastrophe when the number of parts exceeds a critical value. Beyond that level of complexity, selection cannot climb to peaks or remain there.' Stuart Kauffman, The Origins of Order, Oxford: Oxford University Press 1993) at. 36. See also Andreas Duit and Victor Galaz, 'Governance and Complexity – Emerging Issues for Governance Theory', 21(3) Governance 311 (2008) at 318.

which these environmental norms are subsequently reproduced in other trade agreements. Thus, it is with the aid of this dataset that we illustrate how the twin processes of innovation and adoption have fueled the growing complexity of the trade system.

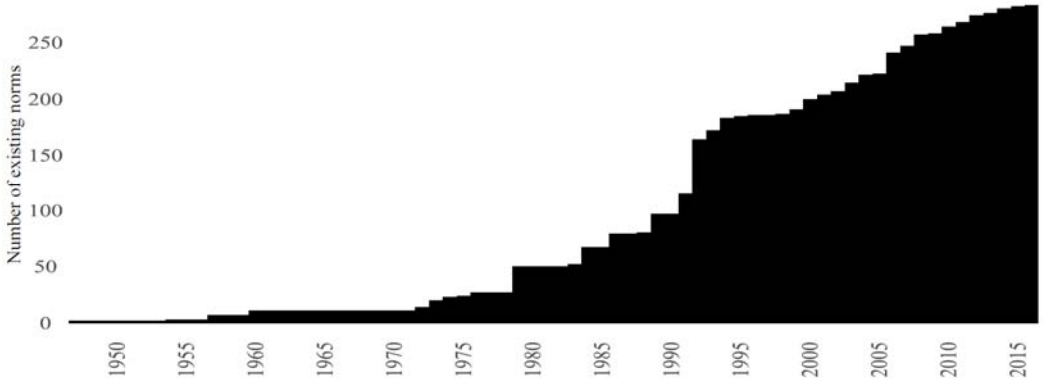
III. EXPLORATION: INTRODUCTION AND INNOVATION OF ENVIRONMENTAL NORMS IN TRADE AGREEMENTS

A. Increased Stock of Innovations

The earliest trade agreement in our database is GATT 1947. It includes just two environmental norms, which also counted as 'innovations': the two exceptions provided for the protection of plant and animal health and exhaustible natural resources, respectively. In contrast, the Trans-Pacific Partnership (TPP) as signed in 2016 has around 136 different environmental norms.

Figure 1, below shows the cumulative number of environmental norms introduced into the trade regime, from 2 norms in 1946 to 288 norms in 2016. The cumulative innovations grow very slowly in the first decades (1950s - 1970s) but accelerate considerably from 1979 to 1991. In 1992, with the creation of NAFTA there is a notable sudden and sharp increase. However, from 1992 we see a more regular growth pattern.

Figure 1: Growth of Cumulative Environmental Innovations in the Trade System

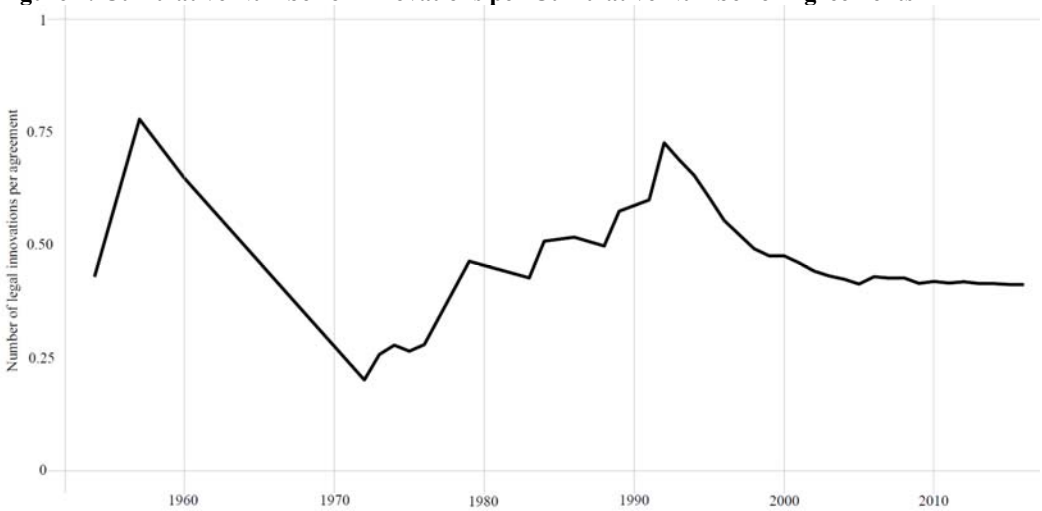


Source: authors.

More trade agreements are signed every year since the 2000s than during the whole of the 1960s, so it is not surprising that we also see more innovations occurring; each new agreement is another opportunity to innovate. However, as

Figure 2 shows, the number of innovations per agreement is not constant.[35] It has not increased as steadily as the average number of environmental norms per agreement. The number of innovations per agreement experienced a steep increase in the earlier years up to 1960, mostly because of the limited number of agreements signed during this period (which makes the denominator smaller). During the 1960s, as the number of agreements signed increased steeply, the number of legal innovations per year remained stable. This explains the sharp decrease in the number of innovations per agreement during this period. From the early 1970s to the 1990s, however, innovations grew more rapidly, which increased the number of innovations per agreement. Since the early 2000s, the number of innovations per agreement remains quite stable as both the number of innovations and the number of agreements have been rising in parallel and indeed both the numerator and denominator are larger integers.[36]

Figure 2: Cumulative Number of Innovations per Cumulative Number of Agreements



Source: authors.

B. Legal Innovation as a Non-Linear Phenomenon

Our data suggests that legal innovations are not randomly distributed among PTAs. If they were random, we would expect a roughly normal distribution of innovations across agreements. Figure 3, by contrast, illustrates the uneven distribution of

[35] The number of legal innovations per agreement is calculated by dividing the number of legal innovations accumulated in a given year by the total number of agreements signed in the same year.

[36] Eric D. Beinhocker, *The Origin of Wealth: Evolution, Complexity and the Radical Remaking of Economics* (Harvard: Harvard Business School Press 2006) 263.

innovation wherein relatively few trade agreements innovate and even fewer include more than one innovation.

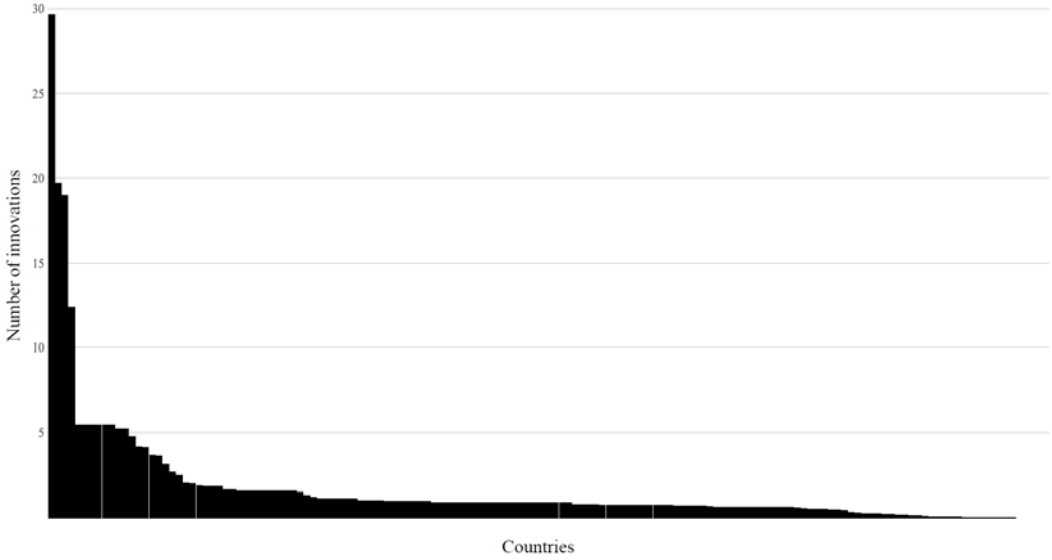
Figure 3: Distribution of Innovation across Agreements

Source: authors.

By the same token, only a few countries participate in most of the innovations. This is illustrated by Figure 4, which sets out the 'proportional' innovation per country. The 'absolute' number of innovations per country has the drawback of not taking into account the number of participating countries in the negotiation process, e.g., innovation in a bilateral trade agreement versus a plurilateral or multilateral agreement. The degree of innovativeness attributed to a country participating in an innovative multilateral negotiation should be lower than when participating in an innovative bilateral agreement. In the calculation of 'proportional' innovations per country, we first divide the innovative points (one point per innovation) that a country obtained from participating in one innovative agreement with the number of participating countries in the agreement before summing up the total innovative points by country.[37] The results appear in Figure 4 which, just like Figure 3, has an L-shaped long-tailed distribution. This observation calls for explanations.

[37] It should be noted that in our analysis the EC (now EU) is considered as one entity in its external trade relations.

Figure 4: Proportional Innovations per Country



Source: authors.

In popular discourse, the distribution of innovations is often explained in one of two ways (see Table 1). First, there is the mystic view of innovation. This outlook makes a cult of the individual "inventor" and considers invention as a supernatural process. Persistent visions of lone inventors struggling against all odds and making out-of-the-blue discoveries in their workshop/laboratory/garage (e.g., Leonardo da Vinci, Benjamin Franklin, Graham Bell, Bill Gates, and Steve Jobs) mythologize this view. This perspective suggests a heroic view to the (negotiators in the) most innovative countries.

The second traditional approach to conceptualize innovation is mechanical, rational, and linear. It represents innovation as an output proportional to the input of investment. To boost innovation, actors must increase their investments into research and development. Edison subscribed to this view and argued that his laboratory could produce 'a minor invention every 10 days and a big thing every six months or so'.[38] This perspective suggests that the most innovative countries are simply reaping the rewards of heavy investment.

Table 1: Three Models of Innovation

[38] Andrew B. Hargadon, 'Firms as Knowledge Brokers: Lessons in Pursuing Continuous Innovation', 40(3) California Management Review 209 (1998) at 209.

Innovation	A mystic process (individual level)	A mechanical process (aggregate level)	A relational process (system level)
Rock and Roll	Elvis Presley	Music industry supported by copyright laws	Combination of folk, country and blues meet in Memphis
iPhone	Steve Jobs	US military R&D (GPS, integrated circuits, internet, etc.)	Combination of investors, researchers and entrepreneurs in silicon Valley
Modern banking system	Cosmo Medici	Capital accumulation during Renaissance	Combination of financial, political and family ties
The best peer-review article of the year	A high IQ scholar	Large research fund and light teaching load	Combination of existing ideas in a novel manner
NAFTA side agreement on the environment	Bill Clinton and Democrats in Congress	Civil society pressure on US government, to put pressure on Mexico	Combination of existing norms

Source: authors.

Both perspectives offer partly accurate accounts, but neither provides a satisfying explanation to understand legal innovation in the context of the trade regime. Both approaches leave out the broader context: the existing system that provides the sources of inspiration and forms of facilitations. The lone inventor point of view (or, in our case, the inspired trade negotiator) fails to conceptualize 'innovation' as a social process, and therefore fails to account for the important systemic or structural features that enable or disable potential innovators. Our data also suggest that the mechanistic model is incomplete. The degree of asymmetrical power relations between two partners (the assumed input in the mechanistic model) is not steadily proportional to the number of innovations per agreement (the output). Table 2 below provides the top 10 most environmentally innovative trade agreements as well as the top 10 most innovative countries. While the U.S. and the E.U. are leading innovators, they innovate in only a limited number of agreements. They mainly innovate in regional and plurilateral agreements, such as NAFTA and the Lomé agreements. Most of their bilateral agreements see little innovation. This observation contradicts the expectation of the mechanistic model, as the relative bargaining power that the U.S. and the E.U. possess is typically higher in bilateral settings. So although there is a positive correlation between GDP per capita (an indicator of bargaining power) and the 'absolute' number of innovation per country, there is a negative correlation

between GDP per capita and the 'proportional' number of innovation per country[39]. This makes sense if we recognize that GDP per capita is also highly correlated with the number of trade agreements. Rich countries conclude more trade agreements, providing more opportunities to innovate, but opportunities they do not use as intensively as poorer countries when they are given the opportunity.

We recognize that some governments might value and cultivate legal innovation more than others. We also recognize that power asymmetry appears to explain partly the distribution of innovation in the trade system. However, as detailed below, we believe that a system-level analysis can contribute to explain why innovations are more common as the number of parties increases.

Table 2: Top Innovative Agreements and Countries

Top 10 innovative agreements			Top 10 innovative countries	
Agreement	**Date**	**Innovations**	**Country**	**Score**
1. NAFTA	1992	48	1. United States	29.64
2. US-Peru	2006	18	2. Canada	19.70
3. Lomé IV	1989	17	3. Mexico	19.00
4. Lomé III	1984	15	4. Peru	12.33
5. Lomé II	1979	12	5. European Union	4.64
6. Single European Act	1986	12	6. Singapore	4.16
7. EU-Hungary	1991	9	7. Japan	3.66
8. Tokyo Codes	1979	8	8. Korea	3.14
9. Colombia Peru	2012	5	9. Australia	2.66
. 10. CEAO	1973	5	. 10. Costa Rica	2.50

Source: authors.

C. Legal Innovation as Recombination

A CAS perspective allows us to reformulate the issue of innovation at the system level and to locate variation in innovation within the structure of the system. We thereby concur with Strumsky *et al* that 'innovation is constrained by the same evolutionary factors that regulate all complex systems.'[40] A CAS, whether it is a biological cell or a social system, may respond to external stimuli but is also autopoietic: it is alive, organic, recursive and constantly produces more of itself

[39] We regress the number of innovation on GDP per capita (of 2014). Of course, some third factors can influence both the GDP and the number of innovation at the same time

[40] Deborah Strumsky, José Lobo and Joseph A. Tainter, 'Complexity and the Productivity of Innovation', 27(5) System Research and Behavioral Science 496 (2010) at 498.

thereby generating its own evolution.[41] Under this lens, one of CAS' key challenges to the existing scholarship in international studies is 'the insistence of the endemic nature of change'.[42]

According to the perspective of CAS, innovations always derive from existing elements (see Table 1). Similar to biological reproduction and genetic recombination, social innovations are the product of recombining existing ideas.[43] Beethoven could not have invented rock and roll, not because he was not creative enough or lacked sufficient funding, but because the musical building blocks of rock and roll—blues, jazz, western and country music—were not available in the early nineteenth century. With this view it was then unsurprising that rock emerged in Memphis around the time it did, and then in turn made possible other musical genres, from heavy metal to disco.[44] Combinatory processes make music genres grow in complexity and diversity over time.

When this combinatorial view of innovation is applied to the trade regime, it implies that trade negotiators invent new legal norms by combining or refining existing norms.[45] For example, a norm calling for a broad public participation to the adoption of domestic environmental measures can be combined with a norm on the

[41] Niklas Luhmann, *Law as a Social System* (Oxford: Oxford University Press, 2004) 152 and Gunther Teubner, *Law as an* Autopoietic System (Oxford/Cambridge: Oxford/Cambridge, Blackwell Publishers, 1993). Jerald Hage 'Organizational innovation and organizational change', Annual review of sociology 25 (1999) at 597.

[42] Emilian Kavalski, Central Asia and the Rise *of Normative Powers: Contextualizing the Security Governance of the European Union, China and India* (Bloomsbury 2015) 64.

[43] See Hyejin Youn, Deborah Strumsky, Luis M.A. Bettencourt and José Lobo, 'Invention as a Combinatorial Process: Evidence from US Patents', 12(106) Journal of the Royal Society Interface (2015) at 17; W. Brian Arthur, *The Nature of Technology: What It Is and How It Evolves* (Free Press, 2009) 21. (Arthur cites Ogburn, a sociologist who provided that 'It would seem that the larger the equipment of material culture the greater the number of inventions. The more there is to invent with, the greater will be the number of inventions.')

[44]Tana Johnson, *Organizational Progeny: Why Governments are Losing Control over the Proliferating Structure of Global Governance* (Oxford: Oxford University Press 2014) 7. (In International Studies, Johnson has recently argued that several new international organizations are produced and generated by existing international organizations (UN creates UNEP, which creates IPPC, etc.) thereby creating a proliferating structure of global governance. However, Johnson does not rely on CAS and looks only at organizations' design rather than rules.)

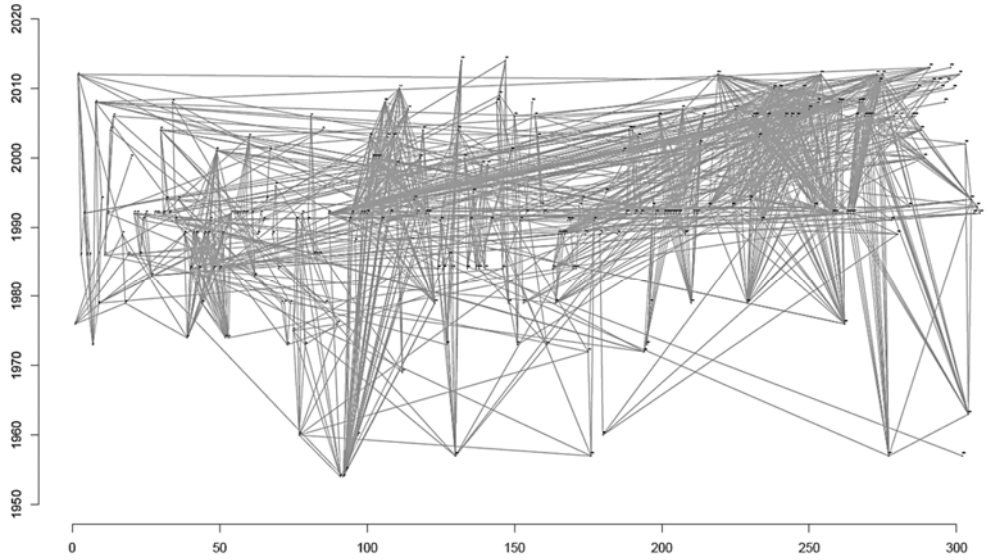
[45] Since human beings are purposeful, innovation is not a blind and random process, as the Darwinian paradigm conceptualizes biological variation. Yet, humans are not fully rational and are limited in their capacity to invent new norms. See Geoffrey M. Hodgson and Thorbjorn Knudsen, *Darwin's Conjecture: The Search for General Principles of Social & Economic Evolution* (Chicago: The University of Chicago Press 2010) 39. (As Hodgson and Knudsen noted that 'the transfer of Darwinian principles from biological to social evolution does not imply that the detailed mechanisms of selection, variation and inheritance are similar.')

regular assessment of the trade agreement's environmental impact to give rise to a norm providing for a broad public participation to the impact assessment of the trade agreement. This last norm was not included in early trade agreements because its building blocks were not available in the normative repertoire of trade negotiators of that time.

Figure 5 shows the proliferation of and interconnection between environmental norms in trade agreements. Each of the 280 norms of our dataset is represented by a node. These nodes are positioned vertically according to the time of their innovation. They are connected by edges that we call 'proximity links'. A proximity link is drawn each time when two norms either (i) concern the same specific issue-area (say, biodiversity, climate change or intellectual property; the "what" question of a norm), (ii) share a principle or underlying objective (for example, helping developing countries, increasing transparency or protecting state sovereignty; the "why" question of a norm), or (iii) rely on the same design mechanism or legal technique (for example, use of an exception or broad principle, reference to or incorporation of domestic laws or outside international agreements, joint cooperation or sanctions; the "how" question of a norm). For example, the norm on traditional ecological knowledge was linked to the norm on the role of woman in environmental protection because both rely on similar inclusive principles. The norm on traditional ecological knowledge was also linked to the norm on the equitable sharing of benefits arising from the use of genetic resources because both are thematically related to biodiversity. This family tree of legal innovation is inspired by technology networks that visualize how a combinatory process could lead to technological innovation[46]. Detecting proximity links between norms, on the basis of the three criteria we identified, is a good example of an exercise where human coding is, at least today, more appropriate than machine-run text comparison.

Figure 5: Proliferation of and Interconnection between Environmental Norms in Trade Agreements

[46] Youn *et al* (2015), above n 41.



Sources: authors.

Our empirical observations regarding the innovation rate, the innovators and the place of innovation are consistent with CAS' combinatory assumptions. First, observed innovation rates suggest that innovations enable even more innovations. Figure 1 provides that the innovation rate was very slow during the 1950s and 1960s, presumably because in these early stages there were few components to be combined. As a threshold was reached in the early 1970s, the number of innovations ascended and increased sharply. As the new innovations develop, combinatory possibilities increase.[47] In this background, some innovations occur simultaneously at different places since various trade negotiators have access to the same components to combine and innovate.[48] As the trade negotiators intensively 'explore' and innovate, the ratio of cumulated legal innovations over cumulated agreements grows steadily. At the same time, the ratio of actual innovations on potential new combinations declines, as expected by CAS' combinatory assumption.[49]

Second, when we look at who the innovators are, we find evidence that normative diversity offers fertile ground for legal innovation. If innovations result from the combination of preexisting elements, as CAS posits, we should expect that countries with direct access to existing norms are better positioned to innovate. This is exactly what we find. Innovative countries endorsed a higher amount of environmental norms

[47] Arthur, above n 43, at 164.
[48] Andreas Wagner, The Origins of Evolutionary Innovations: A Theory of Transformative Change in Living Systems (Oxford: Oxford University Press 2011) 3.
[49] Youn *et al* (2015), above n 41, at 1.

in their previous trade agreements than non-innovative countries. Countries signing innovative agreements adopted on average 39% of the existing norms at the time of signing whereas those signing non-innovative agreements adopted 21% of the norms.

Third, CAS' combinatory assumption provides that new opportunities for innovation occur where connections are made between the preexisting elements. Consistent with this expectation, trade agreements between countries that are more diverse (e.g., have a different portfolio of existing environmental norms in their pre-existing trade agreements), or between countries that negotiate a trade agreement for the first time, seem to be more innovative.[50] Moreover, plurilateral agreements, with many actors involved, include relatively more innovations. This preliminary evidence suggests that legal innovations are partly a function of the network structure and are partly endogenous.

D. Legal Innovation as Feedback

As widely recognized in the institutionalist literature, exogenous shocks and crises can provide the necessary impetus to deviate from the status quo and innovate[51]. In complex systems, change can also arise from endogenous feedbacks. In social systems, these endogenous feedbacks often take the form of learning from earlier experiences.[52] Learning links actors to their environment, and the past to the present.[53] It makes social systems highly dynamic, unstable and non-linear.

In the trade regime, learning from existing trade agreements can occur through various mechanisms, including impact assessments, academic research, intergovernmental committee activities, and dispute rulings. Of all these learning mechanisms, there is strong evidence that controversial dispute settlement rulings lead to legal innovation in new or renegotiated agreements.[54] As Pauwelyn observes,

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[50] J. Hollway, J.-F. Morin, J. Pauwelyn, *Endogenous Legal Innovation in the Global Trade Governance Complex*, Working Paper, 2017.

[51] Jeff D. Colgan, Robert O. Keohane and Thijs Van de Graaf, 'Punctuated Equilibrium in the Energy Regime Complex' Review of International Organization, 7 (2012): at 117.

[52] George Modelski, 'Is World Politics Evolutionary Learning?', 44(1) International Organization 1 (1990) at 7.

[53] Peter M. Haas and Ernst B. Haas, 'Learning to Learn: Improving International Governance', 1(3) Global Governance 255 (1995) at 269.

[54] See Pauwelyn (2014), above n 9, at 380. See also Jean-Frédéric Morin and Gilbert Gagné, 'What Can Best Explain the Prevalence of Bilateralism in the Investment Regime?', 36(1) International Journal of Political Economy 53 (2007) at 68.

disputes force countries 'to organize themselves, reconsider decisions and learn from prior mistakes'.[55]

It is worth noting that countries that are frequently involved in trade disputes are also among the most innovative. The U.S., the E.U. and Canada are most frequently involved in disputes related to environmental measures, either at the WTO or in regional dispute settlement mechanisms. They are also among the most environmentally innovative in trade agreements, as identified in Table 2 above. The U.S. has been particularly challenged for its environmental measures under the WTO dispute settlement mechanism. Of the nine GATT/WTO disputes directly related to an environmental measure, six have the U.S. as respondent[56]. The U.S. was also involved in the greatest number of environmental innovations to the trade regime.

The 'Tuna-Dolphin' dispute, for example, led the U.S to innovate. In the early 1990s, the U.S. was restricting imports of tuna products from countries that did not meet specific dolphin protection standards. Mexico considered this restriction an unnecessary unilateral protectionist measure and filed a complaint under the GATT in 1991, at a time when NAFTA negotiations were about to start. U.S. environmental groups perceived this Mexican complaint as a challenge to hard-fought 'dolphin-friendly' tuna legislation.[57] In this context, a large coalition of U.S. environmental groups, primarily the National Wildlife Federation, the World Wildlife Fund, and the Natural Resources Defense Council, pressured President Bush to address environmental concerns. Importantly, these environmental groups were actively supported by labor unions for whom environmental issues were a convenient way to denounce Mexican weak regulations and weak enforcement.[58] Under this joint pressure exerted by environmental and labor groups, Bill Clinton announced that he would not sign the NAFTA implementing bill unless side agreements on labor and the environment were concluded. Also, at the request of U.S. negotiators, NAFTA includes several legal innovations protecting the regulatory sovereignty of NAFTA

[55] Pauwelyn (2014), above n 9, at 410.
[56] For our purpose, we do not consider disputes primarily related to public health (for example the Asbestos case) to be related to the environment.
[57] Michael Strange, Implications of TTIP for Transnational Social Movements and International NGOs, in Jean-Frédéric Morin, Tereza Novotná, Frederik Ponjaert and Mario Telò (eds) *The Politics of Transatlantic Trade Negotiations: TTIP in a Globalized World* (Routledge 2016) 82.
[58] Vinod K. Aggarwal, 'U.S. Free Trade Agreements and Linkages', 18(1) International Negotiations 89 (2013) at 91.

states.[59] Taken together, NAFTA and its environmental side agreement contain the highest number of environmental legal innovations of all the 680 trade agreements analyzed.

The U.S. has continued to learn from trade disputes after the adoption of NAFTA. Several investor-state disputes relating to environmental protection occurred under NAFTA's Chapter 11 and provided new learning opportunities. These disputes include the Glamis Gold, Metalclad, Ethyl, Myers, Sun Belt, Methanex, Crompton, Clayton, St. Mary's VCNA, Windsteam, and Lone Pine cases. Following these controversial investor-state disputes, provisions related to the environment were added in the investment chapter of subsequent U.S. trade agreements, including a reference to multilateral environmental agreements, a recognition of the parties' right to exercise discretion with respect to environmental matters, and a definition of environmental law.[60] U.S. negotiators also systematically added an annex to clarify that: "[…] non-discriminatory regulatory actions designed and applied to protect […] the environment, do not constitute indirect expropriation".[61] As Jandhyala, Henisz and Mansfield have noted, these safeguards for host countries result from a better understanding of 'the legal liability and the potential costs of BIT signing', gained from the experience of controversial disputes.[62]

The U.S. is not the only actor to have turned learning from trade disputes into legal innovations. An interesting case is the dispute opposing Austria to the European Commission before the European Court of Justice. Austria adopted legislation in 2003 restricting lorries of over 7.5 tons and carrying certain goods from driving on a section of the A12 motorway to protect the quality of the ambient air. In 2005, the European Court of Justice found this restriction to be equivalent to a quantitative restriction to trade that could not be justified under environmental grounds since the

[59] See also Richard H. Steinberg, 'Trade-Environment Negotiations in the EU, NAFTA, and WTO: Regional Trajectories of Rule Development', 91(2) The American Journal of International Law 231 (1997) at 245.
[60] Gilbert Gagné and Jean-Frédéric Morin 'The Evolving American Policy on Investment Protection: Evidence from Recent FTAs and the 2004 Model BIT' Journal of International Economic Law 9 (2006) at 382.
[61] E.g. TransPacific Partnership Annex 9-B 3(b)
[62] Srividya Jandhyala, Witold J. Henisz and Edward D. Mansfield, 'Three Waves of BITs: The Global Diffusion of Foreign Investment Policy', 55(6) The Journal of Conflict Resolution 1047 (2011) at 1056.

aim pursued could be achieved by less restrictive means.[63] A few months later, the 2006 Albania-E.U. Stabilisation and Association Agreement introduced an unprecedented provision stating that 'exceptional national standards [on gaseous and particulate emissions for heavy goods vehicles] should be avoided' and 'vehicles which comply with [international environmental standards] may operate without further restriction in the territory of the parties'.[64] These examples show how the trade CAS throws up novel disputes that it must then resolve itself in new ways, thereby driving innovation.

Analyzing the trade regime as a CAS does not rule out the possibility that exogenous factors, such as the conclusion of new multilateral environmental agreements or the election of new governments, can explain particular innovations. Complex systems remain open to their environment and co-evolve with adjacent systems. However, we find evidence suggesting that at least some legal innovations arise endogenously from the trade system. The next section argues that endogenous processes also appear to drive the adoption of these innovations.

IV. EXPLOITATION: ADOPTION OF EXISTING ENVIRONMENTAL NORMS IN TRADE AGREEMENTS

Innovation can be costly: it can be risky, potentially exacerbating the problem or creating new problems that are difficult to anticipate; it can be expensive to successfully identify and introduce innovative legal norms; and it can be inefficient to search for novel solutions where a wide and diverse pool already exists. Therefore, it can be considerably less risky, less expensive, and more efficient to utilize norms already in circulation.

Thus, while trade negotiators continue to innovate, the rate of innovation per agreement has declined. For example, while the recent TPP may be the "greenest" trade agreement ever, with no less than 136 different environmental norms, only two of these were really new (on the prevention of environmentally harmful subsidies).

[63] Commission of the European Communities v Republic of Austria Case C-320/03 15 November 2005.

[64] Statibilisation and Association agreement between the European Communities and their Member States, of the one part, and the Republic of Albania of the Other, 12 June 2006, Protocol 5 on land Transport Article 15

The other 134 were copied from pre-existing trade agreements[65]. Another recent example, CETA, includes only one innovation amongst 114 environmental norms (an exclusion of water from its scope). What these two examples point to is the increasing use of existing norms as opposed to innovating new ones.

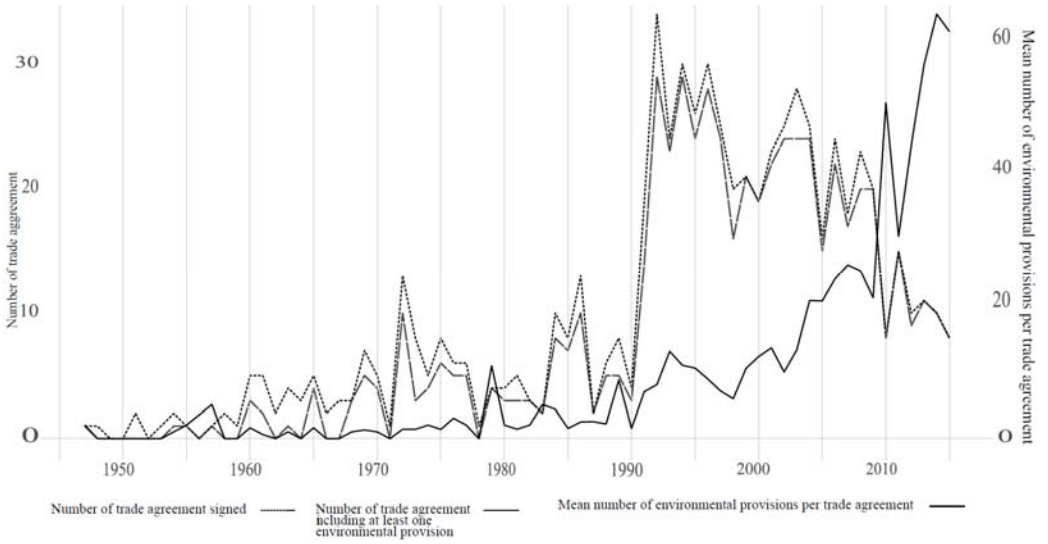
Notwithstanding the absence of central coordination in the trade system, the spread and similarity of environmental norms in the "spaghetti bowl" of trade agreements is striking. This references the feature of CAS of an emerging order in the absence of centralization. The homogenization of the trade system is the result of at least two processes: one operating on norms and one operating on agreements. First, order is achieved by some individual environmental norms being used in most trade agreements. Second, order is achieved by some groups of environmental norms being used across trade agreements.

A. Adoption of Individual Norms

Environmental norms are increasingly found in trade agreements. As Figure 6 shows, almost every recent trade agreement signed includes at least one environmental norm. Moreover, the average number of environmental norms found per agreement has steadily increased. The average amount of environmental norms in trade agreements was only 2 in 1947 but grew to 63.7 in 2014. Of all trade agreements concluded since 2005, 70.4% include at least ten different types of environmental norms.

Figure 6: Growth of PTAs and Environmental Norms per PTA by year (1950 – 2010)

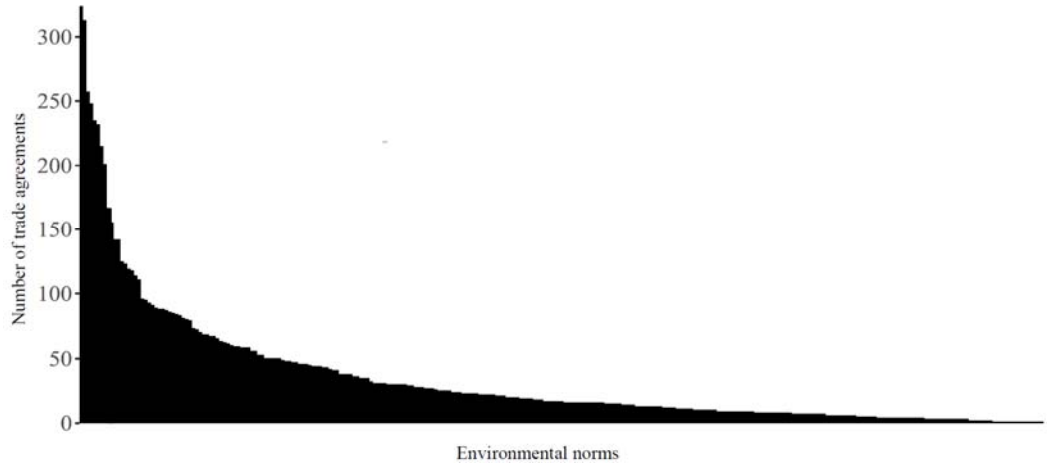
[65] See also Todd Allee and Andrew Lugg 'Who Wrote the Rule for the Trans-Pacific Partnership?' Research and Politics 2016, 1-9. Todd Allee and Manfred Elsig 'Are the Contents of International Treaties Copied-and-Pasted? Evidence from Preferential Trade Agreements' World Trade Institute Working Paper no 8, 2016.



Source: authors.

However, while environmental norms are becoming more common in trade agreements, some environmental norms appear more than others. In fact, most environmental provisions can only be found in a few trade agreements. For example, the common but differentiated responsibility principle, the obligation to ratify the Kyoto Protocol and the use of geographical indications to protect the environment are only found in the EU's trade agreements. Similarly, only in the US' trade agreements do we find the possibility to have a suspension of trade concessions when a country does not provide monetary compensation for failure to comply with its own environmental laws. As Figure 7 shows, only 18 environmental norms are found in more than 100 trade agreements.

Figure 7: Growth of Environmental Norms in Trade Agreements



Source: authors.

At first, this might suggest that there is little order to the trade regime CAS. Most innovations are not widely adopted. But the top 10 most reused environmental norms, shown in Table 3, appear in approximately a quarter to half of all trade agreements.

Table 3: Top 10 Most Reused Environmental Norms

Environmental Norm	Trade Agreement where the Norm first appeared	Number of Trade Agreements that include the Norm
1. Exception for the conservation of natural resources	GATT 1947	323
2. Exception for the life of animal or plant (without necessity condition)	Canada Portugal 1954	312
3. Other reference to international environmental institutions	Treaty of Rome 1957	256
4. Exception for measures necessary to protect the life of animal or plant	GATT 1947	247
5. Right to apply TBT measures related to the environment	Tokyo Codes 1979	234
6. Right to derogate from the regular adoption procedure of a TBT measure in case of environmental emergency	EFTA 1960	231
7. Prevalence of an environmental agreements (other than main MEAs) in case of incompatibility	Treaty of Rome 1957	214
8. SPS measures and the environment	NAFTA 1992	200
9. Commitment to implement an environmental agreement (other than main MEAs)	Finland Poland 1976	166
10. Vague commitments to cooperate on environmental matters	European Community and Algeria 1976	154

Source: authors.

Several factors can explain why some norms are more widely adopted than others, including the relative power of their initial proponents and the number of parties to the agreement that first introduced the innovation.[66] But one important contributing factor seems to be the time of innovation. As Table 3 suggests, most of the widely reproduced norms were first introduced in the early days of the modern trade regime. Innovations introduced by the GATT in 1947, for example, remain

[66] Dominique Bruhn, Jean-Frédéric Morin, Clara Brandi and Axel Berger, 'Diffusion of Environmental Norms through Trade Agreements: Evidence of the Provision-level'.

among the most widely adopted norms in the trade system. These initial innovations have long-term impacts.

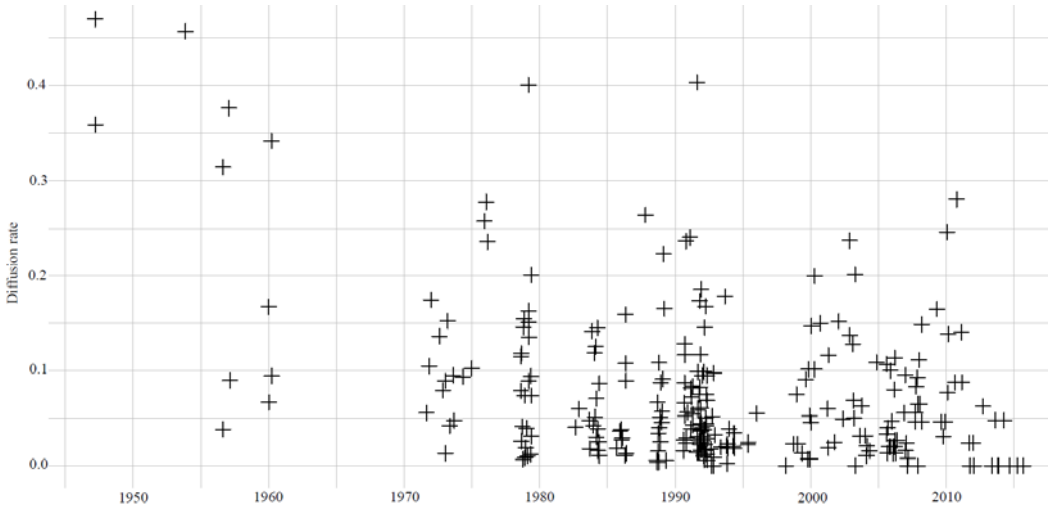
Such sensitivity to primary conditions is typical of CASs. Since positive feedbacks generate increasing returns, relatively minor choices between norms at early stages can cause these norms to accumulate an advantage in popularity over other norms. This is referred to as path dependency, the butterfly effect, preferential attachment, or the Matthew Effect. This can explain why a relatively minor exception for the conservation of exhaustible natural resources became the most widely adopted norm in the trade system, now found in at least 323 trade agreements: it was introduced early in the evolution of the system, in 1947 with the GATT. As Pauwelyn explains:

> Once a product, contract clause, BIT phrase or FTA approach has become the dominant standard in the market … the accrued network externalities [e.g. positive effects linked to many actors using the same standard, think of electric plugs or internet connectivity protocols] give it an important edge over newly introduced innovations, even innovations that are clearly better. Applied to networks linked together by commonly used complementary legal provisions or treaties, the 'excess inertia' of widely used treaty or contract clauses—think of the phrases 'fair and equitable treatment', 'national treatment' or particular formulations of an umbrella clause—essentially derives from a search for predictability with network externalities reducing uncertainty.[67]

Of course, norms introduced early have had more opportunities of adoption than more recent innovations, as more trade agreements were adopted following their introduction. To take this into account, we calculated the "adoption rate", which is obtained by dividing the times that a norm has been adopted after its first introduction by the number of agreements signed since its introduction to the trade regime CAS. This rate is plotted over time in Figure 8. It shows that the older innovations have a higher adoption rate than recent ones, even when we take into account the number of opportunities for a norm to diffuse in agreements adopted after its introduction. This suggests that early norms have a distinct advantage.

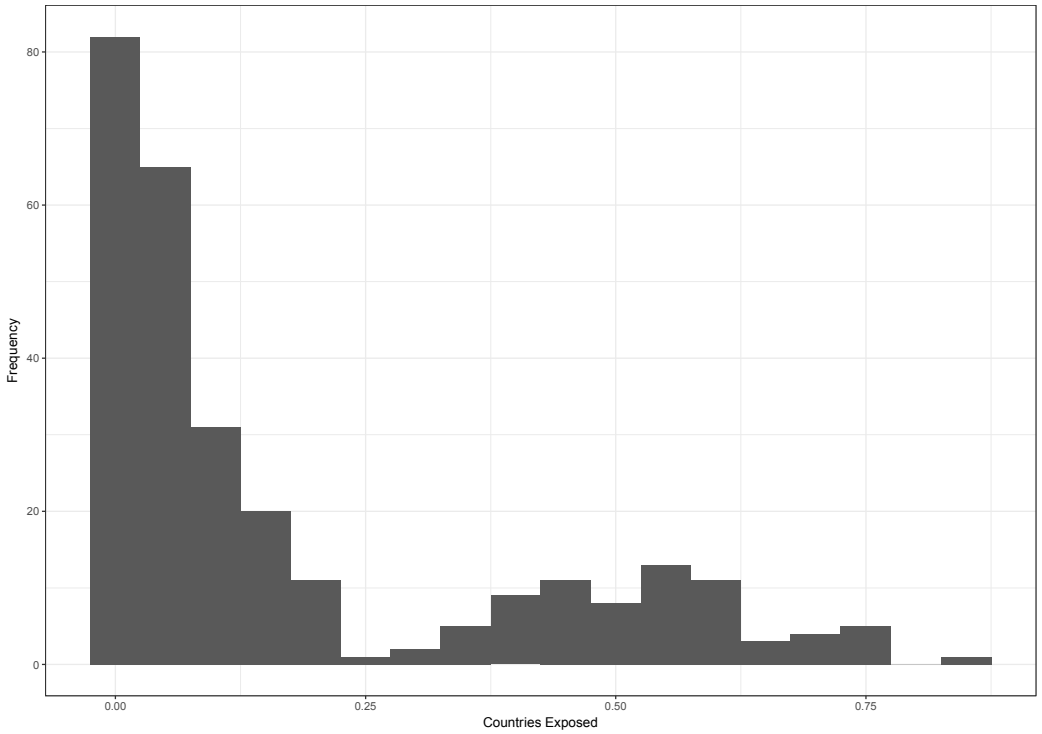
Figure 8: Adoption Rate of Environmental Norms Over Time

[67] Pauwelyn (2014) n 8, at 414.



The most widely adopted norms impose some order on the trade regime CAS through their popularity. Their generality suggests some environmental norms have been consolidated into the trade negotiator's repertoire. Indeed, Figure 9 plots how many norms are exposed to what proportion of countries in the system. After all, a single plurilateral or multilateral agreement covers a wide number of countries; countries that may not need to incorporate that norm into further trade agreements. It shows that while many norms have not been adopted by many countries, a considerable number of environmental norms are exposed to about half the state system. This is indicative of some order spanning a good section of the system.

Figure 9: The Adoption of Environmental Norms Across Countries



B. Adoption of Sets of Norms

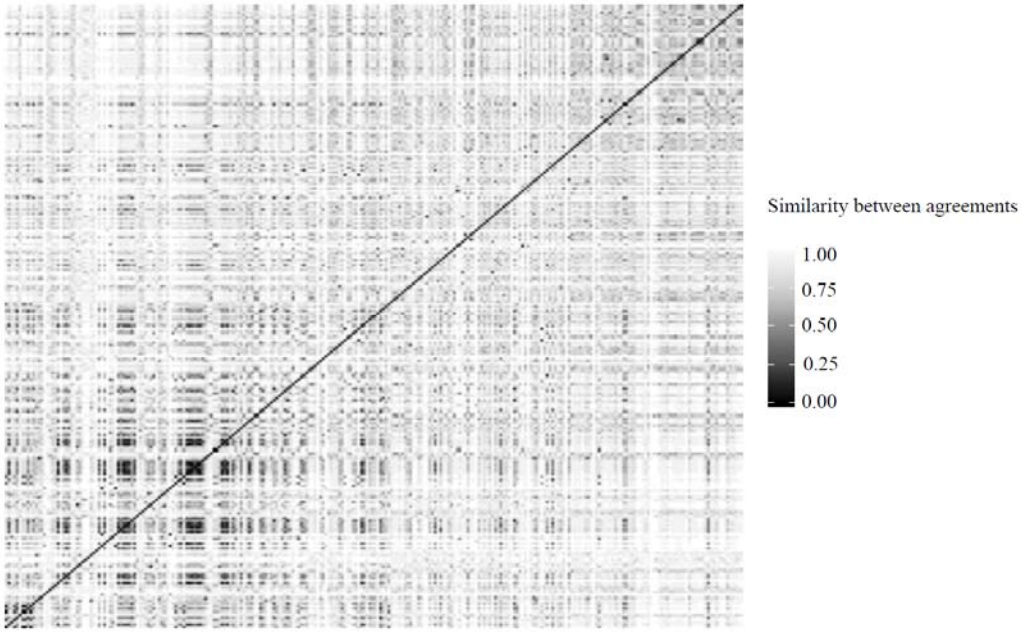
It is not only individual norms that are selected from the pool to mitigate the costs of innovation, but sometimes whole sets of environmental norms. The proliferation of institutions offers negotiators strong incentives to favor isomorphism.[68] By duplicating standardized agreements, negotiators can rationalize their limited resources when they are engaged in simultaneous negotiations. They can assert their authority as experts by concealing their uncertainty as well as reduce transaction and management costs arising from the supervision of several agreements. This may explain why several countries or customs unions have designed template or boilerplate PTAs from which they appear reluctant to deviate.

We can observe this commonality in sets of norms in Figure 10, which provides a heat map of the overlap in environmental norms between trade agreements ordered chronologically along the *x* and *y* axes. The light gray hue at the top left and bottom right corner is associated with higher Jaccard distance measures, suggesting a

[68] Paul J. DiMaggio and Walter W. Powell, 'The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields', 48(2) American Sociological Review 147 (1983) at 156.

considerable disparity between more recent and older agreements. Figure 10 shows that agreements tend to resemble other agreements of their time; that there are trends in institutional design.

Figure 10: Heat Mapping of the Similarity of Trade Agreements by year



Source: authors.

Characteristics of recent PTAs are strong predictors – perhaps even better than power asymmetry and countries' economic properties – of the features of agreements that follow.[69] This is because previous PTAs that are perceived as successful are considered good benchmarks from which to begin negotiations and can even introduce a status quo bias. The consequence for the system though is order. The adoption of whole sets of environmental norms from one agreement to another generates a local form of order as sets of agreements converge to isomorphic forms.

We expect this templating strategy to be increasingly used. As the landscape of environmental norms in trade agreements is expanding exponentially, it becomes less necessary to explore uncharted territories compared to the relatively low costs and positive network externalities of exploiting the known landscape. Trade negotiators face reduced incentives to explore new possibilities where sufficient solutions exist.[70]

[69] See Chen and Joshi, above n 20, at 239; Brandon J. Kinne, 'Network Dynamics and the Evolution of International Cooperation', 107(4) American Political Science Review 766 (2013) at 766.
[70] Youn *et al*, above n 39, at 5.

The E.U., for example, has moved from an eclectic to a highly standardized approach.[71] Until 2008, the E.U. adjusted the environmental provisions in its PTAs to the political, economic and ecological context of its trade partners. However, more recent E.U. trade agreements systematically include a chapter on sustainable development, which evolves only incrementally from one negotiation to the next. While this one-size-fits-all strategy is what the U.S. has been doing since NAFTA, the standardization of trade negotiations is relatively new for the E.U.

The landscape of environmental norms in trade agreements is constantly expanding and becomes more intensively exploited, with neither an endpoint nor any final resting point. As the example of environmental provisions illustrates, the trade regime seems to grow as any other CAS. Evolution at the edge of order (adoption) and chaos (innovation) increases the normative development of the trade regime.

V. CONCLUSION

We have argued that the trade regime can be usefully conceived of as a complex adaptive system. Not only does it have the features of a CAS – multiple heterogeneous elements, no central coordination, interdependency, simple rules of operation, a multiscalar structure, and openness – but adopting a CAS perspective provides a rich view of its evolution. It points to a system that creates its own, nonlinear opportunities for exploration and exploitation beyond simply the influence of exogenous pressures and crises.

We illustrated the interest of a CAS view by looking at the innovation and adoption of environmental norms in the trade regime. These norms and their presence in trade agreement texts were identified by relying on human coding[72]. This is because the same legal norms can be expressed in different ways that computers cannot yet recognize well. That said, the text segments coded for each of our 280

[71] Jean-Frédéric Morin and Myriam Rochette, 'Transatlantic Convergence of PTAs' Environmental Clauses'; Sikina Jinnah and Elisa Morgera, 'Environmental Provisions in American and E.U. Free Trade Agreements: A Preliminary Comparison and Research Agenda', 22(3) *Review of European Community and International Environmental Law* 324 (2013) at 337.

[72] Morin, Dür and Lechner, above n 1.

different categories of environmental norms could be used for training a parser to recognize specific and ambiguous norms in the future.

We argued that it is useful to view the trade regime as a CAS because it highlights endogenous, self-generating processes underlying the contemporary regime's complexity. Legal innovation, it seems, partly emerges out of opportunities in the structure of the system itself. Though legal innovation is influenced by exogenous factors, it seems also affected by endogenous forces, such as the recombination of existing legal building blocks and learning from the experience of earlier agreements and past disputes.

We also argued that, as this pool of environmental norms used in trade agreements increases through innovation, actors turn to strategies of exploitation to reap benefits while curtailing costs associated with innovation. Such strategies can include choosing individual norms "off-the-shelf" as required following a mechanism of preferential attachment. This is corroborated by some environmental norms becoming particularly popular in their employment in trade agreement texts. Other strategies include templating or boilerplating, in which whole groups of environmental norms are ported from one agreement to another. This is preliminarily evidenced in the similarity in the selection of environmental norms across actors and across time.

The aim of this article was to explore what can become a programmatic research agenda on the trade complex system. In doing so, we have identified exploration and exploitation as two broad themes for this research program. We have also highlighted how the growth of the trade system may be driven by endogenous innovation and path dependent adoption. However, specific hypotheses still need to be formulated and tested against other explanations to understand the micro-processes that drive the macro-outcomes observed here.

It might be useful in a first step of this research program to separate research on innovation and on adoption. Among the research questions that concerns the former line of inquiry are 1) Where is innovation more likely to occur in the network of trade agreements?; 2) What systemic factors facilitate learning from past experiences?; 3)

What makes two existing legal norms more likely to be combined to generate a legal innovation?; and 4) Why do innovation rates fluctuate over time? CAS-informed questions regarding adoption within the trade regime complex include: 1) What system-level factors make norms more likely to be adopted?; 2) What are the interactions between the adoption of single norms and the adoption of sets of norms?; 3) How does the co-existence of different templates affect their adoption patterns?; and 4) Why do adoption rates fluctuate over time?

Yet, perhaps the most interesting – but also most difficult – research questions concern the interactions between innovation and adoption: 1) Do the conditions that give rise to an innovation affect its subsequent adoption? 2) Is there a structural explanation as to why some countries rely more on innovation while other rely more on adoption? 3) How does the innovation rate relate to the adoption rate? 4) What are the micro-processes that balance innovation and adoption? This battery of questions drawn from the programmatic and preliminary work done here demonstrates the promise of a CAS lens to inspire new avenues of research to explore, which we hope researchers will exploit.