

Article

Role of Law, Position of Actor and Linkage of Policy in China's National Environmental Governance System, 1972–2016

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Abstract: China is struggling between accelerating environmental protection and accelerating environmental damage. Although the central government is investing extensively in environmental laws and policies, China's annual environmental goals have hardly been achieved. What is often poorly recognized by top decision-makers is that the environmental governance system is so complex that multiple elements, including laws, policy items, actors and issues, have become intentionally or emergently entangled. Without knowing the roles, positions and interconnections of the system elements, it is difficult for people to find the critical points for further improvements. Taking this challenge, this research conducts a retrospective analysis on the developmental trajectory of China's environmental governance. The analysis helps us to pinpoint the role of law, the position of actor, and the linkage of policy that promote or prevent environmental protection; it can also question or reaffirm the effectiveness of the environmental laws and policies, and thereby aid China's future prognosis and some recommendations.

Keywords: environmental governance; environmental policy; complex system; policy network; China

1. Introduction

Since the Open-Door Policies in 1978, China has experienced a rapid economic growth at an average rate of 10% per annum. Not only has the country's fast expanding economy become more powerful, with GDP rising from 3.36 trillion yuan in 1978 to 74.41 trillion yuan in 2016, but also individuals on average have become richer, with GDP per capita increasing from 379 yuan to 54,000 yuan during the same period. (The information is obtained from National Bureau of Statistics of China: <http://www.stats.gov.cn/>.) The strength of China's economy has managed to survive the 1997 Asian Financial Crisis and to recover very quickly from the 2008 Global Financial Crisis [1].

Despite successive economic growth and higher per capita income, there is stronger anxiety among the top political leaders, because, accompanying economic growth, China is facing increasing global pressures on the issue of being the top greenhouse gas emitter in the world. Simultaneously, China is confronted with growing public discontent as the environmental pollution is increasingly harming people's health [2]. Serious environmental problems faced by China include water (including drinking source and ocean) and air pollution, garbage accumulation, biodiversity losses, deforestation, soil erosion, grassland degradation, salinization, disappearing wetlands and increasing frequency of human-included natural disasters [3,4].

The Chinese central government, including its ministries and commissions, are aware of these environmental problems and have tried to tackle them. Since the first event, in 1972, the National Planning Commission and the State Construction Commission launched a policy on mandating industrial factories to install pollutant treatment device before production. China has already

issued nearly 400 legislative terms and policy measures to combat environmental problems by 2016. Milestones include the following. In 1972, China sent a delegation to the First United Nations Conference on Human Environment. In 1973, a Leading Group for Environmental Protection was established, which evolved in 1988 into the State Environmental Protection Administration, in 1998 became the State General Environmental Protection Administration, and in 2008 became the Ministry of Environmental Protection. China declared environmental protection as a basic national principle in 1977 by adjusting its Constitution. In 1996, China formulated its first five-year plan on environmental protection. In 2003, the central government proposed a new development concept, “Scientific Development and Social Harmonization”, emphasizing sustainable and harmonious development between man and nature [3,5]. In 2005, China issued the Renewable Energy Law. In 2008, China had its Circular Economy Promotion Law published. In 2013, China published its first Action Plan for Air Pollution Prevention, which evolved into the adjustment of Air Pollution Prevention and Control Law with the strictest air pollution standards in 2015.

Although the central government invested extensively in environmental legislation and policy formulation, it has not been successful in preventing overall deterioration of environmental quality. China’s annual environmental goals are not achieved. In 2016, for instance, 85.1% of the Chinese cities did not reach the air quality standard; 32.2% of the surface water was highly polluted; heavy metal and organic pollutant emissions exceeded 36.6% of the standard level; and 55.1% of the county areas suffered serious ecological destruction [6].

In China’s environmental governance, what is often poorly recognized by decision-makers is that legal and policy institutions are complex systems [7]. Complex systems are characterized by a diversity of system elements that are related and interact with one another, producing a pattern, a product or an outcome of many different processes and nonlinear dynamics [8,9]. The diverse system elements in environmental governance (see Tables S1–S3 in Supplementary Materials), including legislations (e.g., laws), policy instruments (e.g., regulatory, market-based and voluntary instruments) and actors (e.g., legislatures, bureaucracies, and agencies), are interconnected through commonly faced environmental issues. The introduction, adaptation and termination of any piece of policy will arouse changes on the functioning of other policies. Without systematic attention being paid to environmental governance, or unknowing the mechanisms by which the system elements are getting entangled with one another, despite the large volume of policies, policy targets are hard to achieve.

Drawing on a combination of methods such as the longitudinal research approach, the event sequence analysis method and the graph theory, this article analyzes China’s national environmental governance from a complex system angle. The article aims to answer the following research questions: What are the roles of the environmental laws, and which laws are the most influential in environmental governance? What are the positions and interconnectedness of actors involved in environmental governance? How do the environmental laws and policies interplay and evolve overtime? The analysis attempts to open the “black box” of environmental governance system, and pinpoint the roles of the system elements in steering policy trajectory; it also promotes further reforms of China’s environmental governance.

2. China’s National Environmental Governance System

As briefly mentioned in the Introduction, an environmental governance system may contain diverse elements of environmental laws, environmental policy instruments and various actors involved in environmental governance. In this section, before exploring their complex relations, we first present and clarify the system elements in China’s national environmental governance.

2.1. Environmental Laws

The oldest “events” of environmental governance can be traced back to the late 1960s when the first wave of environmental legislation commenced and high-level government agencies were established in Europe and the United States [10]. Later, environmental laws have greatly increased,

not only in industrialized countries but also in developing countries around the world. These laws draw attention to interventions aiming at establishing, reaffirming and changing institutions to resolve conflicts over environmental resources, and to hold public and private entities accountable for environmental harm [11,12]. Often, these laws take the form of general principles and serve as legal basis and overarching framework in designing and selecting different types of policy instruments [13]. Therefore, environmental laws are one type of element in environmental governance system that we distinguish, and they include the initiation, formulation and adaptation of legal rules as the starting points for different policy instruments of environmental protection to emerge and develop.

China's environmental laws during 1972–2016 are summarized in Table 1. As can be seen, during the socialist period (1972–1978), very few laws were introduced, only that the Constitution of China was amended by including environmental protection as a basic national principle. The economic reform period (1978–2000) witnessed more generation of environmental laws, mainly concentrating on basic laws in different sectors of marine, water, air, forest, mining, and soil. The development of environmental laws in the rapid economic growth period (since 2000) emphasizes stricter standards in environmental protection, and the role of energy-saving and renewable energy usage in sustaining economic development [14].

Table 1. A summary of China's environmental laws.

Year	Name of Law
<i>The socialist period (1972–1978)</i>	
1977	The Constitution of China was amended by writing: “the State protects the environment and natural resources against pollution and other damage”
<i>The economic reform period (1978–2000)</i>	
1979	Environmental Protection Law (trial)
1982	Marine Environmental Protection Law
1984	Water Pollution Control Law
1984	Forest Law
1986	Mineral Resources Law
1987	Air Pollution Control Law
1989	Environmental Protection Law (formal)
1990	Soil and Water Conservation Law
1995	Solid Waste Pollution Prevention and Control Law
1997	Energy Conservation Law
1998	Forest Law (amendment)
<i>The rapid economic growth period (since 2000)</i>	
2000	Air Pollution Prevention and Control Law (amendment)
2001	Sand Control Law
2002	Government Purchasing Law, which stipulates that environmentally friendly products have priority in governmental purchasing
2002	Clean Production Promotion Law
2002	Water Law
2002	Environmental Impact Assessment Law
2004	Solid Waste Pollution Prevention and Control Law (amendment)
2005	Renewable Energy Law
2007	Energy Saving Law (amendment)
2008	Water Pollution Prevention and Control Law (amendment)
2008	Circular Economy Promotion Law
2014	Environmental Protection Law (amendment), which proposes the strictest environmental pollution standards
2015	Air Pollution Prevention and Control Law, which proposes the strictest air pollution standards
2016	Energy Saving Law (amendment)

2.2. Environmental Policy Instruments

Scholars distinguish four types of policy instruments in China's environmental governance [4,15–18].

(1) Regulatory policy instruments

One policy instrument is the command-and-control approach to environmental governance. It is the earliest developed instrument that emphasizes direct regulation: the public authorities prescribe uniform environmental standards across large regions, mandate the abatement methods required to meet such standards, license production permits to firms that adopt the required methods, and assure compliance through monitoring and sanctions [19]. The advantage of the command approach is that, by imposing fixed standards, the government can mobilize various resources and respond directly and rapidly to environmental pollution activities. However, deregulatory policies claim that imposing uniform reduction standards ignores the variable pollution abatement costs facing individual firms; and that the government agencies are facing substantial costs incurred by monitoring and enforcing targets set by regulatory measures [20]. Despite this criticism, it is a fact that the regulatory instruments still continue today and play a major role in environmental governance [21].

(2) Market-based policy instruments

The economic inefficiency, ineffectiveness and costliness of monitoring of the command approach have led to a search for alternative policy instruments. Consequently, deregulatory policies were considered increasingly attractive [22]. Since the 1990s, a wide range of market-based instruments have been employed around the world, which include different types of environmental taxes and charges, the use of tradable pollution permit schemes, subsidies, and deposit and refund programs [23,24]. In this article, we define these instruments as market-based actions, which are important to “get the prices right” and therefore evoke environmental friendly behavior of individual consumers and producers by affecting their costs and benefits of consumption and production in such ways as to promote the use of processes and products which are less damaging to the environment [25].

(3) Voluntary policy instruments

The adoption of the market-based instruments as exogenous incentives to consumers and producers may be not sufficient for inducing environmental friendly behavior. Thereafter, voluntary, or self-regulatory instruments are increasingly used by worldwide governments to create endogenous incentives to increase environmental awareness and responsibility of consumers and producers [26]. These voluntary policy instruments may include, for example, eco-labeling, eco-audits, voluntary agreements on pollution reduction and environmentally friendly certificates. Obviously, voluntary instruments require less government expenditure on monitoring and enforcement, thus reducing both financial and human resource burden of public authorities. However, it is a challenge to encourage firms to actively participate into these voluntary programs. Scholars find that firms only participate if they need the certificates to join in some industrial group membership, or they find themselves increasingly dependent on or involved in a “green” supply chain [27].

(4) Macro-level guiding policy instruments

In addition to the regulatory, market-based and voluntary policies, there are macro-level guiding policies on environmental governance. These policies do not aim at a particular type of policy instruments, and only play a role in improving the awareness of individuals and industries to protect environment, and/or in raising the accountability of governmental organizations for environmental governance [5]. Examples of such policy instruments are the Decisions on Strengthening Environmental Protection during National Economic Reforms, and the Countermeasures of Environment Protection and Economic Development. In this research, therefore, we include such general policies as macro-level guiding policy instruments [28].

2.3. Actors Involved in Environmental Governance

Key actors in the environmental governance at the national level in China include the National People's Congress (NPC), the State Council (SC) and the Communist Party of China (CPC). The NPC is the nation's top legislative body with the highest authority. The SC, i.e., the central government, is the leading administrative unit responsible for implementing laws and enacting policies. The CPC exerts influence on the governance process by controlling political personnel system in governmental organizations [28]. Under the SC, several ministries and commissions are currently associated with environmental governance. Table 2 provides an explanation of their responsibilities in environmental protection.

Table 2. Actors involved in environmental governance at the national level.

Actor Name	Actor Responsibility
National People's Congress (NPC)	Enacting environmental laws.
State Council (SC)	Formulating macro-level national development plans and environmental regulations and guidance.
Communist Party of China (CPC)	Setting environmental targets and controlling political personnel system in governmental organizations based on target performance.
National Development and Reform Commission (NDRC)	Setting the right price for industry operation, and reconciling goals of economic development and environmental protection.
Ministry of Environmental Protection (MoEP)	Preventing and controlling environmental pollution, protecting nature and ecology, safeguard environmental safety.
Ministry of Housing and Urban-Rural Construction (MoHURC)	Conducting environmental impact assessment for construction projects.
Ministry of Commerce (MoC)	Encouraging industries to innovate and apply environmental protection technologies, adopt cleaner production processes and promote green supply chain development.
Ministry of Industry and Information Technology (MoIT)	Encouraging industries to innovate and apply environmental protection technologies, adopt cleaner production processes and promote green supply chain development.
Ministry of Science and Technology (MoST)	Encouraging industries to innovate and apply environmental protection technologies, adopt cleaner production processes and promote green supply chain development.
Ministry of Land and Resources (MoLR)	Resource protection and ecological compensation.
National Energy Administration (NEA)	Promoting energy-saving and the usage of renewable energies.
Ministry of Transport (MoT)	Reducing environmental pollution sourced from transportation and promoting new energy vehicles.
General Administration of Quality Supervision (GAQS)	Giving support to the MoEP for the formulation of environmental quality standards.
Inspection and Quarantine (GAQSIQ)	Giving support to the MoEP for the formulation of environmental quality standards.
Ministry of Finance (MoF)	Providing financial incentives to enterprises to adopt environmental friendly products and processes.
State Administration of Taxation (SAT)	Providing tax incentives to enterprises to adopt environmental friendly products and processes.
Ministry of Supervision (MoS)	Holding public officials accountable for environmental enforcement and sanction.
People's Bank of China (PBC)	Providing financial incentives to enterprises, including green credit, green securities and environmental liability insurance.
China Banking Regulatory Commission (CBRC)	Providing financial incentives to enterprises, including green credit, green securities and environmental liability insurance.
China Securities Regulatory Commission (CSRC)	Providing financial incentives to enterprises, including green credit, green securities and environmental liability insurance.
China Insurance Regulatory Commission (CIRC)	Providing financial incentives to enterprises, including green credit, green securities and environmental liability insurance.

3. Materials and Methods

The methods that we apply in this research are inspired by longitudinal research approaches developed in sociology [29,30] and organizational innovation and change [31]. Longitudinal studies

focus on revealing the developmental process/trend of an entity over a long period of time, often many decades [32]. In this study, we employ the longitudinal approach to trace the evolution of environmental laws and policies, as well as the changes of roles of actors over time.

To operationalize the longitudinal study, we apply the Event Sequence Analysis (ESA) method, which is developed by Spekkink and Boons [33]. The fundamental components of the ESA method are “events” and “event sequences/ties”. Events can be anything that occurs in a certain place during a particular interval of time. If events are launched by certain actors, the events usually carry particular purposes and are expected to arouse changes. Event sequences concern the relations of the events in time matters. One event may lead to several diverging continued events. It may also be possible that several preorder events converge and contribute to the emergence of new events. Therefore, it implies that an event sequence can also be understood as an event network with a time order.

To use the ESA method, the first step is to define the typology of events to be studied. This involves the identification of relevant types of events. In this study, the system elements in environmental governance in Section 2 are used as the guidelines for searching events, as well as the actors associated with the events. The second step in the ESA method is to specify how the events are linked to each other in sequences. This study adopts two judgement criteria for linkage of events: government documents that explicitly indicate some particular events as the decision basis of other events; and news reports that have revealed the source events of something’s happening.

The time span of the events in this study is a period of more than five decades from 1972 to 2016. The events are recorded in Event Sequence Datasets developed by Poole et al. [31] and Spekkink and Boons [33]. Each event has a time stamp calculated from the time point it occurred, a brief qualitative description of actions and interactions, the actors involved, the type of action and the pre-conditional events for its occurrence.

The data collection process started in January 2017 and ended in May 2017. Three researchers were collecting the event data at the same time, and then synthesized the data to cross-check any missing events in individual collection. Finally, we collected 357 events (1121 intentional and emergent linkages) as national legislative and policy actions for environmental governance.

Our sources of data include web pages, media reports, academic papers, various types of documents produced by the actors involved in the environmental governance in China. The main webpages we searched include open information platforms of each involved governmental organizations (see Table 2). In addition, we used “baidu.com” as the main search engine to find webpages outside the governmental organizations. For media reports and academic papers, we used “CNKI.net” to collect event data. CNKI (China National Knowledge Infrastructure) contains information generated from scientific research, newspapers, conferences and statistics yearbook. For the government documents, we went to the electronic resource platforms of the archives for the past decisions made as to environmental management. The total event datasets can be found in the second part of the Supplementary Materials.

To visualize and explore the developmental trajectory of environmental governance, we also adopt the graph theory that pays more attention to the relations between system elements and roles of the elements in driving the developmental trajectory. This study adopts three types of graph. The first type is called “event graph”, which is a directed graph in which the nodes represent events and the edges represent relationships between events. The horizontal layout of the nodes is based on the time of occurrence of their corresponding events. Figure 1 is an example of an event graph. For example, if we find an event (E1) where a law is enacted to combat air pollution becomes the basis/condition for policies (E2 and E3) to occur, we draw a link between Event 1 and Event 2, and another link between Event 1 and Event 3. The second type is called “two-mode network graph”, in which the nodes represent either actors or issues of environment governance (distinguished by different colors) and the edges represent which actors are involved in which issues (see Figure 2 for an example). The third type is called “three-mode network graph”, in which the nodes represent either actors, issues, or laws/policies (distinguished by different colors), and the edges represent which

actors are involved in which laws/policies, and which issues are touched upon by which laws/policies. In the three-mode network graph, to reveal the interconnection of the environmental laws/policies, we adopt two types of linkages [33]. One is “intentional” linkage between laws/policies, meaning that a connection/dependence exists between two laws/policies if one law/policy uses the other as reference or become a condition for the other. The second is “emergent” linkage between laws/policies, meaning that two laws/policies are not connected by an intentional link but they are relevant in the sense that they address the same environmental issues or they are formulated by the same actors. Accordingly, the intentional linkages indicate the evolutionary pathway of laws/policies; and the emergent linkages reflect the similarities between two laws/policies that are not intentionally designed but face the common issues and involve the common actors (see Figure 3 for an illustration).

We visualize the graphs using Gephi software. This technology can help us to perform a series of analyses on the graphs. In this study, we performed a network density analysis and a centrality analysis to reveal the critical system elements driving the developmental trajectory. In addition, the network layout plugin and the algorithm of the software itself can help us to display the longitudinal process in time order and categorize events into different groups, which provide us with indication on the mechanisms of policy interplay. Table 3 provides a summary of our research questions and the approaches and indicators that are used to answer the questions.

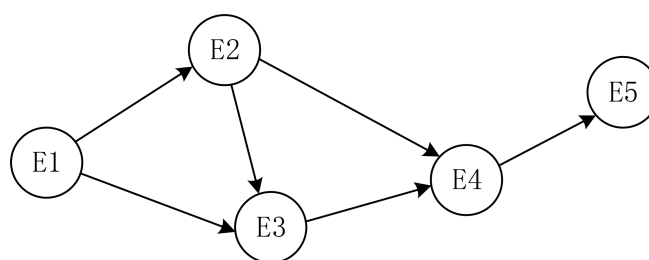


Figure 1. An illustration of an event graph.

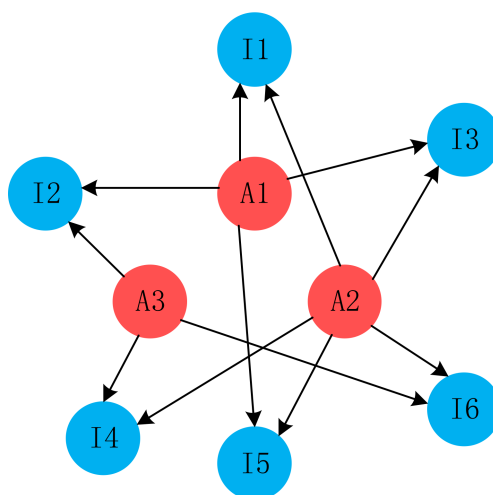


Figure 2. An illustration of a two-mode (actor and issue) network.

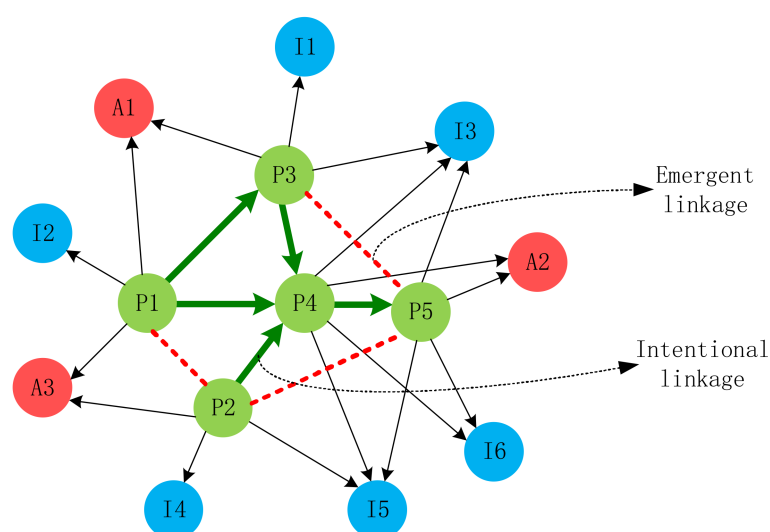


Figure 3. An illustration of a three-mode (actor, issue and policy) network.

Table 3. A summary of research questions, analytical approaches, measurement indicators and indicative patterns.

Research Questions	Analytical Approaches	Measurement Indicators	Indicative Patterns
How do environmental laws and policies evolve overtime?	Event graph	Qualitative description of an event; Directed edges between events.	The contents and sequence of the events indicate the evolutionary trajectory of environmental governance.
What is the role of law in generating policies?	Event graph	Out-degree of a node: number of following events, to which an event may lead.	The higher the out-degree of a node (e.g., a piece of law), the more powerful the law is in generating policies.
How do actors and issues evolve in environmental laws and policies overtime?	Two-mode network	Weight of an edge: frequency at which an actor deals with an issue.	The higher the frequency, an actor deals with an environmental issue more frequently.
What is the position of actors in environmental governance?	Two-mode network	Betweenness centrality: a node with higher betweenness centrality would have more control over the network, because more information will pass through that node.	The higher the betweenness centrality, the actor is more important in environmental governance.
How do environmental laws and policies are intentionally and emergently linked with one another?	Three-mode network	Number of intentional linkage (edge); Number of emergent linkage (edge); Qualitative description of an event.	The higher the number of emergent linkages, and the lower the number of intentional linkages, the environmental laws and policies are more fragmented.

Notes on the measurement indicators:

After loading the event data, the Gephi software may calculate the values of the indicators by built-in algorithm:

- (1) Out-degree of a node: counting the number of following nodes that a node may bring about.
- (2) Weight of an edge: counting the frequency at which an actor deals with an issue.
- (3) Number of intentional or emergent linkage: counting the number of intentional or emergent linkages.
- (4) Betweenness centrality: betweenness centrality is a measure of centrality in a graph based on shortest paths. For every pair of nodes in a connected graph, there exists at least one shortest path between the nodes such that either the number of edges that the path passes through or the sum of the weights of the edges is minimized. The betweenness centrality for each node is the number of these shortest paths that pass through the node.

4. Results

4.1. Laws Create Windows of Opportunity for Policy Generation

Environmental law creates a window of opportunity for policy generation when the governments wish to invoke their authorities to direct societal behavior towards environment, and to trigger new policy instruments to environmental protection [34,35]. By 2016, China has enacted 35 national laws associated with environmental governance, which led to the birth of 319 environmental policies (Figure 4).

As Figure 4 displays, the 319 environmental policies distribute unevenly with regard to temporal order. In the socialist period (1972–1978), environmental governance was largely ignored by the central state. The only legal event was the adjustment of the Constitution of China by incorporating environmental protection as the basic national principle, which did not arouse any policy generation.

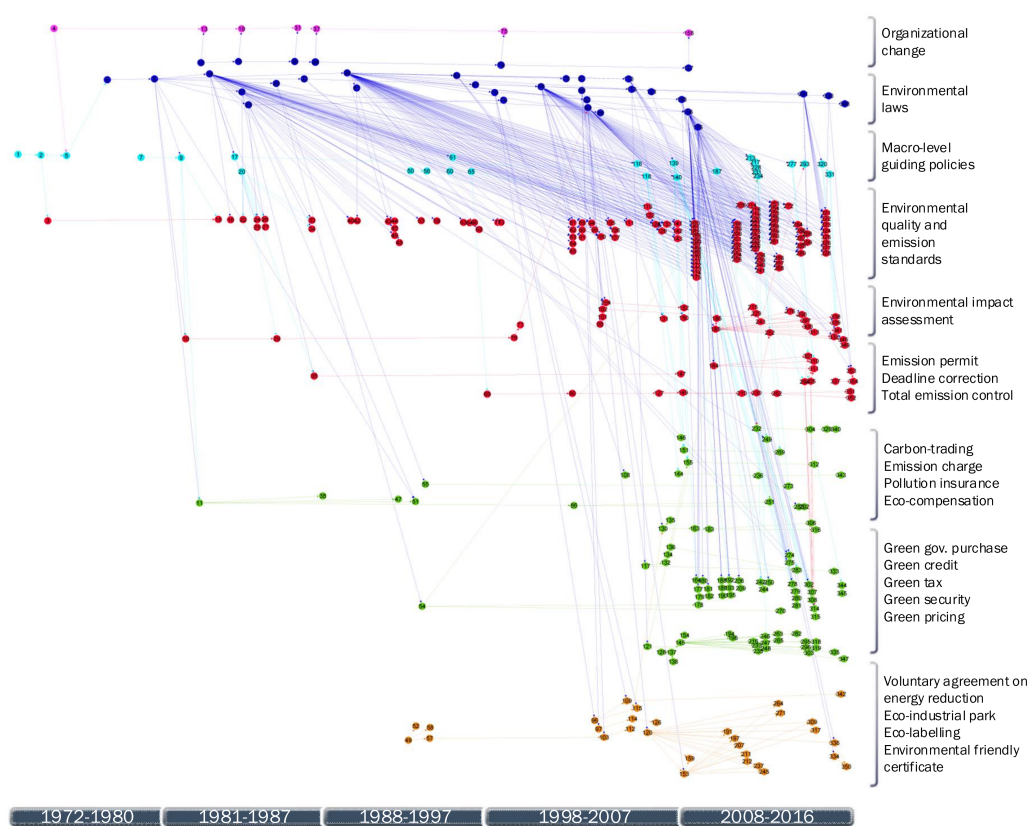


Figure 4. The legal policy system of environmental governance in China. (Laws and policies are represented as nodes in different colors, decision basis, reference or condition between policies as edges. Nodes are plotted along the x -axis according to an order variable that is calculated from the time point the law or policy is promulgated, and along the y -axis by hand-dragging in order to place the policies of the same category near to each other.)

In 1978, China introduced the economic reform policies. In the economic reform period (1978–2000), this adjustment of the Constitution provided a great momentum to the birth of China's environmental laws (see Table 1). Under these laws, environmental policies in this period concentrated on state's efforts in constructing regulatory framework, only sparsely. China had three categories of policies to control pollution in this period. The first one was the establishment of standards in the form of monitoring techniques of environmental quality and standards for polluting behavior. An important complement to the standards was the requirement of Environment Impact Assessment

(EIA) for urban economic development projects. The second category was the “three synchronizations” policy. The policy stipulated that pollution prevention and control measures should be synchronized with production at three stages (planning, construction and operation) of enterprise activity. The third category was the “total pollutant load control” policy, aiming at formulating the ceiling of total pollutants that can be discharged. This policy was operated by the Emission Permit Approach. The industrial enterprises must register and apply for the emission permits before discharging.

Since 2000, China has experienced rapid economic growth. During this period, environmental policies have no longer only concentrated on the establishment of standards but emphasized the development of market-based and voluntary instruments. The design and implementation of market-based and voluntary approaches are not limited to the environmental agency but associated with many governmental departments including tax, financial, pricing, purchasing agencies in the public sector. These agencies are encouraged to work together to formulate integrated policies. Until now, China has had green government purchase, green credit, green tax, green security and green pricing policies to provide industries with economic incentives (e.g., priority in government purchase and making bank loans, tax reduction, and preferential price for energy consumption) to be clean and green. In addition, some voluntary policies are proposed, including eco-labeling and environmentally friendly certificate, to encourage enterprises to produce clean products.

Despite the substantial efforts of the central state to enact laws, not all of these laws have equal power to bring about new policies. We find the top five most powerful laws in creating windows for the production of new environmental policies (Figure 5).

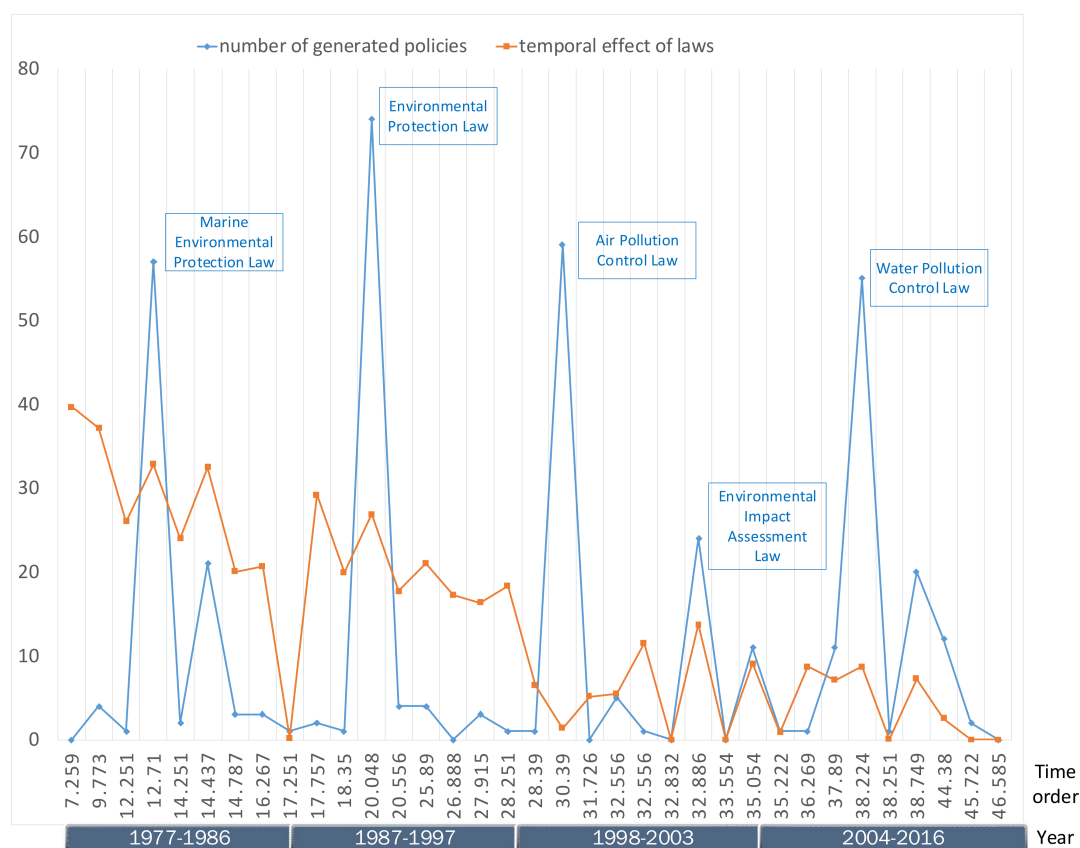


Figure 5. The effects of laws in generating policies in terms of quantity and time span. (The x-axis represents the laws with a time order, and the y-axis represents two indicators, the number of policies the law has generated (shown in the blue polyline) and the time span that the law has to trigger new policy (shown in the orange polyline). The time span is calculated from the time point of the policy it finally generated minus the time point the law was enacted.)

The Environmental Protection Law (formally promulgated in 1989) ranks the first (in terms of out-degree) in generating the largest amount of new policies. It created a policy window for launching 70 Pollutant Discharge Standards (PDSs) in different industries through introducing the issue of environmental standard and putting the standard issue onto government agenda. The second powerful law, the Marine Environmental Protection Law, stipulates the issuance of Marine Pollutant Discharge Standards (MPDSs), which created a window of launching 56 discharge standards for land-based pollutants and coastal engineering projects. The Air Pollution Control Law and the Water Pollution Control Law, ranking third and fourth in out-degree, respectively, gave birth to 57 atmospheric emission standards and several deadline correction policies in water management, especially in inter-basin water areas. The Environmental Impact Assessment Law, at the fifth position, stipulates the design for procedures and methods to implement the assessment, which gave birth to 17 environmental impact assessment plans and approaches in different sectors.

It is apparent to see that the laws with the strongest influential power (i.e., the highest out-degree) and the longest-term effect on policy generation are of a regulatory nature. Laws are rare in stimulating market-based or voluntary instruments. Only in the recent decade, some market and voluntary policies emerge after a few laws are enacted. The Energy Conservation Law and the Circular Economy Promotion Law jointly promote the use of market and financial-based incentives to encourage industries to save energy and adopt clean production process; and this created an opportunity to issue 71 “green” policies, including green tax measures, green government purchase, green electricity price and green bank loans. The Clean Production Promotion Law, on the other hand, promotes industries to spontaneously adopt clean products and processes; this thus created the window for several voluntary policies such as eco-labeling, voluntary agreements on pollution reduction and environmental friendly certificate.

4.2. Policies Activate Actors and Demarcate Issues

A policy usually defines what issues it involves, what it tends to address, and which actors are relevant and responsible for their resolution. Over the past four decades, China’s environmental laws have generated more than three hundred policies on environmental governance. These policies gradually activated actors, pulled them into the system, and demarcated environmental issues among them.

Figure 6 shows “actor–issue” two-mode networks in the years 1980, 1998 and 2016. The figure already reveals that both actors and issues are remarkably increased in environmental governance in China. Only three actors (SC, MoHURC and NDRC) were active in environmental protection in 1980, dealing with five environmental issues (construction, water, standard, waste and charge). In 1998, there were seven actors (SC, MoHURC, NDRC, MoC, MoF, MoEP and GAQSIQ) that took part in 16 environmental protection issues (including new issues of ecological and natural resource). In 2016, the number of actors that tend to be active increased to 17 (involving new actors from the financing sectors) and the environmental issues touch upon 29 items (fresh issues include, for instance, environmental credit, environmental information disclosure, clean production, and carbon trading).

After new actors and issues are introduced, the central actors and issues in environmental governance have shifted in China. Table 4 reports the top five most central actors and issues in 1980, 1998 and 2016. In 1980, NDRC, SC and MoHURC had relatively equal power in environmental governance, and the most important environmental issue was dealing with pollution from construction projects. In 1998, MoEP and MoF were pulled in and became the most central actors as well as NDRC, SC and MoHURC. The most important issues were no longer limited to construction, but issues of water, waste, charge and standard also came into the foci of environmental governance. In 2016, MoHURC became less important, and PBC was involved and became central in environmental governance. In addition, in relative to peer ministries, MoEP became extremely important in environmental regulation and enforcement. Regarding the issues in this period, coal, energy, natural resource,

carbon trading replaced construction, waste and standard, representing the most important issues on government agenda.

Therefore, this developmental trajectory indicates that actors from the financial sector began to be active in environmental governance; traditional bureaucracies gradually withdrew from the central positions; and environmental issues actors concerned shifts from direct regulation to market incentives, and from pollution induced by construction to natural resource protection and energy saving.

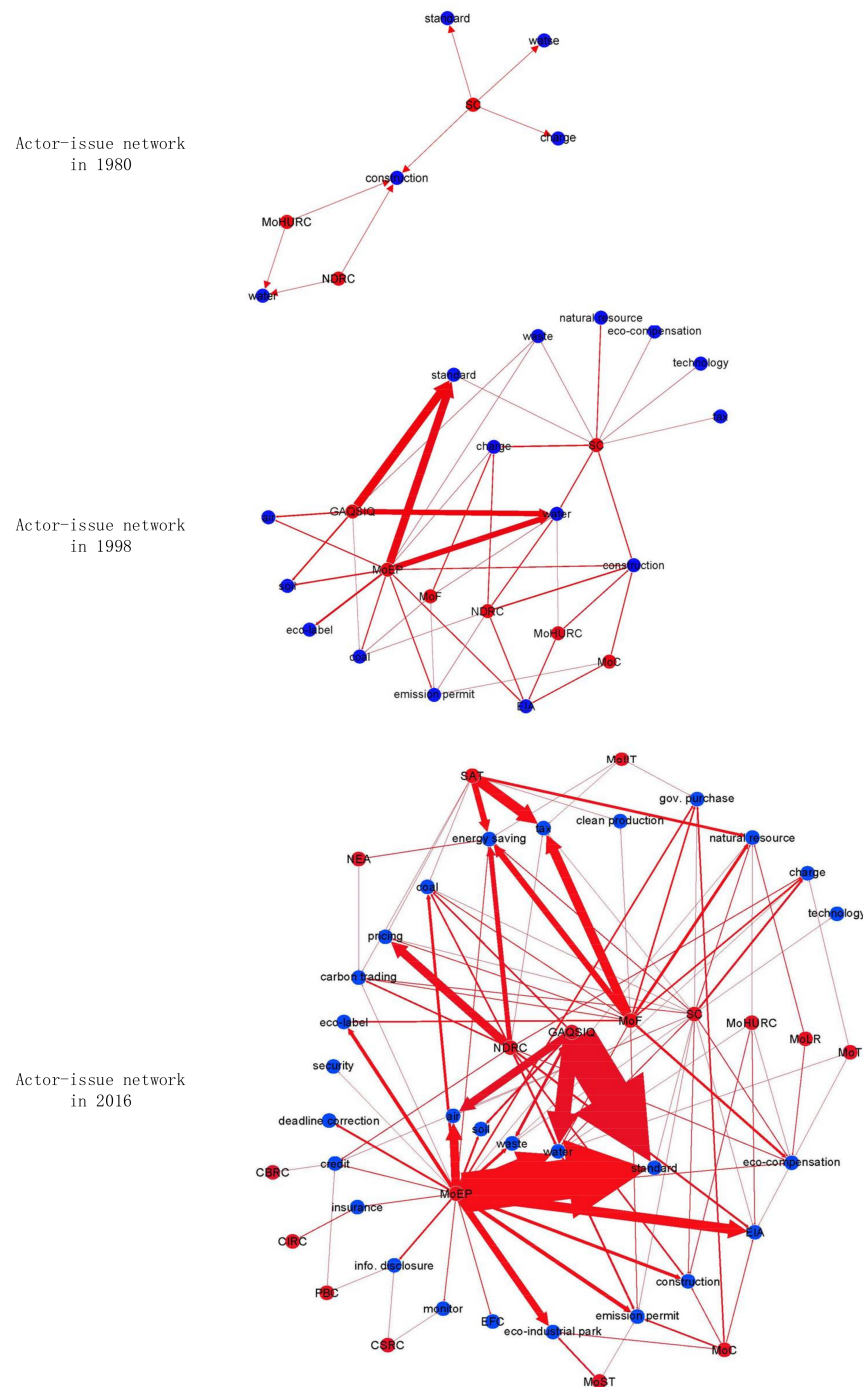


Figure 6. The evolution of actors and issues in environmental governance in China. (Actors (red nodes) and issues (blue nodes) are represented as nodes, the affiliations of issues to actors as edges. The thickness of edges represents the frequency at which an actor deals with an issue.)

Table 4. Top five most central actors and issues in China's environmental governance in 1980, 1998 and 2016.

	1980		1998		2016	
	Name	Betweenness Centrality	Name	Betweenness Centrality	Name	Betweenness Centrality
Top 5 most central actors	NDRC	0	MoEP	1.333	MoEP	31.111
	SC	0	NDRC	1.333	NDRC	9.028
	MoHURC	0	SC	1.333	SC	9.028
			MoHURC	1.333	MoF	3.472
			MoF	1.333	PBC	1.250
Top 5 most central issues	construction	50	water	5.275	water	0.850
	water	0	construction	5.275	coal	0.850
	charge	0	charge	5.275	charge	0.850
	waste	0	waste	5.275	energy	0.850
	standard	0	standard	5.275	carbon-trading	0.850
					natural resource	0.850
					eco-compensation	0.850
					gov. purchase	0.850

4.3. Actors and Issues Build Intentional and Emergent Bridges between Policies

We visualize the intentional and emergent linkages between policies in a three-mode graph (Figure 7). We observe that the intentional linkages (204 in total) largely exist within the same category of policy instrument. For instance, intentional linkages exist within pricing preferential policies (i.e., market-based instruments) for environmentally friendly enterprises, within environmental impact assessment policies (i.e., regulatory instruments), and within eco-labeling and environmentally friendly product certificate (voluntary instruments). It indicates that the environmental policies primarily develop from the same type of policies that pre-exist. It also indicates that a fragmentation exists between different categories of policy instruments. Regulatory, market and voluntary policies exist side by side, and do not interplay to generate systematic effects. Only three exceptions exist. One is that eco-labeling becomes a condition for the Implementation Advice on Government Procurement (market policy). That means governments only purchase products that are eco-labeled. The second and the third are that the regulatory policies, Coal Energy-Saving and Emission Reduction Action Plan, lead two market-based measures, the Reforms on Coal Resource Tax and the Increase on the Consumption Tax on Refined Oil, respectively.

Looking at the emergent linkages (917 in total), the fragmented policies actually have something in common. Based on the qualitative descriptions of the policy events, we know that the environmental issues do not arise from an overarching plan, but they emerge independently, as key words of the policies that actors formulate. In China, the Energy Saving and Natural Resource issues create emergent relationships between regulatory instruments of total control, market-based incentives on energy saving, and voluntary agreements on energy conservation. The Water issue builds bridges between regulatory policies (water emission standards) and market ones (water pollution charges). The EIA issue links the regulatory environmental impact assessment policies to industrial enterprises' environmental credit by creating an assessment record. The Coal Use issue bridges the regulatory reduction on coal use with the market-based incentives to reduce coal use.

Regarding the actors, some of them are involved in multiple policies and can act as bridges between policies. Among the top five most central actors, MoEP is involved in regulatory, market and voluntary policies. NDRC and MoF are tied to set the right prices for industries and designing preferential tax incentives on energy saving and natural resource protection and bridge these market policies to the regulatory emission standards. SC often launches guiding policies that do not have indication for the use of particular type of instrument. These guiding policies further bridge regulatory and market-based measures. GAQS is tied to all environmental standards and entirely creates bridges between standards in various industries.

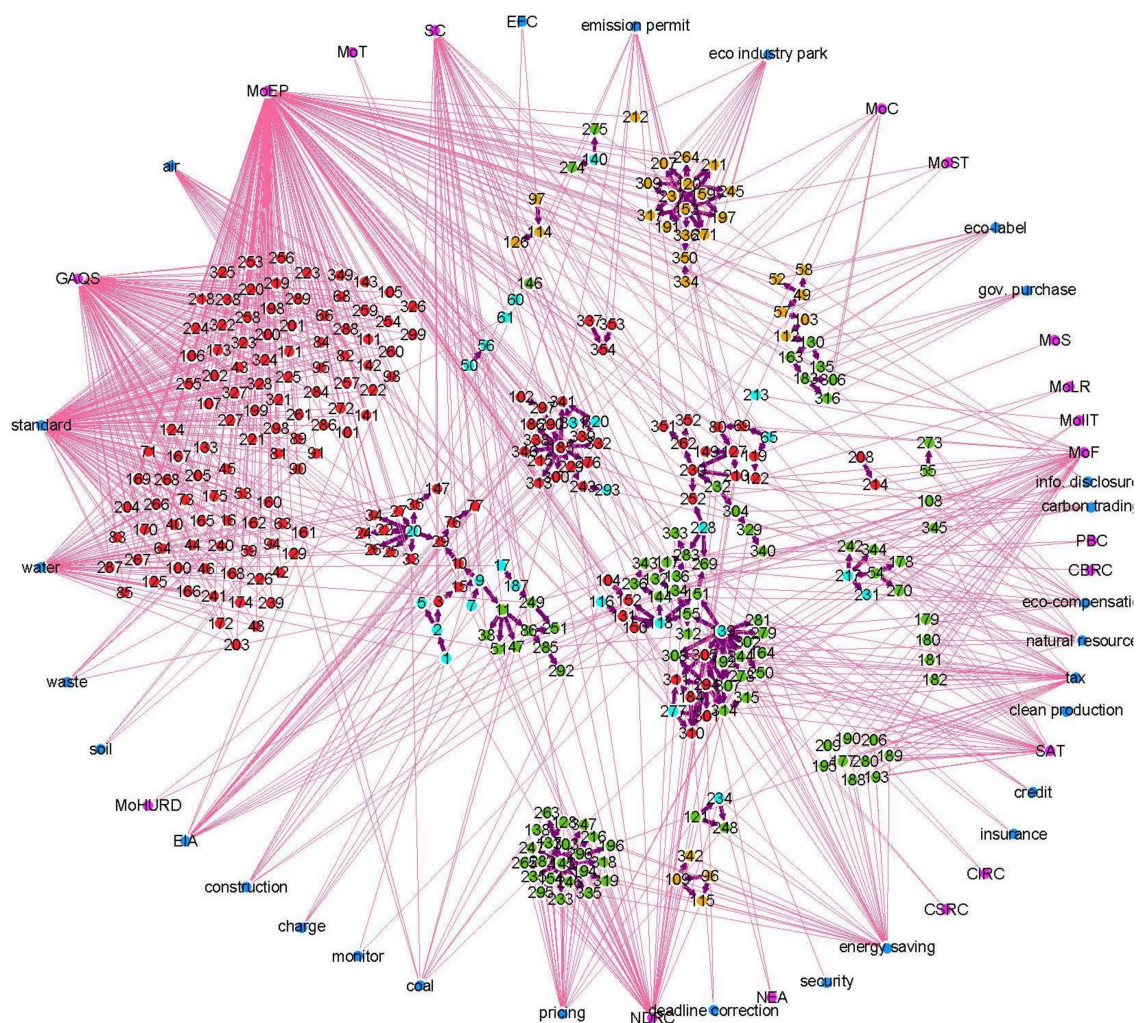


Figure 7. The intentional and emergent linkages of policies. (Policies are represented as nodes in the center. Regulatory policies are in red nodes, market-based policies in green nodes, and voluntary policies in yellow nodes. Actors (pink nodes) and issues (blue nodes) are represented as nodes at the periphery. Thick edges represent the intentional linkages between policies; Thin edges represent the emergent linkages between actors and issues to policies.)

5. Conclusions

Wrestling with environmental pollution and reducing its socioeconomic losses and health costs, China has appeared determined to institute changes to stem further degradation over the past four decades. Environmental laws and policies grow exponentially, making the governance system more complex than before.

A scrutiny on the environmental governance system improves our understanding of environmental governance in China over time. First, via the ESA method, we trace the developmental process of environmental laws and policies in China. We recognize that China during the socialist period did not have any legal and policy solutions for environmental protection. During the economic reform period, environmental governance started to sprout in China, and the primary policy instruments centered on command-and-control approaches and regulatory measures. During the economic growth period, China began to use market-based and voluntary instruments to encourage industries to adopt environmentally friendly production processes. However, China's environmental laws play excessively roles in generating regulatory instruments, while create few windows of

opportunity to foster market-based and voluntary instruments. The top five most powerful laws (Environmental Protection Law, Marine Environment Protection Law, Air Pollution Control Law, Water Pollution Control Law and Environmental Impact Assessment Law) produced hundreds of regulatory standards but did not generate any market-based or voluntary policies. Second, the actor–issue two-mode networks in 1980, 1998 and 2016 allow us to see the transformation of actors and issues involved in environmental governance in China. Over the past forty years, the number and the diversity of actors in environmental governance has been increased remarkably. It has witnessed that environmental governance no longer has only the mission of the environmental sector, but also the tasks of financial, tax, energy, transport, construction and technology sectors. Third, by exploring the intentional and emergent linkages between policies, we found that China's environmental policies are largely fragmented. Particularly, the linkages between different categories of policies are substantially missing.

Further reform of China's environmental governance seems urgent. Many specific recommendations follow from our research. First, as China moves towards a more market-based economy, the environmental laws should give more space for market and voluntary instruments. Focus attention is not only paid to introduce new market-based legislations and policies, but also to couple these new laws and policies to the existing ones. Second, as China's environmental governance currently involves multiple actors from various sectors, more legal foundations should appear to encourage multi-actor collaboration. To promote various actors to design collaborative policies, the top authorities should be more effective in policy coordination. The authorities' positions and their hidden bridging roles have strong indications that more collaborations between sectors of government could be triggered. In addition, financial governing bodies such as PBC, CSRC, CIRC, and CBRC could play larger roles in encouraging industries to spend resources on preventing or cleaning up environmental degradation.

Supplementary Materials: The following are available online at <http://www.mdpi.com/2071-1050/10/4/1065/s1>, an actor list of environmental governance in China, and an event dataset of China's environmental governance actions. Table S1: System elements dataset—actors, Table S2: System elements dataset—issues, Table S3: System elements dataset—legislation and policy events.

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