Chapter 2
Hierarchical Structure of Water Governance

This chapter first of all reviews the organizational theory of new institutional economics in order to pave the way in literature and methodology for the study of water governance structure. Then, it proceeds with the basic implications of water governance and finds that the most important output of water governance is to ensure water security. The collective actions for this purpose result in a continuum of governance structure. China's "hierarchy" model is the highest level of hierarchical system in water governance structure, which is unique in the world. It contributed to the unification of the country in the Qin Dynasty more than 2000 years ago and has continued with the unified political system till today.

This chapter constructs a classical choice model for water governance structure that is used to explain the origin of the hierarchy water governance structure. The demand for hierarchy water governance structure is the decisive factor for the formation of the early unified political system in China. This is the view of scholars of the water governance school (Curtis, 2009; Huang, 2002; Needham, 1981; Wittfogel, 1957). By employing the modern economics analytical tools to interpret the relations between water governance and state governance, this chapter enriches and develops the theories of the water governance school.

2.1 Review of Organizational Theory of New Institutional Economics

The path-breaking economic analysis of transaction costs did not occur until 1937, when Ronald Coase (1937) published "*The Nature of the Firm*". Williamson completed the integration of transaction cost economics. From then on, transaction cost economics has not only scored glorious achievements in the theories about the firm but also been applied in much broader areas such as political organization, international relations and the governance of environment and natural resources,

Y. Wang, *Assessing Water Rights in China*, Water Resources Development and Management, DOI 10.1007/978-981-10-5083-1_2

thus building up a sizable library with a considerable amount of organizational theories of transaction costs.

2.1.1 Transaction Cost

Transaction cost did not receive enough attention until 1937 when R.H. Coase wrote "*The Nature of the Firm*", in which he, for the first time, used transaction cost to explain the existence and size of firms. In his article "*The Problem of Social Cost*" (Coase, 1960), he used the concept of zero transaction cost to criticize A. C. Pigou for his logic of state intervention to solve harmful effects of pollution. If transaction costs are zero, Coase argues, then through a process of bargaining an efficient outcome would be achieved without the need for government intervention.

The idea advanced by Coase in his "*The Problem of Social Cost*" was summarized as 'Coase Theorem' (Coase, 1960; Gjerdingen, 2014). According to this theorem, given well-defined property rights and all transaction costs are zero, resources will be used efficiently and identically regardless of who owns them. Property rights and transaction costs are the two sides of a coin, saying that if transaction cost are really zero, the definition of property rights may be ignored (Cheung, 2000, p. 442). Transaction cost is the core concept of new institutional economics. It is exactly the acquisition of positive transaction cost into the framework of neoclassic economics that new institutional economics has gradually revealed the important functions of property rights and economic organizations in the allocation of resources and made politics and institutional structure to become key to understanding economic growth (Thráinn Eggertsson, 2009, 2013).

The accusation that transaction cost lacks accurate definition has never stopped ever since Coase developed the concept. Nearly all prominent new institutional economists have presented their views from different angles. According to Coase, transaction costs are search and information costs, bargaining and decision costs and policing and enforcement costs. Later on, new institutional economists have added more means to transaction costs. Williamson compared transaction costs to friction in physics, which include advanced transaction cost and the costs for signing contracts, defining the rights and obligations of transaction parties and also, after the signing of contracts, the cost for solving problems left over from the contracts per se and for changing articles or withdrawing from contracts. Defining transaction cost from the same perspectives are also Matthews, who holds that the fundamental idea of transactions costs is that they consist of the cost of arranging a contract ex ante and monitoring and enforcing it ex post, as opposed to production costs, which are the costs of executing a contract. Barzel defines transaction costs as costs for acquiring, protection and transfer of rights. Eggertsson (1997) holds similar views as Barzel (1989), asserting that transactions costs are the costs that arise when individuals exchange ownership rights to economic assets and enforce their exclusive rights, namely, exchange cost plus enforcement cost. Transaction costs are argued as costs for the operation of the

economic system (Arrow, Sen, & Suzumura, 2011). Similarly, Cheung (2000) views that transaction costs include not only costs for signing contracts and negotiations but also costs for measuring and protecting property rights and costs for obtaining rights and their governing activities, supervision behaviors and organizational costs.

Superficially, differences exist among prominent economists in the definition of transaction costs. John R. Commons (Van de Ven & Lifschitz, 2009), the founder of the contemporary institutional economics pioneered the notion that all human activities may be regarded as transaction corresponding to production activities between man and nature. Commons sums up transaction into three basic types: (1) trade transaction or exchange relations among equal persons; (2) management transaction, which is an exchange relation between superordinates and subordinates; (3) quota transaction, which is a relation between government and individuals. Transaction activity is the basic unit of institution. The operation of institution that is made of numerous transactions and different institutions is nothing but the combination of the three types of transactions according to different proportions (Commons, 1983). Coase takes the first type of transaction as the target of transaction costs and scholars after Commons's explanation of types of transactions (Coase, 1937, 1960). However, the definition that transaction costs are costs incurred in market transactions is relatively narrow, while defining transaction cost as institution cost is broad and comprehensive (Barzel, 1989; Thráinn Eggertsson, 1997, 2009, 2013). All these definitions have inherent interconnections, referring to the costs of exchange among people as contract relations that are all costs of people-to-people exchange (Arrow et al., 2011; Cheung, 2000). Further, transaction costs are analysed in relation to complicated governance structure and social context (Challen, 2000; Krutilla & Krause, 2010; McCann, 2013; Schlager & Ostrom, 1993; Williamson, 2000).

Since social organization is a collective of human relationship, transaction costs are important to understand all social organizations. Organizational cost, agency cost and supervision coast can be regarded as transaction costs. Factors determining transaction costs are complicated. If human activities are regarded as "transaction", then all factors associated with humans are subject to the impact of transaction costs, such as the behaviors of participants, including bounded rationality and opportunism; transaction, including frequency, asset specificity and uncertainty; governance structure, such as market, hierarchy and the combination of the two, legal system, government control and public bureaucracy; institutional environment, including property rights, contracts and culture.

2.1.2 Transaction Cost Economics

Neoclassic economics after Adam Smith regards price mechanism as the most effective in regulating transaction and market as being better than centralized organizations in the allocation of resources. In his 1937 paper, R.H. Coase raises

two problems: one is why firms have emerged and the other is what determines the size of a firm (Coase, 1937). He comments that the use of price mechanism needed costs, including the costs for discovering price and negotiations. Transaction costs are the fundamental factor that leads to the existence of firms. Firms employed hierarchical directions to replace voluntary market transaction. The size of a firm is determined by transaction costs. There is a critical point between firms and market, at which the marginal cost of a transaction organized internally is equal to the marginal cost of the transaction concluded on the open market. Coase is the founder of transaction cost economics. His contribution lies in the revelation of the decisive significance of positive transaction costs in organizational choice (Coase, 1960).

What Coase pioneered has been pursued by many new institutional economists. In the 1970s, Williamson picks up Coase core argument and developes it into what is known as 'transaction cost economics'. He holds that, concomitant with the exchanges among individuals with bounded rationality and opportunism in an environment filled with uncertainties is of necessity the transaction costs that often lead to organizational failures. He makes transaction as the basic unit of analysis. He points out that when transaction costs are too high, market will no longer be the most effective governance structure and it is necessary to design a property governance structure (Williamson, 1977). Different transaction costs entail different governance structures. The size of transaction costs requires the study of the specific features of transactions, including frequency of transaction, problem of asset specificity and uncertainties of transaction. Different from Coase, Williamson gives particular stress to transaction costs associated with asset specificity.

Coase regards the power of planning and employer and employee relations as the essence of firms and the activities in the absence of such power and transaction in resources by signing contracts independently as the essence of the market (Putterman & Kroszner, 2000). Coase courts opposition from some new institutional economists for diametrically separating firms and market. Cheung points out that "market transactions involve products or commodities ... 'firm transactions' involve factors of production, and the replacement of a product market by a factor market" (Cheung, 2000, pp. 240–264). Alchian and Demsetz hold that market contracts and firm contracts have de facto continuity (Putterman & Kroszner, 2000). Benjamin Klein also holds that Coase mistakenly distinguishes the transactions within enterprises and among enterprises, adding that the latter is a market contract while the former is a planning one. Economists have become aware that such distinction is so meaningful, suggesting that transaction should be considered within enterprises as market and contract relations (Klein, 1983). However, economists have not reached a common understanding and the disputes will continue over whether or not a firm is an entity under administrative directions without being influenced by the market force or merely an entity linked up by a series of contracts signed among individuals.

Miller (1992) argues that hierarchy and market are different in nature. The coordination within firms is mainly realized by hierarchical instructions, and the transition from market to hierarchy has enabled individual behaviors to undergo

tremendous changes. Hierarchy realizes coercive coordination by administrative orders. The significance of the criticisms against Coase lies in the revelation of the contract nature of the firm, that is, the firm involves the series of long-term contract relations among those who have input factors and the firm tends to replace factor market with product market. The benefit of regarding the firm as a contract association of resources holders lies in the diversity of the forms of associations of resources owners, which can be explained from the cost economizing feature of different contract arrangements. Nonetheless, it is also necessary to see at the same time that the price signals on the factor market has little roles to play and it is often the case that hierarchy, i.e. power relations, has replaced market exchange (Miller, 1992).

2.1.3 Market vs. Hierarchy

Figure 2.1 shows the differences between the two kinds of governance structures of market and hierarchy. In the figure, every arrow represents a transaction and this is the basic unit of analysis. The relations of any two individuals form a contract and one contract may include a number of transactions. A contract may be formal or definite and may be non-formal or hidden. In this framework, market and hierarchy are merely the connections of contracts. The only difference lies in the contract organizational structure. Hierarchy and market are not necessarily simple two divisions. Most scholars are inclined to hold that the firm and the market are incrementally changing from one form to another. In order to characterize the incremental changes of the two structures, we view the tendency of organization away from hierarchy but closer to market 'leveling off'; while the tendency of organization closer to hierarchy but away from the market 'hierarchy'.

Different transactions are conducted in different organizational forms in that the society always favors organizational structures that are most conducive to transaction cost economizing as explained by transaction cost economics. The transaction

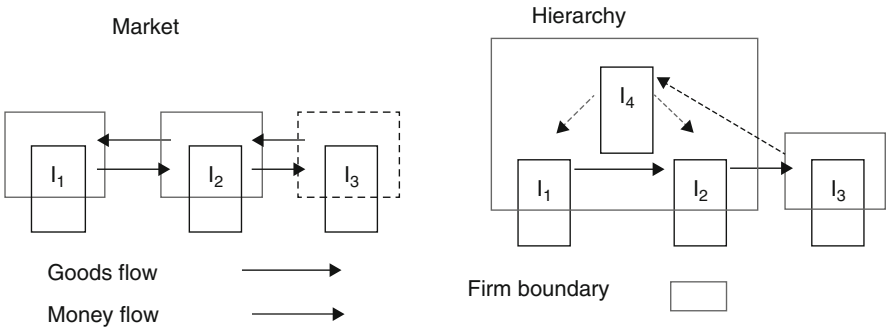

Fig. 2.1 Comparison of market and hierarchy structures

cost economizing by replacing hierarchy with market comes from many aspects: (1) the cost for searching market information; (2) cost for negotiation and drawing up contracts; (3) cost for enforcing the contracts and settling conflicts; (4) cost associated with market incompleteness, which might come from externalities, natural monopoly, information asymmetry and asset specificity; (5) scale economy and scope economy possibly brought about by the firm. The existence of hierarchical firms is the result of market efficiency failure, which may be resulted from the above factors (Beckmann & Padmanabhan, 2009).

When market fails, hierarchy may sometimes improve the low efficiency of market, but not always so. In reality, there is also hierarchical failure, associated with low efficiency. This is because, while reducing the transaction costs, there might be new costs arising with hierarchy, that is, the costs for forming and maintaining associations of producers, which is usually termed 'agency cost' (Thráinn Eggertsson, 1997). Agency cost come possibly from the following: (1) cost of supervision by principal over agents; (2) efficiency loss associated with "moral risks" of agents due to incompleteness of supervision; (3) costs of coordination between different agents; (4) efficiency loss due to incomplete information associated with information filtering.

The firm or the market, each organizational form has transaction costs and the size of the costs is determined by the degree of mutual replacement. As the firm expands, the agency cost within the firm may increase and when the internal marginal gains (cost for negotiation and price discovery is reduced and the problem of asset specificity is eased or other factors) are equal to the marginal cost of integrated management, and the firm has reached the optimal scale. More generally, economic organizations are designed, through identifying transaction features, to be a governance structure that seeks transaction cost economizing.

2.1.4 Expanded Application of Transaction Cost Methodology

While transaction cost theory has achieved tremendous successes in explaining economic organizations, its methodology has been extensively applied in the study of non-economic organizations. In fact, in his paper "The Problem of Social Cost" in 1960, Coase states that transaction cost methodology can be used to explain all kinds of social arrangements, including market, the firm, government and their evolution (Coase, 1960). New institutional economics also puts forward 'General Coase Theorem' that when transaction costs in political and economic areas are zero, the economic development of a country is free from the influence of the government; however, if there are positive transaction costs, the institutional structure that allocates and formulates rules by the political power of a country will become a key factor in determining the economic development. The General

Coase Theorem illuminates that transaction cost economics has explanatory power over non-economic organizations (Gjerdingen, 2014).

In terms of states, a theory of defining how states implement property rights, which considers transaction costs as a variable of state behavior (North, 1981, 1990). Moe (1984) publishes his article "Organizational New Economics", suggesting that since new institutional economics has made revolutionary contributions to the understanding of hierarchical structure in the private areas, it should also be conducive to understanding the hierarchical system of public departments. North (1990) uses the analytical framework of transaction cost economics to analyze political problems. After more than 10 years of literature accumulation, what is termed 'transaction cost political science' has taken shape (Ma, 2003). According to Ma Jun, what the transaction cost political science concerns about is how the transaction costs in political deals influence the design of political system. As it is built on the Western soil, what this branch of science answers are all problems about Western democracy, such as why rational voters choose to vote? Can political principal effectively control bureaucracy? How does parliament take authorization decisions? How to overcome political opportunism effectively? Why some public service can only be generated within public bureaucratic organizations? These subjects of study are far from the Chinese social structure and political activities and for such discussions this book will not go into details.

Transaction cost methodology has also been applied in the studies of international relations and politics, such as why countries adopt different forms in cooperation with different countries. Lake (1996) uses transaction cost theories to explain why some countries have resorted to relatively loose cooperation in the production of state security while others prefer hierarchical cooperation. Lake points out that in the process of the production of state security, a state must exchange with other countries and therefore opt for a certain form to govern the exchange with other countries, which ranges from non-governmental and loose alliance to protectorate and non-official empire and to highly hierarchical empire, which form a continuum. In his model, Lake uses governance costs and expected costs of opportunism to explain the options for country-to-country relations. The governance costs rise with the rise in the levels of hierarchy while expected costs of opportunism rise with the lowering of the levels of hierarchy, with the two going together to decide on the optimal relations in the exchanges of countries (Lake, 1996).

Weber (1997) constructs a transaction cost model for inter-country cooperation by using the two variables of external threat and transaction costs. The bigger the external threat, the closer the alliance countries tend to develop; the higher the transaction costs, the more inclined the countries tend to opt for non-cooperation or non-official alliance. Weber's model is in fact much similar to Lake's. Its variable of external threat is amounting to the expected costs of opportunism of the latter and transaction costs are amounting to governance costs of the latter. These achievements are of great significance for this book to draw on.

Since the 1990s, transaction cost methodology has widely been applied in natural resources and environmental economics. Before that, this branch of sciences

mainly adopted the neoclassical economics method. With the introduction of transaction costs, a new branch of sciences 'institutional environmental and resource economics' (IERE) has taken shape. The founding work of IERE is Bromley's property rights system and Ostrom's studies of public pool of resources (Bromley, 1995; Bromley & Segerson, 1992; Ostrom, 1990). On this basis, Ray Challen (2000) develops a conceptual framework for transaction costs and institution options, which provided a method for the comparative study of different institutional structures by using cost-effectiveness framework, which will be introduced and quoted in later chapters of this book.

2.1.5 Effectiveness of Transaction Cost Organizational Theories

The extensive application of transaction cost methodology reflects in a way the expansionist nature of "economics imperialism". Why has the transaction cost methodology been so widely applied in all economic, political and social organizations? Williamson (1985) has given the answer when he asserts that the basic unit of analysis is transaction and contract and any relations concerning contract may be approached from the angle of transaction cost economics. Economic activities, political activities and the relations among regions or countries may, in fact, be regarded as a kind of transaction among individuals or groups, which can be examined from the angle of contract. Statesmen and voters may be regarded as a contract relationship and statesmen and bureaucratic organizations may also be regarded as a contract relationship. International relations may be regarded as contract relations among different countries; the relations between the central and local governments can also be regarded as being bounded by contract. Some of the contract relations are clear but most are hidden, thus bringing about huge transaction costs in drawing up and performing the contracts and affecting the design of organizational form and institution. So, transaction cost theories are useful in analyzing all kinds of social organizations (Ma, 2003).

The core of transaction cost organizational theories is how to realize transaction cost economizing governance structure. This depends on how people are organized and on what scope it can produce the maximum cost-effectiveness. However, efficient organizations will not form automatically. The efforts to reduce transaction costs depend on external pressure. The effectiveness of economic organizations depends on the competitiveness of the market; and the competitive environment may make efficient economic organizations to replace inefficient economic organizations. North's statement on behavior theories have revealed that a country must maximize not only rents of the ruler but also social output by reducing transaction costs. The two objectives are conflicting with each other. It is exactly the abuse of the first objective that has caused the non-competitive environment and led to the existence of a large number of inefficient economic organizations, hence the

decline of countries in international competition (North, 1981). Other social organizations follow the same logic. The effectiveness of a political organization is determined by how big a pressure for reform the political ruler has to bear and what efficient organizations to develop. The efforts by a country to develop effective international relations are determined by how grave the challenges the country faces in state security.

Since transaction costs economizing does not come automatically and it is associated with external circumstances, an organization that can minimize transaction costs is the imagination in the ideal sense. But how to look at the effectiveness of all organizations in realities? Any organization has its case for existence and its aim is to undertake one or multiple tasks and that will force the option for a form that can economize costs. An organization may not perform well due to insufficient external pressure. If it cannot resolve the established problems for long, it would lose its ground for existence. If all the constraints, including external pressure, existing technology, information cost and future uncertainties, are taken into consideration, people would always opt for effective organizations from the static approach as among all optional structures under constraint conditions, the transaction costs of the existing organization have been minimized. What is thought to be an inefficient organization has its roots in that all sorts of constraints and inefficiency. With the changes in constraint conditions, an organization has to respond to external changes and such response determines the organizational changes—to be replaced by a new organization or to die out. The continued existence of inefficient organizations in history may be explained by the 'interest group model' developed by Mancur Olson (Olson, 1971, 1982, 1996). Social organizations are in essence 'institutional arrangements', encompassing a series of rules and conventions, subordinating procedures and moral and ethical behavioral standards (Olson, 1990). The combination of institutional arrangements forms an 'institutional framework', which resonates with North's (1981) explanation of 'structure'. In this book, water governance structure is the institutional framework for water governance, and transaction cost theories play important roles in explaining water governance structure.

2.2 Water Governance in the History and Outcome

2.2.1 Differences of Water Governance in Ancient and Present-Day China

China is a big country in terms of water governance and it has a long history in this regard. The history since legendary Da Yu is also history of the Chinese nation in the fight against drought and floods. Water control in China is large in scale and is

of special significance in the continuity and development of the Chinese civilization.

In ancient China, flood prevention, irrigation and navigation were the three main areas of water governance. The first and foremost is the fight against drought and floods. The country is known as "suffering from starvation in every 3 years, from a decline in every 6 years and from a crop failure in every 12 years". It is ranked first in the world in terms of the frequency and intensity of natural disasters, especially floods and droughts. From 180B.C. to AD1949, of all the natural disasters China sustained, more than 90% were droughts, floods, earthquake and tidal waves and the tolls taken by droughts and floods made up 51% of all tolls of natural disasters, averaging 14,210 and 1863, respectively, a year. The economic losses were inestimable (Wang & Tian, 2010). The country frequently built large scaled water projects to resist droughts and floods. In ancient time, the country committed a great deal of human, materials and financial resources to the building, maintenance and protection of dykes along major rivers, especially along the lower reaches of the Yellow River. China's farming was highly dependent on irrigation and the number of irrigation projects was far more than in any Western countries. The number of irrigation project before the Tang Dynasty averaged 10 to 16 for every 100 years. In the more than 1300 years after the Tang Dynasty, the number of such projects rose sharply, with the areas under irrigation in 1400 and 1820 accounting for 30% of the total arable land while the proportion in India in 1850 was only 3.5%. There is no country in the world other than China that has committed such human and financial resources to the building of water projects. Waterway shipping also occupied a significant position in China's water control history. The most important shipping project that linked the south with the north is the Grand Canal. Work on the canal started in the Sui and Tang periods. It links Qiantang River with the Yangtze River, Huaihe River, Yellow River and Haihe River. It is a major artery that links south and north in the Chinese history. It is a lifeline that has made north China able to maintain its position as political and cultural centers. The Grand Canal served as a waterway hub for nearly 1000 years and did not phase out until the end of the Qing Dynasty, when land and marine shipping began to pick up (Shen, 2014). After the founding of the P.R. China, the fight against droughts and floods remained the main area of water control. Statistics show that droughts and floods assumed an upward trend (see Table 2.1) from 1949 to 2000 in terms of areas stricken, disaster areas and disaster rate. Droughts and floods have caused huge losses. The areas of farmland stricken by droughts averaged 20 million hectares a year, causing grain reduction by tens of billions of kilograms, about 50% of the total caused by meteorological disasters. The seven major river basins suffered a flood in every 3 years on average and the areas affected every year reach 7,333,333.3 ha and the grain output reduction accounted for 27.6% of the total output reduced. Economic losses run up to tens or dozens of billions of yuan (MEPPRC, 2016). The 1991 Huaihe River floods and the 1998 three rivers floods caused heavy economic and social losses. In order to fight against floods, the country, during the planned economy period, mobilized mass movements to build water control projects and tamed major rivers at a very low cost. During the period, the country built more than 80,000 reservoirs

Table 2.1 Areas flooded, areas stricken by drought and disastrous areas in years from 1950 to 2011

Year	Flood			Drought		
	Areas stricken (ha/year)	Disaster area (ha/year)	Disaster rate (%)	Areas stricken (ha/year)	Disaster area (ha/year)	Disaster rate (%)
1950–1959	7,891,300	4,962,500	57.53	13,223,800	4,166,300	34.11
1960–1966	9,420,000	5,854,300	57.74	21,647,100	10,025,700	45.80
1970–1979	5,357,000	2,243,000	39.64	21,641,000	7,500,000	28.02
1980–1989	10,425,000	5,529,000	52.71	24,638,000	11,761,000	47.56
1990–2000	14,593,600	9,230,000	63.2	26,322,700	13,318,200	50.60
2001–2011	112,727,000	59,439,000	52.7	239,812,000	133,464,000	55.70

Sources: Calculated based on data in "China Statistical Yearbook"

and more than 200,000 km of dykes, thus ensuring the demand for water by the rapid economic and social development. Unprecedented achievements have been made in flood control of the Yellow River. Irrigation developed at a pace never seen in history, with the areas brought under irrigation from 199.60 million hectares in 1952 to 538.51 million hectares in 2000. The total irrigated areas were raised from 18.5% to 51.8% (1995) while it was 29.5% in India, 11.4% in the United States and 4% in Russia during the same period (WB, 2016). "A good ruler controls floods and drought first"—this saying by Guan Zong of the Spring and Autumn period still stands today (Gu, 1997).

Prevention and control of water pollution is something new in water governance since the country introduced reform and opening up policies. Since the founding of New China, thanks to economic development and the application of modern water control technologies, water governance has been diversified. Apart from anti-flood and irrigation projects, it also includes hydropower, control of waterlogging and salination, water and soil conservation, urban water supply and drinking water for man and animal. With the increase in population and urbanization, water shortage has become acute. Urban water supply has become more and more important. Since the country introduced reform and opening up policies, China has become a country in the world that discharges the biggest amount of sewage water (Jin, Zhang, & Tian, 2014; Yang, Flower, & Thompson, 2013). Water body pollution has become more and more serious, thus intensifying water shortages and posing a direct threat to the health of the people. Water pollution control has thus become a new area of water governance, which has equal importance as controlling floods and fighting against droughts. Up to the beginning of the twenty-first century, the ecological restoration in some river basins has been put on the agenda. By now the ecology-associated water resources regulation projects have been set up in the Tarim, Heihe and Yellow river basins. Water ecology restoration project has also kicked off in the Haihe River basin. Although the water governance in contemporary China has been greatly enriched, with increasingly wider coverage, in general, the prevention and control of floods, fight against droughts and water pollution have remained the three most important tasks for China in the first half of the twenty-first century.

Compared with ancient China, the present-day water governance has acquired an entirely new meaning (Liu et al., 2013).

2.2.2 Outcome of Water Governance

Water is the controlling factor, inseparable from the whole water ecological system. Other factors in water and ecological environment together go to form the natural ecological system, which provides humankind with all service assets, not only food, medicine and other daily use materials but also life support system on which human survival depends. Water on earth is in a cyclic state, including rainfall, evaporation, run-off and evaporation cycle. The land water cycle system directly acts upon humans. As the land water takes watershed as the unit, land water cycle may also be regarded as watershed water cycle system, which is an organic component part of the natural ecological system, with the point where watershed water cycle system and natural ecological system together comprises a natural water ecological system.

Natural water system demonstrated by Fig. 2.2, as part of the ecological system, also provides mankind with a diverse of goods that produce economic products, such as water volume and water energy source; environmental service as water environmental capacity; and ecological service, biological habitat and comfort service. As an asset, natural water system, like ecological system, has the biggest value of providing social and economic system with support service. Such asset has been meticulously utilized and protected. When man and nature exist in harmony, the natural water system provides humankind with all kinds of welfare and support for the healthy development of the economic and social system. If the asset is over-used, as much as that it has gone beyond what the water resources of the natural water system and water environment can take, man and nature would come into conflict, thus hampering the sustained development of the economy, threatening the normal social order and even leading to instability.

The topmost task of water governance is to ensure social and economic development, with the fundamental purpose of keeping balance between socio-economic system and the natural water system in order to realize harmonious development. During different social and economic stages and historical periods, the principal contradictions between social-economic system and the natural water system assume different forms, which determine the requirements for water governance. Generally speaking, water governance has to ensure the requirements of social and economic development at the following levels. The first level is the security of drinking water, that is, to supply clean drinking water to the people. This is the most essential requirement by the society for water. The second level is the security against floods, that is, to protect the lives and property of the people. The third level is food security, that is, to ensure food grain supply, which is especially important to China. The fourth level is water security for the economic and social development

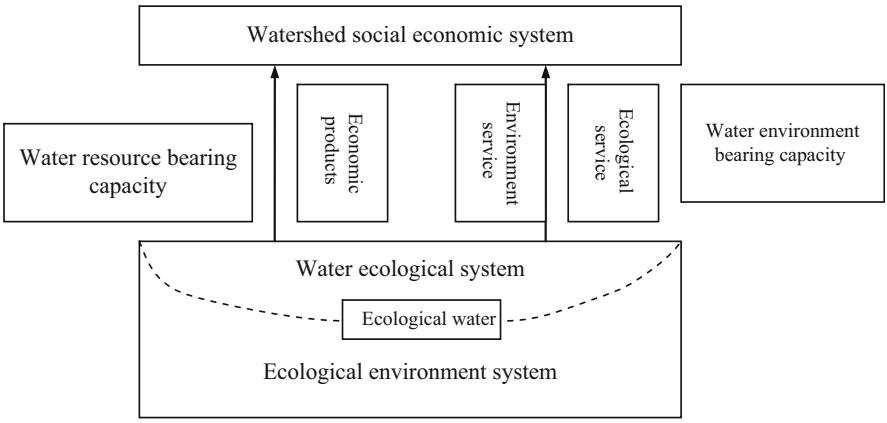

Fig. 2.2 Water ecological system and social-economic system

as economic and social development raise higher demand for water volume and water quality under the condition of satisfying survival. The fifth level is ecological environment security. After the requirements at the above five levels are satisfied, the important task is to improve ecological environment (Yahua Wang, 2013b).

Water security occupies a very prominent position in China. China has carried out long and large-scaled water control in which the natural geographical conditions have made the Chinese society in a state of extremely insecurity. Ancient China made water control as a matter of major importance in maintaining national stability, because floods and droughts were the biggest threat to human survival and the strongest destruction to the society. There were many incidences of social upheaval due to floods and droughts that accelerated the collapse of dynasties.[1] In contemporary China, flood remains a sting in the heart of the Chinese people and water shortages and water pollution have become important factors holding up economic development. That determines that the central task in water governance is to ensure security against floods, security in water supply and water environment and support for sustainable economic and social development. The book makes water security as the objective of water governance structure and the basic point of departure in analysis.

[1]For instance, the 16-year-long drought in 1628–1644 caused dramatic drop of crop fields and people to die of famine in 13 provinces and cities including Shaanxi, Shanxi, Shandong, Henan and Jiangsu. The severe drought accelerated the collapse of the Ming Dynasty.

2.3 Water Governance Structure

2.3.1 Importance of Water Governance Structure

Threat by water is a challenge a society has to face up to. In order to maintain survival and development, a society has to take up the challenge. To cope with challenges, the establishment and improvement of institution is fundamental. It is both the result of successful coping with challenges and the prerequisite for meeting new challenges. In order to ensure water security, it is necessary to make long-lasting institutional arrangements and shape up a governance structure good enough to cope with challenges. Governance structure is of vital importance in ensuring water security. Efficient economic organizations hold the key to economic growth of a country, while inefficient economic organizations are the cause of economic stagnation and recession (Song, 2016). Careful examination of the history of China's water governance could easily arrive at similar conclusions as those done by North, emphasizing that governance structure and economic organization are equally important. An efficient water governance structure, though not necessarily ensuring good water governance, holds the key to good water governance while inefficient water governance structure is, of necessity, unable to ensure good water governance and on the contrary even aggravates water disasters or even leads to conflicts or war. The following is a simplified model that can explain the relations between water governance structure and its governance performance.

Water governance performance can be measured by the level of water security ensured. The model assumes that under a given natural geographical condition, the performance is determined by governance ability, which is expressed in the function of three variables: economic, technology and institution. During a given period, the economic strength of a country determines the amount of input into water governance; technical level determines the actual efficiency of economic input; and economic and technical conditions together determine the possible maximum output level in water security, which is expressed in production possibility curve in the model. Figure 2.3 shows the coordinate may be seen as the specific goods produced from water governance such as X is anti-flood security level; Y is food grain security level. The production possibility curve is the combination of the two goods, which reflects the maximum governance ability under the constraint of technical and economic conditions during a given historical period.

It is only a theoretical possibility for economic and technical conditions to determine the maximum governance ability. The actual governance ability is always lower than the possible maximum value, which is located within the production possibility curve in the figure. The model assumes that the actual governance ability is determined by a given institutional framework (governance structure). A good governance structure is useful in mobilizing to the maximum the social resources so that the actual governance ability gets closer to the possible maximum value. Conversely, inefficient governance structure is unable to mobilize

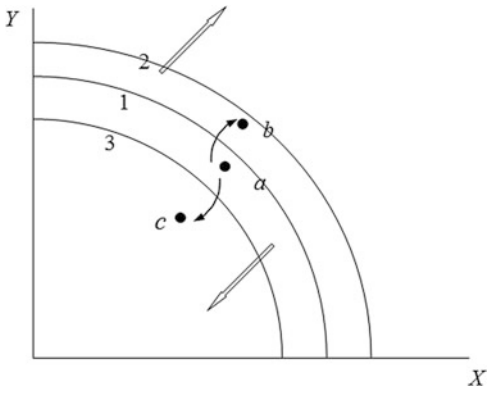

Fig. 2.3 Water governance structure and governance ability under constraint conditions economically and technically

social resources effectively and on the contrary artificially reduces the actual governance ability to make it far away from the possible maximum value. Statically, the model shows that economic and technical conditions during a given period of time and governance structure together determine the actual governance ability and correspondingly the water governance performance in the period, that is, actual output level of water security.

Dynamically, the model shows that the economic and technical conditions are constantly changing. If the economy grows sustainably, the input into water governance would increase and the production possibility curve would move outward (1→2). If the economy is in long-term recession, the input into water governance would be reduced and the production possibility curve would move inward (1→3). Technical progress can improve the efficiency of input in water governance and the production possibility curve may also move outward. The outward movement of the production possibility curve means the opportunities for increasing actual governance ability. If the governance structure makes effective response, the actual governance ability would rise correspondingly(a→b). If the governance structure is unable to be adjusted timely, the actual governance ability would not necessarily grow with the outward movement of the production possibility curve. The inward movement of the production possibility curve may make the original governance structure unable to continue and thus the actual governance ability drops correspondingly (a→c). That is to say, efficient water governance structure may, by mobilizing social resources to the maximum, elevate the actual water governance ability closer to the possible maximum ability while inefficient water governance structure would artificially lower the governance ability, thus dragging the actual governance ability far away from the maximum governance ability. That means that economic and technical conditions can only determine the governance ability, which could not turn into actual governance ability automatically. Only when under a given governance structure, can it turn into actual governance ability. This is the important manifestation of institution.

2.3.2 Water Governance Continuum

Water is a unity composed of basin or hydro-geological unit and that determines that water governance requires overall arrangements of a whole basin. Water governance involves the interests of decision-makers of all regions in the basin. In order to prevent and mediate trans-boundary disputes and reduce negative externalities resulting from cross-boundary damages and expand the positive externalities of cross-boundary cooperation so as to produce economy on a larger scale, it requires all policymaking entities to carry out collective actions. There are two reasons for collective action of different regions within the basin. One is to reduce negative externalities and prevent and mediate disputes resulting from cross-boundary conflicts. There are usually four kinds of disputes over water among different regions: (1) disputes arising from the building of water projects by one region that would affect the rights and interests of neighboring regions; (2) disputes arising from the allocation of water quantity or other rights and interests in the use of water; (3) disputes arising from flood-prevention, water drainage and river course control; (4) disputes arising from water pollution. The second disputes can expand the positive externalities and produce economies on a larger scale. Usually, integrated development, utilization and governance of water on the basin basis according to unified arrangements and planning may bring about greater scale economy. If different regions do not act collectively, the supply of the behaviors with positive externalities would be reduced. This has made necessary the collective action in building reservoirs along the middle and upper reaches, river course control in the lower reaches and in building anti-flood dykes. So long as there are externalities, positive or negative, all demand for collective action exist. The model of collective action of interest groups of different regions in a basin may largely be summarized as the following forms in Fig. 2.4.

The first is anarchy. Every region has its own independent action, without interfering in each other. This model is applicable to rivers that are not so harmful and there are no externalities in the use of water, especially international rivers. In ancient times when productivity was underdeveloped, the governance of many rivers was regional and there was not the necessity for collective action. The water governance of rivers was the affairs of each and every region. With the rise in the level of the development and utilization of water resources, the potential contradictions among different regions in a river basin increases and the anarchical governance model was prone to induce conflicts and even wars and there arose the necessity of united action in the governance of rivers. In the twentieth century, 145 agreements were signed on the governance of international rivers (Wolf, 1998). This shows that the anarchical model tended to be reduced in a modern society.

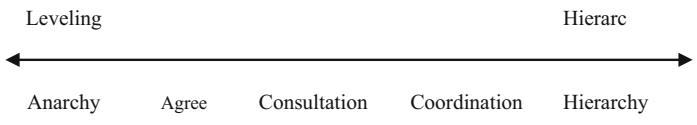

Fig. 2.4 Continuum of water governance structure

The second is agreement. Different regions in a river basin conclude agreements in the common interests of river governance and carry out collective action according to the agreements. This model has been extensively applied in the governance of international rivers. For instance, Lake Ontario is surrounded by eight states of the USA and two provinces of Canada. They reached an agreement in 1982 that there should be no change of water course without the unanimous consent of the ten local governments. Another instance is the water resources of the Nile River. Egypt and the Sudan signed a water use agreement in 1959, which provided a framework for the allocation of the water resources. Even within a country, this model is also mostly adopted in the cross-regional river basins, especially among federal states. In the United States, interstate agreement is one of the three major ways of easing conflicts in the use of water (the other two are to bring cases to the highest court and the establishment of interstate organizations). At present, there are many single purpose interstate water agreements, such as agreement on the allocation of water resources, agreement on controlling water pollution and agreement on setting up related public organizations. There are also some multiple-objective interstate agreements. The American Colorado River flows across seven states and the allocation of the water resources is mediated according to a series of agreements signed in the recent century (Kauffman, 2015; Schmidt & Shrubsole, 2013).

The third is consultation. In order to better oversee the implementation of river governance agreements or more flexibly resolve transboundary problems, unofficial consultation organizations may be set up to coordinate the action of different regions. This method has been extensively adopted in the governance of rivers, international or domestic. The main functions of the consultation organization are coordination, study and promotion. The policy decision taking must usually get the unanimity of all members. There is almost no coercive power. In the instance of the Nile, Egypt and the Sudan later established a joint committee on the basis of the agreements they signed to solve the water problems of the Nile by consultation. The water pollution control of River Danube in Europe is undertaken by a joint organization formed by a number of countries. Canada has also adopted this model in the management of part of its rivers. Taking Fraser River basin as an example, before the formation of a whole basin management organization, the upper and lower reaches of the river were managed separately. The Fraser Basin Council is a pure non-governmental consulting organization, governed by the unanimity of all regions and communities, without coercive powers. But in the United States, it is only in recent years that formation of interstate organizations has become the trend of the day. For instance, the Mississippi River has set up two non-official organizations to coordinate the interstate water affairs. The Great Lakes area has set up a Great Lakes Commission to coordinate the water issues in the lake area (Kauffman, 2015).

The fourth is coordination. When it is difficult to reach unanimity, it is necessary to introduce a coordination mechanism that is coercive in nature. This model often involves the establishment of official organizations that have varying degrees of coercive powers. This model is often adopted in federal states. The coercive power grows from weak to strong as in the following three cases. In India, irrigation and

flood prevention are the affairs of states while the central government coordinates interstate relations by setting up a national water resources committee, the central water committee and the Ministry of Water Resources, which work together to realize the coordination among different states. In the United States, the Delaware River basin and the Susquehanna River basin have set up official river basin councils with a status between federal and state, which have coercive powers over their respective river basins. There are also several other river basins in the United States that have set up basin management organizations that have coercive powers with the approval of the Congress. The New York-New Jersey—Connecticut Interstate Environmental Commission and the Ohio Valley Water Sanitation Committee have the management authorities in water quality.[2] The United Kingdom have set up water management bureaus with independent powers for major rivers to undertake the governance and water resources management of river basins, without being subject to the intervention by local authorities. The biggest among them is the Times River Management Bureau.

The fifth is hierarchy. If the coordination model is not enough to settle the problem of collective action among different regions, then, there is a more powerful centralized model. That is the government or quasi-governmental authorities to directly intervene in the inter-regional water affairs. This book calls this water governance structure with the highest centralization of power "hierarchy" model. Centralized states often resort to this model in river governance, such as the UK, France and Japan. However, due to constant delegation of power over the last century, their water governance often has the characteristics of other models of separation of power. China is one of a few centralized mono-system states and has adopted the pure "hierarchy" model in its river governance. The central government plays the leading role in inter-regional water affairs. Federal states may also adopt the "hierarchy" model in governing some rivers. The best known is the Tennessee Valley Authority, which was established in 1933 with the approval of the Congress. It is like a federal organization, with an extensive coercive power not only in water resources management but also in such regional development projects as power generation, waterway shipping and land resources development.[3]

[2]There are seven interstate agreements in the United States approved by the Congress and based on these agreements interstate water management organizations have been set up. They have different degrees of management authorities. The strongest is the Delaware River Basin Council (DRBC, http://www.state.nj.us/drbc/drbc.htm) and the Susquehanna River Basin Council (http://www.srbc.net/),followed by the New York—New Jersey-Connecticut Interstate Environmental Commission (http://www.iec-nynjct.org/) and the Ohio River Valley Water Sanitation Commission (http://www.orsanco.org/). The other three are Potomac River Basin Commission (http://www.potomacriver.org/), the Great Lakes Commission, (http://www.glc.org/), and the New England Interstate Water Pollution Control Commission (http://www.neiwpcc.org/),which have limited coercive powers.

[3]Rivers subject to the management by the 'hierarchy' model can also have basin organizations to coordinate the interests among different regions of the basins. The basin organizations are mainly acting on behalf of local interests. But in the coordination model, the basin councils or other organizations are something in between.

What is discussed above are the basic forms of five kinds of collective action, but they are not diversely different in practice. They are all in a continuum, developing from anarchy to hierarchy, with one level being higher than the other, which is measured by the concept of "residual control power". In the anarchy model, decision-making entities have nothing to do with one another. They have the entire control power over their own decisions. In the agreement model, decision-making entities have lost part of the control power due to agreements, but the residual control power is still held by each group. In the consultation model, a consultation organization settles common affairs through consultation, which is not necessarily based on 'unanimity'. Even there is 'unanimity', some decision-making entities are possibly forced to do so. In fact, they have lost part of their residual control power. In the coordination model, a coordination organization holds a fairly big independent decision making power to bring together the collective actions of the decision-making entities at lower levels, which have lost more residual control power. In the hierarchy model, all the residual control power is held by the decision-making entities at the superordinate level, with those at lower levels losing all their residual control power.[4]

The water governance structure in China is of the hierarchy model in that the residual control power is held in the hands of the government. As China is a mono-system country, the de facto residual control power is held in the hands of the central government. But in practice, management at different levels is necessary. Local governments have also been granted a certain measure of residual control power. In the hierarchy governance structure, the central government is the ultimate principal while local governments are but the agents of the central government. As far as the basic form is concerned, China's hierarchy water governance structure has undergone no fundamental changes over the past more than 2000 years since the Qin Dynasty, with all water related activities, such as waterway shipping, flood prevention and the building and maintenance of major water projects, put under the direct control of the central government. All the canals and waterways and dykes and dams, irrespective who have built them, have always been subject to the management by the government, except for small irrigation projects without large water allocation systems are left to private management. The fact that China has been able to effectively control water and maintain the continuity of the centuries-old civilization is inseparable from the hierarchy governance structure.

[4]This is only a single tier analysis instead of multi-tier analysis. The five typical water governance structures mentioned in the book, arising from the level of cross-boundary regions, are applicable to collective action at every level of the hierarchy structure. In the tiered structure, the policy decision making entities at every level may have different models of collective action. For instance, for a cross-country river, the upper-most level is the agreement of national policy decision making entities while at the intermediate level, provincial decision making entities within a state adopt the coordination model. At lower levels within a province is still the hierarchy model. The bottom level adopts the consultation model again.

2.4 Choice Model of Governance Structure

The literature cited above shows that the option for governance structure follows the general logic of transaction cost organizational theories, that is, under circumstance constraints including objective constraints, organizations seek a structure that can minimize transaction costs, i.e. governance costs. Given in the following is a governance structure choice model, which illustrates the inherent logic in the option for water governance structure. The model is also applicable in explaining the option by a state for governance structure.

We define governance structure as variable e, with the increase in e, the governance moves toward the higher level in the continuum. It is, therefore, necessary to define transaction costs that move in the opposite direction. In the governance structure continuum, with the rise in level, the costs also increase. For instance, the agency cost, also known as management costs (C_m). With the level descends, the costs increase, such as negotiation costs, contract performance costs, which are called collectively cooperation costs (C_n). The total governance costs (TC) is the sum total of cooperation and management costs, which are all water governance structure e's function. The definition is as follows:

$$C_m = L(e_i); C_n = I(e_i)$$

$$\text{Of which: } e > 0, \dot{L}(e) > 0, \dot{I}(e) < 0, \ddot{L}(e) > 0, \ddot{I}(e) > 0,$$

$$TC = C_m + C_n = L(e_i) + I(e_i) \tag{2.1}$$

$$\text{The condition of the first order of Min}(TC) \text{ is: } \dot{L} + \dot{I} = 0. \tag{2.2}$$

Define $\dot{L} = MC_m, -\dot{I} = MC_n$; MC_m is the monotonic increment function of water governance structure e; MC_n is the monotonic decrement function of water governance structure e, implicating respectively the marginal management cost curve and marginal cooperation cost curve (absolute value taken). As is shown in Fig. 2.5, the two marginal cost curves cross at e^*, the minimum value point of the total governance costs and also the equilibrium point of the governance structure.

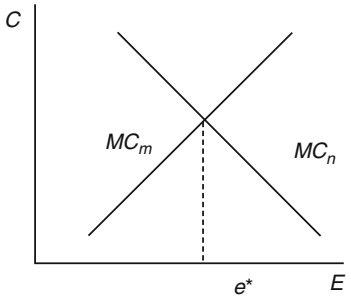

Fig. 2.5 Optimal equilibrium model of governance structure

2.4.1 Cooperation Costs

The less tiers of the governance structure hierarchy increase cooperation costs, which include the costs for collecting information about cooperation partners, the cost of reaching agreements and the cost of enforcing the performance of the agreements. Cooperation costs are originated in the opportunism of participants in collective action. For instance, some participants lack the sincerity in cooperation or ask for exorbitant prices in negotiations, resort to deceits or breach of contracts by taking advantage of information asymmetry, or adopt actions harmful to other participants under uncertainties. Such costs in the firm theories are costs of utilizing market mechanism. Here they refer to costs by taking advantage of political negotiations (Thráinn Eggertsson, 2014).

In the model, the cooperation costs are the function of the governance structure, which increases with the decrease in e. Marginal cooperation costs are also the function of e, which decreases with the increase in e. In an anarchy governance structure, participants in different regions each holds a fairly large amount of residual control power and there are, therefore, very big opportunities exist for resorting to opportunism behavior and the cooperation costs are high. If the cooperation costs of collective actions are too high for the society to pay, the only way to avoid their conflicts is to increase the levels of the governance structure hierarchy so as to reduce the possibilities of opportunism and the cooperation costs.

Although cooperation cost is regarded as the function of governance structure, there are in fact many more kinds of costs that affect cooperation. The first is the characteristics of the participants. Generally speaking, the stronger the asymmetry among participants, the higher the cooperation costs and vice versa. In water governance, due to asymmetry of negotiating forces among different regions, their concerted action reached is naturally concomitant with very high cooperation costs. If participants can easily turn to other cooperation partners, opportunism would lead to less losses and lower cooperation costs. Otherwise, if cooperation partners are fixed, the opportunism of cooperation partners would lead to bigger losses and higher cooperation costs. The cooperation partners are usually fixed in water governance and that has boosted the cooperation costs.

Secondly, the asset specificity of the target of cooperation affects cooperation costs. The higher the asset specificity of the goods involved in cooperation, the higher the losses that would be caused by opportunism of cooperation partners as in the case of having only water source in a region on the lower reaches of a river. In order to prevent the occurrence of such opportunism, the region has to make extra investments, which refers to a higher cooperation costs caused by asset specificity. This is universal in water governance. Even under the condition in which all participants fully honor their contracts, due to the incompleteness of contacts, opportunism may occur under many uncertain situations. Thus, the stronger the uncertainty of the environment, the higher the possibility of the occurrence of opportunism and the higher the cooperation costs. In the circumstance there is a strong variation of water, it is very costly to seek collective action by horizontal

cooperation. The changing circumstances are an important factor for increasing the levels of the governance structure hierarchy.

Many other variables can also affect cooperation costs. For instance, a social circumstance or cultural tradition full of cooperation spirit is conducive to lowering cooperation costs. Otherwise, it increases such costs. The greater the number of participants, the higher the cooperation costs and vice versa. The more complicated the water systems, the higher the cooperation costs, and vice versa. In the framework provided by the model, factors affecting the cooperation costs change the inclination of the marginal cooperation cost curve in Fig. 2.5.

2.4.2 Management Costs

The rise in the governance structure hierarchy will increase management costs. Management costs come from the principal and agency relations between the decision-making entities at superordinate and subordinate levels. The objective functions of decision-making entities at a lower level and the principal are different as they would not carry out superordinate orders unconditionally. The incentives for agents to carry out superordinate orders are often inadequate. They tend to distort information in their own interests so that the efficiency of the structure drops. In order to prevent opportunism of agents, the superordinate decision-making entities must commit resources to control, oversee and coordinate subordinate agents so that their behaviors would get closer to the objectives set by the principal.

Our model also regards management costs as the function of governance structure e, which increases with the increase in e. Marginal cooperation costs are also the function of e, which decreases with the decrease in the value of e. As the price of reduction in cooperation costs, the management costs will increase with the levels increased in the governance structure hierarchy. This is a force that restricts the infinite rise in the hierarchy. The main reason for the increase in management costs is the reduction in the residual control power in the hands of subordinate decision-making entities, and with the rise in the degree of hierarchy its own incentive drops accordingly, thus leading to more outstanding problems between agents and the principal. The lower the efficiency of the hierarchical governance structure, the higher the management costs rise and the bigger the inclination of the marginal management cost curve.

Like cooperation costs, there are many other factors influencing the management costs. Usually, the greater the number of agents, the longer the agency chain, and the greater the asymmetry of information between the agents and the principal and the higher the management costs, and vice versa. Information asymmetry is one of the root causes of agency costs. The greater the asymmetry of information, the higher the management costs and vice versa. The role of factors affecting management costs is to change the inclination of the marginal management costs in Fig. 2.5.

2.4.3 Equilibrium in the Governance Structure

The optimal governance structure is a structure that has the least transaction costs. When marginal cooperation costs are equal to the marginal management costs, the governance structure is the equilibrium structure with the least transaction costs. To put it more simply, the option for water governance structure is, in reality, the trade-off of advantages and disadvantages brought about by the rise in the hierarchy structure. The main advantages of the hierarchical structure are: (1) it can obtain greater security guarantee, which is exhibited in the mobilization and regulation of resources by the authoritative decision-making entities in the environment of great uncertainties; (2) it can obtain the greatest efficiency in the unified planning for water governance; (3) it can provide more coercive implementation mechanism in settling conflicts of interests. The main disadvantages are: (1) the concentration of residual control power and the arbitration of the superordinates in decision making would result in the increase in the possibilities of errors; (2) it would reduce the incentives to decision-making entities at lower levels and aggravate the distortion of information in the hierarchy; (3) the authority derived from hierarchy is easy to make the whole system rigid and slow in response. In a word, the advantages of the hierarchical organizations lie in a high level of security while the disadvantages lie in a low level of efficiency. The anarchical organization can fully mobilize the initiatives of all quarters, however, it is very difficult for it to mediate conflicts.

The cooperation cost curve and the management cost curve go together to determine the equilibrium governance structure. Statically, if the marginal curve of cooperation and management costs can largely be fixed, the point where the two curves cross is the equilibrium of the governance structure. Dynamically, with the changes in the influencing factors, the forms of the two curves may all change, thus causing the marginal curves and the equilibrium point to move. For instance, if the uncertainties and sudden changes increase in the hydrological system, they would raise the cooperation and management costs, with the cooperation costs rising even faster, thus the equilibrium point will move toward higher tiers of the hierarchy structure. If there is progress in hydrology and information technology, the cooperation and management costs would be lowered, with the management costs lowering faster, thus increasing the levels of the governance structure hierarchy.

2.5 Origin of China's Hierarchical Water Governance Structure

2.5.1 Views of the Water Governance School

The birth of China's hierarchical water governance structure is a response to the frequent droughts and floods and the consequences of the interaction between

human and nature. The hierarchical structure took shape in the year 221 when the Qin Dynasty unified the country. The national unification means the establishment of the hierarchical water governance structure. In fact, hierarchy is not only a feature of water governance structure but also a feature of social governance structure. The origin of the water governance hierarchy and the origin of the unified political system have inherently close relations. The following is a review of the origin of this idea.

There are many scholars who have touched the subject over the past century, that is, the inherent relations between China's early unification and the unique natural geography and climatic conditions. The "water governance" school represented by Marx and Wittfogel is most influential. The school holds that large irrigation projects have their unique importance in the East and they are of great significance in the emergence of the oriental despotism or centralism (Curtis, 2009).

Marx was the earliest to see the importance of irrigation project in the Asian civilization. In the Orient where civilization was too low and the territorial extent too vast to call into life voluntary association, the interference of the centralizing power of Government. Hence an economical function devolved upon all Asiatic Governments, the function of providing public works. This artificial fertilization of the soil, dependent on a Central Government, and immediately decaying with the neglect of irrigation and drainage, explains the otherwise strange fact that we now find whole territories barren and desert that were once brilliantly cultivated, as Palmyra, Petra, the ruins in Yemen, and large provinces of Egypt, Persia, and Hindostan; it also explains how a single war of devastation has been able to depopulate a country for centuries, and to strip it of all its civilization (Marx & Engels, 1972, p. 64). Wittfogel goes a step further when he points out in his "*Oriental Despotism*" (Wittfogel, 1957) that irrigation was the primary cause for despotism in China. It is defined that civilizations whose agriculture is dependent upon large-scale waterworks for irrigation and flood control are 'hydraulic society', which featured despotism and centralized bureaucratic administrative system. Although Wittfogel's theories of are much disputed, they provide clues to the importance of irrigation in the oriental civilizations (Gregg, 2016).

Huang (2002) further developes the theories of the water governance school. He holds that the unification of China was a response to the force of nature and irrigation played a major role. Relative to the irrigation projects Marx and Wittfogel stressed, Huang puts more stress on the importance of fighting against floods. He gives special stress to the severity of the floods of the Yellow River. He argues that local control would come to nowhere. Only there is a centralized government that controls all the resources and gives equal treatment to all parties concerned, is it possible to ensure security and free the people from constant threat. It is underlined that water control alone is enough to demonstrate that the centralized system is inevitable in China. Moreover, regarding unification of China, Huang believes that the Yellow River flood is an important variable, but not the only one explanatory variable. It suggests that work relief and national defense are the two factors for promoting the unification of the country (Huang, 2002, pp. 6–10). All the three factors are determined by the natural geography of China and that is why Huang

holds on to the view that natural force is the more decisive factor behind the unification of China. Toynbee advances the 'challenge and response' model for the rise of civilization. The ancient Chinese civilization was originated in response to the challenges by the difficult conditions of the Yellow River just as the ancient Egyptian civilization was originated in response to the challenges by shrubs and marshland in the Nile Delta and the Maya civilization was originated in response to the challenges by the tropical forests and Minoan Civilization was originated in response to the challenges by the sea (Toynbee, 1989; Lang, 2011). Needham (1981) sees the importance of water control in China, saying that the existence of the 'bureaucratic system' is the need of safeguarding the irrigation system.

2.5.2 Particularities of China's Option for Water Governance Structure

The preceding section advances the choice model for governance structure, which may provide scholars of the water governance school with an official theoretical connotation. This section explain why China has opted for the hierarchical water governance structure and, in the next section, it will show how the hierarchical water governance structure led to the hierarchical structure in state governance. Based on our model, the water governance structure of a country is determined by the comparison of cooperation and management costs. The particularities of China's option for water governance structure lies in the high cooperation costs, which is expressed in the difficulty for carrying out equal and cooperative collective action in the supply of large scaled public services such as flood prevention and work relief.

Now, first of all, let us examine the option for collective action in fighting against floods. China's unique monsoon climate and geographical conditions determine the big threat of floods, especially from the Yellow River, because it carries the largest amount of mud and sands downstream (Xia & Pahl-Wostl, 2012). The river course on the lower reaches is very easy to be choked. Although large scaled collective action took place during the Qin Dynasty when the social productivity was at a very low level, the people were gravely threatened by floods. Without a highly authoritative organization to coordinate the actions of various regions, the local conflicts were constant, as cooperative action was quite difficult. This is evidenced by historical literature. In the Western Zhou period, dykes already appeared on the lower reaches of the Yellow River, indicating the need for collective action among various regions. During the Spring and Autumn period, various kingdoms on the lower reaches began to build dykes, which threatened each other's security. Some kingdoms viciously imposed disasters on neighbors. In order to prevent the act of "making neighbors as water outlet" and "using water as a weapon", there was the need to make contracts among the minor kingdoms. In 651 B.C., Qi Huan Gong called all the dukes to meet in Kuiqiu and took oath not to build dykes secretly and

ban secret dykes. This shows that the kingdoms of dukes ensured each other's security against floods by signing agreements. Up to the Warring States period, the dykes on the lower reaches of the Yellow River began to assume a considerable scale, which is evidenced by the description by Jia Rang of the Western Han Dynasty, which states that the building of river dykes started in the Warring States period to protect all the rivers and all benefited from them. The State of Qi shared a river as borders with the State of Zhao and the State of Wei, which set against mountains. The State of Qi built a dyke along the river, extending 12.5 km. The river flowed eastward to the dykes of the State of Qi. Threatened by floods in the west, the State of Zhao and the State of Wei also built dykes, extending 12.5 km (Waley, 2012). The State of Qi was the first to build a dyke due to its low-lying terrain to ward off floods. Seeing that the floods invaded Zhao and Wei, the two states also built dykes. In 332 B.C., the State of Zhao was engaged in a war with the State of Qi and the State of Wei and breached the Yellow River dyke to flood them. This shows that the states of dukes could not reach unanimity in collective action by taking oath and it is impossible to ensure security against floods by signing agreements. After the Qin unified the country, water governance, which was cut up by various states during the Warring States period, was also unified, with all the military installations that obstructed water flow and all the passes that obstructed communications removed, making it possible to link up all the states of dykes. This is what was done by Qin Shi Huang, the first emperor of the Qin Dynasty (Sima, 2007).

The difficulty in cooperation on an equal footing is seen not only in the flood control of the Yellow River but also in disaster relief, including both droughts and floods. As natural disasters visited all different states of dukes every year, there was a need of "mutual assurance" and sharing of the obligations of disaster relief among the states. When there was a famine and neighboring states fail to provide relief, it would probably lead to war. At the Kuiqiu meeting, the participating states also promised not to wage war in famine. However, such promise was in fact very feeble. War took place very often. According to the records of "*Zuo Zhuan*", famine struck in the State of Jin in 647 B.C.. The State of Qin came to its rescue. The following year, famine visited the State of Qin. Yet, the State of Jin, instead of providing relief in return, waged a war against it. There were many wars like this during the Spring and Autumn period. Huang Renyu points out that the above background could only increase the possibilities of conflicts. Vexation by war for hundreds of years gave rise to the desire for unification. The benefit of unification is that a big state controls more resources and can more efficiently provide relief to disaster victims (Huang, 2002).

The particularities of China's choice for water governance structure lies in the changing natural and geographical environments. In the early period of civilization, there was the need for large scaled collective action in controlling floods. But under the then productivity level, the costs for collective action based on equality among states were extremely high. In our model, it means the marginal cooperation cost curve MC_n is very steep, resulting in a very high degree of the equilibrium water governance structure hierarchy e^* (see Fig. 2.6). Our model shows that the

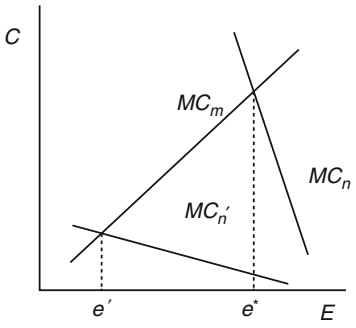

Fig. 2.6 Economic explanation of China's choice for water governance structure

hierarchy structure is optimal for China in water governance. In the early period of the growth of the Western civilization, for instance, in the ancient European continent, there were neither so capricious weather conditions as in China nor such disastrous floods like those brought by the Yellow River. There was, therefore, not the need for large scaled collective action in water control. That means that under the natural geographical conditions in Europe, the cooperation costs needed in collective action in the public service like water governance among countries was quite small, which is shown as very flat in the marginal cooperation costs curve MC'_n, hence the very low level of the water governance structure hierarchy e'. (see Fig. 2.6). The comparison is conducive to our understanding why China needed a highly centralized and unified system in water control—the cooperation costs in joint water control were too high, that is, the cost of political negotiation mechanism among states was too high. The highly centralized system can economize the cost of political negotiation to the maximum. It is, therefore, an equilibrium governance structure.

2.5.3 The Formation of Hierarchical State Governance Structure in China

According to the theories of the water governance school, the requirements of water governance for centralized system are the inherent driving force behind the unification of China. In the dissertation language, it means that the demand of water governance for hierarchy structure determines the demand for the hierarchy structure in the governance of the state, ultimately leading to the birth of an empire. Starting from Western Zhou period, there were more than 100 states ruled by dukes. The water governance structure was also dispersed. That is a kind of instable governance structure. The society thus developed an internal driving force for contraction toward equilibrium structure, thus leading to, step by step, great unity from the segmentation by dukes. This is a process of long-time games, a process of transition from instable governance structure to stable structure. Before Qin unified the country, China had been in a long period of mutual slaughter. The original more

than 100 states were reduced to dozens and ultimate to 13. In the last 200 years of the period there were only seven bigger states left. Qin annexed the other six to complete the unification. There has no such a scaled centralized movement in the world history. It is no doubt that natural forces are the deciding factors behind the unification of the country (Sima, 2007).

In the framework provided by our model, China, which used to be cut up by more than 100 states, became one country after more than 500 years of merger and what is behind is the natural force and the too high cooperation costs in the supply of public affairs that led to prolonged wars and conflicts. The essence of the matter is the extreme instability of the flat governance structure. Such a society has the powerful internal driving force to lower the governance costs by raising the flat governance structure to a high degree of hierarchical structure and at the end it is evolved into a stable hierarchical structure. This vibrating process that extended for as long as 500 years as shown in $e^0 \rightarrow e^*$ in Fig. 2.7, is a process of movement from a point far away from the equilibrium point to the most optimal equilibrium point, thus giving rise to a hierarchical structure in the governance of state, that is the empire system.[5] This shows that the formation of the hierarchical governance structure is, in fact, for the purpose of economizing cooperation costs, that is, the cost of political negotiation in the inter-regional public affairs. However, while economizing cooperation costs, the hierarchical structure has to pay a fairly high price for management in order to maintain the stability of the governance structure, hence there is its internal driving force for lowering management costs. Once the hierarchical structure is formed, it would develop its culture compatible with the system, lower management costs, thus enabling the marginal management cost curve to move inwardly, which is shown in $e^* \rightarrow e^{**}$ in Fig. 2.7, a movement toward the higher and more optimal equilibrium point in the hierarchy, the higher the degree of hierarchy, the more centralized power in the empire. The above

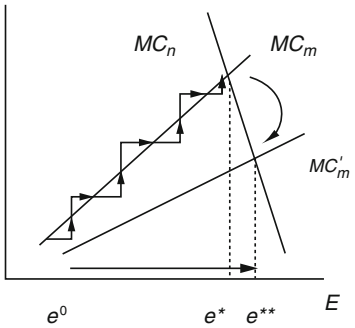

Fig. 2.7 Early origin of China's hierarchical water governance structure

[5]China's empire started in the Qin Dynasty which unified the country. Before that, China had the features of federal states. What the centralized system pioneered by the Qin Dynasty was known as "province and county system" or unitary system.

analysis reveals two features of the hierarchical structure: first, the formation of the hierarchical structure is the result of economizing cooperation costs; second, the maintenance of the hierarchical structure necessitates the lowering of management costs, hence determining the "self-reinforcement mechanism" of the hierarchical structure. In other words, once the centralized structure is formed, the degree of centralization would tend to be self-maintaining and reinforcing. The logic is applicable to the hierarchical water governance structure and also to the unified empire system.

The above is a re-explanation of the theories of the "water governance" school by employing the model constructed in this book. It is not a simple repetition of the existing thought but new propositions deduced from the existing theories by employing a modern economics model, which have enriched and developed the existing theories. The following are the three major propositions that have brought the theories of the "water governance" school into depth.

First, China's unified system is the product of transaction costs (cooperation costs) economizing. The book analyzes the logic that the building of an empire is for the purpose of economizing the high cooperation costs by replacing vertical administrative control with horizontal political deals. This almost runs in the same groove as Coase Theory of the Firm. This discovery is the deepening of the theories of the "water governance" school, which holds that the unified system is the demand for centralization of power in water control. This book has further revealed that the exact meaning of such demand is to lower cooperation costs in the supply of inter-regional public affairs. The unified system is, in essence, a model of collective action by exercising the centralized power and vertical orders that replaces the model of collective action featuring separation of power and horizontal association. This is the result of the efforts by the early civilization to cope with the challenges by nature and seek transaction cost economizing.

Second, a unified empire has the powerful motivation to lower transaction costs (management costs). In order to maintain its stability, an empire has to lower effectively management costs and make institutional arrangements, cultural orientation and ideology compatible with the centralized system. This can explain the series of important measures adopted by all kingdoms in a bid to strengthen the centralized system. For instance, after unifying China, the Qin Dynasty replaced the feudalism system with the "*Jun (province)-Xian (county) system*", unified measurement system and the language, burnt books and buries alive Confucian scholars and banned freedom of thought. All these institutional arrangements were aimed to lower management costs. Later dynasties drew on the experience of their predecessors to introduce new institutional arrangements to further lower management costs. The Western Han Dynasty introduced the policy of "*banning all schools of thought but Confucianism*" to lay the cultural foundation compatible with the unity of the country. Sui and Tang dynasties introduced the imperial examination system to select officials as spokesmen for the ruler. These major institutional arrangements constantly reinforced the empire system.

Third, the disintegration of an empire is the result of inability to effectively control transaction costs (management and cooperation costs). Effective lowering

of management cost is the prerequisite for maintaining an empire. Management costs are mainly the costs of entrusting agents, that is, the costs for the operation of the entire bureaucratic system. At the beginning of a kingdom, as immediate interest groups were smashed or weakened, it was easy for the ruler to lower management costs and the operation of the bureaucratic system was fairly efficient. But, with the passing of the time, new interest groups began to form and the operation of the bureaucratic system became less efficient and even rigidified, with corruption and bad administration running wild, thus resulting in a rapid rise in management costs. When the management costs rose too high, it became difficult for the centralized governance structure to go on, thus causing the social cooperation costs to rise rapidly. All these added to the total transaction costs until the society was unable to bear and the empire was going to collapse. But as the motivation for national unity was still there, and there was the inertia of civilization, that is, the features of 'path dependence' (David, 2007) for the changes of system, there was still the tendency of re-embarking on unity after the separation. This is, in reality, an explanation of the changes of ancient kingdoms in China.

2.6 Water Governance Structure and State Governance Structure

There are inherent relations between the water governance structure and the state governance structure, because water is a public resource involving the interests of all people and the population covered by water governance and state governance is the same. For most countries, water governance structure is selected after the state governance structure takes shape. State governance structure is exogenous of water governance structure and has a major impact on the option for water governance structure. In the early period of the Chinese civilization, due to the particularities of water problem, such as frequent droughts and floods and the severity of the Yellow River floods, the option for water governance structure had a decisive impact on the option for the state governance structure.

Why, then, water governance has such an explanatory power of the Chinese civilization? The following is a further illustration provided on the basis of Fig. 2.3. In this model, we have added another new conceptual curve, known as the "minimum governance ability demand curve", which refers to the minimum governance ability required for a certain degree of water security in an area. It is expressed in a dotted production possibility curve in Fig. 2.8. We assume that it is relative stable. The particularity of China is that in ancient China when productivity was at a very low level, the maximum possible governance ability curve(C_0)was still lower than the minimum governance ability demand curve (D). That means that even in the early period of the Chinese civilization, the country was gravely challenged by water. Under the low production and technology conditions, even if the country acquired the maximum possible governance ability, it was not enough to ensure

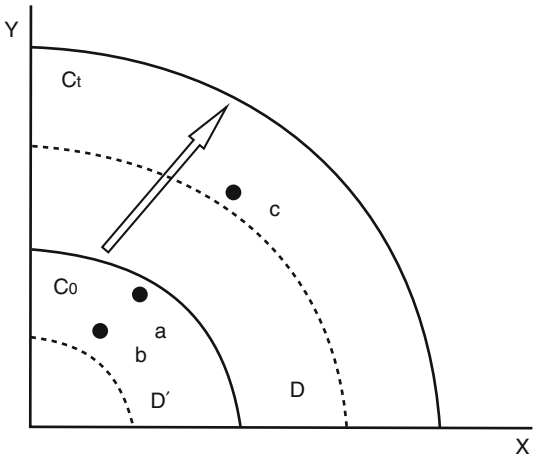

Fig. 2.8 Minimum governance ability demand curve and water governance structure options

water security. In face of such tremendous pressure brought about by the threat of floods, the society had the powerful intrinsic driving force to opt for a governance structure that could economize transaction costs to the maximum, thus making the actual governance ability to get closer to the maximum to the then maximum governance possibility curve (point a). Such governance structure is a highly centralized hierarchical structure, which is the most optimal to cope with the challenges by nature under the then low level of productivity.

The civilizations in Europe and the Americas were quite different from the Chinese civilization. In the early period of the European and American civilizations, challenges by floods were not so grave to the society. The minimum governance ability demand curve is not only at a very low level (D′) but also far lower than the then maximum governance possibility curve (C_0). It was not necessary for such society to tap fully the maximum governance ability. A quite low actual governance ability (point b) is enough to satisfy the need for ensuring water security. The early civilization was in such an environment that water governance did not have much explanatory power about the growth of civilization. But just the contrary is true with China. In such a civilization, state governance structure determines water governance structure and the formation of state governance structure requires explanation by other factors. The comparison of the Chinese and Western civilizations shows that a hydraulic society is indeed an important clue for knowing the unique features of the Chinese civilization.

In the ancient agricultural society after the Qin Dynasty unified China, water governance still had a strong explanatory power about the Chinese empire that continued for more than 2000 years. It is discovered that in the time-honored ancient Chinese history, even in the peaceful period, the country did not have enough strength to resist the Yellow River floods. During the 23 years of the Reign of Zhen Guan of the Tang Dynasty, the Yellow River was flooded in eight; in the 134 years of the reign of Emperors Kangxi and Qian Long of the Qing Dynasty, the Yellow River was flooded in 47 (Zhu, 2004). This shows that under the

production and technology conditions of the ancient agricultural society, the economic surplus and technical ability accumulated by the society were hardly enough to ensure water security in the Yellow River basin. It can also be deduced that the maximum governance possibility curve (C0) was always below the minimum governance ability demand curve (D). Till the modern society, due to the development of industrial civilization, the economic surplus has increased in large amounts and technology has progressed rapidly, making the maximum governance possibility curve move far away in the outward direction (C_t), higher than the minimum governance ability demand curve (D). That is the basic pre-condition for ensuring the security of the Yellow River and realizing peace every year. Although the hierarchical governance structure is also the institutional guarantee against Yellow River floods, because the maximum governance possibility curve is already higher than the minimum governance ability demand curve, it is not necessary to make the actual governance ability to get as close as possible to the maximum governance possibility curve. What is required is to make it slightly higher than the minimum governance ability demand curve (point c). We can also say that the demand of the modern society for the hierarchical water governance structure has dropped to a certain extent and so has the explanatory power of water governance structure on the state governance.

The unified system of China is super stable, just as the "Qin system" that lasted for thousands of years. Although ancient China saw the successive rules by dozens of dynasties, the centralized system as the basic form of state governance has not changed much.[6] Such super stable structure is closely associated with the hierarchical governance structure, which is the result of the response to the challenges by nature. Once it was formed, the centralized empire would by all indigenous means to maintain the central power, thus giving rise to a political structure and economic system compatible with the centralized system and also giving shape to the unified culture and mentality. These and the natural geographical conditions have made the centralized system acquire its self-maintenance inertia and shaped up a form of civilization that can constantly strengthen itself. Such civilization has a tremendous inertia. It is impossible to reshape fundamentally the civilization without revolutionary external forces. China is, therefore, a 'hydraulic society' for thousands of years. Even today, it is left with the lasting imprint of a hydraulic society.

[6]In the more than 2000 years since the Qin Dynasty, China was in unity for two-thirds of the time and in disunity in one-third of the time. Even during the period of disunity, the popular feelings also pointed to unity. So, unity is the constant state of China. Such super stable centralized system that has continued for more than 2000 years is unique in the world history.

http://www.springer.com/978-981-10-5082-4

Assessing Water Rights in China
Wang, Y.
2018, XVII, 242 p. 38 illus., 6 illus. in color., Hardcover
ISBN: 978-981-10-5082-4