Chapter 3 Main GEC Research Contents

3.1 Understanding of Relation Between Environment and Economy

Environment and economy are two factors of a system. Between the two there is a kind of both opposition and unity dialectical relations. On the one hand, the environment and the economy are interdependent and closely linked entity. Environment is the basis and conditions for economic development, for any economic activity is under certain environment and resource conditions, environmental pros and cons will play a direct or indirect role in promoting or inhibiting economic development. And economic development, in turn, can provide guarantee funds and technical support for environmental protection and improvement to promote the virtuous cycle of economy and environment. On the other hand, the environment and the economy the environment and the economy are opposite and mutually exclusive to each other. Human has to continue to develop and utilize natural resources in the process of production and living which is bound to have an impact on the environment. Especially after the industrial revolution, with the rapid development of global industrial production and a surge in resource utilization, environment pollution is worsening, which has brought a huge threat to human survival and development, but also limits the further development of the economy. With the development of economy and the progress of human society, awareness of environmental and economic relations mainly experienced the following three stages:

3.1.1 Understanding of the Relation Between Environment and Economy Before the Industrial Revolution

Early development economists in discussing development issues, mainly focus on issues such as the economic growth, income distribution, employment and other ones, and often neglect environmental concerns, or just simply mentioned. Therefore, during this period the environment is simply seen as "library materials" providing resources for the economic development and "natural container" accommodating unlimited waste, and the emission is also lower than the capacity of natural environment. Environmental issues are not particularly prominent during this period, the harmfulness of environmental problems also lack enough understanding. In understanding the relationship between environment and economy, it is widely believed that environmental pollution is the price to pay for economic development, thus making the policy choice is to pursue rapid economic growth, consume large amounts of resources, at the expense of environment, damage ecology, which is simply "economic development determinism." Especially for developing countries, economic growth becomes a priority target.

3.1.2 Understanding of the Relation Between Environment and Economy After the Industrial Revolution

Human production technical level and material civilization level has been greatly improved after industrial revolution in the middle of the eighteenth century. However, large-scale industrial production and a substantial increase in the population makes the use of resources growing rapidly, resulting in economic development, at the same time, resulting in increasingly serious environmental damage, and natural resources are exhausted, natural ecological environment system is unable to recover in a short time, thus restricting the progress of human society and economic development.

In recognition of this reality, people began to attach importance to environmental protection, through a variety of systems, policies and techniques to bring economic development to reduce pollutant emissions. However, investment in environmental protection has to spend a high price, but also restrict economic development; so many people think that environmental protection and economic development are mutually contradictory and incompatible. Under the influence of this idea, people making policy choices are biased. One view is blindly emphasizes environmental protection, at the expense of economic development, namely "antigrowth theory" or "zero growth" theory, "Limits to Growth" published by Meadows and other scholars is the typical view. "Zero growth theory" is unrealistic for developing countries which in the urgent need to achieve industrialization and modernization, and promote economic growth. But to some extent, it poses a challenge to traditional concept of development centering on growth, and has positive significance in promoting coordinated development of environment and economy. There's viewpoint putting forward the development path of "treatment after pollution", that is taking steps to control the environment after economy developing to a certain stage. In essence analysis, these views and the aforementioned "Economic Development Determinism" regarded environmental protection opposites to economic development, while ignoring the mutually reinforcing and connecting linkages between them.

3.1.3 Understanding of the Relation Between Environment and Economy Since the 1960s

In 1950s and 1960s and 1980s, with two serious outbreak of environmental crisis in human society, contradictions between environment and economic development are increasingly acute. Environmental problems quickly develop from local, regional problems into global issues around the world. Humans also gradually realized the relations between the environment and economy which are mutual promotion and mutual restraint. Therefore, in order to avoid environmental problems, economic activity must be in the range of environmental carrying capacity, so as to achieve coordinated development of economic and ecological environment, namely to achieve a virtuous circle between the two. Since the 1960s, in order to strengthen environmental protection, the world has held a series of Environment Conference, adopted a series of environmental declarations, environmental conventions, and proposed the concept of sustainable development. Under the guidance of this idea, economic development and environmental protection are not contradictory, but can achieve harmony and promote each other. Environmental issues are generated in the process of economic development, but also needs to be properly addressed in the process of economic development. It is possible to promote the economic development while improving the quality of environment through effective policies. In the process of global environmental protection, the world has reached such a consensus that economic development must coordinate with environmental protection and ecological balance. Only insist global sustainable development can we achieve the improvement of living standards and quality of all mankind and promotion of the common prosperity of human society.

3.2 Environment and Competitiveness Relevance Analysis

Researches on the relation between environment and competitiveness began with people's recognition of the importance of environmental protection due to environmental deterioration, ecological damage and resource depletion. Further attention on the subject could be traced back to both the impact of environmental protection on production cost and then on international trade and the increased economic loss caused by environmental pollution. Environment and competitiveness is not only an economic issue; it has been more a comprehensive issue involving social development, political and diplomatic areas. The issue now has become a focus for governments and the entire humankind. Following are the main views about the relevance between environment and competitiveness.

3.2.1 Equivalence Theory: Environment Is Competitiveness

Since the start of ecological civilization, the harmonious cohabitation of both humans and nature has become the objective of development. In 1992, the United Nations Conference on Environment and Development proposed and approved the Agenda 21; China's State of Council approved White Paper on China's Population, Environment and Development in the twenty-first Century in 1994; USA released a plan for sustainable America towards twenty-first century in 1996; EU established the green Europe development strategy in 1998; and Japan proposed the new national policy of building up the nation from environment in 1999.1 All countries of the world are putting the maintenance of environmental balance and the survival and sustainable development tightly tied together. The viewpoint of equaling environment to competitiveness emphasizes the decisive effect of environment in enhancing the competitiveness of a nation or region and believes that environmental strength level will directly decide the strength of regional competitiveness and that regional competitiveness will gain new driving force and source through environmental competitiveness. This theory is mainly adopted and applied by cities or regions with superior natural environment, comfortable living environment and outstanding investment environment. Of course, this point of view regards environment as equal to competitiveness, which neglects the effects and influences of other factors and mixes up the connotation and significance of environment and competitiveness.

3.2.2 Element Theory: Environment Is a Component Element of Competitiveness

Element theory regards environment as one of the component elements to weigh the strength of competitiveness, but it is not the only element; instead, environment, as well as the economic, social and political elements, together constitutes competitiveness. Douglas Webster and Larissa Muller (2000) is the first to introduce natural

¹ZHU Da-jian and LI Jing-sheng. Strategic Steps to Enhance the Green Competitiveness of Shanghai Metropolis: A Research on Building Chongming into an International Comprehensive Ecological Demonstration Site. Journal of Tongji University (Social Science Section). 2001, vol. (12), No.5: 21–27, 54.

environment into the framework for city competitiveness research and elaborates from the impact of natural environment on the non-transferable regional endowment to the process of city competitiveness.² In Blue Book on China's Provincial Competitiveness, sustainable development competitiveness and development environment competitiveness are included in the evaluation system, which reflects the importance of environment. IMD Business School also puts health and environment as one of the 20 sub-index of the national competitiveness indicator system. The formation of this point of view indicates growing emphasis on the position of environment in assessment of competitiveness and the effect as an element to measure the strength of competitiveness at national and municipal level; but, the theory failed to stress the relative importance of environment and neglected the assessment of the potential and ability of environment to influence competitiveness.

3.2.3 Influence Theory: Environmental Protection Influence Competitiveness

Influence theory mainly aims at the relationship between environment and international trade; it argues that environment influences international competitiveness from aspects like comparative advantage, industrial transfer and trade barrier.³ At present, the international academic circle has put forward three related theoretical hypotheses: the race to the bottom (RTB) hypothesis based on prisoner's dilemma, assuming that all countries will select to adopt tolerant antipollution measures in order to obtain competitive advantage and increase international competitiveness, which will intensify global environmental deterioration; the pollution haven hypothesis based on industrial transfer, assuming that adoption of tolerant antipollution measures is favorable to cost reduction, investment increase or production advantage, thus would pull industrial transfer towards it; Porter hypothesis based on longterm change, assuming that from the long term, adoption of strict antipollution measures will produce positive effect greater than the negative effect caused by cost up.⁴ Hence we see two totally opposite point of views. On the one hand, they say strict environment regulation will increase production cost and management expenditure and thus will decrease output and profit, increase management difficulty, hamper technological innovation and finally influence competitiveness; on the other hand, people think that strict environmental regulation will promote enterprise innovation, increase resource utilization efficiency and finally promote

²YANG Tong and WANG Neng-min. Literature Review and Some Issues on the Relationship between Environment Protection and Urban Competitiveness. Journal of Qingdao University of Science and Technology (Social Sciences). 2008, vol.24 (2): 22–26.

³ZENG Fan-yin and FENG Zong-xian. Environment-Based International Competitiveness of China. Economist, 2001.5: 28–33.

⁴ZHAO Xi-kang. Environment Protection and International Competitiveness. China Population Resources and Environment. 2001.11(4): 12–16.



Fig. 3.1 Environment-competitiveness model

structural upgrading of industry and enhancement of competitiveness.⁵ The relationship between environmental protection and competitiveness is influenced by cost and differentiation these two factors, which can be described in the Environment-Competiveness Model (ECM).⁶ As the social cost effect induced by environmental deterioration, the economic growth effect of endogenous environmental cost, and the endogenous growth effect of environment as a production factor, all influenced environmental cost, different competitiveness models based on different "costprofit" ratio appeared. Besides, since the strictness of environmental regulation distinctly differentiate competitors, the impact of environment on competitiveness shows dynamic changes alternating between positive and negative. Environmental protection influences competitiveness, but in varied direction and degrees. This point of view emphasizes the impact of environmental regulation strictness on international competitiveness and confines the issue within the scope of international competitiveness; it neglects both the endogenous influence of environmental quality on competitiveness and the influence of environmental management steps outside environmental regulation.

3.2.4 Summary: Environmental Competitiveness Is an Integrated Concept

Environment is competitiveness, environment is a component element of competitiveness, and environmental protection influences competitiveness, the forming of which indicates increasing attention to environmental issues on the one hand, and on the other shows the intensity of international competition under globalization. However, the current discussions mainly focus on the levels of natural environment, environmental protection, product competitiveness and enterprise competitiveness,

⁵QU Ru-xiao and WANG Yue-shui. Environmental Protection: An Important Instrument to Enhance International Competitiveness. Commercial Research. 2002.10: 84–85.

⁶FU Jing-yan. Environmental Regulation and International Competitiveness of Industry [M]. Economic Science Press, 2006: 69–77.

regarding environment as a sub factor or subsystem of enterprise/industrial/regional/ national competitiveness, and environmental competitiveness is not put on the same layer as enterprise/industrial/regional/national competitiveness, thus purposely narrowed and restricted the connotation and denotation of environmental competitiveness. The researches neither consider the long-term potential impact of environment, especially natural environment, or the follow-up influence on competitiveness by environment improvement after adoption of environment and neglect its social and cultural impacts. In fact, either discussion of competitiveness apart from environment or vice versa would be segmented discussions. Environmental competitiveness itself is just an integrated and unified concept that can be discussed at the same layer as enterprise/industrial/regional/national competitiveness is discussed.

3.3 Economic Transition and Environmental Competitiveness Promotion Coupling Analysis

In the face of today's environment and development issues, we need to observe and analyze in a global perspective, to grasp and process with a development vision, to plan and solve from the strategic level, so as to actively explore an effective environmental protection path. Economic development and environmental protection are two aspects of one contradictory; they are mutually conditional, interdependent and inseparable. Environmental issues in its essence, is the economic structure, mode of production and development path problem. Talk about environmental protection without economic development is "climb trees to look for fish" and talk about economic development scale and development space. Conducting "anti-driving mechanism" of environmental protection to the structure adjustment and economic transition will be better able to promote the whole society onto the civilization development path of production development, affluent life and sound ecological development.

3.3.1 Green Economic Transition Is the Common Choice of the World

Economic transition refers to transformation of the allocation of resources and economic development pattern, including changes of development model, development factors and development path. Both developed countries and newly industrialized countries, none is not to achieve sustained and rapid development in the economic transformation and upgrading. The outbreak of the international financial crisis in 2008 indicates that the original economic development model has become obsolete and must be changed. In post-crisis era, the global production and trade patterns change significantly, challenges like slow economic recovery, relative shortage of resources and growing environmental pressures are universally faced. Traditional economic development mode which relies on high input, high consumption, high pollution and extensive growth has been difficult to sustain. To achieve strong economic growth, improve the quality and efficiency of economic development and crack resource and environmental constraints become the world's main task. In this case, the global economic recovery requires a new development concept as a guide, and it has become the trend of the times to speed up economic structural adjustment, transform the pattern of economic development, and accelerate the economic transformation and innovation. We must promote the transformation in development, development in the transformation.

At the end of 2008, the United Nations Environment Programme (UNEP) put forward "Green Economy" and "Green New Deal" initiative, green economy has become the new trends and fashions of world's environment and development field. Green economy also points the way for the reshuffle of the world economic pattern and become the direction of the world economy. At present, many countries in the world has put green economy as the key driver to promote economic recovery, also sounded the horn of developing green economy, rushed to introduce all kinds of green economic development plans and policy measures, to develop all kinds of green technology innovation. A global "Green Economy Revolution" involved in production mode, lifestyle, values is quietly opened.

Green economic transition is the requirement of changing the traditional pattern of economic growth which relies on large resource consumption, environmental pollution to the new pattern relying on scientific and technological progress, improvement of the quality of workers, management innovation and green production. Only if we vigorously develop the supporting key technologies of green economic development, improve the level of environmental technology innovation, promote the adjustment of economic structure, expand development space, improve the consumption pattern, improve the use efficiency of resources and environment, can the economy development based on energy and resources saving and environment protection, so as to optimize the economic development through energy conservation and environmental protection, and to improve the sustainable development ability and level. From the connotation and objectives of the green economy perspective, strengthening energy conservation and environmental protection is not only an important starting point and end-result of economic development, but also a booster and important breakthrough in the transition of the green economy. Energy conservation and environmental protection is beneficial to form a new growth area, a variety of means and tools of it will be promising in the development of green economy. For example, strictly implement the assessment system of environmental impact is helpful to adjust industrial structure and spatial layout at source; improve environmental standards can promote the adjustment of industrial structure in the end of the upstream; strengthen environmental law enforcement can reduce economic output pressure on the environment; promote environmental product certification can lead green consumption; formulate environmental economic policies can

promote the development of environmental protection industry; improve the level of environmental information disclosure can encourage the public to actively participate in the green economic development; strengthen environmental technology applications can provide technical support for green development. In addition, strengthening energy conservation and environmental protection has reversed transmission function for improving the quality of economic development. That is conduct the "anti-driving mechanism" of energy conservation and environmental protection to the economic transition, would be able to promote industrial structure adjustment and technology upgrade, eliminate backward production technology, techniques and project. The precious environmental capacity will be reserved for those projects with less resource consumption, high technological content and good environmental benefit. Besides, create more space for economic sustainable development, promote the transformation of development pattern, and to obtain environmental benefits from better way of development, promote the whole society to embark on the civilization development of production development, affluent life and good environment, which is both an important content of economic transformation, but also an important symbol of economic transformation effect.

3.3.2 Greatly Enhance the Competitiveness of the Environment Is an Important Breakthrough in Economic Transformation

Since the twentieth century, in the process of industrialization, human beings has experienced high speed of production and economic prosperity, but the environment is rapidly deteriorating, environmental crisis is pressing harder and harder, environmental issue has not only become a global problem and the primary issue affecting the future world, but also a hard constraint of economic and social development in the future. Compared with the past, the main body, nature, methods, scope and extent of contemporary international competition have changed a lot with the new features. Environmental issues as a multi-dimensional complex involving economic, political, social, cultural, science and technology of multi-level, it has a special important role in the international competition. Under the constraints of the environment, competition between different countries is not only in comprehensive national strength taking economic strength as the main, environment which is longneglected is also brought to the foreground of international competition. It is not only an integral element of national economic competition, but also becoming a more critical competitive factor. Fierce competition and game have been launched around the environment among developed countries, between developed countries and developing countries. Many countries put environmental governance and tackling climate change as a major chip in diplomacy and international competition is a proof. In this context, environmental competitiveness has become an important evaluation index of national competitiveness. Environmental protection industry and technology becomes a new field of the international competition of economy,

science and technology, and environmental protection has become the main land of environmental protection and cooperation in international competition. Meanwhile, with the increasingly intense competition in trade between countries, some countries began to frequently use environmental barriers to protect domestic industry and market, so as to maintain and enhance its competitiveness, as a result, energysaving and environmental protection has become an important means to enhance the international competitiveness.

Environmental competitiveness is a new way to measure competitiveness, a comprehensive system, including both the natural environment and ecological environment, including environmental quality and environmental safety, but also the environment management and coordination of government and society, involving political, economic, social, cultural and other aspects of systems engineering. In its essence, environmental competitiveness is also a development mode, economic structure and consumption patterns, etc. Environmental competitiveness represents the country's economic and social development potential and sustainability, and is the foundation of competitiveness in other areas, relation with national economic and social long-term development. At present, countries around the world are in a critical period of economic transition, and development goals and tasks of environment are extremely arduous. Efforts to promote the competitiveness of the environment is the inevitable requirement to strengthen energy conservation, environmental protection, also is the inevitable choice and a new platform of all countries in the current world to solve environmental problems, open up new avenues of growth, breakthrough development bottleneck, grab competitive high ground. Whose environmental competitiveness is high, who will be able to take the initiative in international competition.

Enhance the competitiveness of the environment is the inevitable choice of all countries in the current world to solve environmental problems, breakthrough development bottleneck, grab competitive high ground. In recent years, there is a fierce debate and game around the environment among the developed countries, between developed countries and developing countries. In view of this, promote the competitiveness of the environment is the inevitable requirement and the realistic choice of global economic transformation, is to realize the sustainable development of the world, to solve problems like the human resource, ecological environment, natural disasters, population health, at the same time also is a new platform for countries to seize the high ground of the future development, so it has very important practical significance.

3.3.3 Enhance Environmental Competitiveness Coupled and Consistent with Economic Transformation

Coupling is a physics concept, refers to the phenomenon that two or more than two systems or motion forms influence each other through a variety of interaction. From synergy point of view, the key of system evolving from disorder to order is the synergy between the internal parameters, which determines the characteristics and the law of phase transition. Coupling is a measure of this synergy effect.

Environmental subsystem and economic subsystem constitute the environmental economic system, and the interactive coupling relationship exists between the two sub-systems. On the one hand, economic subsystem has strong interference to the environmental subsystem (resource utilization, environmental pollution, waste discharge, etc.), and with the development of economy, the growing role; Environment subsystem, on the other hand, provides social and economic activities with resources for production and processing, as well as the space for emissions of pollutants and waste, and the environmental subsystem has a certain ability to repair and regeneration, that is under the influence of economic subsystem, not only try to keep the structure, function and stability of their systems, but also produce a certain degree of counter and constraints to the economic subsystem. Good environmental subsystem can efficiently support the development of economic subsystem; provide power and condition for enhancement of economic subsystem, good economic subsystem. At the same time, good economic subsystem can minimize the negative effect on the environmental subsystem, promote the improvement of the environmental subsystem, interact with each other, and jointly promote the environmental economic system's co-evolution development.

Enhancement of environmental competitiveness and economic transformation belong to one aspect of environmental subsystem and economic subsystem respectively, which influence each other and interact with each other. In the context that current world are faced with pressure of economic transformation, promoting environmental competitiveness and economic transformation is a dialectical unity. Promoting the competitiveness of the environment is the real needs of the economic transformation, is an important reflection and logo of shift of economic development mode; enhancing the competitiveness of the environment must have reversed transmission on economic transformation, promoting the development of economy.

To enhance the environmental competitiveness requires the implementation of concrete practice, not only including the ascension of hard power, for example, resources environment, ecological environment and environmental carrying, also containing the ascension of soft power, such as the ability of the environmental governance, environmental coordination, etc. This necessarily requires countries to accelerate economic transformation, continue to strengthen environmental protection work, and make sure to pay attention to environmental protection in economic development, focus on economic development in environmental protection, to combine the two. Take environmental protection as an important starting point of transformation. View the resource and environment carrying as basic premise of development, take environmental governance as an important means of development, consider environmental and economic coordination development as the goal, give full play to the optimization of environmental protection on the role of safeguard effect on economic growth and the reversed transmission effect on

economic transformation. Conduct these effectively in all aspects of the economic and social development, to promote the establishment of resource-saving and environment-friendly economic and social system. Meanwhile, promote the reform and innovation throughout all areas and all aspects of environmental protection, and actively explore small cost, good efficiency, low emission, sustainable new roads of environmental protection, to promote the improvement of environmental protection and environmental quality and effectively enhance the overall environmental competitiveness around the world. Improvement in environmental quality, resource conservation and environmental competitiveness will bring a lot of new demand, promote technological progress and product innovation, create new industries, and give new impetus to economic development. Transform the mode of development and realize win-win effects of economic benefit, social benefit, and resource environmental benefits, to promote the long-term stable and rapid economic development and build a harmonious and progressive society.

Of course, to achieve the coupling between enhancement of environmental competitiveness and economic restructuring is a long-term and complex process, since enhancement of environmental competitiveness is the common choice of countries around the world, all countries in the process of solving environmental problems and enhancing environmental competitiveness must adopt the method of global cooperation. However, it is very difficult and complicated to contributing to global cooperation. Because global cooperation is mixed with the common interests and own interests of all countries and regions, at the same time, also need to pay a high economic cost and social cost. So how to coordinate the interests of all parties and reduce the cost is the key to deal with environmental problems, which must be a gradual and slow, full of twists and turns process.

3.3.4 Empirical Analysis on Consistency of Environmental Competitiveness Enhancement and Economic Transformation

In order to further illustrate the consistency of coupling of the environmental competitiveness enhancement and the economic transformation, the following will be the empirical analysis on coupling degree of environmental competitiveness system and economic system. Coupling is to describe the strength degree of synergy of order parameter in the process of system development, according to the principle of synergy theory (Wu Dajin et al. 1990), and the key of a system to order lies in synergy effect between each subsystem in the internal system, the degree of coupling is a measure of this synergy (Jia Shi-jing et al. 2008). Here, the respective elements of the two systems of environment and economic competitiveness interact and influence each other is defined as the degree of coupling. The coupling model is established to illustrate the consistency of environmental competitiveness enhancement and economic transformation. Firstly, create a power function. Set variable X_i (i=1,2,, m) as an order parameter for the system, x_{ij} is the j-th index of the i-th order parameter, and its value is x'_{ij} (j=1,2,, n)., Respectively, α_{ij} , β_{ij} is the max and min value of order parameter on the stable critical point, then the efficiency coefficient of x_{ij} is expressed as:

$$x_{ij} = \begin{cases} \left(x'_{ij} - \beta_{ij}\right) / (\alpha_{ij} - \beta_{ij}), \text{ possitive effect} \\ \left(\alpha_{ij} - x'_{ij}\right) / (\alpha_{ij} - \beta_{ij}), \text{ negative effect} \end{cases}$$
(3.1)

In formula (3.1), x_{ij} represents the contribution of the variable x'_{ij} to the efficiency of the system, and its range is between 0 and 1. "Total contribution" of order parameters within the system is:

$$\mathbf{x}_i = \sum_{j=1}^n \lambda_{ij} x_{ij} \tag{3.2}$$

In Formula (3.2), \mathbf{x}_i is the efficiency contribution of subsystem i to the overall system, λ_{ij} stands for the weight of i-th order parameter, and $\sum_{j=1}^{n} \lambda_{ij} = 1$.

Secondly, establish the coupling model. Learn concepts of capacitive coupling and capacitive coupling coefficient model in physics (Valerie Illingworth 1996), to obtain the coupling model of the two systems as follows:

$$C = 2 \cdot \{ (x_1 \cdot x_2) / [(x_1 \cdot x_2) \cdot (x_1 \cdot x_2)] \}^{1/2}$$
(3.3)

In formula (3.3), C is the coupling degree, and the value between 0 and 1.

To calculate the system coupling, it is necessary to establish index system of environmental competitiveness and economic subsystem. Environmental competitiveness index system will have a special introduction in the fourth chapter, with 1 primary index, 5 secondary indexes, 16 three-level indexes, 60 four-level indexes. In line with principles of representative, comparability, dynamic and data availability, we establish an index system of economic system, containing 1 primary index (economic subsystem), 6 secondary indexes (GDP, per capita GDP, GDP growth rate, industrial added value, industrial added value, net exports of goods) the weight of each index was determined through expert survey method, respectively 0.2, 0.2, 0.2, 0.15, 0.15, 0.1. All indicators data derived from the statistics released by World Bank, the United Nations and other international authoritative organization.

The order parameter and coupling degree of 133 national environmental competitiveness subsystem and economic subsystem can be calculated by coupling model, as shown in Table 3.1.

The table shows that there is a high degree of coupling between world's environmental competitiveness subsystem and economic subsystem, with a minimum of

	Item				Item		
	Environmental	-	-		Environmental	-	:
Country	competitiveness order parameter X	Economic order parameter Y	Coupling degree C	Country	competitiveness order parameter X	Economic order parameter Y	Coupling degree C
Albania	0.5312	0.1483	0.8260	Libya	0.4034	0.0996	0.7969
Algeria	0.4650	0.2409	0.9482	Lithuania	0.5130	0.2089	0.9070
Angola	0.4803	0.2805	0.9649	Luxembourg	0.5166	0.3497	0.9813
Argentina	0.4988	0.2245	0.9253	Macedonia, FYR	0.4758	0.1703	0.8812
Armenia	0.4916	0.1594	0.8600	Madagascar	0.4406	0.1574	0.8808
Australia	0.5484	0.3406	0.9723	Malaysia	0.5153	0.2452	0.9348
Austria	0.5665	0.2720	0.9363	Mali	0.3893	0.1586	0.9070
Azerbaijan	0.4622	0.2605	0.9603	Mauritania	0.3927	0.1920	0.9392
Bangladesh	0.4698	0.1675	0.8803	Mauritius	0.5181	0.1858	0.8816
Belarus	0.4844	0.1767	0.8851	Mexico	0.5052	0.2483	0.9401
Belgium	0.5399	0.2644	0.9395	Moldova	0.4487	0.1753	0.8989
Benin	0.5028	0.1461	0.8354	Mongolia	0.4769	0.2482	0.9489
Bolivia	0.5522	0.2056	0.8893	Morocco	0.4745	0.1728	0.8848
Bosnia and Herzegovina	0.4651	0.1636	0.8775	Mozambique	0.4637	0.2195	0.9339
Botswana	0.5238	0.2233	0.9156	Myanmar	0.5247	0.2079	0.9017
Brazil	0.5746	0.2624	0.9278	Namibia	0.4928	0.1897	0.8959
Bulgaria	0.4824	0.1840	0.8942	Nepal	0.5107	0.1561	0.8468
Cambodia	0.5201	0.1656	0.8560	Netherlands	0.5278	0.2906	0.9571
Cameroon	0.4922	0.1788	0.8842	New Zealand	0.5767	0.2332	0.9056
Canada	0.5497	0.3216	0.9651	Nicaragua	0.5472	0.1617	0.8392
Chile	0.5425	0.2238	0.9094	Niger	0.3227	0.1524	0.9336
China	0.4803	0.5826	0.9954	Nigeria	0.4854	0.1988	0.9080
Colombia	0.5489	0.2127	0.8973	Norway	0.5820	0.3933	0.9811
Congo, Rep.	0.5092	0.2674	0.9503	Oman	0.4602	0.3192	0.9835
Costa Rica	0.5720	0.1831	0.8572	Pakistan	0.4521	0.1919	0.9147

Table 3.1 Order parameter and coupling degree of environmental competitiveness system and economic subsystem

(continued)							
0.8613	0.1580	0.4844	Togo	0.9422	0.2207	0.4432	India
0.9288	0.2238	0.4873	Thailand	0.9020	0.1984	0.4997	Hungary
0.8209	0.1403	0.5140	Tanzania	0.8536	0.1739	0.5521	Honduras
0.8872	0.1648	0.4473	Tajikistan	0.8509	0.1462	0.4700	Haiti
			Republic				
0.9043	0.1808	0.4501	Syrian Arab	0.8884	0.1736	0.4682	Guinea
0.9698	0.3568	0.5868	Switzerland	0.8656	0.1835	0.5516	Guatemala
0.9539	0.2974	0.5526	Sweden	0.8690	0.1793	0.5303	Greece
0.8401	0.1412	0.4760	Sudan	0.8877	0.1819	0.4922	Ghana
0.8850	0.1917	0.5258	Sri Lanka	0.9859	0.4169	0.5845	Germany
0.9469	0.2552	0.4972	Spain	0.8856	0.1860	0.5084	Georgia
0.9168	0.2027	0.4721	South Africa	0.9730	0.3435	0.5495	Gabon
0.8900	0.2011	0.5382	Slovenia	0.9545	0.3042	0.5628	France
0.8987	0.2175	0.5573	Slovak Republic	0.9380	0.2584	0.5324	Finland
0.9651	0.2816	0.4813	Singapore	0.8552	0.1450	0.4570	Ethiopia
0.9088	0.1894	0.4607	Serbia	0.9136	0.2087	0.4946	Estonia
0.8554	0.1603	0.5050	Senegal	0.8954	0.1670	0.4351	Eritrea
0.9851	0.3627	0.5133	Saudi Arabia	0.8622	0.1658	0.5064	El Salvador
			Federation				
0.9722	0.3009	0.4846	Russian	0.9059	0.1867	0.4611	Egypt, Arab Rep.
0.9067	0.2013	0.4950	Romania	0.8748	0.1941	0.5589	Ecuador
0.9993	0.4783	0.4430	Qatar	0.8787	0.1790	0.5059	Dominican Republic
0.8842	0.1894	0.5214	Portugal	0.9427	0.2655	0.5314	Denmark
0.9033	0.2109	0.5278	Poland	0.9174	0.2225	0.5168	Czech Republic
0.8823	0.1913	0.5316	Philippines	0.8774	0.1736	0.4938	Cyprus
0.8933	0.2011	0.5294	Peru	0.8397	0.1527	0.5157	Cuba
0.9048	0.1981	0.4920	Paraguay	0.8704	0.1748	0.5138	Croatia
0.8065	0.1400	0.5452	Panama	0.8644	0.1539	0.4651	Cote d'Ivoire

	Item				Item		
	Environmental				Environmental		
	competitiveness	Economic order	Coupling		competitiveness	Economic order	Coupling
Country	order parameter A	parameter Y	degree C	Country	order parameter A	parameter Y	degree C
Indonesia	0.5171	0.2559	0.9412	Tunisia	0.4846	0.1694	0.8761
Iran, Islamic Rep.	0.4589	0.2505	0.9559	Turkey	0.4800	0.1985	0.9099
Iraq	0.3802	0.3214	0.9965	Turkmenistan	0.4326	0.2308	0.9526
Ireland	0.5143	0.2637	0.9467	Ukraine	0.4741	0.2066	0.9196
Israel	0.4949	0.2196	0.9228	United Arab	0.4500	0.3386	0.9900
				Emirates			
Italy	0.5304	0.2902	0.9562	United Kingdom	0.5658	0.3032	0.9532
Jamaica	0.5286	0.1536	0.8354	United States	0.5383	0.6458	0.9959
Japan	0.5721	0.4204	0.9882	Uruguay	0.4948	0.1932	0.8988
Jordan	0.4394	0.1750	0.9027	Uzbekistan	0.4030	0.1852	0.9289
Kazakhstan	0.3984	0.2472	0.9722	Venezuela, RB	0.5582	0.1648	0.8390
Kenya	0.4776	0.1367	0.8319	Vietnam	0.4678	0.2100	0.9248
Korea, Rep.	0.5026	0.2808	0.9591	Yemen, Rep.	0.4160	0.1801	0.9184
Kuwait	0.4237	0.4274	1.0000	Zambia	0.5251	0.1749	0.8658
Kyrgyz Republic	0.4252	0.1925	0.9263	Zimbabwe	0.4899	0.2197	0.9247
Latvia	0.5282	0.1981	0.8907	Maximum	0.5868	0.6458	0.9999
Lebanon	0.4747	0.1473	0.8503	Minimum	0.3227	0.0996	0.7970
Lesotho	0.3572	0.1795	0.9436				

52

Table 3.1 (continued)

0.7970 and a maximum of 0.9999, the coupling degree of 121 countries is more than 0.85, and the coupling degree of 76 countries is over 0.9, which shows that there is intrinsic consistency of coupling between the environmental competitiveness subsystem and economic subsystem. Two sub-systems are interdependent and influent each other with good synergies in the same direction, and jointly promote the co-evolution development of large system of environment and economy. Good economic development is the guarantee of promoting environmental competitiveness; unreasonable economic development model will aggravate destruction and pollution to the natural resources and environment. And enhancement of environmental competitiveness, in turn, promote the rational development of economy, it will set up a good resources environment structure, keep the benign substance cycle and energy conversion, control the interference and impact of human production and living on natural resources and environment within its bearing range. Therefore, countries in accelerating the development of economy need to pay attention to promote the competitiveness of the environment at the same time, both are integral and mutually reinforcing. If we only attaches great importance to the economic development and ignore the environmental protection and enhancement of environmental competitiveness, then the whole system of environment and economy will have the risk of imbalance, which will eventually corrode fruits of economic development.

3.4 Connotations of GEC

3.4.1 Concept of GEC

Since the 1990s, environmental competitiveness as a concept was frequently used and gradually valued by people; but as the discussions about the concept was done in different angles, there has been no unified definition for the term. In a broad sense, environmental competitiveness has rich contents: it can be classified into natural environmental competitiveness and social environmental competitiveness by nature; or into national environmental competitiveness, regional environmental competitiveness, city environmental competitiveness, development area environmental competitiveness by spatial dimension; or into tourism environmental competitiveness, ecological environmental competitiveness, investment environmental competitiveness, humanistic environmental competitiveness, living environmental competitiveness and talent environmental competitiveness by focal point.

GEC is a whole new way of weighing under the context of increasing contradiction between economic development and environmental protection. It takes competitiveness as the core supported by natural environment; technology innovation as the main instrument; market mechanism and government regulation as the means; bearing capacity-coordinating capacity-executive capacity-influencing capacity-contributing capacity as assessment basis; capacity-response-feedback-adjustment-optimization



Fig. 3.2 Connotation of GEC

as main line; intensifying environmental development and utilization, reducing environmental damage, maintaining global ecological equilibrium and realizing global sustainable development as objectives; and ecological environment, resource environment, environmental bearing, environmental management and environmental coordination as contents. It reflects the environmental competitive capacity of different countries of the world in a comprehensive and systematic way.

The concept of Global Environmental Competitiveness proposed in this study is different from terms like green competitiveness, ecological competitiveness, energy competitiveness or low carbon competitiveness; it is neither attached to enterprise competitiveness, industrial competitiveness, regional competitiveness or national competitiveness. GEC is independent of and somewhat related to these concepts. Compared with the traditional competitiveness concepts, GEC emphasizes environment more as the basic element of human production and living; it places stress on the coordinated development of both human and environment and focuses on the existing and potential impact of environment.

3.4.2 Connotations of GEC

As given above, GEC is a huge comprehensive system involving economy, society and environment; it can be divided into five aspects, as shown in Fig. 3.2:

3.4 Connotations of GEC

- 1. Bearing Capacity. It reflects a nation or region's capacity of ecological and resource environment to bear the regional sustainable development. The area and space of the nation or region is limited, its environmental basis available for development and utilization is limited, and its capacity to bear pollutant is also limited. Environment with different size, structure and function will show different bearing capacity. But environmental bearing capacity is never unalterable. Through environmental protection and technological advancement, the capacity to bear the intensity and scale of development and utilization may be enhanced. At the same time, once environmental damage exceeds the highest threshold, it would influence environmental function and damage ecological balance, while recovery of the damage would require payment of high cost.
- 2. Coordinating Capacity. It reflects a nation or region's capacity of ecological and resource environment to coordinate with the regional production and living activities. Environment provides the fundamental physical and spiritual conditions for normal production and living activities for humans, and digests and absorbs various pollutants generated by human activity; and human activity, particularly large-scale organized production activity, will also influence environment in aspects like earth surface formation, material cycle, heat budget and ecological balance. Coordinating capacity is an important component of environmental competitiveness; it may be adjusted and optimized by means of lifestyle transformation, readjustment of industrial structure and emission control. The stronger coordinating capacity is, the more harmonious the symbiotic relation between environment and human will be and the stronger environmental competitiveness will be.
- 3. Executive Capacity. It reflects a nation or region's executive capacity of all levels of government to manage ecological and resource environment and so as to realize environmental optimization. Relying on the administrative, economic, legal, educational and technological management functions of all levels of government, with public participation and social supervision as supplement and by means of environmental monitoring, environmental inspection and environmental assessment, environmental pollution can be prevented and controlled, ecological environment can be protected and repaired, environment can be comprehensively optimized and environmental competitiveness can be enhanced. Executive capacity is shown in almost all links of production and life and the entire course of production-distribution-trade; focusing on innovation in technology, system and mechanism and combining both price and non-price instruments, it will gradually strengthen environmental competitiveness.
- 4. Influencing Capacity. It reflects a nation or region's capacity of ecological and resource environment to influence neighboring regions and the capacity of human activity, especially major construction projects, to influence the regional internal environment. Influencing capacity comprehensively reflects the influencing capacity of regional natural environment and social environment through assessment of environmental quality status and impact; it is an important part to weigh

environmental competitiveness. Such capacity varies with the improvement in environmental management and management pattern, and also varies with the influencing capacity of surrounding areas.

5. Contributing Capacity. It reflects a nation or region's capacity of existing, improved ad damaged environment to make contributions to regional sustainable development. The quality of environment, efficiency of environmental management and implementation of major projects will directly influence the contributing capacity of environment. Vice versa, contributing capacity influences the bearing capacity of regional ecological and resource environment and the coordinating capacity between human and environment. Contributing capacity is the manifestation of the externality of GEC and core of GEC.

In summary, the concept of GEC used in this study has the following characteristics: (1) It considers both existing environmental competitiveness and the potential impact of environmental change; (2) It mainly investigates natural environment and its contents have overlapping areas with ecological environment and hard environment; (3) It also investigates the impact on all nations inside and outside the region by environmental quality improvement under the concept of environmental protection; (4) It considers the multi-layer superimposed effects of implementation of environmental protection under the current global environmental status.

3.5 Compositions of GEC

3.5.1 Component Elements of GEC and Their Functions

Based on the research results on GEC, the component elements of GEC in this study include five parts, i.e. ecological environmental competitiveness (EEC), resource environmental competitiveness (REC), environment carrying competitiveness (ECC), environmental management competitiveness (EMC), and environment harmony competitiveness (EHC).

3.5.1.1 Ecological Environmental Competitiveness (EEC)

Ecological environmental competitiveness (EEC) is the basic element of GEC. Ecological environment is the main component that attracts inhabitants and capital input and also an important factor that influences environmental competitiveness in long term. The cost to obtain ecological environment is very low; but once damaged, the cost for recovery is huge. Ecological environment includes natural ecology, rural ecology, biodiversity and biosafety. On the one hand, EEC looks at the utilization efficiency of ecological environment during the course of production and living, mainly shown as indicators like emission quantity and industrial added value ratio, pesticide and fertilizer consumption and available irrigation area; on the other hand, it also looks at the intensity of ecological environmental protection, mainly shown as indicators like amount and area of public park, green surface and natural reserve used. ECC should reflect not only the contributing capacity of ecological environment for human activity, but also the utilization intensity and level of ecological environment by humans; it also reflects the degree of emphasis put by humans on ecological environment; it is the assessment basis of GEC.

3.5.1.2 Resource Environmental Competitiveness (REC)

Ecological environmental competitiveness (EEC) is the fundamental condition of GEC. Resource environment includes water environment, land environment, atmosphere environment, forest environment, mineral product environment and energy environment; it is the existing element of GEC and provides necessary support for human production and living. Water environmental competitiveness looks at the amount of existing water resource, its utilization efficiency and pollution status; land environmental competitiveness looks at the quantity intensity of using farming land, garden plot and construction land; atmosphere environmental competitiveness looks at the pollutant discharged by industrial activity into atmosphere; forest environmental competitiveness looks at the reserve status of mineral product environmental competitiveness looks at the status of energy production, consumption and utilization. REC is an internal element of GEC and the necessary guarantee to form GEC; it comprehensively reflects environmental capacity to bear human production.

3.5.1.3 Environment Carrying Competitiveness (ECC)

Environment carrying competitiveness (ECC) is an important aspect to weigh the strength of GEC. Environment carrying involves industrial production, agricultural production, energy consumption and climate change; it reflects a nation or region's capacity of ecological and resource environment to bear regional sustainable development and also human activity's influence on natural environment, or, the response and restorability of environment against human activity; it is an important indicator to weigh the strength of environmental competitiveness. Again, ECC is never unalterable. Through environmental protection and technological advancement, the capacity to bear the intensity and scale of development and utilization may be enhanced. At the same time, once environmental damage exceeds the highest threshold, it would influence environmental function and damage ecological balance, while recovery of the damage would require payment of high cost.

3.5.1.4 Environmental Management Competitiveness (EMC)

Environmental management competitiveness (EMC) is a powerful support to GEC. Government and the public are the key players of environmental management; it coordinates the supervision relationship between socioeconomic development and environmental protection by various administrative instruments and economic and legal means. EMC includes two aspects, resource utilization and environmental safety, used to show utilization efficiency and environmental pollution governance results respectively. On the one hand, EMC needs economic and non-economic input to guarantee the smooth execution of environmental management and execution intensity of such; on the other hand, environmental management efficiency can only be observed after long-term observation. EMC comprehensively reflects the executive capacity for environmental governance; it is an important step to enhance GEC.

3.5.1.5 Environment Harmony Competitiveness (EHC)

Environment harmony competitiveness (EHC) is an important assessment reference for GEC. Population, economy, society and environmental coordinated development are the important criteria to judge the superiority or inferiority of environmental competitiveness and also an important way to realize the objective of sustainable development. EHC is present via the harmonious degree of population and environment and the harmonious degree of economy and environment. EHC can be optimized with improvement in production technology, readjustment of production structure and transformation of lifestyle. It is the external factor that influences GEC and also an important guarantee for formation of GEC; it even influences the changes in GEC.

3.5.2 Internal Relations of GEC Elements

The formation of GEC is a dynamic complex process. EEC, REC, ECC, EMC and EHC are the foundation stones of GEC and at the same time an important link to influence GEC. The objectives of these five elements are to increase the efficiency of environmental development and utilization, reduce environmental damage, maintain global ecological balance and realize socioeconomic sustainable development; through economic and administrative means, it can comprehensively reflect and influence environmental competitiveness.

EEC and REC reflects environmental bearing and contributing capacity by the way of capacity-response; they are the foundation and guarantee of EMC, ECC and EHC. Without ecological and resource environment, human production and living would have no support, not to mention utilization and protection of environment. And, for ecological and resource environmental protection and governance by means



Fig. 3.3 GEC elements and their internal relations

of various administrative and economic policies, system and mechanism, the process and effect receive feedback through environmental management and bearing competitiveness and they are kept under readjustment and improvement based on the representation. The ultimate objective of improving environmental quality is to promote the harmonious unification of humankind and environment, and to realize the sustainable development of both; this is the essential contents to be reflected by EHC and the key part where environmental optimization lies (See Fig. 3.3). Therefore, EEC, REC, ECC, EMC and EHC are never mutually independent units; instead, they are an interactive unity focusing on the main line of capacity-response-feedbackadjustment-optimization. Appropriate degree of enhancement and collaboration of the five elements can push the overall enhancement of GEC.

Open Access This chapter is distributed under the terms of the Creative Commons AttributionNoncommercial License, which permits any noncommercial use, distribution, and reproduction in any medium, provided the original author(s) and source are credited.