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RESEARCH ARTICLE

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Value and governance of high-speed railway

Abstract This paper considers multiple perspectives to explore the concept of high-speed railway (HSR), rationally abstract its value formation mechanism, and quantitatively measure its actual performance. This paper analyzes the governance potential of major countries in the high-speed railway value chain and studies the feasible ways and development strategies to enhance the high-speed railway governance in China. Findings of this paper are as follows. First, the government, as the early manager of high-speed railway governance, has given way to Siemens and other integrated enterprises. Second, the high-speed railway standard output has become the core competitiveness that embodies high-speed railway. Third, the global high-speed railway market presents a hierarchical high-speed railway governance model and changes to a modular approach to governance.

Keywords high-speed railway value, communication value, high-speed railway value governance, governance path upgrade

1 Introduction

China is now the world's largest country in high-speed railway construction and operating mileage. On June 16, 2016, Shanghai–Kunming high-speed railway opened across the board and was complimented as the longest "one cross" in China's "four vertical and four horizontal" railway planning. At this point, China's 2008 "long-term railway network planning" was proposed in the "four vertical and four horizontal" passenger line of the basic formation of the railway line. At the end of 2016, the national railway operating mileage reached 124,000 km, of which 22,000 km accounted for high-speed railway, Shanghai–Kunming high-speed railway, and Yunnan–Guangxi railway. Yu Wan high-speed railway was placed in operation, and the central and western railway operating mileage expanded to 9.5 million km. The national railway investment for 2017 will maintain the scale of 2016 and is expected to place the new line of 2100 km, 2500 km of new railway line, and electrified railway of 4000 km. On February 4, 2017, the state council issued the "National Land Planning Outline (2016–2030)," and this "outline" proposed the following: establishment of a well-developed railway network, speed up high-speed railway, inter-regional trunk, land development railway construction, active development of intercity and suburban (domain) railway, improve the regional railway network, and optimize the urban dense area traffic network. By 2030, the national railway operating mileage will exceed 200,000 km.

In the context of the rapid formation of China's high-speed railway network, achieving "maximize the value of high-speed railway" is the most fundamental purpose of the high-speed railway economy and management research. Based on the present value theory, this paper provides the definition of high-iron value and points out that the government and enterprises must perform the directional work to achieve the goal "maximize the value of high-speed railway." This article includes three core elements. (1) According to the existing theory of value, the author proposes the definition of the high-speed railway value which satisfy the actual characteristics of high-speed railway. "The high-speed railway value" is both a noun and a verb; it is an input and output process. Input refers to the value of the creation process, and the output is the value of the form of expression. In the process of input, labor, technology, capital, and other elements create high-speed railway value. Labor is the source of high-speed railway value creation, technology, capital, and other elements are necessary conditions for value creation. Many forms of high-railway value exist, such as time and space, communication, economic, ecological and employment values, and the value of the form of expression depends on the "high-speed railway characteristics." People are willing

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to opt for high-speed railway for the exchanges, which not only satisfy their communication needs but also further promote the economic development due to the high accessibility, safety, and other characteristics. Corresponding to the form of value, people generally use the value of time and space to measure the accessibility of high-speed railway; the value of traffic measurement of high-speed railway to satisfy people's needs; and economic, ecological, and employment values and other forms to express the effect of high-speed railway. (2) According to the definition of high-speed railway value, time and space value is the cornerstone of communication, employment, and ecological values. The value of communication is the transition from the value of time and space to the employment, ecological, and other forms of values. Demand originates from employment, ecological, tourism, and other forms of value. Based on the preceding analysis, the following works are performed: quantify the impact of high-speed railway characteristics on the value of the form of expression and propose high-speed railway effect to maximize the targeted recommendations. (3) According to the first two parts, labor is the source of value. According to the principle of controlling key points, we should focus on the key labor and labor object in value creation, which is the governance and value chain, respectively. In this part, this paper initially explores the governance methods of high-speed railway value on the main countries. The direction of China's high-speed railway value management is then put proposed. Finally, according to the situation, the paper presents the specific high-speed railway value governance path of China.

2 Value of HSR

2.1 Value theories

The theory of value is the science of movement and law of the relationship between social things. This theory is the foundation and core of economic theory. The three theoretical systems of value are labor, neoclassical, and Sraffa's theories of value. Value theory is important because it determines distribution theory, which is related to the theoretical basis of a country's distribution system.

Three value theories have scientific elements and a few explanatory shortcomings on the real economic phenomenon. Table 1 shows the characteristics of the three preceding major value theories mentioned. The purpose of these values is to learn from the essence of various theories of value and provide a scientific theoretical basis for the new problems encountered in the development of market economy and economic construction from a broad perspective.

2.2 Value of HSR

Unlike simple products, high-speed railway has its own unique characteristics. From the individual level, high-

Table 1 Summary of the three major theoretical characteristics of the value

Compare items	Labor theory of value	Neoclassical theory of value	Sraffa's theory of value
Representative person	David Ricardo, Karl Heinrich Marx	Marshall	Piero Sraffa
Research purposes	In addition to reflecting the values of the people, the fundamental purpose of this theory is to reveal the most essential laws of the operation of the capitalist economy, analyze the inherent contradictions of capitalism, and explain the inevitable causes of capitalism	This theory aims to study the efficient rather than fair allocation of resources and improvement of the welfare of the participants in the market rather than discussing class antagonism. The theory is exploited by the bourgeoisie and becomes a defense tool for them because the theory itself avoids a few of the problems	This theory aims to restore the theoretical study of labor theory of value based on the criticism of marginal analysis method
Essence of value	The value reflects indiscriminate human labor that condenses in the commodity. The two goods can be exchanged with each other because they have the same social labor time necessary	The value of the commodity is simultaneously determined by supply and demand. The value considers not only the power of demand but also the extent of the scarcity of goods and other factors	The value reflects the proportional relationship between a commodity and another commodity exchange when the economy is balanced, and this ratio is determined by technology, labor, and capital. However, labor is not an indispensable factor
Relationship between value and price	Value and price are two different concepts. Value is the basis of price, while price is the form of value. Value determines the price, and price fluctuates around the value	Value is equal to price	
Quantitative form of value	Social labor time necessary is the measure of value quantification considering the supply and demand factors.	Marshall first finds the supply and demand according to a few necessary conditions and then directly analyzes the value of the decision.	The amount of value is determined by a series of simultaneous input-output equations. The left side of the equation is the input and the right side is the output. The power of demand is not considered.

speed railway is a service product, and its value is related to a specific displacement service. At the national level, high-speed railway is a commodity that can promote national economic development. The value of high-speed railway viewed as a national commodity is larger than the sum of individual service values. According to the three theories of value, two perspectives will be explored regarding the value of high-speed railway formation. (1) Labor theory of value: From a national perspective, the value of high-speed railway is the indiscriminate human labor embodied in the process of making high-speed railway, and its value is determined by the time required for social labor. From an individual perspective, the value of high-speed railways is mainly related to the amount of labor input in the operational service phase. (2) Neoclassical theory of value: The value of high-speed railway is determined by supply and demand at the national level. High-speed railway is a commodity whose value corresponds to the equilibrium price when the supply and demand are in a state of balance. By contrast, high-speed railway is a service rather than a commodity on the individual level, and high-speed railway fares reflect the service value from an individual perspective. (3) Sraffa's theory of value: In this theory, the high-speed railway value is created by labor, technology, capital, and other elements.

Clearly knowing the definition of high-speed railway values is of practical significance. Determining the necessary measures to be taken to maximize the value of high-speed railway is possible by identifying the relationship between high-speed railway properties and various value forms. The manifestation of the value of high-speed railway is reflected in all aspects, such as economy, politics, and society. The development of high-speed railway plays an important role in promoting the economic development of China. On the one hand, high-speed railway can promote the transformation of urban structure, industrial upgrading, and the city function. In addition, high-speed railway can produce city effect and indirectly affect the layout of the city's planning. On the other hand, the development of high-speed railways can improve economic development. Economic globalization has facilitated the linkages between countries. In addition, the development of high-speed railway can effectively reduce the time cost of passengers and improve business efficiency. As a major artery of the national economy, the country's infrastructure, and popular means of transport, the railway development model is not only an economic issue but it also embodies the political forces. High-speed railways play a very important role in enhancing the political influence of the country and the nation at the international level.

High-speed railway is a fast mode of transport, and its fundamental feature is to shorten travel time and combine with other modes of transport to realize high reachability. Space–time value is one of the indicators to measure the basic characteristics of high-speed railway and is embodied in two aspects. First, high-speed railways create time value by shortening travel time. Second, high-speed railways show spatial value by enhancing the reachability of the region. In addition to the most fundamental value of time and space, the value form of high-speed railway also includes communication, employment, economic, structural optimization, ecological, and tourism values. Figure 1 shows the formation mechanism of high-speed railway value.

3 Theoretical mechanism of HSR communication value

As a transport model, the fundamental role of high-speed railways is to provide irreplaceable services. High-speed railways can satisfy the basic travel needs of the people by providing high-speed, long-distance, multi-node, networked, safe, and comfortable special time and space displacement services. High-speed railways can further promote the development of productive forces by improving the way people travel.

3.1 Communication theory

Social attributes are the basic attributes of people. People in the community will continue to communicate and exchange information. The promotion of social development and growth is precisely attributed to the exchanges between people. Marx's theory of communication has three main viewpoints. (1) Production and exchanges are prerequisites. The relationship of production and exchange is characterized by interaction and mutual restraint. On the

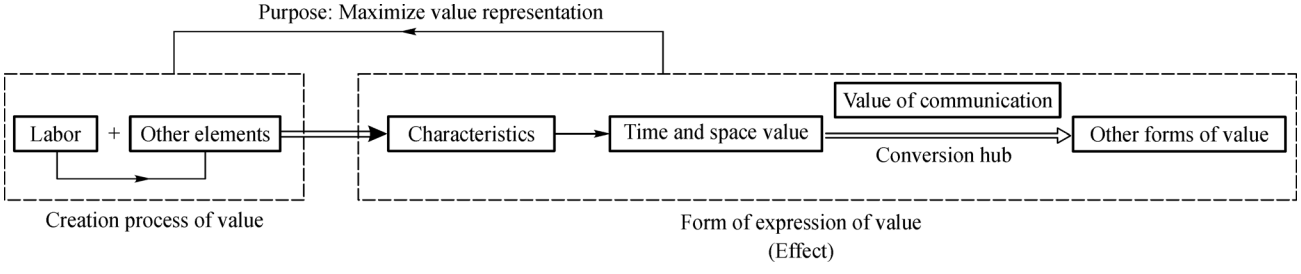

Fig. 1 High-speed railway value formation mechanism

one hand, communication is the premise of production; on the other hand, "this form of communication is determined by the production." People combine in a certain way to work together and exchange activities through the interactions between them. Communication itself has also become a source of human needs and abilities and has contributed to the cooperation of producers based on social division of labor (Zheng, 1999). (2) Interaction activity is the same with production activity, which together constitutes the social productive forces. The interaction of the two activities is the driving force behind the development of social history. Marx and Engels believe that the real last motive force of historical development is "the development of productive forces and exchange relations (Marx, 1975)." (3) People must have contacts in life, and society is the result of people's activities. Marx argues that the development of social relations is manifested in the development of the communicative force, which is compatible with the level of development of productive forces at different stages of social development.

Marx's theory of communication belongs to the category of generalized communication theory, including the interaction between material production and social relations. The broad relationship of communication is manifested by the relationship between people and things. Traffic behavior covers a broad transaction relationship. Thus, the network between the main behaviors of the relationship can be explained by the basic principles of communication theory. Intercourse, in fact, is a spatial interaction. Increasing the frequency and speed of communication is an objective of transport infrastructure construction. "No space would exist without any social process because no pure space process exists. Traffic, which is a production object as well as a consumer object, is a tool for providing space–time displacement services (Liang, 2010)." The production process, reproduction process, and the construction of the system structure require the participation of traffic. "To be a rich first road" fully embodies the role of traffic. Developed traffic not only takes a few areas out of poverty and backwardness but also promotes the further development of established areas. The development of the economy depends on efficient exchanges, and the developed economy can react to technological progress. Communication theory is an effective tool for analyzing high-speed railways.

3.2 HSR facilitates communication

High accessibility is the most important feature of high-speed railway, which is derived from its speed and high punctuality rate. High speed contributes to reducing the travel time between the nodes of the city, which, in turn, reduces the difficulty of communication between different regions. High punctuality is another huge advantage for attracting passengers to take high-speed railway. Although the aircraft has the same speed advantage, it can be affected by weather conditions. Meanwhile, weather, traffic jams, speed, and other conditions can cause trouble for the road transport. Owing to the high punctuality of rail systems, passengers can rationally set their own travel plans. High-speed railway departure frequency is relatively high. For example, in 2014, the average departure interval of Beijing–Shanghai high-speed railway line reached 4.5 min.

The high-speed railway can play its role well only when the overall arrangement has formed a network structure determined by the characteristics of high-speed railway. High-speed railway owns many stations. For example, Beijing–Shanghai high-speed railway, which runs from Beijing South Railway Station to Shang Hai Hong Qiao Railway Station, has 23 stations in total, thereby exceeding the seven stations of the civil aircraft between BJ & SH by far. In the context of China's economic "New Normal," stations and hubs are core aspects that determine network efficiency (Huang, 2010). Therefore, the high-speed railway can provide multi-node and network displacement services, which perfectly satisfy the needs of passenger transfer and enhance the continuity of communication.

The safety and comfort of the displacement service provided by the high railway are approved by the public. High-speed railway automatically operates in a fully-enclosed environment, and the operation avoids external environment interference in a significant way. Further, high-speed railway has a series of comprehensive security systems to ensure safe operation. Since the advent of high-speed railway, except for the German ICE884 high-speed train major accident in the alteration line and China's Ningbo railway accident, other countries did not experience any major accidents. The Japanese Shinkansen has not reported a single injury since its first day of operation. This record cannot be surpassed by any other modern means of transport. In addition, the high-speed railway train is very luxurious. It has complete work/living facilities, clean and tidy compartments, and good sound insulation effect. Unlike aircraft, the Japanese Shinkansen does not cause any ear discomfort or turbulence.

For example, take the case study of Japan's Shinkansen. When the Japanese Shinkansen began its operation, the daily passenger count was only 60,000 people. However, the number increased to 300,000 passengers after 10 years. Today, Japan's daily traffic reaches 360,000 passengers. The annual daily traffic volume is 120 million people, which is equivalent to the volume of 10 highway lines. High-speed railway transport services to can attract more passengers because such transport service can satisfy the need of passengers with regard to social development.

3.3 Communication improvement to promote production development

The improvement of communication shows that the

exchange of the results between the main bodies and the capability to share knowledge has been strengthened. High-speed railway, which has unique characteristics, promotes the perfect communication and the development of production. The improvement of communication alleviates the "isolation" of the individual separated by the social division of labor, thereby allowing the product to enjoy the improvement of local efficiency due to the social division of labor in the process of production creation. The capability to improve the allocation of resources and the overall efficiency of collaborative production are additional advantages. High-speed railway speeds up the product exchange link and facilitates easy attainment of the product value, thus promoting social reproduction.

For individuals, high-speed railway saves travel time of passengers, improves inter-regional accessibility, and creates more job opportunities for passengers. Hence, improving the conditions of communication can help expand the development platform of people. The development space of people is no longer confined to the original small local. Such space promotes the ideas of people. Take Taiwan high-speed railway as an example. Taiwan's high-speed railway through the western part of the island, which connects Taipei, Hinchey, Taichung, and Tainan to Kaohsiung 8 stations, is designed to reach more than 300 $km \cdot h^{-1}$ from Taipei to Kaohsiung in only one and a half hours. The high-speed railway along the station can be easily connected to the Sun Moon Lake, Alisha, southern Taiwan Changchun Peninsula Kenting, and many other tourist attractions along the way. You can also enjoy the beautiful scenery of the island. This advantage is the reason why many tourists travel using Taiwan's transport as their first choice. Thus, the development of production along the region should be promoted.

At present, in the production of goods belongings to a social division of the precision era, high-speed railway brought the space–time compression effect due to the spatial location of the distance or the passage of time and the long formation of the regional segmentation. Therefore, production factors within a given time achieve a large range of space flow. Various enterprises can opt to produce their own advantages of products. The same production chain on the quality of business exchanges can be improved to maximize the division of labor fines and the overall production.

In summary, high-speed railway with high accessibility and other characteristics optimize the travel problems of people and facilitates the exchange of people and things, thereby promoting the development of productive forces. The value of time and space is the cornerstone of exchange, employment, and ecological values. The value of communication is the hub of time and space value to the employment, ecological, and other forms of values. The values of employment, ecological, and tourism are essential demands. The right part of Fig. 1 reflects the transformation relationship between the manifestations of the high-iron value. Table 2 summarizes the status of key factors in value creation and representation. From a single high-speed railway use of the main body or a small amount of high-speed railway use of the main viewpoint, the value of high-speed railway promotes improved exchanges from the social viewpoint. The improvement of exchanges can promote economic development. The increase in the value of corporate brand, the number of employed persons, and the development of services, such as tourism, are forms of economic development.

Table 2 Status of key factors in value creation

Process	Elements	Status
Creation process	Labor	Source
	Technology, capital, and other elements	Necessary condition
Manifestations	Time and space value	Cornerstone
	Value of communication	Conversion hub
	Employment value, ecological value, and other value forms	Essential demand

4 Governance of HSR value

According to Marx's view of political economy, only human labor can create value which is the only source of value (Marx and Engels, 1995). Land, capital, and other factors of production are necessary to the creation of value. However, the achievement of value depends not only on labor but also on various factors of production of the integrated system, which is regarded as the value chain. Governance is one of the labor processes which can promote the system within various components to achieve a good combination of the states and significantly improve the value of labor creation through the key factors of system management. Today, the high-speed railway attracts growing attention from the public. The value of high-speed railway is closely related to its construction, operation, and maintenance.

4.1 Value chain

Value creation is a very complex process involving research and development (R&D), design, manufacturing, sales, delivery, consumption, after-sales service, recycling, and other value-added activities. These value-added activities are the sub-systems of value creation, which are interrelated and dependent on each other. Any problems with the subsystems will affect value creation. According to system theory, the whole is larger than the sum of parts. The optimization of all the subsystems does not necessarily guarantee the achievement of the overall value of the goal. This section will analyze the existing value chain research to better understand the value creation

process.

Michael Porter, the world's first scholar of value chain research, pioneered the concept of value chain in his book "Competitive Advantage" in the mid-1980s. Porter divides the value creation of a company into two parts. The first part includes basic activities, such as design, production, manufacturing, and sales. The second part includes ancillary activities, such as enterprise procurement, technology development, human resources, and finance. The value creation activity forms a functional value creation chain, which is called the value chain (Potter and Chen, 2014). The internal chain of the enterprise is the focus of the first part of the study, with the economic integration and the development of international division of labor. The research of Porter will be a single enterprise value chain research extended to several enterprises. Kogut (1985) uses the value-added chain to analyze international strategic advantages. He extends the corporate value chain research of Porter into regional and national research to promote global value chain research.

In the 1990s, Gereffi and Korzeniewicz (1994) proposed the concept of global commodity chain (GCC) in the US retail industry, focusing on the relationship between value-added links in the internal structure of the global commodity chain and the developed countries to lead enterprises to form and control the chain of issues to study. Later, Gereffi (1999) published an article on the global value chain at the IDS Bulletin. The global chain of valuations played a milestone in the development of global value chain theory. The previous research focused on the characteristics of general commodities and their producers. The value chain analysis has a certain theoretical framework for the global value chain management and upgrading, which is dominated by enterprises.

Since then, the United Nations Industrial Development Organization in the annual (2002–2003) industrial development report puts forward that the global value chain aims to achieve the value of goods or services in series production, sales, recycling, and other aspects of the global cross-enterprise production network organization, including raw material procurement and transportation, production and distribution of semi-finished and finished products until the final consumption and recycling process is involved. Global value chain includes all the organizations involved in production and sales activities and the distribution of values and profits. The different companies currently in the global market are involved in R&D, design, manufacturing, sales, delivery, consumption, after-sales service, recycling, and other value-added activities (United Nations Industrial Development Organization, 2002).

Owing to the constant efforts of many scholars, the value chain evolved from the value chain of corporate activity relationship (Porter) to the value chain and distribution of global value chains linked to products and services (the development of the global value chain is shown in Table 3) and has become a powerful tool for analyzing global economic activity. At present, most of the studies on the global value chain focus on embedded barriers, dynamic mechanism, governance model, industrial cluster upgrading, economic rent generation, and distribution, which are the core of the global value chain; the value chain economic rent is the value. The purpose of chain governance and global value chain theory has become a subject undergoing intense study for domestic and foreign scholars.

Initially, rents were defined as gains from heterogeneous natural resources. With the extensive research, the connotation of rents is extrapolated, and the portion of income that exceeds the competitive income through the use of resources becomes rent. With regard to governance, the purpose of the value chain is to obtain economic rents through value chain appreciation. Depending on the value chain, rents of the value chain can be divided into three broad categories and dynamics, as shown in Fig. 2. The first category is the rent of a single action within the value chain, including entrepreneurship, organization, technology, and marketing capabilities. The rent from the enterprise level exists in three forms.

The relationship between the second group of actors within the chain of rents, including network members through the exclusive and collective investments, generated excess profits (Dyer and Singh, 1998). Relationship rents are the excess profits that must be created by the joint efforts of the partners over the sum of the independent income of the firm. The essence of relationship rent is based on the relationship between the proprietary investment and the elements and mechanisms created by inter-organizational values. The third category is the externally-generated rent of the value chain, including policy, infrastructure, and financial rents (Kaplinsky and Morris, 2002). Embedded global value chain allows the local industrial clusters to transcend the national borders, and the regional factors are embedded into the global value chain

Table 3 Development characteristics of value chain theory

	Corporate value chain	"Fragment" value chain	Global commodity chain	Global value chain
Characteristic	Porter first analyzed the links between the basic and ancillary activities of a single company and later extended to the company	Kaput analyzes the "fragmented" production network, thereby resulting in a global distribution of value across regions	To the product-centric global production organization system research	A study of value added and value chain coordination by global production organizations connected by products or services

Note: The author of the data department is arranged according to relevant literature.

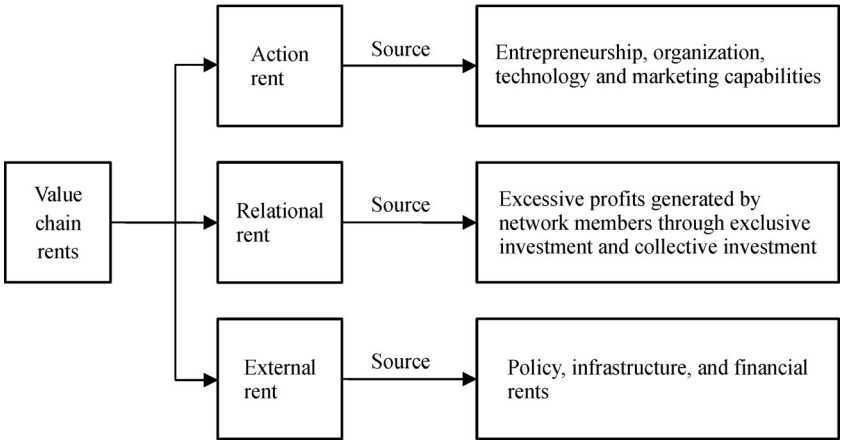

Fig. 2 Composition of rents on the value chain

rents to create governance and form the rents of the policy system, infrastructure, and financial funds. These factor rents will affect the cornerstone of local industrial clusters in the global context.

Gereffi (1999) believes that rents driven by producers are divided into technical and organizational rents, and rents driven by buyers are divided into relational, policy, and brand rents. Cao and Li (2005) indicated that the source of interest value chain is comparative and scale advantages of "division of labor benefits" and "trade price tipping interest," the developed countries can obtain the "division of interests," while other countries acquire "trade benefits." Lin et al. (2008) believe that the key to obtaining and creating a rental source to gain competitive advantage lies in gaining market and leadership powers with an advantageous position, which is determined by the governance characteristics of the value chain.

4.2 Value chain of HSR

According to the analysis framework of the value chain, this complex system of high-speed railway which can be considered as a kind of special "product," which covers line EMU construction, equipment manufacturing, other related hardware and operation control system, traction system, and collection of software "road" and "car." Preliminary line planning, design, construction, and matching of product R&D, EMU equipment manufacturing, and eventually forming such products to provide transportation services are necessary to realize the delivery of high-speed railway products. Thus, this paper argues that the value chain of high iron refers to high iron around one of the special products, the global market participation of enterprises with high technology research and development, design, manufacturing and marketing of iron, delivery, service, and recycling value-added activities. These activities constitute the value chain through the predevelopment, construction, operation, and maintenance of the entire life cycle in the process of high iron.

In this value chain, a large difference exists in the available rents for each activity, knowledge, capital, technology, and policy agglomeration, as shown in Fig. 3. R & D, design, brand, standard and marketing links are high value-added areas of high-speed rail value chain. These links are generally in the front and back of the value chain. The large portion of the labor input and the distribution of profits showing the dumbbells in the middle thin and thin form a single business action rent. In different sectors, leading companies not only use the value chain on the cooperation of enterprises to carry out exclusive and collective investments but also to produce excess relationship rent. Through the relationship between rent and external rent stack, the resulting total rents show V-type differences.

4.3 Value governance of HSR

China's high-speed railway sources its rich development from the overall perspective of the current global high-speed railway problem and then takes appropriate measures. Governance is the main process of value creation. Value chain governance is necessary to expand the value of high-speed railway and improve its influence in China. Humphrey and Sehmitz (2002) indicate that the importance of value chain governance is concerned with developing countries' understanding of market access, rapid access to productive capacity, grasping the distribution of rents on the value chain, obtaining technical assistance from developed countries, and finding policy and the fulcrum of technological innovation.

The distribution of rents in the high-iron value chain presents a considerable difference in the different links of the value chain, the result of different factors, and the result of participating enterprises in guiding the governance. Value chain governance refers to the arrangement of relationships and rules between companies through the

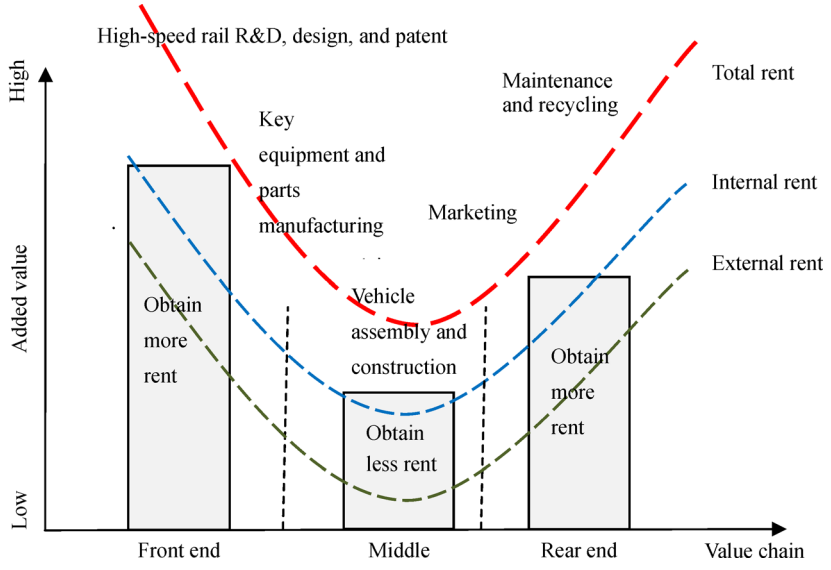

Fig. 3 Rent distribution on high-speed value chain

value chain, thus realizing the coordination of various economic activities and links within the chain (Qin, 2014). The value chain management of high iron is the high value-added location at both ends of the rental line. Technology, standards, brand, and other first-mover advantage are used to coordinate the distribution of high-speed railway enterprises to participate in the production and value distribution and comparative advantage based on the formation of a standardized management model, thereby ultimately leading to a certain standard system (Fig. 4) to achieve high-speed railway products, global orderly configuration, and uneven distribution of rent among high-speed railway multinational companies. The main motivation for enterprise participation through contracts, trust and rules, and other non-market forces is to achieve the coordination between manufacturers; these elements eventually form different high-speed railway market standards. In the high-speed railway value chain management, high-speed railway managers of the value chain division and cutting are particularly important. Under the guidance of different managers, high-speed railway enterprises are involved in the complexity of the transaction, and the transaction can be encoded. Based on this viewpoint, the management of high-speed railway value chain masters the core technology through the establishment of multinational enterprise output standardization system, control, distribution, and coordination of enterprises in the chain of production and value distribution; the overall value to the world is achieving the premise of governance, "maximize the value share."

5 HSR value governance in major countries

In the value chain, the leading enterprises control the strategic links and have the power of coordination and management of the value chain, whereas other manufacturers led and participants in the entire chain have different strengths in the position (Sacchetti and Sugden, 2003). Leading multinationals in developed countries (such as Germany, Siemens) have key factors, such as R&D, design, core technology, high-speed railway standards,

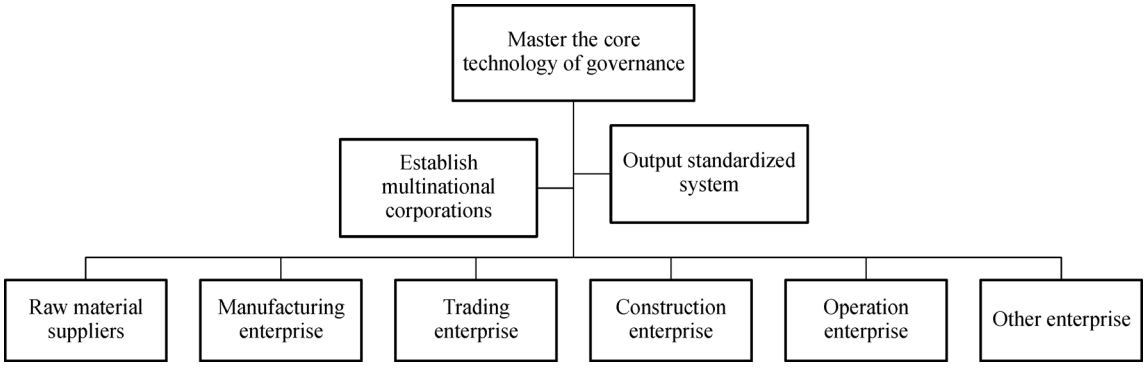

Fig. 4 High-speed railway value chain governance

branding, and marketing, as key governors in the value chain to capture enormous economic rents. The technology behind the development of high-speed railway companies participates in the use of domestic cheap labor, land, and other primary elements of the comparative advantage, which are embedded into the high-speed global high-end low-value. Low value-added links engage in manufacturing in the governance position.

The R&D key equipment parts manufacturing and aftermarket value are high in the value chain of the rent curve. Therefore, the corresponding departments have the right to speak in the high-speed railway industry and will be subject to regulatory authorities, industry associations, and other external conditions. Consequently, high-speed railway managers in the global market are mainly systems integration companies (large multinationals) represented by Siemens, with key equipment and component manufacturers represented by Knorr and other governing entities, such as the International Railway Alliance (Fig. 5), to form a governance system. In this governance system, enterprises (including core and marginal enterprises) are mainly involved in internal governance, government, associations, and other subjects mainly related to external governance.

5.1 German hierarchical governance

The German high-speed railway ICE (Intercity Express) was first developed and manufactured by the Federal Ministry of Communications, the Federal Ministry of Education and Research, and Siemens-based manufacturers and was operated by the National Railway Corporation (Zhou, 2002). In 1991, the Germany Hannover–Würzburg high-speed railway opening marked the German entry into the high-speed railway era. Throughout the development of German high-speed railway, the German high-speed railway value chain governance presents the following characteristics.

The German high-speed railway standard, which is represented by Siemens, is an important criterion for global high-speed railway. Rail transportation companies include Germany's Hubner, Knorr–Bremse, Schae–Pfler, Voith, Vossloh, and Siemens, of which Siemens is the leading high-speed railway enterprise in the world. In the SCI Verkehr released in 2015, the world's rail transportation equipment ranked Germany's Siemens and Knorrins fifth and seventh, respectively, the vehicle business ranked sixth and seventh, and the train control and signal company Siemens ranked first. Siemens has mastered high-speed railway body R&D, traction power system, train network control system, signal system, system integration, and other key technologies. In the global high-speed railway output, the technology output of Siemens to Spain, China, Russia, and other countries has become an important configuration of the global high-speed railway. Siemens uses the position of high-speed railway operators to market the operation and control the high-speed railway standard. The high price of Siemens' products enables the company to seize huge profits, control key technologies, and secure a dominant position among high-speed railway manufacturers.

Government and other organizations have become an important component in high-speed railway value management. In 1970–1990, the German government invested 450 million German marks (approximately 225 million euros) to develop high-speed railway. The Eco Rail Innovation platform, which is an important technology intermediary service agency, is a comprehensive innovation platform established by the German government. This institution is used for high-speed railway governance. Moreover, such institution cooperates with Siemens and other enterprises and provides access to a considerable amount of

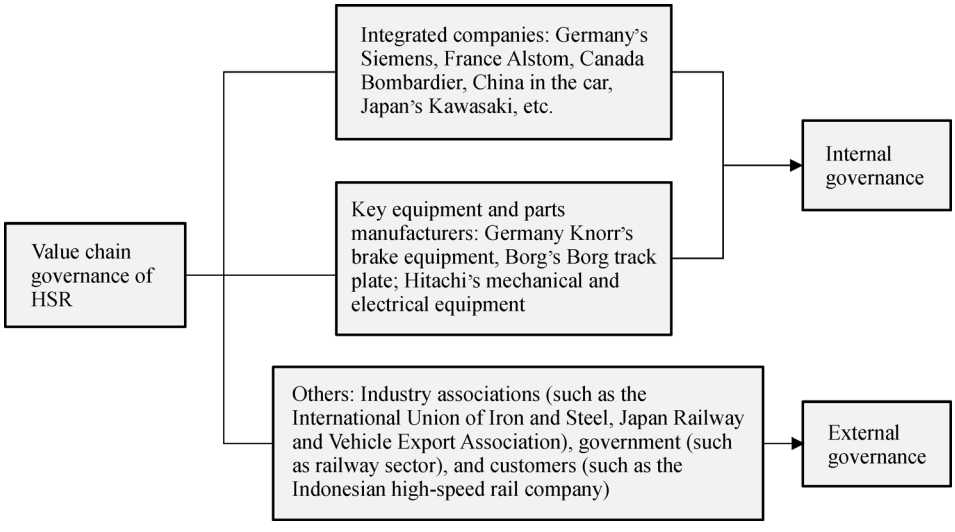

Fig. 5 High-speed railway value chain management system

government support (Zhang, 2008). Government and associations should participate in high-speed railway research and development to become managers of high-speed railway. Through the annual procurement, research funding support, and other means, the government can guide Siemens and other manufacturers to carry out technological changes.

Germany has formed a hierarchical high-speed railway governance structure. According to the German rail market of SCI Verkehr, Germany, Siemens, Knorr, and other leading companies accounted for a large market share. Through the formation of relationships with other enterprises, leading companies aim to expand its control of the value chain. Leaders have absolute leadership power to incorporate the value of other links into their own systems through ownership. Enterprises that master the core technology can control other enterprises through the development of standards and hierarchical governance.

5.2 French hierarchical governance

The TGV (TGV is French high-speed railway system, which is translated from French) of France is the world's leading high-speed railway technology, and Alstom is famous among French high-speed railway enterprises (Sha, 2000). TGV series has repeatedly broken the world's high-speed railway record. Alstom, as the representative of the high-speed railway standard, has become the European standard for high-speed railway.

In the high-speed railway management, considering the railway network of France, state-owned railway companies, and years of practical experience, Alstom has become a world-class high-speed railway power. The 2020–2050 "Excellence in France" program aims to optimize the way French railways operate by providing customer-centric service to maintain the leading position of the French rail system in the global railroad. Alstom, a state-owned railroad company of France, is a purchaser and producer of high-speed railways. Considering advanced technologies and ideas, Alstom, as a French high-speed railway, provides passengers with fast, safe and environmentally friendly transport services. Alstom high-speed railway products are leading globally with their annual sales of at least 10% of the world's rail passenger sales. In addition, fastest and most automated trains in the world are produced by Alstom. The high-speed railway advantage of Alstom has repeatedly broken high-speed railway records. Furthermore, the technical standards of Alstom have become the overall standards of European high-speed railway. Technical recognition of Alstom is good in relation to independent intellectual property rights products.

The high-speed railway value management of the French government mainly come from the allocation of research funding, the establishment of railway growth fund, and the foundation of I-Trans railway technology park. Alstom and other enterprises obtain government subsidies to speed up the pace of its technology R&D to obtain a large degree of total rent on the value chain. The French railway company is a state-owned enterprise which can be managed by high-speed railway enterprises through tender procurement. Through the procurement standards, France formed a landlord and Alstom-based level of governance.

5.3 Japanese modular governance

Japan is not only the world's first high-speed railway operation country but also the earliest to use the systems integration approach to develop high-speed railway countries. Japan's high-speed railway system constitutes Kawasaki Heavy Industries, Hitachi, Mitsubishi Electric, Kinki vehicle manufacturing and the construction of the Tokugawa vehicle, Japan Research Institute, Japan Railway and Vehicle Export Association, and International High-speed Railway Association (Gao and Gan, 2011).

Japan's Kawasaki Heavy Industries is a business representative of high-speed railway system integration. The high-speed railway research of this industry started early with tight security. In recent years, Japan Kawasaki technology has been exported to India and other countries to compete with the high-speed railway of China and the surrounding areas. Japan's JR East Japan, the East China Sea, West Japan, and Kyushu are four major railway companies that jointly established the "International High-speed Railway Association." The purpose of this association is to hand out globally the Japan Shinkansen technology. The international competitiveness of Japanese companies improved through this association. Japan's high-speed railway is the first to use the system integration approach. Their government supports a number of institutions for technology R&D.

5.4 Chinese semi-hierarchical governance

The high-speed railway technology of China is strongly supported by its government through the introduction, absorption, digestion, and new formation of rail technology, which involves Siemens from Germany, Kawasaki Heavy Industries from Japan, Alstom from France, and other technologies. The high-speed railway system of China includes the following: enterprises (China Railway Corporation), system integration enterprises (vehicles), associations (China Railway Institute, etc.), equipment and spare parts manufacturing enterprises (Ding Han Technology, Connie Electrical), transport technology (high-speed railway of China, etc.), and construction enterprises (China Railway and China Railway Construction).

China Railway Corporation as a landlord is the core position in the domestic high-speed railway management system. Domestic high-speed railway formation similar to the domestic subway half-level type of governance is also consistent with the identity of the government department.

Railway Corporation provides a significant impact to other enterprises through the proposed high-speed railway construction and vehicle procurement, which affect other enterprises through a series of standards. CRRC as a high-speed railway system integration enterprise has made considerable progress in recent years and is an important high-speed railway manufacturer with certain technological advantage. However, CRRC still exhibits technical blind spots and has to rely on Siemens, Knorr, Mitsubishi Electric, and other enterprises to provide the technology and key spare parts. CRRC relies on foreign manufacturers due to the constraints of intellectual property and standards.

The high-speed railway of China is weak in the value chain management. The high-speed railway of China possesses the characteristics of low cost and strong construction technology (Lv, 2015). However, the world's high-speed railway manufacturers have risen to the highest point in the value chain in the course of many years of development and have completely utilized the international division of labor, transferring the low value-added part to foreign countries.

Leading manufacturers use a few global high-speed railway technology standards; however, the high-speed railway system of China has less involvement in this area and their voice is weak. Intellectual property issues directly restrict the participation of China in market competition with other developed economies.

6 Comparison and performance evaluation of HSR value chain governance in major countries

6.1 Comparison of value chain governance of HSR in major countries

From the German, French, and Japanese governance practices, the following characteristics are analyzed. The government, as an early manager of high-speed railway, has given way to an integrated enterprise, such as Siemens, thus allowing such enterprise to fully market its operations by controlling the internal value of the traditional value chain. Further internalization of government rents, such as government subsidies, is necessary to obtain excess returns. The development of high-speed railway is inseparable from government support. The funds, policies, and other aspects of government support contributes to the rapid progress of high-speed railway technology and nurtures high-speed technology.

Germany Eco Rail Innovation Platform, the French Railways Growth Fund, and Japan Research Institute are strong supports of the government; ultimately, these supports are concentrated in the Siemens, Alstom, Kawasaki Heavy Industries, and other high-speed railway enterprises. These companies use the leading technology to rapidly seize the domestic and international high-speed railway market by accessing government subsidies, co-production yield and monopoly rent. Moreover, these companies control the entire high-speed railway production network and seize the value chain when internalizing the value of the chain. The development of high-speed railway is also a manifestation of global configuration. Under the government strategy of China, the high-speed railway is devoted to expanding the international market rather than seeking satisfactory profits similar to that of Siemens and other companies. However, a few disputes regarding the ownership of patents may arise, which will put adverse impacts on the export of high-speed railway in China.

The formation of high core competitiveness is reflected in the construction of a complete industrial chain, which continues to move upstream and downstream with high value-added links and high-speed railway standard outputs. The high-speed railway standard of France is the European standard. The French high-speed railway in the European market is strong and competitive. Through the standard construction, Alstom earned a huge income. With the current global railway market, the share of Japanese companies is only approximately 10%. Moreover, competition among Canada Bombardier, France Alstom, and Germany's Siemens (“Big Three”) is difficult. On the one hand, the top three high-speed railway enterprises of the world have to provide rail cars, after-sales service, and operating system construction, including a basket of institutional construction. By contrast, Japanese companies basically do not have this comprehensive capability. The independence and integrity of the core technology of high-speed railway, from the wheel and traction motor to the electronic module chip, is the performance of high-speed railway competitiveness. Especially in the international division of labor under the premise of high-speed railway, mastering the key technologies and accessories provides access to high profits.

The global high-speed railway market presents a hierarchical high-speed railway management model and modular transition. In high-speed railway technology, capital, and other entrance barriers, most of the late-funded enterprises focus on assembly and other low-tech aspects of the link, thereby facing the dilemma of the low-end lock. Siemens and other high-speed railway companies control the production standards for global production arrangements. These companies set up factories and other ways to quickly embed into the value chain of the input country, thereby reaching the control purposes. In recent years, high-speed rail value management model is from the level of governance to modular governance changes.

6.2 Performance measurement of HSR value chain governance

Value chain governance of high-speed railway in different

countries shows different states. The purpose of governance is to logically allocate resources in the global high-speed railway market and obtain access to a large value chain rent. The governance of high-speed railway is diversified. In this paper, we construct an evaluation system of value chain governance performance to analyze the effect of high-speed railway enterprises participating in value chain management. Analysis of the country's governance time found that the high-speed railway value chain of the government has been mainly attributed to the business-oriented, of which the most important is the first-mover advantage of high-speed railway integrated enterprise governance.

The special developmental history of several leading high-speed railway manufacturers locally and internationally indirectly reflects the development of the global high-speed railway development trend (Liu et al., 2016). This paper selects the most representative high-speed railway enterprises, including the German Siemens, France Alstom, Japan Kawasaki Heavy Industries, and China to analyze the car. From the preceding governance mechanism and practice mentioned, the effect of high-speed railway governance mainly reflects its capability to control the market, its utilization of standards to reduce costs and simplify the coordination between enterprises, thereby cutting different value chain links to capture different rents (profit margins), patents (intellectual property), and external rent internalization (government subsidies) to obtain high returns. Accordingly, the performance of high-speed railway value chain management refers to the core technology of enterprises in using their dominant position in market conditions, profitability, mastery of the standard system, and internal and external rental traits and other aspects of performance. This is mainly related to the market, products, technology, capital, management, human, intellectual property, and other aspects of the performance of high-speed railway management evaluation. We focus on the four typical national high-speed railway benchmarking enterprises, namely Germany (Siemens), France (Alstom), Japan (Kawasaki Heavy Industries), and China (China Railway Rolling Stock Corporation) for evaluation. The overall idea of evaluation is to construct the index system of performance evaluation and then select the corresponding data for quantitative analysis. Finally, we compare the performance of the major high-speed railway enterprises, determine the key to governance, and tap the elements of China's high-speed railway participation in value chain management.

6.2.1 Modeling

The level of governance of high-speed railway value chain can be determined by the governance performance. The value chain performance value can be evaluated by sustainable development theory using the economic, social, and environmental index system (Sun and Yan, 2016) or using the upstream value to calculate the competitiveness of the chain industry (Liu and Cao, 2014). This part is based on the analysis of internal control and external governance in the analysis of the high-iron value chain mechanism. The combination of Liu et al. (2016) uses the expert scoring method to screen out the factors that have considerable influence on the competitiveness of high-speed railway to build the performance evaluation index system of the high-speed railway value chain governance. The principle of indicator selection is that the model uses the result indicator to consider the availability, validity, and comparability of the data. Meanwhile, the model partly adopts the process indicator to increase the comprehensiveness of the model. The construction of the entire model is carried out in two steps. The first step is evaluating the construction and rationality of the evaluation system. The selection of nine indicators is based on Liu et al. (2016). The results of the study and the high-speed railway characteristics are analyzed in this paper. The indicators from the nine angles are as follows: asset status, market performance, market demand, human input, profit level, technical level, level of R&D, international level, and external income for high-speed railway management performance feedback; the specific secondary indicators are shown in Table 4. This paper uses the factor analysis method to test the accuracy of the selection of the nine indicators to ensure the completeness of the indicator system constructed in the model.

The second step is measuring the performance of the evaluation system. First, the weight of the indicator is determined using the correlation matrix assignment method, and the performance of the governance is evaluated using the compound system coordination model of Qingsong. Currently, determining the weight of the indicator uses the expert scoring method and the neural network. However, this study employs a new method used by Wenshu and other scholars with regard to the relevant matrix assignment method to determine the indicator. The main idea is to derive a relative weight in the indicator system based on the importance of the different indicators (Meng and Han, 2010). If an indicator is important in the system, then a large weight is provided; if the importance is small, then the assigned weight is small. The specific formula is shown as follows.

Based on the assumption that n second-order indicators exist in the index system, the correlation matrix is given by Q below.

$$Q=\begin{bmatrix} q_{11} & \cdots & \cdots & q_{1n} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ q_{n1} & \cdots & \cdots & q_{nn} \end{bmatrix}, q_{\mathrm{ii}}=1(i=1,2,3,\ldots,n). \quad (6\text{–}1)$$

If $Q_i=\sum_{j=1}|q_{ij}|-1, i=1,2,3,\ldots,n$, then Q_i represents the

Table 4 Performance evaluation indicator system on HSR value chain governance

First level indicators	Second level indicators	Explanation of indicators
Condition of assets	Total assets	Absolute size of the enterprise
	Asset-liability ratio	Reflect the corporate liability situation
Market performance	Sales revenue in the railway sector	Reflect the power of market competence
	Per capita sales revenue	Reflect the income level
	Market distribution	Reflect the global allocation of HSR
Market demand	New adding order amount	Reflect the condition of future market
Human resource input	Amount of staff	Reflect the total workers of railway industry
Profitability	Net profits	Reflect the profitability
	Profits of per capita	Equal to total profit/worker number
Technique	Intangible assets	Reflect the patent, intellectual property can be standardized
	Intangible assets ratio	Intangible assets / total assets
	Number of patents that can be retrieved	Reflect the development level of governance standards
R&D	R&D input	Reflect the capability to occupy the upper reaches of the value chain
	R&D investment intensity	R&D investment/sales
Internationalization	Output country/region	Reflect its standard output
	Number of overseas institutions	Foreign branch, the number of R&D institutions
External benefit	Government subsidies	Reflect the high-speed railway enterprises to capture the external rent from the government

degree of influence on the other (n − 1) indicators. Q_i is standardized to obtain the ultimate weights of the individual indicators represented by W_i.

$$W_i = \frac{Q_i}{\sum_{i=1}^{n} Q_i}, i = 1,2,3,...,n \tag{6–2}$$

In this study, the composite system is used to calculate the performance value. The principle of this method is to use collaborative innovation to the preceding indicators to determine the performance of a subsystem. From market performance to external income, a total of nine subsystems is used in this study. When the nine subsystems are coordinated to form a composite system, the values calculated by the composite system indicate performance levels. Among the 17 secondary indicators, if a subsystem is compared to the composite system, and the resulting degree of coordination is high, then the contribution of that subsystem to the overall performance is high, which is the key to control the elements.

Taking the subsystem S_1 as an example (the same logic applies to the other subsystems), the order parameter variable in the evolution is $e_1 = (e_{1n}, e_{2n}, \cdots, e_{nn})$, $\beta \leqslant e_{1i} \leqslant \alpha_{1i}$, where $i \geqslant 2, i \in [1,n]$. When the parameter variable is positive, a high value of $e_{1n}, e_{2n}, \cdots, e_{nn}$ leads to a high order of S_1 subsystem and vice versa. When the parameter variable is negative, a high value of $e_{1n}, e_{2n}, \cdots, e_{nn}$ leads to a low order degree of S_1 subsystem and a small result. Thus, the ordering degree of the parameter component e_{1i} of the subsystem S_1 is defined as:

$$U_1(e_{1i}) = \begin{cases} \dfrac{e_{1i} - \beta_{1i}}{\alpha_{1i} - \beta_{1i}}, \text{when the ordered parameter is positive} \\ \dfrac{\alpha_{1i} - e_{1i}}{\alpha_{1i} - \beta_{1i}}, \text{when the ordered parameter is negative} \end{cases} \tag{6–3}$$

From the preceding definition, a large value of $U_1(e_{1i}) \in [0,1]$ leads to a large ordered contribution of the corresponding subsystem S_1. Moreover, the general contribution of the order parameter variable e_{1i} to the ordering degree of the subsystem S_1 can be obtained by using the weighted sum of $U_1(e_{1i})$ (see Eq. (6–4)). Using existing research results as reference (Wang, 2013), this study employs the method of linear weighted sum to calculate the order degree of the subsystem.

$$U_1(e_{1i}) = \sum_{j=1}^{n} w_j U_1(e_{1i})$$

$$\text{and } 0 \leqslant w_j \leqslant 1, \sum_{j=1}^{n} w_j = 1, \tag{6–4}$$

where $U_1(e_{1i})$ denotes the order degree of the system parameter variable e_{1i}. A high value of $U_1(e_{1i})$ results in a considerable effect of e_{1i} on the system order, thus providing a high degree of system order. Notably, $S_j (j \in [1,9])$ can be particularly discussed as follows.

Given the initial time T_0, the order degree of each subsystem $S_j(j \in [1,9])$ is $U_j^0(e_j)$. For time T_1 of the evolution of the composite system, if the system coordination degree of S_j is $U_j^1(e_j)$ and at T_1, then the overall coordination degree of the composite system can be expressed as:

$$S = \lambda \sqrt{\prod_{j=1}^{9} |U_j^1(e_j) - U_j^0(e_j)|}$$

$$\text{and } \lambda = \begin{cases} 1, U_j^1(e_j) \geqslant U_j^0(e_j) \\ -1, U_j^1(e_j) \leqslant U_j^0(e_j) \end{cases}. \quad (6\text{–}5)$$

The preceding formula shows that a high value of $S \in [-1,1]$ results in a high coordination degree and a good performance of the high-speed railway value chain governance and vice versa.

6.2.2 Data source and processing

Data sources used in this study include the following: financial medium and annual report of the related companies, research report of the authoritative consulting company of the railway transportation industry (such as SCI Verkehr in Germany, International Railway Union, and China Railway Research Institute), and relevant domestic research papers and periodicals. The data used in this study are accurate and underwent rigorous validation.

The indicators used in this study are shown in Appendix A-1. Notably, the preceding data are sourced from the financial data of companies. The companies' business, which not only covers high-speed railway but also urban rail transit and other fields, is diversified. These data do not have a unified standard stripping, but the companies' main business is in the rail transport industry. These data can also explain the high-speed railway market performance of companies with significant credibility.

The total assets are converted according to the exchange rate of October 1, 2016, reflecting the asset size of the high-speed railway manufacturers, reflecting the capital strength; the asset-liability ratio reflects the corporate debt capacity; the net profit rate reflects the enterprise's ability to obtain the value chain rental capacity; Distribution reflects the layout of its high-speed railway in the global market, the more the number of institutions outside the chain that the chain of embedded value chain longer, and its capture ability; intangible assets and patents that enterprises in the high-speed railway standards and other aspects of the layout, the more The R&D level reflects the capability of enterprises to occupy the upper reaches of the value chain, the more the degree of its grasp of the core technology more; market performance reflects its downstream performance in the value chain, the per capita sales income more To a certain extent reflect its ability to obtain downstream rents, financial subsidies reflect the high-speed railway manufacturers to capture the ability to outside the value chain, but also an important manifestation of governance.

6.2.3 Result analysis

Index data are standardized prior to the analysis to eliminate the effect of different units used. This study used SPSS version 22.0 to standardize the index data (Feng, 2015). Table 5 shows the transpose matrix of the post-standardization evaluation system.

Table 5 Standardized value of HSR value chain governance indicator system

Siemens	Alstom	KHI	CRRC
1.42778	−0.3728	−0.89215	−0.16283
−0.40217	1.18215	0.36387	−1.14385
1.43304	−0.6866	−0.6866	−0.05985
−0.37484	−0.36388	−0.73839	1.47711
0.6065	0.72067	0.1213	−1.44847
0.50764	0.55754	−1.49803	0.43285
0.48107	0.58797	−1.49666	0.42762
−0.472	−0.39494	1.49306	−0.62612
−0.55487	−0.63359	1.4843	−0.29584
1.25268	−0.12865	−1.18752	0.06349
0.23836	1.1021	−1.31449	−0.02596
1.45323	−0.48583	−0.78713	−0.18027
1.37334	−0.04571	−1.00334	−0.32429
0.38476	−0.70186	−0.91595	1.23304
1.4921	−0.35262	−0.56351	−0.57598
1.42257	−0.81076	−0.56261	−0.0492
1.34073	0.0398	−1.04235	−0.33818

(1) Effectiveness of the index system analysis

Factor analysis is used to determine the effectiveness of the preceding index system mentioned, and the criteria are as follows. Generally, KMO and Bartlett have a spherical degree test value of 0.5 or more; the variance of each common factor should not be less than 0.4. The results of the factor analysis using SPSS 22.0 are shown in Table 6 below.

In the preceding table, the KMO test result is 0.677, which is larger than the standard at 0.5. Bartlett's spherical test value Sig. takes 0, which is less than its significance level at 0.5. Therefore, the indicator system constructed in this paper is tested by KMO and Bartlett's test.

Table 7 shows that the extraction of the common factor

Table 6 Spherical degree test of KMO and Bartlett

KMO measure	Bartlett test		
	Approximate chi-square	Df	Sig.
0.677	320.175	23	0.000

Table 7 Common Factor Variance

	Initial	Extract
VAR00001	1.000	0.992
VAR00002	1.000	0.844
VAR00003	1.000	0.998
VAR00007	1.000	0.997
VAR00008	1.000	0.957
VAR00009	1.000	0.999
VAR00010	1.000	0.9380
VAR00015	1.000	0.900
VAR00016	1.000	0.994
VAR00017	1.000	0.924

Extraction method: principal component analysis.

variance is larger than 0.4. This finding implies that indicators with variance of at least 40% of the indicators can be used to explain the common factor.

In the preceding table showing analysis of variance, number 1 and serial number 2 are extracted as the main factors, and their initial eigenvalues are 7.120 and 1.885, respectively. The variance of these factors are 71.202% and 18.847%, and the cumulative variance is 90.049%, which is sufficient to explain the variation of the evaluation system.

After SPSS 22.0 analysis, KMO test results were 0.677 larger than its 0.5 standard; Bartlett's spherical test value Sig. was taken as 0, which is less than its significance level of 0.05; extracted common factor variance was greater than 0.4, thereby indicating that the index system within the target of at least 40% of the indicators can be used to explain the common factor. The common factor cumulative variance of 90.049 is far larger than 40%. Therefore, this study established a performance measurement system of high value-chain governance with structural rationality.

(2) Weight determination of the index

The weighting of the secondary indicators is shown in Table 9 below. The weight of government subsidies evidently reflects that internal and external governance is high, which can have a considerable impact on the entire governance system. This finding also confirms the result of the previous high-speed railway value chain analysis on the importance of internal and external governance.

(3) Calculation results and analysis

Using the complex model of the previous formula (shown in Eq. (6–5)), Table 5 is normalized after the value input and combined with the index weight in Table 9. The score after data processing is shown in Fig. 6.

In the preceding chart, China's car company ranked third with a performance index of 0.68. Siemens, Alstom, and Kawasaki Heavy Industries ranked first, second, and fourth with performance indexes of 0.98, 0.74, and 0.48, respectively. High-speed railway management perfor-

Table 8 Interpretation of total variance

Initial eigenvalues			Extraction sums of squared loadings		
Amount to	PC	CPV	Amount to	PC	CPV
7.120	71.202	71.202	7.120	71.202	71.202
1.885	18.847	90.049	1.885	18.847	90.049
0.995	6.951	97.000			
0.187	0.921	97.921			
0.162	0.914	98.835			
0.081	0.623	99.457			
0.046	0.455	100.000			

Extraction method: principal component analysis.

Table 9 Weight of secondary indicators

Indicator	W_1	W_2	W_3	W_4	W_5	W_6
Weight	6.93%	4.12%	6.37%	3.42%	3.31%	6.28%
Indicator	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}
Weight	6.18%	6.48%	6.25%	7.47%	4.70%	6.69%
Indicator	W_{13}	W_{14}	W_{15}	W_{16}	W_{17}	
Weight	7.08%	5.52%	6.14%	5.94%	7.09%	

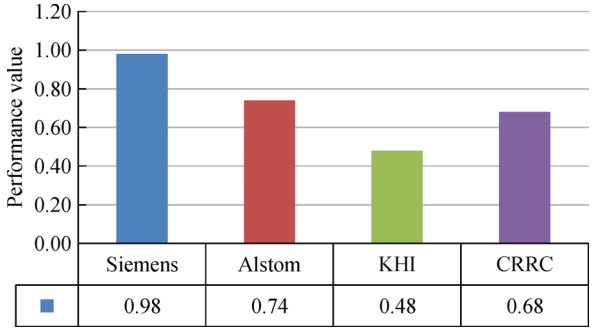

Fig. 6 Rank of governance performance for major high-speed railway manufacturers

mance of Siemens is in the leading position with a performance index of 0.24 more than Alstom. The performance gap between China with Alstom is only 0.06. The governance performance of Kawasaki Heavy Industries is behind the three other countries. The results of this study are consistent with those of Ma (2015) based on the international input-output table for calculating the value chain length and upstream coefficient of rail transit. These results further illustrate that the German high-speed railway and French high-speed railway management model have high degree of centralized control and access to huge gains through the downstream enterprises. By contrast, the chain of business control is weak for Japan's modular governance model, and its governance performance is not at par with the high-speed railway leading enterprises of Germany and France. China's governance performance is good. However, the overall view of the global high-speed railway management from the level of capture of the modular transition trend recommends China to adapt to the changes in the overall market governance to achieve better governance needs.

This paper simplifies the processing of the indicators in Table 4 from large to small and recorded as 4, 3, 2, and 1 to further comprehensively analyze each index. Figure 7 shows the scoring radar for 17 secondary indicators from Siemens, Alstom, Kawasaki Heavy Industries, and China.

In Fig. 7, the railway sales revenue of China in the field of the four countries ranked first mainly in the domestic large-scale construction of high-speed railway while the main income from domestic and overseas markets accounted for less. Compared to the lower proportion of high-speed railway sales in the international market, China has introduced a large number of foreign high-speed railway technologies for urban rail transit, light rail, and general railway since 2004. Although the unified standard of China's number of searchable patents is numerous, recognition from the international community is relatively low.

Three different indicators of sales revenue exist in the railway sector, namely the market distribution, the per capita profit, and the number of overseas institutions. The three indicators in the four countries ranked in the last one. The reasons behind the three indicators are as follows. The market distribution: China's high-speed rail in the overseas market has a relatively low proportion. Per capita profit: The high-speed railway enterprises of China in the value chain are located in a low value-added position. And China has less core technology. Most of our enterprises are also labor-intensive enterprises, and these factors pull the per capita profits of China. Number of overseas institutions: External development failure because the high-speed railway of China is in its infancy.

Overall, the high-speed railway of China in recent years rapidly progress in the international market and reaches the upper status in the industry. Moreover, the high-speed railways of China have obvious advantages in terms of integrated services, non-critical technology, and cost. However, compared with Siemens and Alstom, the core technical and management levels are lagging behind. To

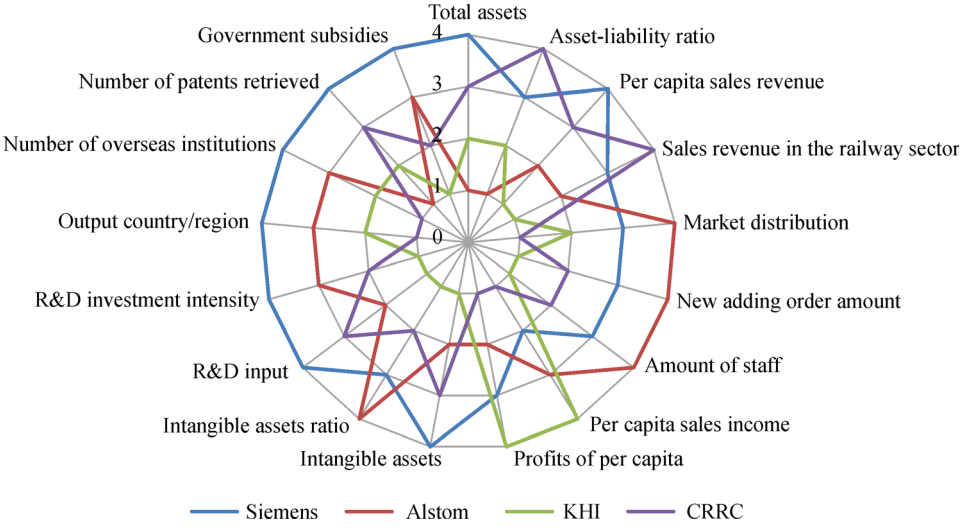

Fig. 7 Indicator radar map

this end, the high-speed railway construction enterprises of China should learn from foreign enterprises with regard to the cooperation of foreign advanced technology and management experience to promote high-speed railway "going out" strategy implementation.

7 Conclusions and suggestions

7.1 Conclusions

In the context of the rapid formation of China's high-speed railway network, achieving the value of high-speed railway is the most fundamental purpose of high-speed railway economy and management research. Hence, this paper provides the definition of the value of high-speed railway based on existing value theory. The value of high-speed railway has nouns and verbs meaning. Value is a process of input and output, where input refers to the value of the creation process and output is the value of the form of expression. In the process of input, labor, technology, capital, and other elements create the value of high-speed railway together. Labor is the source of high-speed railway value creation; hence, technology, capital, and other elements are the necessary conditions for the creation of value.

High-speed railway value has many forms, such as space–time, communication, economic, ecological, and employment values. The value of such forms of expression depends on "the characteristics of high-speed railway." Owing to the high accessibility of the high-speed railway and other characteristics, people are willing to take the high-speed railway as a communication tool, which not only satisfy their needs but also further promote the economic development. Corresponding to the form of value, we usually take the value of time and space to measure the accessibility of high-speed railway and communication value to measure the degree of communication needs. Economic, ecological, and employment values express the promotion effect of the communication value.

According to the definition of the high-speed railway value, the communication value is used as a bridge in this paper. The influence of high-speed railway on the expression of value is quantified through the system dynamics model. The following conclusions can be drawn. By increasing the number of high-speed railway pairs (100 pairs) to increase the passenger capacity of the high-speed railway, GDP is expected to increase by 2 percentage points. Compared to the program that increases 100 pairs of high-speed railway by adjusting the speed of high-speed railway (from 300 $km \cdot h^{-1}$ to 350 $km \cdot h^{-1}$), GDP will increase by nearly 3%.

According to the judgment of the first two contents, labor is the source of value. Based on the principle of controlling key points, we should focus on the key labor and labor object in value creation, namely governance and value chain, respectively. After the study of high-speed railway value chain management in Germany, France, Japan, and China, the three following details were identified. First, government, as a high-speed railway early manager, has given way to Siemens and other integrated enterprises. Second, the standard output of high-speed railway has become the core competitiveness of high-speed railway. Third, the global high-speed railway market presents a hierarchical management model and changes to the modular governance. By constructing the index system for the performance of high-speed railway governance, the following conclusions are drawn. Siemens and Alstom are among the highest in the governance level, CRRC is third, and Kawasaki Heavy Industries ranked fourth. From the specific indicators, the sales revenue of CSR ranked first in the railway field due to the construction of domestic high-speed railway. The large market share of CSR can be attributed to two points: per capita profit and the number of overseas institutions. The three indicators ranked last. First, the position of China's high-speed railway value chain is relatively weak; second, a certain gap exists in the operation of the government background and the market operation of Siemens.

7.2 Suggestions

7.2.1 Governance direction of HSR value

The high-speed railway enterprises in the value chain governance of China is relatively weak in all aspects of the capability. In a low embedded position, China is in a weak position compared with the chain of other strong business negotiations. This study found that in the hierarchical value chain governance, controlled companies are more likely to adopt product and process upgrades in governance. These upgrades also included the development of a new, cost-effective, and acceptable product, the production process optimization and innovation, and the introduction of new management and control system. In the short-term, these upgrades can improve the profits of high-speed railway

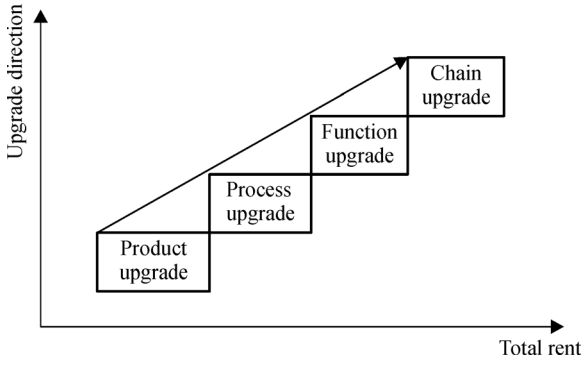

Fig. 8 Updated governance path of China's HSR value chain

enterprises in China. However, the purpose of the two governance methods is passive and is obtained from the customer's product quality requirements.

China's governance of high-speed railway value chain is half-level governance. Although supported by the leading enterprises, the current governance situation has been considerably improved but is still subject to the value chain-led enterprise control. Owing to the limited development space, obtaining a fundamental upgrade is difficult. Therefore, China's high-speed railway enterprises should be based on the domestic value chain, with the support of half-level value chain governance enterprise and learning advanced technology and management philosophy. The enterprise market channels should be broadened and output high-speed railway standards should be improved. With the development and growth of an enterprise, the focus will be transferred to the design, R&D, sales, after-sales, and so on to enhance the level of our value chain governance. Figure 8 reflects the path of China's high-speed railway value chain governance, namely product, process, function, and chain upgrades.

7.2.2 Upgrade path of the value governance of HSR

According to the preceding summary of the high-speed railway value chain governance mechanism and the experience of leading enterprises, combined with China's current situation, the following ways are proposed to achieve governance path upgrade.

(1) Guide the aggregation of the core elements to promote product upgrades

The high-speed railway of China exhibited many technical deficiencies (e.g., lack of core elements). In recent years, China's high-speed railway has rapidly developed through the introduction, digestion, absorption, re-innovation, and other processes. However, owing to technical barriers and other restrictions, learning all the leading technology from others is difficult. Value chain network has a very typical learning effect. Through the strategic cooperation with foreign manufacturers and the advantage of their capital and technology, we can promote the product upgrades of China and simultaneously enhance the innovation capability of China, cultivate high-tech talent, and enhance the core technical level.

(2) Strengthen collaboration with affiliated enterprises to promote the upgrading process

Action, relational, and external rents are three types of rents on the high-speed railway value chain rent curve. China should not only focus on the operating rent of individual enterprises but should also pay attention to the relationship between rent and external rent to maximize the total rent of high-speed railway. Specifically, we need to actively participate in the value chain collaboration, with particular emphasis on collaboration with leading enterprises, thus promoting the process of upgrading. The company's trading within the value chain can reduce transaction costs and significantly increase the speed and quality of the transaction. Through cooperation with large enterprises, we can also obtain better technology spillover and knowledge spillover effect, which brings considerable benefit to the innovative learning of the company.

China's high-speed railway companies should actively participate in and lead the international division of labor and cooperation. With the development of high-tech technology, China can be widely accepted by the international market equipment, advanced equipment, and construction technology. We promote the establishment of high-speed railway interests of the community to reduce trade barriers between each other. Clearing the obstacles and strengthening the localization strategy are necessary for the development of high-speed railway to boost the high-speed railway global configuration and standard output of China.

(3) Value chain linkage between local and abroad to promote functional upgrading

At present, a big difference is observed in China and foreign value chain, which is an important part of the impact of governance performance. Patents and standards are not only an important means of standardized management of high-speed railway managers but also a bridge between domestic and foreign value chain. Although China's high-speed railway technology through the introduction, digestion, absorption, re-innovation and other processes have rapidly developed, a big gap with Siemens, Alstom, Kawasaki Heavy Industries, and other advanced enterprises exists. Data shows that the patent applications of China in the United States and Europe accounted for only 0.38% and 0.28%, respectively, in which the core patent application is few. We must obtain the core intellectual property rights by reinforcing the global layout of the patent and participate in the development of high-speed railway standards to achieve the goal of high-speed railway global distribution.

Although China's high-speed railway standard system has not been accepted internationally, especially high-speed railway rivals, such as Japan, China has been striving in this direction. For example, Yavan high-speed railway has adopted Chinese standards. At present, in the International Standardization Organization (ISO), the International Electro-technical Commission, and other international organizations, China has achieved a permanent member status. In the International Union of Railway and railway cooperation organizations, China served as a leading position. By attending to this and other influential organizations, we can participate in the high-speed railway international standard-setting process, enhance international cooperation, and obtain authority in international high-speed railway technical standards setting.

(4) Internal and external governance to simultaneously promote and achieve chain upgrades

In the governance of high-speed railway value chain,

apart from internal governance, the government is supposed to improve the necessary external governance and simultaneously promote high-speed railway value chain of internal and external governance. The ISO as the representative of the international standardization of development is the embodiment of this concept of governance.

CRRC, CWYCY, and other integrated enterprises should actively cooperate with leading enterprises by participating in the construction of foreign high-speed railway projects. The position in the value chain is maintained through leading technology and low transaction costs to seize the commanding heights of the value chain. High-speed railway key parts manufacturing enterprises, such as the China Academy of Railway Sciences, should participate in the chain of the transaction process to improve the international level of high-speed railway. Simultaneously, with regard to internal governance, we should strengthen the government and industry associations on the value chain governance through bilateral or multilateral cooperation and build technical standards to enhance internal and external governance level. As the main body of external governance, government and industry associations should work with internal governance to discuss ways to build governance. In the process of governance, playing not only the role of the market but also the role of government is necessary. The government needs to change the functions of its government, perform macro-control on the market environment, strengthen market supervision, and compensate for market failure. Specifically, the government needs to establish a sound system of laws and regulations to urge enterprises to form industry associations, chambers of commerce, and through a unified code of conduct to develop industry standards to facilitate the existence of competition and cooperation together among enterprises.

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