Development Model for Competitive Construction Industry in the People's Republic of China

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Abstract: This paper identifies and analyzes the open-policy trend of the Chinese construction industry, which is characterized by trade liberalization, the underlying principle of the World Trade Organization (WTO). Compared to the construction industries in the United States, Japan, and the U.K., the construction industry in China is less developed in its legal framework, industrial structure, technological level, and international market share. To develop a competitive construction industry, the Chinese construction industry needs not only to accommodate appropriate international practice, but also to adapt and adopt it according to the market environment in China. A model to enhance the performance of the Chinese construction industry is proposed. The model consists of six modules: defining government's role, opening up the construction market and establishing a competitive mechanism, promoting design institutes' services and empowering professional bodies, encouraging technological innovations, upgrading employees' educational level, and adopting multiprocurement routes. Recognizing China's recent accession to the WTO and the attendant boost to its economy and industry development, the paper gives a timely evaluation of the post-WTO Chinese construction industry and proposes a model for its development. The model may serve the needs of academics, Chinese construction policymakers, construction enterprises, design institutes, and foreign contractors.

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Introduction

Topics related to the Chinese construction industry have gradually received more academic interest in the English-language literature since commencement of the country's economic open door policy in 1980. Mayo and Liu (1995) reported the reform agenda of the Chinese construction industry. Flanagan and Li (1997) introduced the Chinese construction industry and identified some opportunities for foreign contractors working in China. Wang et al. (1998) analyzed the evaluation and competitive tendering of build/operate/transfer (BOT) power plant projects in China. Li et al. (1999) investigated risk management in international construction joint ventures in which a multitude of risks were identified for such ventures in China. Similarly, Shen et al. (2001) also reported risks for construction joint ventures in China. Ye and Tiong (2000) argued for the government support and risk-return trade-off in China's BOT power projects. Wang (2000) illustrated coordination issues between Western consultants and Chinese designers.

Recently Meng (2002) studied the guarantee system for the contractor's performance and the owner's payment in the Chinese construction industry. Xu et al. (2002) analyzed international contractors' practices in China and offered integration approaches for international contractors. All of these researchers have mentioned unique problems facing the Chinese construction industry, albeit to a different degree. While little literature has been found on the impact on the Chinese construction industry of the World Trade Organization (WTO), few studies have been reported on the development of the industry. Vigorous research is thus needed for development of the Chinese construction industry.

This research aims to evaluate the weaknesses of the current Chinese construction industry and develop a model for its enhancement. A study of the Chinese construction industry may not be valid without considering the impact of the World Trade Organization (WTO), and this is addressed in this paper.

World Trade Organization Impact on Chinese Construction Industry

During the Uruguay Round of trade negotiations in 1993, China decided not to open its construction market due to the country's economic condition at that time. Prior to China's entry into the WTO, foreign contractors were only allowed to tender for World Bank, Asian Development Bank, and other multilateral or donor-funded projects. Although regulations that allow foreign contrac-

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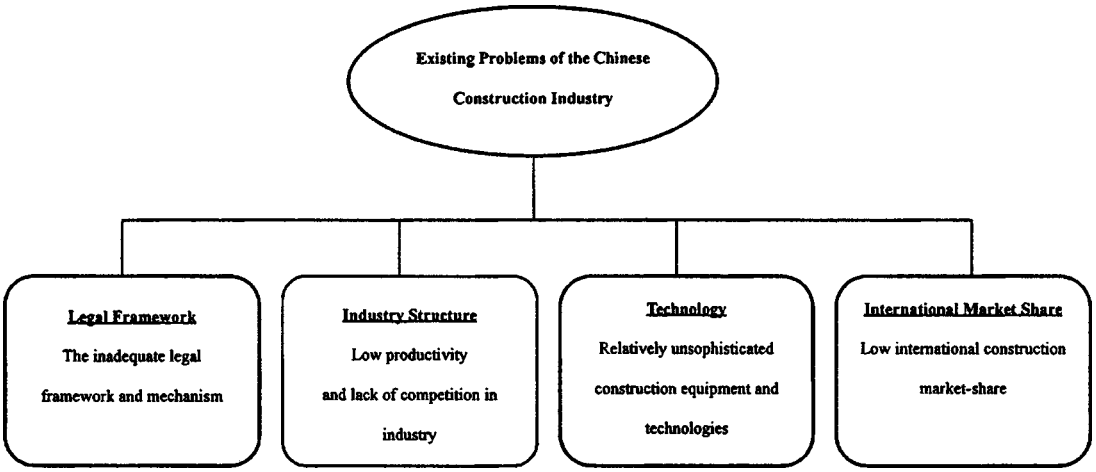

Fig. 1. Status quo of Chinese construction industry

tors and foreign design firms to register as wholly foreign owned "construction enterprises" and "construction engineering design enterprises," respectively, were both effected on December 1, 2002 (MOC 2002a,b), the scope of services is limited in foreign-funded projects and those domestic funded projects that require special technologies. In short, the Chinese construction market and construction enterprises are largely under the protection and control of the government.

However, the underlying principle of the WTO is to encourage global trade liberalization with the core criteria of market access and national treatment. This is in accordance with the relevant clauses of the General Agreement on Trade in Services (GATS), which is the first multilateral, legally binding set of rules related to the international service trade. GATS defined the service trade as consisting of four parts: cross border, consumption abroad, commercial presence in the consuming country, and presence of natural persons. Construction engineering is one of the major international services trade components, and it falls within the category of trade liberalization. During the negotiations between China and other WTO member countries regarding China's entry into the WTO, some of the countries required China to open its construction market to foreign companies, especially those from Japan, the United States, and Europe. After China had been formally admitted to the WTO on December 11, 2001, one of its commitments was to liberalize the construction market.

Status Quo of Chinese Construction Industry

From the 1950s to the 1970s, construction projects were all assigned to design institutes and construction enterprises by relevant authorities in China. Employees' salaries were paid according to their vocational grades, regardless of which design institute or construction enterprise they worked for, and which had nothing to do with the revenues of that company. Tendering practice was nonexistent until the early 1980s (Flanagan and Li 1997; Wang et al. 1998; Shen et al. 2001).

With the rapid development of China's economy since the open door policy at the beginning of the 1980s, the construction industry has grown dramatically in recent years. For example, floor space of building construction completed was 739,249 million m^2 in 1999, 4.3 times that of 1985, or 170,727 million m^2. The Chinese construction industry has contributed significantly to the country's economy. The proportion of the construction industry in the gross domestic product (GDP) was 4.3% in 1980, continuously increasing to 6.6% in 1999 (SSB 2000). However, the construction industry is considered a weak sector of the economy by international standards. This is largely because the Chinese construction industry is lagging that of the developed countries in its legal framework and institutional mechanism, industrial structure, technology, and international market share. The problems are highlighted in Fig. 1 and discussed in the following sections.

Inadequate Legal Framework and Mechanism

The status of the legal framework and mechanism are the key underpinnings of a country's construction industry. To move away from the constraint of the planned economy, the Chinese construction industry has achieved significant improvement through the reform of its industrial structure. However, the Chinese construction legal framework and mechanism are behind those of developed countries, as indicated by the following three aspects:

1. The roles of government, construction enterprises, and design institutes in the construction market are not well defined.
2. The equal opportunity rules have not been fully applied to the construction market, and thus further discipline is needed for the desirable behaviors and relationships among the competing bodies in the construction market.
3. The mechanism and environment for the market-oriented construction enterprises have not yet been established.

A construction industry faces a serious problem when there is no separation between government and construction enterprises and there are too many independent functional units. For big construction enterprises, many representations of the roles and responsibilities of legal persons are often ambiguous, notwithstanding that the project legal person's regime has not been formed. Moreover, the government administrative influence powerfully shapes the enterprises' internal management. The government is not regulating the construction enterprises in a macro way that empowers the construction enterprises, but instead government authorities are directly involved in the construction enterprises' business most of the time. Many administrative prerogatives need to be established, such as setting up a workable legal framework, maintaining the order of the market, supervising the quality and safety assurance systems, and so on. Hence these high-level administrative units are tied up with marketing, operational issues,

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Table 1. Size and Output Comparison of Construction Companies among China, United States, Japan, and U.K. in 2000

Country	Number of construction enterprises	Construction output (millions of US$)	Number of employees (millions)	Average number of employees per enterprise	Average construction output per person (US$)
China	97,263	150,573	27.41	282	5,493
United States	709,590	820,345	6.573	9	124,805
Japan	600,980	653,200	6.53[a]	11	100,030
United Kingdom	163,426	99,537	0.946	6	105,219

Note: Sources are CEIN (2003); U.S Census Bureau (2002); Research (2002a,b); NBS (2002). Currency converters are according to World Bank (2003), excluding Japanese figures.

[a]From Japan Ministry (2003).

setting and interpreting codes and standards, and contract management of the construction enterprises. Besides, they are also involved in examinations and verifications for the qualifications of construction professionals and technicians. As a result, they interfere with the normal functioning of the market and activities of the enterprises, engendering greater complexity and difficulties for the construction enterprises' business.

A majority of construction enterprises face a multitude of problems, such as ineffectiveness, overstaffing, financial mismanagement, and the lack of potential for future development. These problems, which correlate strongly with ownership ambiguities of assets, lending and debt irregularity, local protectionism, and sectoral monopolies, have not been resolved (Zang 2001). Mergers and acquisitions among the construction enterprises are not easy to undertake whenever they are needed because of intervention by local governments, resulting in isolation and a wasteful state of the construction enterprises' asset and organizational capabilities. Consequently, optimal resources allocation could not be achieved through economic leverage via mergers and acquisitions.

Court decisions might not be enforceable as the debtor could be plagued with huge financial problems, even if the court charges have been paid. While this risk is not uncommon among clients, the Chinese construction enterprise, and its subcontractor, some foreign contractors also have encountered similar problems in China.

On the other hand, the government has not given sufficient support to non-state-owned construction enterprises, many of which are private small and medium enterprises (SMEs), in terms of a favorable tax rebate, loan consideration, and cross-border businesses. There are many restrictions on permits for such enterprises, such as obtaining and upgrading licenses, accessing bank loans, and undertaking construction projects, which need to be urgently streamlined through reforming the ownership structure and amending the regulations for the construction industry at large.

The mechanism of the construction industry is defined as the internal relationships among the parties involved, which are formed in their respective economic activities in the entire construction process. The concept of a construction market here can be understood as the sum of all purchasing and selling relationships in the construction process in which the parties involved are the main players in the construction market (i.e., clients, design institutes, construction enterprises, suppliers, etc.). Thus the efficient and effective mechanism model should include the appropriate contracting, partnering, or supervision relationships among the parties, which are formed through the market competition mechanism for the entire construction process, under the governance of construction law.

Table 2. Ratio of Equipment for Chinese Construction Industry

Year	Ratio of technical equipment (yuan/person)	Index of technical equipment	Ratio of power equipment (kilowatts/person)	Index of power equipment
1980	2,333	100	4.0	100
1990	3,277	140	4.9	123
1997	4,729	203	4.1	103

Note: Source: NBS (1998).

Low Productivity of Chinese Construction Industry

Researchers have claimed difficulties in making an absolute comparison between the construction markets of different countries because of political and economic differences (Cox and Townsend 1998; Xiao and Proverbs 2002). However, Cox and Townsend (1998) argue that drawing a few broad comparisons is worthwhile to get an appreciation of the key figures of a number of construction markets. Compared with the developed countries, China has more large-sized construction enterprises in terms of employee numbers. There were 97,263 construction enterprises in China in 2000, with a total of 27.41 million employees or an average of 282 employees in each enterprise. The output per employee is US$ 5,493 (CEIN 2003). Unlike the Chinese construction industry, only 789 construction enterprises have more than 80 employees each in the United Kingdom, which constitutes only 0.48% of the total workforce in the U.K. construction industry. While 5,778 enterprises have 14 to 79 employees each, accounting for 3.54% of the U.K. construction industry, the remaining 95.98%, or 156,859 enterprises, have less than 13 employees each. The output per employee of the U.K. construction industry is US$ 105,219 (DTI 2002). Table 1 compares Chinese construction enterprises with those in the developed countries in 2000. The average number of employees of Chinese construction enterprises was 31 times more than that of the United States in 2000, while the output per person of Chinese construction enterprises was approximately 23 times less than that of their U.S. counterparts that year.

There are many measurements for construction productivity. Arditi and Mochtar (2000) categorized the measurement of productivity into three types: total factor productivity, total productivity, and labor productivity. The fundamental concept of productivity is the ratio of output to input, though many factors affect this ratio, such as labor, machinery, and management. In the Chinese construction industry, output per employee is a measurement of productivity (SSB 2000; CEIN 2003). Table 1 shows that the productivity measured by output per employee in the Chinese construction industry is much lower than that in the U.S., Japanese, and U.K. construction industries.

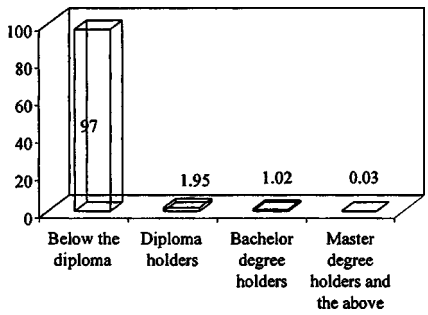

Fig. 2. Distribution of education level of PRC construction employees (He 2000)

Relatively Unsophisticated Construction Equipment and Technologies

For a long time, the Chinese construction industry used purely to emphasize size without ascertaining market condition using investment analysis techniques. Due to the influence of a planned economy, firms invest in projects that are big and new on the surface while the internal rates of return are low or negative if carefully investigated. Often these firms stick to low entrance barrier investments, neglecting the use of advanced technology and new equipment. Inevitably, they are equipped with old machines and outdated technology. Table 2 shows that the growth of the Chinese construction industry's ratio of equipment is very low, to the extent that virtually no improvement occurred between 1980 and 1997 (NBS 1998). Although the total value increased, the construction industry's technology level per person decreased since the number of employees went up dramatically. It is also important to note that the Chinese construction industry is a highly labor-intensive sector.

The weaknesses of the Chinese construction industry with regard to technology can occur for five reasons. First, most construction enterprises have insufficient exposure to and adoption of advanced construction materials and technologies.

Second, as indicated in Table 1, the excessive average number of employees of Chinese construction enterprises is made up mainly of unskilled workers who previously were farmers with no proper training for construction. The technology index is below that of the other sectors in China. Fig. 2 shows the educational level distribution of the Chinese construction human resources. The proportions of holders of a diploma, a first degree, and a master's degree and beyond are too small in the construction industry.

Third, the Chinese construction industry is not active in adopting state-of-the-art technology for marketing and management, such as the use of portable projector and videoconference equipment. The applications of information technology and e-commerce are progressing relatively slowly if at all. These construction enterprises are not competitive internationally against their foreign peers in engineering design, project management, information system, and application of the computer software. Some large Chinese construction enterprises do not even have engineering software for international bidding work, such as ETABS (structural design) and Primavera (project scheduling and control), which are prerequisites set by many overseas clients.

Fourth, too much work done on construction sites is manual instead of machinery based, in which advanced equipment is used only for large or major construction projects. And fifth, some key personnel from clients, design institutes, construction enterprises, and relevant authorities do not have appropriate knowledge of construction laws, codes, standards, and drawings, resulting in many quality and safety problems on-site. Cases such as the collapse of the Hong Qiao (or Rainbow) bridge in Chongquing, Sichuan Province, in January 1999, and the collapse of a building in a commercial district in Dongguan, Guangdong Province, on December 1, 2000, where severe casualties were incurred, have drawn serious attention from the government.

Low International Construction Market Share with Limited Types of Projects

Table 3 compares the international construction market shares of construction enterprises from different countries from 1997 to 1998. It shows that the revenue of Chinese construction enterprises increase from US$ 4.0793 billion in 1997 to US$ 5.0286 billion, at a growth rate of 18.9%, while its market share increased from eighth to sixth position. However, Chinese construction enterprises are still unable to match the performance of their counterparts from developed countries. According to *ENR* (2001),

Table 3. International Construction Market Share during 1997–1998

	1997				1998			
Country	Number of enterprises	Revenue	Market share (%)	Rank	Number of enterprises	Revenue	Market share (%)	Rank
United States	65	24,553.7	22.3	1	64	28,246.2	24.3	1
Japan	19	12,867.3	11.7	3	20	16,444.0	14.1	2
France	10	16,532.5	15.0	2	7	15,396.5	13.2	3
Germany	13	9,431.9	8.6	5	13	13,814.1	11.9	4
Other EU countries	23	9,854.6	8.9		22	10,115.3	8.7	
The rest	28	6,651.4	6.0		31	7,808.0	6.7	
Holland	2	1,481.1	1.3	9	3	5,167.1	4.4	5
China	26	4,079.3	3.7	8	30	5,028.6	4.3	6
Italy	15	6,299.8	5.7	6	13	4,938.0	4.2	7
South Korea	10	4,922.0	4.5	7	11	4,700.1	4.0	8
United Kingdom	7	1,2674.1	11.5	4	5	4,480.2	3.8	9
Canada	7	876.7	0.8	10	6	256.3	0.2	10
Total	225	110,224.4	100.0	—	225	116,394.4	100.0	—

Note: Source; ENR (1998, 1999).

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Table 4. Proportion of China's Top 10 Construction Enterprises' Market Segmentations in 2000

Company	Rank	General building	Manufacturing	Power	Water supply	Sewer waste	Industry/ petrol	Transportation	Hazardous waste	Telecommunications
China State Construction Engineering Corp., Beijing	19	82	1	0	1	1	3	10	0	2
China Harbour Engineering Co. Group, Beijing	42	1	56	0	35	3	0	6	0	0
China Civil Engineering Construction Corp., Beijing	70	53	0	0	0	0	0	46	0	0
China Road and Bridge Corp., Beijing	74	18	0	0	0	11	0	0	71	0
China National Chemical Engineering Corp., Beijing	76	1	3	3	6	1	61	17	0	0
Shanghai Construction General Co., Shanghai	78	100	0	0	0	0	0			0
China National Overseas Engineering Corp.	87	90	0	0	0	0	10	0	0	0
China Railway Engineering Corp., Beijing	88	8	0	0	0	0	0	92	0	0
China Jiangsu Int'l Econ-Tech. Coop. Corp., Nanjing	94	96	0	0	2	0	2	0	0	0
China Int'l Water & Electric Corp. (CWE), Beijing	101	9	0	19	43	5	0	16	0	0

Note. Source: ENR (2001).

the total revenue of China's top 30 international construction enterprises is not even up to that of any one of the world's top three contractors. It is interesting to note that international market shares of Chinese construction enterprises are concentrated in Asia and Africa, whereas there is little presence in the Latin American, U.S., and EU construction markets.

As to market segmentation, China construction enterprises are focused mainly in traditional construction projects such as general and industrial buildings, with fewer in specialist technology areas such as intelligent buildings, underground rapid transit systems, and nuclear power stations. Currently, the majority of them derive their profits from exporting contract labor rather than from technology or management contracting. Table 4 presents an overview of the market segmentation distribution of China's top 10 construction enterprises, which were ranked among the top 225 international construction enterprises in 2000. These construction enterprises are too concentrated in one or two types of engineering projects in the context of business portfolios (Xu and Wang 2001).

Development Model

The international comparisons made in the previous section show that the U.S., Japanese, and U.K. construction industries have performed better than the Chinese construction industry. Porter (1990) concluded that the U.S. construction industry has sustained a strong position in the international construction market despite high factor costs because of a favorable structure for determinants of competitive advantages. These determinants are factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry (Porter 1990).

Haley (1994) identified advantages in the Japanese construction industry model, such as close links between enterprise groups and trading companies, the protected domestic market, and favorable interest rates. Cox and Townsend (1998) mentioned three aspects of the problems in the U.K. construction industry: demand issues, supply issues, and common issues. The problems are low and discontinuous demand, frequent changes in specifications, inappropriate selection criteria, and inappropriate allocation of risk as demand issues; poor quality, inefficient methods of construction, and poor public image as supply issues; and poor management, inadequate investment, adversarial culture, and fragmented industry structure as common issues. Janssen (2000) criticized the concept of a "knock-out" system of competition in the EU member states and proposed a disparity model for the European construction industry. These thoughts could serve as references for the development of the Chinese construction industry.

However, the models of those advanced construction industries are unlikely to be applicable to the Chinese construction industry because of differences in the social political system and culture. China is a socialist country, as enshrined in its *Constitution* (1980). China needs socialist democratic politics with Chinese characteristics and vows not to copy the Western political systems (Jiang Zeming 2002). Although the Chinese construction market is slowly evolving toward an international construction market, the Chinese construction industry is unlikely to be the same as that of the United States or Japan in its industrial mechanism within the next 20 to 30 years.

To improve and sustain its competitiveness, it is important for the Chinese construction industry to study the construction service rules of the WTO and to know its own weaknesses before reforming its industry and integrating with the world market. The writers developed an integrated model that aims to reform the existing construction industry by tackling problems through six modules, as illustrated in Fig. 3. The objective of the model is to provide a framework for the construction industry to cope with the challenges brought about by the country's accession to the WTO, more sophisticated domestic market requirements, and international market requirements, in order for the industry to reinvent itself to become competitive.

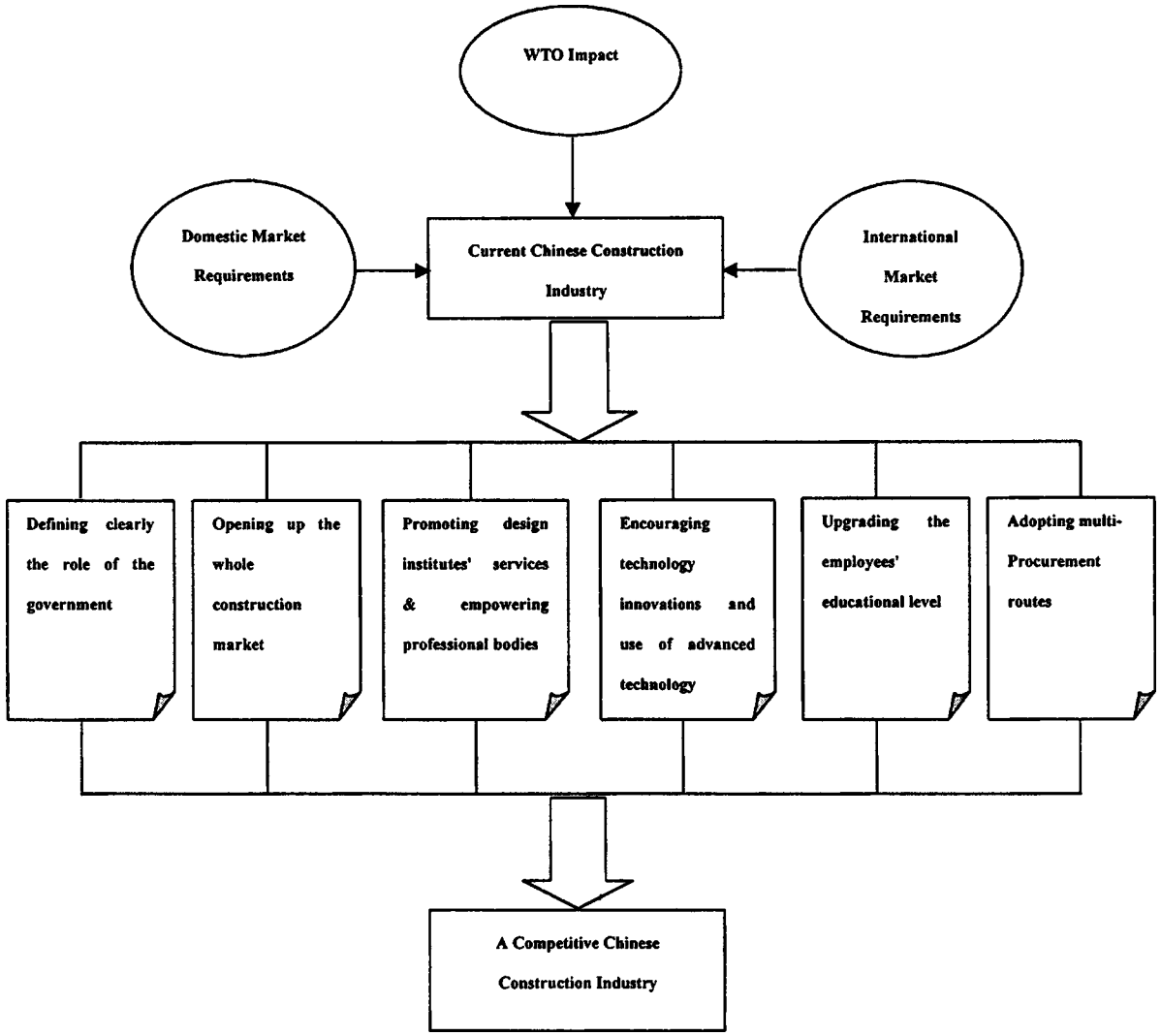

Fig. 3. Development model of Chinese construction industry

Clearly Defining Role of Government

Porter (1990) studied government policies in developing countries for the competitiveness of the industries. He stressed that government's proper role is to encourage or even push firms to raise their aspirations and move to a higher level of competitive prowess, even though this may be an unsettling and even unpleasant process. Therefore construction authorities should not interfere with the construction enterprises' business of marketing, management, and operation. The basis of government control in the construction industry shall be transparent law and regulation instead of "red-stamped files" (official documents with red stamps, issued top down from a higher-level authority, informing of changes of regulation without noticing the industry at large), which are currently prevalent in China.

To streamline government's role, two steps could be taken by the government. First, the government could merge the existing State Environmental Protection Administration, Ministry of Transportation, and Ministry of Construction into one department. Such an action is not only downsizing the government machinery, but also fostering the requirement of management focus. It emphasizes the goal of the construction industry to provide quality of life for the people, where home, transportation, and environment facilities are of equal importance. Second, some work, such as examinations and verifications of the qualifications of construction professionals and technicians previously carried out by the government, should be transferred to professional bodies. In anticipation of greater efficiency and to prepare the Chinese construction industry for full competition in an open market by all WTO members in the future, the Chinese government has to allow a greater role for professional bodies in the market.

Opening the Entire Construction Market and Establishing a Fair and Transparent Market Competition Mechanism

The Japanese construction industry has benefited from its protected domestic market (Haley 1994). Porter (1990) argued that protections given by governments (e.g., subsidies, domestic mergers, supporting high levels of cooperation, providing guaranteed government demand, and artificial devaluation of the currency) will not enable firms to take the steps necessary to create sustainable competitive advantage. The reform agenda of the Chinese construction industry has been discussed by Mayo and Liu (1995). The disadvantages of its protected domestic market make reform of the construction industry difficult and thus delay its intended schedule.

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China's state-owned construction enterprises are large sized, whereas some of their management and technology are inefficient and not at all competitive. Most of them have an equity debt ratio of 75% (He 2000), which is very high for construction enterprises, and some are likely to declare bankruptcy, even if no competition is posed by foreign enterprises. On the other hand, many non-state-owned construction enterprises are in good shape and grew up very fast in recent years. They mushroomed together with the market-oriented economy since the early 1980s, having become flexible and adaptable to the external environment. They should be treated equally with state-owned construction enterprises in terms of accessing bank loans and obtaining licenses.

A basic strategy of any foreign contractors that venture into China is to localize their operations (Xu et al. 2002). To survive in the business, they have to utilize local resources such as labor, materials, and technologies. Through localizing, foreign contractors contribute to the local economy through tax contributions, offering improved employment opportunities, acting as role models/examples to local contractors, and stimulating quality services from the local supply chain (Xu et al. 2002).

In light of the above, restrictions imposed on non-state-owned construction enterprises and foreign construction enterprises will not be helpful to the Chinese construction industry's growth in the long term. An equitable, fair, and transparent construction market environment should be established to facilitate reforming and restructuring the Chinese construction enterprises and design institutes at the current time.

Enhancing Design Institutes' Services and Empowering Professional Bodies

The main parties to the international construction market consist of clients, consultants, contractors, and suppliers. In China, professionals from the design institutes are planning, designing, estimating, managing, and supervising the whole construction process of projects. They have qualifications and know-how about the construction technology, economy, and management, and therefore they serve a significant role in both the effective operation of the market mechanism and the successful completion of construction projects. A number of established international construction engineering consulting firms from developed countries have attained worldwide prominence, but Chinese design institutes have not been well positioned and developed internationally, and few are able to undertake international design and build projects. The China National Chemical Engineering Corp., in Beijing (ranked 40th), is the only one listed in the top 100 construction design firms worldwide in *ENR*'s top 200 international design firms, according to international revenue in 1999 (*ENR* 2000).

The development of design institutes should be supported by the government, which should encourage the existing design institutes, of which a total of 12,572 existed in 1999 (SSB 2000), to extend their service scope, developing the monodesign institutes into multiservice engineering firms offering services from feasibility study, planning and designing, estimating, procurement, and project management to project finance arrangements (Xu et al. 2004).

With economic reform, the continuous expansion of the Chinese private sector is a form of privatization, which generated diversity ownership patterns to the construction industry. Currently the privately owned consulting firms are small sized, although the total output of the whole private sector has surpassed that of the state-owned enterprises since 1989. These privately owned consulting firms often have to maintain administrative links with the state-owned design institutes. To introduce more efficiency to the construction industry, the relevant laws, standards, and regulations should be reviewed and adjusted to allow qualified personnel, such as professional engineers and registered architects, to register their own consulting firms. Restrictions on mergers and acquisitions for such consulting firms should be ruled out.

Construction professional societies and associations are the major assistants of the government in establishing the laws, maintaining the orders, and supervising the market for an equitable, fair, and transparent construction industry. They are indeed indispensable. Professional societies and associations need to be given more authority by the government and should be entrusted with setting and reviewing construction laws, regulations, and details concerning professional practice. In addition, professional societies and associations should establish the quality, environmental standards, and safety management systems that are recognized internationally. The European Community is committed to using standards set by the International Organization for Standardization (ISO), according to Yates and Anoftos (1997), who recommended that the U.S. construction industry increase its awareness level and become more actively involved in the development and implementation of international standards that will impact the international competitiveness of the industry. Similar principles apply to the development of the Chinese construction industry.

Encouraging Technology Innovations and Popularizing Use of Advanced Technology

The construction-related authorities in China should set the strategic plan and policy for technology development. The construction parties should allocate more funds for science and technology innovation and adoption and should pay more attention to research and development (R&D), as well as transferring science and technology achievements into productive applications. Active R&D and applications of new construction methodologies and management skills can speed up the construction modernization process. Information technology (IT) applications in construction should be encouraged in architectural design, construction engineering, and management, and construction enterprises should cooperate more with both domestic and foreign research institutes and universities to enhance their ability to adapt and adopt technological innovations.

Another aspect of IT application, which concerns electronic commerce (e-commerce) for the construction industry, is also recommended. Being one of the traditional industries, the emergence of e-commerce has a great impact on the construction industry, which faces a profound revolution in its existing marketing and management model. For the Chinese construction industry, the influence of e-commerce is an opportunity rather than a threat for speeding up its growth (Xu et al. 2004). A major barrier to entering e-commerce for the construction-related companies is the large amount of expenditures. To mitigate the problem, leading companies in a region could jointly set up an electronic market platform that contains business-to-business and business-to-customer information. Then small and medium-sized companies can participate at certain administrative charges.

In addition, electronic data interchange (EDI), or information exchange (direct communication between computer applications) using the standard electronic format (Kalakota and Whinston 1996), shall be applied to construction enterprises, design institutes, and government agencies. The EDI changes the traditional

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manner of connecting between construction-related companies. For example, just-in-time (JIT) manufacturing and quick response supplying are able to facilitate construction business transactions. However, the benefits of EDI, such as paperless, reduced stock holding, quicker cash flow, and client lock-in, could only materialize when the corresponding parties are using the same technology (Xu and Wang 2001).

Upgrading Employees' Educational Level

Competition among construction enterprises is largely competition to attract more talent. The traditional staff selection and promotion schemes have to be changed to ensure the growth of the enterprises. Personnel problems are often created when promotion is based on Guanxi (relationship with the leader), age, seniority of service, and experience instead of qualifications and actual performance. To change the situation, construction enterprises must apply tougher staffing policies, such as fair and transparent staff selection, serious performance evaluation, and open competition for all available positions. Staff training does reduce the risk of man-made mistakes and is the key to improve productivity. Downsizing is what the government is imposing now as it reforms the state-owned construction enterprises. Such measures will ensure the optimal utilization of resources. As can be inferred from Fig. 1, it is very crucial to recruit more skilled workers and project level managers.

Both state-owned and non-state-owned construction enterprises should not overlook the potential of retaining more overseas-trained graduates for their companies. This is because they not only know international practices but are also familiar with the local working environment. They are the right personnel to serve as the bridge between foreign clients and local construction enterprises and design institutes. Sponsorship and internship schemes for Chinese students overseas should be established by construction enterprises for this purpose. Joint master's degree level courses in construction management between overseas universities and local Chinese universities should be organized to meet this need.

Adopting Multiprocurement Routes

Evolving from the planned economy to a socialist market economy, the majority of the construction projects in China are now procured through the traditional design/bid/build route (Xu et al. 2004). To optimally utilize resources, alternative procurement methods should be adopted such as design/build, build/operate/transfer (BOT), and partnering. Contingent upon a particular procurement method, the standard condition of contracts such as ICE, FIDICS, AIA, or an amended version based on clients' needs and Chinese context, should be applied accordingly.

Design/Build

With one-stop shopping for design and construction under the design/build procurement route, the client is able to benefit from time and cost savings. Compared to the design/bid/build procurement route, the contractor could secure a higher margin through taking more risks in a design/build contract. Recently, it is estimated that up to 25% of all newly awarded construction work is based on the design/build method in the United Kingdom. A significant number of both public and private sector projects are based on design/build, covering areas such as housing, industrial, retail, leisure, health, offices, and utilities (Anumba and Evbuomwan 1997).

In the United States, the design/build procurement route has been increasingly accepted by the public sector since 1992, after several years of implementation in the private sector (ASCE 1992; Denning 1992). One main reason for this increased use of design/build construction practice is the spurt of innovation in the construction process. Innovation in construction provides opportunity for improved value-added solutions to meet the clients' needs (Songer et al. 1994).

As mentioned above, most of the domestic construction projects in China are currently using the design/bid/build procurement method. Although foreign direct investment projects are often procured through the design/build route, the contracts are awarded to foreign contractors and consultants with or without joint ventures with the Chinese partners.

The design/build procurement route is particularly suitable for complex public sector projects where technological expertise is not available or when cost and time considerations are paramount. Often a public sector project is organized and supervised by a temporary unit staffed by government officials. It is not uncommon that the key personnel in this unit may be inexperienced or have no professional qualifications in design and construction. This may result in improper use of taxpayers' money through corruption or unprofessional decisions (Jing 2002). The design/build method compels the contractor to manage design and construction.

There is no universal best procurement method. Every procurement method has its advantages and disadvantages. As the design/build method encompasses the time and cost of the proposed projects, quality problems might surface due to inadequate design and use of low-quality materials. To overcome this problem, an established design/build tendering evaluation system should be set up accordingly, using a multicriteria system to evaluate the contractors's technical and financial proposals. Thus the design/build procurement method can be appropriate for public sector projects in China. Implementing design/build is also an alternative for the Chinese construction industry to link up with international practice.

Build/Operate/Transfer

The first BOT project in China, the Shajiao B Power Plant in Guangdong Province, was successfully transferred to the Chinese side in September 1999. The project, which was started in the beginning of 1989, had generated a total of 46.2 billion kwh electricity by July 1999 (Xu and Chew 2004). Research and detailed analysis of BOT projects in China are increasingly popular in the literature (Zhang et al. 1998; Ye and Tiong 2000). Due to the pent-up demands of infrastructure and the prospective private financing for China's long-term economic development, the BOT procurement route for infrastructure is now more attractive to local governments. Construction enterprises including foreign firms should be more aware of this niche area and should extend their service scope toward project financing and maintenance of infrastructure.

Partnering

Partnering (Conley and Gregory 1999; Lazar 2000) is expected to increase productivity and heighten competition for the fragmented construction industry. Partnering among client, construction enterprise, design institute, and supplier could commence with a single project (project partnering) before extending to a long-term alliance (strategic partnering). The win-win principle is widely accepted in Chinese business practice, but a formal partnering

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agreement should be provided and a standard process needs to be followed to ensure the success of the partnerships (Conley and Gregory 1999).

In summary, diversified procurement routes offer more possibilities for construction parties to mitigate the risks and therefore maximize their profits. In light of the different procurement routes, innovation of procurement methods is advocated and the Chinese construction industry should facilitate adoption of appropriate routes for greater benefits for all.

Conclusion

China is now a WTO member country. Through the process of accommodating and adapting to international best practice, the Chinese construction industry has the opportunity to consolidate its domestic market and venture into new markets overseas. The Chinese construction industry is able to establish its own market competition mechanism and streamline the industrial structure, thereby contributing more to the country's economy. The development model proposed in this paper has considered the various factors affecting the Chinese construction industry, such as reforming the Chinese political system, culture, WTO impact, and domestic and international market requirements.

In conclusion, first a framework incorporating WTO requirements must be established for development of the Chinese construction industry. Second, the government's role should be clearly defined and reinforced to facilitate construction activities. Third, an equitable, fair, and transparent market mechanism should be established to promote healthy industry competition. Fourth, competitiveness of the industry could be strengthened by improving the technology level and encouraging R&D. Fifth, human resources are an asset of the construction enterprises and design institutes that can be enhanced through education and training. Sixth, design institutes have the potential to lead construction services while professional bodies should be given more authority. Finally, adopting multiprocurement routes and promoting innovative procurement methods is a strategy to achieve optimal resource utilization by the construction industry.

The paper marks a milestone in research on the modern Chinese construction industry. Research focusing on existing problems of the Chinese construction industry and its evolution can be the concern of professionals and industrialists involved in construction engineering and management, besides the academics. The model developed in this paper offers a new perspective on how a developing country's construction industry can reinvent itself to become internationally competitive.

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