An Empirical Investigation of China's Construction Industry Development: Shifts in Factors of Production Usage from 1990 to 2014

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Abstract

This paper analyzes the progressive evolution of the China's construction industry over the past three decades through Cobbs-Douglas production function. Three distinct stages are identified: 'incubation period' from 1990 to 1997, 'growth period' from 1997 to 2008, 'maturity period' from 2008 to 2014. The relationship between construction output and its production input factors of labor, capital and technology, are explored and compared across the three different stages. In the earliest stage, construction depended heavily on a bountiful supply of cheap labor. As growth rates increased and prosperity improved, the industry began to attract private investment, further expanding the industry. However, with shrinking returns on construction projects now falling the industry is looking to technological solutions to boost construction value added. This study supports the view that the pursuit of greater efficiencies, at both firm and industry level, will be best served by investing in further technological advancement.

Keywords: China, construction industry, C-D production function, production factors.

1. Introduction

In the past three decades, since the reform and 'opening up', construction sector, as a pillar industry of the national economy, has made significant contributions to economic growth and social development of China. The evolution of the industry itself has played a critical role in transforming China from a planned economy to a market economy, also shaping significantly China's industrialization and urbanization process. Nevertheless, the sustained growth of the construction industry over such a lengthy period has also fermented vast internal challenges requiring changes in the industry itself. Specifically, the industrial rapid growth rate, in order to be sustained over time, has forced the industry to adjust its reliance, on the three major factors of production on which it depends: labor, capital and technology. These three production factors represent major elements of input-output analysis that define the characteristics of construction industry. Indeed, the developmental trends of China's construction industry can be characterized by the varying degrees to which these input factor combinations occur at various historic stages in the evolution of the construction industry, while an understanding of specific combination of factors under which construction industry is operating at any particular time provides valuable information to the government in the formulation of policy, legislation and regulations.

China’s construction industry has been influenced by the central government planning of the economy, as expressed in the 'Five Year Plans', which have been delivered over the last thirty years. 'Five Year Plans' had a particularly strong influence on China's industry development during the economic recovery after the Cultural Revolution. The impetus to modernize brought on substantial construction works around the country, supported by a vast amount of state investment. The effort elevated the prominence of the construction industry, as it became to be regarded as an engine of economic growth, and as it absorbed the abundance of labor resource throughout the country, providing sufficient jobs and employment security. Over time, the construction industry began to absorb a vast amount of investment which further bolstered the output. Thus, even when the first financial crisis broke in 1997, dampening the economy, the response from government was to grandly attempt to buoy economic growth by providing massive additional investment in construction industry. This too was the government response in the second economic crisis of 2008. Such direct interventions, while arguably effective in the short term, may have however interfered with the natural course of development the industry may have followed, had the industry been allowed to adjust itself independently by free market mechanisms. Therefore, a scientific evaluation of the industry trends and identification of the industry evolution over time may prove to be a useful tool by which to better understand the limits and needs of industry, thereby offer government a sounder basis for policy formulation.

Over the years, numerous scholars and practitioners have provided an evaluation of the development of the construction industry, across different stages. Turin observed a remarkable difference in the proportion of GDP contributed by construction industry between developing countries and developed countries, with 3%-5% and 5%-8%, respectively (Turin, 1973). This finding was endorsed by Edmonds, who asserted that the prerequisite for continuous economic growth was that the construction industry contributes a minimum 5% to GDP (Edmonds, 1979). Also, the causal relationship between construction activities and economic development has been investigated in various countries, revealing that the construction industry is responsible for a significant interaction with the rest of economy through multiplier effects that have strong backward and forward linkages (Lopes et al., 2011).

Bon postulated that construction activity follows an inverted U-shape relationship examining the changing role of the construction sector at various stages of economic development, in terms of construction share and total construction volume. This finding stands in contrast with the S-shaped pattern of construction development proposed by Turin (Bon, 1992). The samples selected by Turin are mostly from less developed countries and newly industrialized countries, while ignoring the characteristics of advanced industrial countries. Moreover, relevant detailed studies between the sub-sectors of construction industry and the aggregate economy confirm their causal links over the time and across different periods (Chiang et al., 2015). However, significant imbalances in construction development at regional level may contradict those findings which suggest that construction sector serves as a main engine of economic growth. Despite these efforts to describe the construction industry, remaining lingering uncertainties make the case that a new approach is needed; one that offers a broader, holistic view.

Cobb-Douglas production function is a widely-applied econometric methodology employed to measure the production process of industry development. It examines the contributions of labor, material and technology to the final output (Cobb and Douglas, 1928). The theory of the Cobb-Douglas (C-D) production function is established on the assumption that each factor in the production process has a positive but decreasing marginal product, which exactly follows the pattern of industry development within the national economy. The selection of time periods over industry development process is critical, determining the outcome among different phases. Since the role of construction industry tends to be influenced by a combination of related factors, a scientific phase division aimed at describing its development process, provides a useful means of understanding past and present scenarios within the construction industry. Considering the impacts of economic crises occurred in 1997 and 2008, associated with a series of responding policies and measures launched by the government, the study period is divided into three stages and defined as incubation period from 1990 to 1997, growth period from 1997 to 2008, and maturity period from 2008 to 2014, in terms of growth rate of construction industry over time. The aim of this study is to discover and analyze the historic trends of the China's construction industry, evaluate the development of construction industry from 1990 to 2014. The Cobb-Douglas production function analysis is then introduced using the three key production factors of labor, capital and technology, to examine the dynamic relationship across the various stages of construction development. Empirical results provide insights into major drivers and patterns of construction development. Corresponding measures are proposed to assist policy makers formulate effective strategies from an informed evaluation and assessment for existing issues.

2. Research Methodology

2.1 Cobb-Douglas Production Function

The Cobb-Douglas production function has been widely adopted to investigate the relationship between the input and output of an aggregate economy. A production function denotes what outputs can be obtained from various combinations of factor inputs. The inputs refer to the production factors of labor, capital and technology, on the assumption of elasticity coefficients, for determining the contribution rate to industry output. This is based on a number of methods, such as the growth rate equation, labor and capital productivity calculations, and Solow growth model, among others (Douglas, 1976). Compared to other research methods, the Cobb-Douglas production function provides a more accurate approach for defining the elasticity coefficients of each essential element, including labor and capital resources. Without these coefficients in place, flawed results will be generated, and these will have a direct impact on the calculations of the contribution rate, including OLS in the following steps. Moreover, data selection of the input and output within the industrial system of the Cobb-Douglas production function also remains quite significant determining final results. Thus, each production element, including labor, capital and technology, should be taken into careful consideration. The common form of the Cobb-Douglas production function is displayed with the definition of three production factors including L, K, Q (labor, capital and technology), two coefficients α (L), β (K), representing the elasticity of output due to labor and capital, and Y for industry output. The function is shown as Equation 1.

$$\mathrm{Y} = \mathrm{Q}L^{\alpha}K^{\beta} \quad (1)$$

This original production function is normally, however, transformed using natural logarithms in order to examine the relationship between the input and output indicators after passing a series of F&T significance tests. Corresponding coefficients are generated through regression analysis for further calculations. The natural logarithm transformation is shown as Equation 2.

$$\mathrm{LnY} = \mathrm{LnQ} + \alpha\mathrm{LnL} + \beta\mathrm{LnK} \quad (2)$$

2.2 Data Sources & Collection

According to the classical theory of economic growth, labor is the most flexible factor of production within industrial development system. In the initial stage, construction industry tends to absorb large amounts of labor force from rural areas, and in so doing, develops rapidly, but with low labor productivity. During this growth period, the employment provided also contributes to steady industrial development. However, there inevitably comes a time when the stock of cheap labor is fully absorbed, and labor begins to become in short supply. At this stage labor itself, specifically the lack of labor, creates a barrier to further economic growth. This barrier thus signals that the time has arrived for industry transformation and upgrade. In this context, the element of labor is the major, indispensable factor, with close association to the final output. Three representative indicators of labor have been widely applied; these being number of employed persons, total hours worked, and total labor remuneration. Of these, the number of employed persons in the construction industry provides the most convenient measure; it is straightforward, reliable, and relatively easy to tabulate, while data on hours worked is less reliable, and remuneration difficult to compare over time, space and skill levels.

Similarly, capital is the second key factor of production. It is a proxy for raw building materials, construction equipment, and other inputs, bought on the market, that go into construction projects. The nature of the inputs available, and their usage, both shapes and transforms construction industry, while generating affiliated upstream supply industries that manufacture inputs, while also stimulating downstream client industries that utilize and benefit from the capital assets that construction industry provides, such as commercial properties and factories. Thus, the utilization of capital in the construction industry can further stimulate economic growth by both supporting suppliers, while generating demand from users. Moreover, in times of economic downturn, injections of capital into the construction industry has been attempted by government as a means of reinvigorating the economy. Arguably, however, the contribution of capital to economic growth by this means may result in marginal revenue generation, leading only to a short-term solution. Combinations of fixed assets owned, together with the net value of machinery and equipment, or liquid assets held, can be used as proxies to depict the status of capital input. Nevertheless, the direct linkage between liquid assets held and industry growth is disputed. Thus, the net value of machinery and equipment, including other long-term fixed assets owned, are selected to represent the total capital input. These nominal values are then converted into an adjusted value that corrects for inflation, by a fixed asset investment deflator, to provide a final value able to be compared across time.

While production and labor tend to be external factors, technology has been described as an internal factor, though associated with labor and capital when the technology is reproduced. Technology plays an important role in combining with labor, capital, and in balancing these production factors within the industrial system, in order to maximize returns. Sometimes inputs of labor and capital, alone, may not be adequate to realize a sufficient return on investment. Typically, this may be due to problems such as low labor productivity, ineffective equipment, inefficient production processes, or poor management, etc. In such events, technological advances may offer complementary solutions which improve construction outcomes by other means. Indeed, increasing the degree by which technological applications augments labor and capital has emerged as an overriding driving force in the search for continuous economic growth. Hence, the key to maximize industry returns is to search for the optimal combination of appropriate production factors. Getting the balance between the inputs of labor, capital and technology will achieve the optimum production output. The contribution of the technology production factor to total output value can be calculated deductively by first calculating the total added value of construction output, and then deducting the contributions from labor and capital. The value added of the construction industry is a comprehensive index, being a direct and realistic reflection of industry output. Again, it should be processed with a gross domestic product deflator to convert the nominal value into a final value able to be compared across time.

3. Empirical Results

3.1 Cobb-Douglas Production Function Analysis

The empirical results of the Cobb-Douglas production function, along with various parameters, are displayed in Table 1. The outcome of whole time period from 1990 to 2014 reveals that the contribution rate of labor, capital and technology was 85.7%, 5.07%, and 9.20%, respectively. Clearly, the overwhelming main driver of construction development over the past 25 years is shown to be a ready supply of cheap labor. In stark contrast, the contribution of capital and technology to China’s construction development turns out to be dramatically less than that of labor. The corresponding intermediate parameters over the period of 1990 to 2014, gained from calculations of the elasticity coefficients, α and β, also indicate that the construction industry tended to be labor-intensive. Nevertheless, these figures are an average over 25 years, and can only provide a summative picture of the industry over the quarter century. A more informative profiling of the industry development can be obtained by considering three intermediate stages, as previously defined. The average variations of main parameters within three ranges were verified to be valid for further investigation.

Table 1 - Empirical results of the Cobb-Douglas production function

Stage Division	1990-2014	1990-1997	1997-2008	2008-2014	Average
ΔY/Y	1205.89%	122.62%	192.59%	100.48%	138.57%
ΔC/C	722.42%	125.59%	144.09%	49.35%	106.35%
ΔCE/CE	58.79%	-1.31%	19.87%	34.23%	17.60%
ΔL/L	390.81%	107.93%	57.74%	49.64%	71.77%
ΔLE/LE	166.07%	7.07%	85.48%	33.98%	42.18%
β	0.0620	-0.2056	0.2248	1.0883	0.3692
α	1.4845	1.1480	1.6195	0.5830	1.1168
α+β	1.5465	0.9424	1.8443	1.6713	1.4860
Technical Contribution	9.20%	16.44%	14.64%	5.82%	12.30%
Capital Contribution	5.07%	-20.92%	18.53%	61.22%	19.61%
Labor Contribution	85.73%	104.48%	66.83%	32.96%	68.09%

Note: Y (Output), C (Capital), L (Labor), CE(Capital Efficiency), LE(Labor Efficiency)

Prior to the outbreak of Asian Financial Crisis, the major driver of industry development was abundant labor, with little capital or technological support. But in the following decade, capital input became increasingly important, with rises in improvement of technological applications as well. Interestingly, the dominant role of labor contribution began to weaken in the period of economic downturn. In response to the Global Financial Crisis, a vast amount of state sourced investment was allocated to revitalize the economy, through investment in substantial projects for construction industry. The development of construction industry became heavily reliant on extra demand created by government funds. Market forces calling for industry transformation and upgrade were thus largely delayed due to the government intervention. In fact, the injection of funds was so great as to reverse the industry's efforts at the technological advancement, while the artificial oversupply of construction works generated a major labor shortage.

The sum of elasticity coefficients, α and β, illustrate that the scales of economies initially decreased progressively due to less capital support in the first stage, but then developed rapidly, adjusting to comparable combinations of production factors, with the growth rate of economic scale higher than that of the total average level. Although the subsequent six years witnessed continuous growth, the marginal benefit might not be so desirable, compared with average level, with the vast amount of investment experienced over that period not immediately transformed into the actual output. Again, this may interfere with the natural evolutionary development of construction market, leading to irregular fluctuations of related indicators. Therefore, the lag effects of capital transformation should be consdiered in examining the exact annual conditions for the reliability and credibility.

3.2 ALMON Parameter Estimation

The Almon method is introduced to weaken the direct loss of useful information, 'K' means depreciated value, and cannot be immediately transformed into GDP, thereby considering the impact of lag effects within certain time, as shown in Equation 3 (Almon, 1965). According to the form of Cobb-Douglas production function, all the parameters corresponding to the annual value were input into the function for ordinary least square (OLS) the regression analysis. The elasticity coefficients, α, β and Q, could be acquired by passing the F and T significance tests. Otherwise, elasticity coefficients might be adjusted on the assumption of certain values until meeting related requirements. However, as the subjective value of elasticity coefficients, α and β, could directly determine the contribution of each production element, thereby the definition process of α and β turned out to be rather critical. Although average outcome could be deduced from several combinations of elasticity coefficients, construction development is ever changing and cannot be easily explained by fixed coefficients over various periods. Hence, the conception of lag effects of production factors was then proposed to optimize the original model to gain better performance.

$$\mathrm{LnY} = \mathrm{LnQ} + \alpha\mathrm{LnL} + \beta(LnK_1 + LnK_2 + LnK_3 + \cdots + LnK_n) \quad (3)$$

Due to the characteristics of capital transformation and technical support, lag effects should be introduced for these two production factors. Additionally, since the result for technology was indirectly obtained by calculations for labor and capital, based on the Solow residual approach (Solow, 1956), the lag effects should also be considered. Thus, the improved equation was established on the assumption that capital investment can be evenly transformed into final output in the subsequent lag periods. Once those parameters were input, the appropriate lag for capital was determined to be 4 years, with a significance level of 10%, and 5 years, with a significance level of 5%. The five-year lag period was thereby selected. The original research input data were extended to 1984, then inflation adjusted to 1990 price figures. The contribution rate of each production element to the construction output can be calculated by their growth rates, along with the elasticity coefficients over the time span from 1990 to 2014. This relationship is shown in Equation 4.

$$G_Q = G_Y - \alpha G_L - \beta\left(G_{K_n} + G_{K_{n-1}} + G_{K_{n-2}} + G_{K_{n-3}} + G_{K_{n-4}} + G_{K_{n-5}}\right) \quad (4)$$

The elasticity coefficients were subjected to the significance tests, and a desirable fit was obtained where the lag effects of α and β equaled 1.382414 and 0.04536, respectively. The elasticity coefficients indicated that the scale of economy increased gradually over the last three decades, and that in so doing, depended overwhelmingly on the labor input, confirming again the labor-intensive construction development in China. The annual contribution of labor, capital and technology to construction output can be derived by calculating the corresponding annual growth rates, as presented in Figure 1.

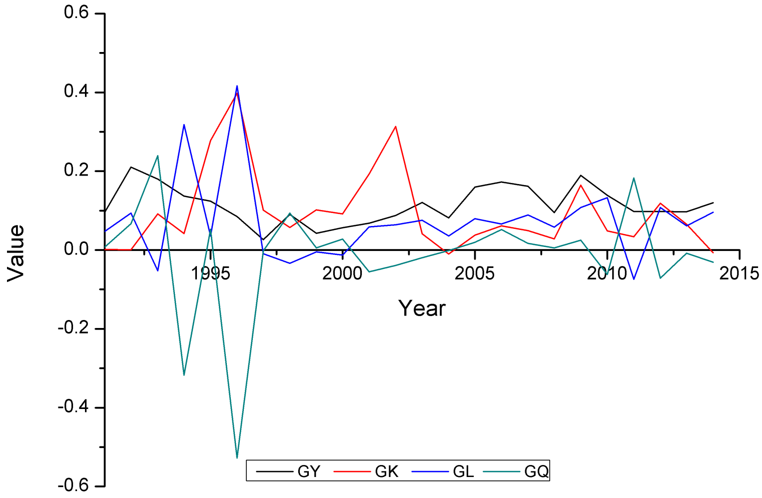

Figure 1 - Growth rate of input and output factors in China's Construction Industry

Note: GY (Growth Rate of Output), GK (Growth Rate of Capital), GL (Growth Rate of Labor), GQ (Growth Rate of Technique)

The contribution rate of labor, capital and technology, exhibit different trends across the three stages of China's construction development in Figure 2. From 1991 to 1997, capital and labor input are the major motivators stimulating growth of construction output; though 1994 and 1996 do stand out as abnormal values. The contribution of technology seems to increase in the initial stage, but remains unstable as it was heavily affected by external factors in the following years. However, the dominant role of capital motivation begins to weaken with the rising labor participation in next decade. The capital contribution to construction output decreases dramatically from 52.51% to 4.87%, whereas labor contribution remains steady, and close to the average of 70%, briefly attaining a peak of 84.17% in 2008. Abundant labor input hinders the wider application of advanced technology in the industry. However, in subsequent stage, the situation changes as construction development returns to rely more on capital investment. At this time, labor is not as freely available, and this explains the shift to capital. Nevertheless, without a shift to technology, and with the ensuing economic situation in which investment returns to construction begins to falter, capital contribution stalls at less than 15%, while labor continues to hover near 80%. To the detriment of the construction industry, technology remains the least important contributor, at below 10%.

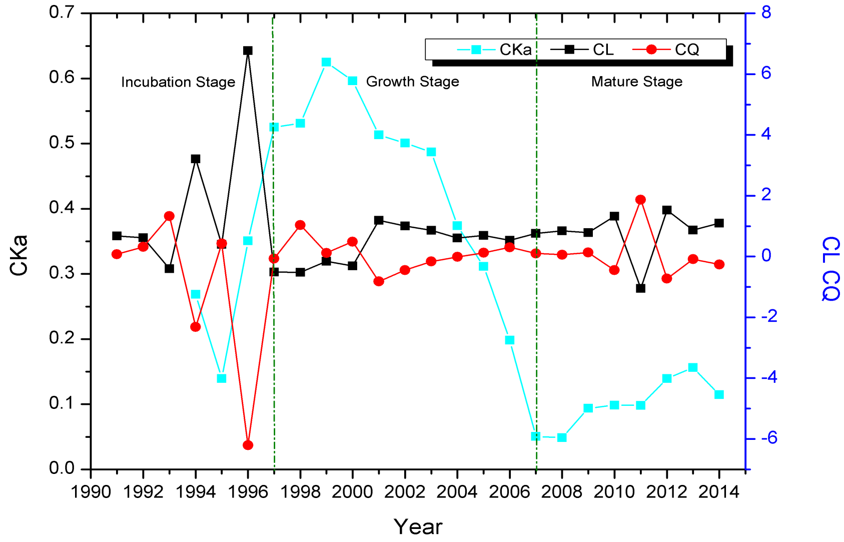

Figure 2 - Contribution rate of Labor, Capital and Technology to construction output (lag)

Note: CKa (Accumulative Contribution Rate of Capital), CL (Contribution Rate of Labor), CQ (Contribution Rate of Technique)

4. Discussion

4.1 Incubation Period - 1990 to 1997

The 'Incubation Period' encompasses the years from China's opening up to the onset of the Asian Financial Crisis in 1997. During the incubation period, China's economy was still run under a communist command system, in which both input and output factors were determined by government planning and scheduling of production quotas. Similarly, construction projects were assigned to and carried out by state-owned construction enterprises, where allocations of projects, as well as material and equipment needed to carry out works, were also allocated by government (Chen, 1998). Under these conditions, though capital input was nominally listed as one of the 'four pillars of industries' in communist rhetoric, construction development was almost wholly reliant on labor, which was cheap and abundantly available in rural areas from where it could easily be tapped (Han and Ofori, 2001). Nevertheless, as it became evident that construction activities stimulated the economy more broadly, government began to encourage the use of public funds in construction projects.

However, Chinese construction market, along with construction enterprises, remained under control and protection of government. Given the communist systems decoupling of construction activity from return on investment, this left few incentives for construction industry to improve overall productivity or enhance comprehensive competitiveness. Even the few private firms that emerged as players in construction field looked for low entrance barriers and emphasized cheap labor over other factors. Indeed, where rates of return were calculated, advanced technologies and new equipment represented costs far in excess of the labor on hand (Chen, 1998). The industry with low rates of return, moreover, made it imprudent to consider longer term investment in such factors in the hopes of moving cost curves downward, long term. Low labor costs, combined with limited financial accountability for performance and steep industry protections by government, thwarted incentives and dampened efforts by construction firms to establish a sustainable competitive advantage.

4.2 Growth Period - 1997 to 2008

The 'Growth Period' covers the years between the two financial crises: The Asian crisis of 1997, and the Global crisis of 2008. The outbreak of Asian Financial Crisis in 1997 came at a time when China was engaging economically with the world, and consequently brought with its unprecedented economic pressure. Although the lag effects of previous capital investment played a major part in maintaining growth over the first several years of the period, the development of construction industry was heavily and negatively affected by socioeconomic situation across both horizontal and vertical linkages. The effect was so dramatic that the 'iron rice bowl' doctrine was threatened, with many employees of state-owned enterprises being laid off from what were previously considered 'jobs for life'.

In response to such macro-liquidity downturns, Chinese government had historically responded with its own austerity measures, tightening controls on the state investments. However, many provincial governments adopted a Keynesian stimulus approach and attempted to sustain local economy by releasing a number of construction projects, hoping that by increasing construction activity the depressing effects of the crisis may be well offset; increasing employment, personal income, and consequently demand for goods and services throughout the economy. However, the stimulus efforts were flawed. While the construction industry may have been an effective motor of economic growth over a short period, the projects undertaken were improperly timed and poorly selected, and ultimately unable to contribute flow on effects (Han and Ofori, 2001). In fact, by squandering further financial and material resources the Chinese economy shrunk even further than it otherwise would have; an experience visited previously on Singapore and Taiwan in the recessions of 1980s and 1990s, respectively (Ofori, 1988; Ofori, 2007).

This recession hastened China’s effort to transform from a planned economy to a market economy, with a consequent shift in economic emphasis from equity to efficiency. Again, the construction industry gained impetus from a new surge of activities under a revitalized government policy to stimulate domestic demand offsetting the impact of the Asian Financial Crisis. The central government prioritized infrastructure development, while also encouraging residential construction development. The breadth of activities, it was hoped, would stimulate the construction industry, yet also stabilize the construction market, since the volume of construction works would effectively accommodate all players while dampening the intense competitive pressure that foster the reform. The aim was to stimulate downstream economic growth, with the ultimate goal of sustaining employment levels country wide.

In 2003, SARS virus epidemic swept across the country, and direct investment in construction activities decreased. In any case, capacity was in excess and the market needed time to absorb what had already been built. But while projects completed prior to the outbreak managed to stimulate the economy through the crisis, overall, by the tail end of the crisis the construction industry was experiencing greater declines than elsewhere in the economy, and suffered them for longer periods (Abdullah et al., 2004). Meanwhile, the enormous demand created by a vast amount of real estate investment generated by the process of urbanization in China, had left the construction industry dependent on an ever-present supply of low-cost labor force. This dependency led to a shunning of technical innovation, and thus even though China was producing massive capital stock in housing and infrastructure, the industry competitiveness was failing to develop, while productivity remained low, and costs relatively high (Ofori, 1994b).

Certain small-and-medium sized enterprises attempted to compete directly with state-owned construction firms, but again, without the ability to find an effective cost reduction strategy, were unable to secure any enduring or unsustainable competitive edge. Government did not help, and as both regulator and frequently as client, called the shots and maintained the status quo for low innovation. Growth through quantity rather than the improvement of quality was sought as the mechanism of lifting China out of economic depression. The main engine of industry growth gradually shifted back from capital intensity to labor intensity. The role of construction industry in contributing to the economy and GDP thus began to plateau (Ofori, 2007). The resistance to technical innovation persisted to 2007, where a second, greater, economic crisis heralded a new stage in the China's construction industry.

4.3 Maturity Period - 2008 to 2014

The 'Maturity Period' includes those years from the global financial crisis of 2008, to the present. The crisis of 2008 imposed a significant stalling influence on China's economic growth (Abdullah et al., 2004). Declines in construction industry triggered a ripple effect throughout the economy. To mitigate this effect, a second government stimulus package as a national strategic plan was then introduced, encompassing construction projects along with strong capital support for subsequent Five-Year-Plan. Traditionally, Chinese construction enterprises were mainly focused on low technology endeavors, such as residential and industrial buildings, with little capacity or interest in technology fields. However, some larger firms began showing some interests in pursuing areas of technology (Jaafar et al., 2007) as a pathway to improve labor productivity and firm performance (Manley and McFallan, 2006; Goodrum and Haas, 2004), and efforts to up-skill employees gained some traction (Nikas et al., 2007). Meanwhile, the uncertain economic outlook hit the developers' confidence in the property market, and investment in the residential housing market shifted to infrastructure construction at the crossroads. At this time, construction firms also began exporting construction services to overseas markets, while government aimed at attracting more participation from the private sector; both ploys hoping to sustain economic growth and socio-economic stability (Wibowo, 2009). Domestically, the delivery of infrastructure projects created significant employment opportunities, which generated further investments in other sectors of the economy through multiplier effects (Dlamini, 2012). The national stimulus package of 4 trillion RMB created a huge demand for infrastructure, covering the construction of buildings, railways, highways, and airports.

Nevertheless, chronic low productivity continued to put a drag on the economic recovery, as transforming solutions were sought that would not significantly disrupt the industry nor its ability to function as an engine of growth (Wang et al., 2015). A turning point came around 2011, when it became apparent that the construction industry was finding it difficult to attract workers with low wages it was offering, and on which it depended to compete. Large numbers of migrant workers were now able to be selective as to where they might work, given the huge number of construction projects underway. Moreover, they were becoming more concerned about conditions, and found manual labor unattractive, whilst the socio-economic conditions on offer in other emerging sectors were improving. In short, work choices and opportunities were getting better across the board. In fact, tertiary educational opportunities were also increasing, leading to difficulties replacing older workers with local youths. Certainly, it was true that increasing wages could attract replacement workers, particularly in rural areas where economic downturn was the hardest felt, but on the other hand, a newly recruited construction worker needs, on average, about six months to become semi-skilled, and three years to be fully skilled. It was this calculation that accelerated interest amongst construction managers to explore the introduction and application of new technologies (Abdul-Aziz, 2001).

While the rebound in the Chinese economy during the post-period of global financial crisis, has been attributed to the ability of government to sustain frenetic activity in the construction sector, and the buoyancy of the sector explained by low labor wage, it is also true that the construction development witnessed a significant and ground-breaking transition. The tight construction labor market, combined with a massive shortage in building materials, saw construction costs escalated by more than 30%. However, there is evidence that these cost pressures, rather than create a motivation to innovate or improve technologies that may reduce costs, have rather resulted in cost reductions though poorer construction, compromised safety standards, and lowering of quality performance (Chiang et al., 2001). Consider Japan's response, in contrast. In reaction to strong cost-cutting pressures in its own experience of economic crises, Japan strived to innovate ways in reducing dependence on labor, focused on developing long-term market share through a heavy commitment to research and development. Japan has by this means achieved world-class benchmarks in efficiency, and this has no doubt contributed to the success of the Japanese construction industry globally (Raftery et al., 1998).

5. Conclusion

This study surveys and describes trends in the contribution of the three factors of labor, capital and technology, over the years from 1990 to 2014, in the China’s construction industry. The developmental process of the China’s construction industry was then divided into three stages, based on historic trends. Three periods were accordingly identified: 'incubation period' (1990-1997), 'growth period' (1997-2008), and 'maturity period' (2008-2014). Three main production factors of labor, capital and technology, were incorporated in order to analyze the overall trends of China’s construction development. This was carried out using the Cobb-Douglas production function. Moreover, the optimized parameters of labor, capital and technology within the different stages were also estimated by considering the lag effects, based on the Almon method, for further comparisons.

The scale of economy within the construction industry appears to be lower in the incubation stage, but becomes much higher over the growth stage to the maturity stage. The development of construction industry begins with an abundant labor force and certain capital support, while technical advances are scarce. With gradual significant contributions to the national economy over time, the construction industry was listed as one of four pillar industries in China. This announcement aroused extensive interest and attracted huge amounts of fixed capital formation. After the outbreak of Asian Financial Crisis, this capital investment, taking into consideration lag effects, played the dominant role in promoting consistent growth within the construction industry. Meanwhile, China's construction industry seized on the opportunity created by the property market boom, starting from the early twentieth century, to achieve extensive growth. A sufficient labor supply combined with low labor cost facilitated the rapid development of the construction industry. This dependency on cheap labor, however, led to a neglect to secure a technologically based competitive edge. Thus, in the subsequent decade, most construction firms were left to focus on increasing 'quantity' rather than on improving 'quality'. This short-term solution again failed to arouse concern about reforming the construction industry until a second and greater economic crisis fell on China in 2008. This time, in response to the 'Global Financial Storm', a significant national strategic plan was released to revive the economy. However, the huge demand for construction projects created by a vast amount of the investment stimulus that was flushed into the market by the government, quite distracted the industry from meaningful reform as firms preoccupied themselves with capturing the profits available from the plethora of public projects. This only exacerbated the industry longer term problems: excess capacity, homogeneous competition, market polarization, low innovation, high inefficiencies, poor quality, low safety and limited competitive advantages.

If these issues are to be addressed, a long-term vision dedicated to the construction industry is required. Stabilization of the real-estate market is essential, however, attempting to achieve this through short-term government interventions in the market, as has been practiced, is not recommended. Rather, there must be on-going targeted investment in R&D, accompanied by broad applications of new and emerging technologies, such as prefabrication, industrialization, automation, and green energy, etc. The Chinese construction market needs the managed transition into one with a clear structure and a specialized hierarchy. Larger construction firms must be supported to extend their original business scope to achieve lower risks, combined with better rates of return; small-and-medium sized firms need to find activities based on a core competitive competency. The functional complementation between large and small construction firms can be deepened through the development of synergies built on complementary competencies. Ultimately, the evolutionary and transitional process that needs to be found for the China's construction industry must effect a transition from labor-intensive production to one that is technologically based in world class competencies. Failure to do so will expose China to significant economic distress when the next financial crisis comes around, and to limit significantly China's ability to compete as an equal on the world economic stage.

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