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Comparative analysis of regional construction labor cost variations via panel data modeling: the evidence of Mainland China

Ming Luo^{a,*}, Hongqin Fan^a, Guiwen Liu^b

^aDepartment of Building and Real Estate, The Hong Kong Polytechnic University, Hung Hom, Kowloon, 999777, Hong Kong

^bSchool of Construction Management and Real Estate, Chongqing University, No.174 Shazhengjie, Chongqing, 400044, China

Abstract

Labour cost estimation, control, and regulations are of great importance to the final success of construction project, and sustainable development of construction industry. Over the recent years, the affordability and availability of construction workforce, underpinned by rich labour resources across the Mainland China, has gradually become the history and exerted ripple effects on the construction manpower recruitment, cost management, and even industry development. However, little research has been found with focus on labour cost fluctuations at regional level in China. This study attempts to explore the major factors affecting regional construction labour cost variations over the past two decades, from 1995 to 2015. Panel data analysis, and time series econometric modelling, is thereby applied to identify critical determinants of construction labour cost fluctuations across three regions of different levels of economic development, i.e. underdeveloped west region, developing central region, and developed east region, within Mainland China's construction industry. Empirical results indicate that gross domestic product (GDP), unemployment rate, construction labour productivity, construction technical equipment ratio, and construction profit rate are five key factors determining the variations of unit labour cost in Mainland China's construction industry. GDP, construction labour productivity and unemployment rate are three common factors that affect regional construction labour cost; Besides, construction profit rate is found to be another dominant determinant of construction labour cost in west region, while construction technical equipment ratio acts as a significant but negative factor in central and east regions, with incremental effects towards construction unit labour cost from west region to central region, then east region. For the evolving construction market, these principal findings provide valuable insights for construction enterprises to formulate forward-looking market strategies, and for governments to fine tune economic policies.

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Keywords: Construction labor cost; Critical determinant; Mainland China; Panel data analysis; Regional level.

1. Introduction

Labor cost estimation, control, and regulations are of great importance to the final success of construction project, and sustainable development of construction industry. Cheap construction manpower, provided by rich surplus labor force across Mainland China, has been regarded as a major superiority over other competitors in the past domestic market. With the fast-growing labor cost during recent years, prior labor advantage established has been largely diminished and become the history, exerting widespread effects towards construction manpower recruitment, cost management, and even industry development. Understanding potential reasons for labor cost variations in construction market can facilitate the responsive adjustments of market strategies of construction enterprise, and policy makings of related government, particularly during the period of construction boom. Therefore, labor cost variations need to be overall

explored from the industry level, ensuring that construction labor cost can be better interpreted and reasonably tackled from various perspectives in a tight and competitive market. However, construction labor cost performance not only varies with time series but also changes greatly from region to region. The regional divergence can be partly attributed as a combined result of unbalanced distribution of industry demand, and uneven allocation of local resources. According to the market supply and demand, disparities exist within these two sides will probably lead to fluctuating labor cost and vice versa. Such differentials in construction labor market originate from the great variations in regional economic development, market structure, and industry performance. It is never an easy task to capture those complicated variations without a reliable and reasonable modelling and estimating approach.

2. Literature Review

2.1. Labor costs and changing trend-related research

Previous studies concerning labor cost within the construction industry mainly focused on the qualitative analysis to reveal underlying factors for its rapid rising trend over recent years. Wu et al. analyzed the major causes for fast-growing labor costs from the perspective of market supply and demand, and they found that the fundamental driving force comes from the need of economic growth with increasing levels of commodities price and inflation rate^[1]. On the other hand, given that the poor image of construction industry characterized by harsh working conditions and long working hours, people who are willing to enter the industry become less if paid with uncompetitive wage or salaries^[1]. The change of market supply and demand for construction workforce is thereby attributed to the rising labor cost, with additional burdens from raising price level and improving wage safeguard^[2]. With closer linkages between construction industry development and economic performance, prevailing labor supplies hardly have the capabilities to meet soaring construction demands, hence labor shortage and skills crisis become the main barriers impeding the continuous growth of construction development, particularly during the booming periods of large-scale investment. An improved understanding of complex interplay of factors that shape the labor market will facilitate the identification of measures that can be taken to circumvent the negative effects^[3]. The practicable strategies for resolving these problems are identified with assessing their effectiveness via questionnaires, and found that increasing labor wages, importing foreign workers and engaging employers to provide training are proved to deliver quick results^[4], and other essential measures over the medium and long terms^[5]. Confronted with the changing labor market and skills requirements, establishing a robust and reasonable model to estimate the occupational trends of labor supply and demand can facilitate effective construction manpower planning and responsive policy making, which is of immense importance to sustainable development of construction industry^[6].

2.2. Multivariate time-series analysis of microeconomics and labor costs

For the estimation of labor supply and demand within the construction industry, five main classes of models including employer surveys, models of evolutionary comparison, mechanistic models, econometric modeling and cohort models^[7], are assessed by examining their rationale, strengths and constraints, and compared with their reliability, capacity and other aspects, respectively^[8]. A number of quantitative econometric modeling techniques including multiple regression^[9], artificial neural networks (ANN)^[10], vector error correction (VEC)^[11, 12], autoregressive integrated moving average (ARIMA)^[13] and gray model (GM)^[14], have been utilized for simulation and prediction via a set of inter-related factors such as social variables, economic variables, industry variables and etc. Box-Jenkins approach called ARIMA model, is widely acknowledged as a benchmark technique for univariate method due to its structured modelling basis and acceptable forecasting performance^[15]. However, univariate projection is not appropriate for estimating construction labor demand with limited data, similar with that of GM model^[16], the forecasting accuracy will be largely disturbed if merely on the basis of its historic trend, particularly when encountering unforeseen or unexpected perturbation events. Therefore, multivariate time-series analysis such as VEC and multiple regression models perform more suitable and reliable for extensive simulation in the short-and-medium term^[17]. Compared with multiple regression models^[18], VEC modeling can better capture the causal relationship between construction manpower demand and associated factors covering the periods of ups and downs^[12]. In the context of global economic turbulence, dummy variable is thereby introduced to propose a VEC-D modeling for diminishing external impacts towards accurate estimation^[19]. On the other hand, considering the forecasting results, i.e. out-of-sample VEC modeling, are derived mainly depending on the simulation of in-sample fittings and the selection of variables. With this respect, some internal changes might be ignored or underestimated by subjective and patchy

modelling for econometric forecasting, and a number of advanced models are thereby proposed by incorporating both qualitative and quantitative data to better manage and estimate the supply^[20] and demand^[21] of construction workforce, simulate their complex interplay via systematic dynamics (SD) modelling^[22], thus improving the accuracy and consistency of forecasting based on construction projects^[23]. Unfortunately, limited research has been devoted to constructing comprehensive models to capture both horizontal and longitudinal changes of construction labor market.

2.3. Panel data modelling for economic analysis

Panel data is an econometric approach for analyzing dynamic relationship due to its capability of coping with missing data and individual heterogeneity, and can automatically diminish the negative impacts of collinearity within various data sets that time series modeling and other regression techniques have no capabilities to avoid these aspects^[24]. It has been widely applied in econometric analysis at firm^[25], regional^[26], or sectoral^[27] levels within different time periods. Panel data consists of not only time series data but also cross section data, the introduction of cross section data increases the degrees of freedom and the reliability of statistics tests. Considering the sensitivity of time series modelling against external changes, construction sector and study period are thereby divided into several categories or stages^[28], for better exploring causal relationship between construction activities and economic development within sub-study periods via Granger causality tests^[29, 30]. Using the technique of panel data regression develops original error correction model (ECM) into a panel error correction model (P-ECM), which is able to outline the short-run dynamics associated with unexpected shocks of the economy, and account for the regional disparities based on long-run equilibrium function^[31]. Besides, panel data modelling provides the possibility of generating more accurate estimations for regional variations and individual outcomes than time series projections.

Existing construction labour research mainly focuses on investigating the critical issues of labour market, for example, labour recruitment & employment^[32], labour shortage & skills gaps^[33], and labour supply & demand modelling^[17, 34]. However, there have been few empirical studies concerning regional construction labour cost. Limited research has been conducted to explore the relationships between construction labour cost and its explanatory factors among different regions, albeit continuous upward trends of development across Mainland China in the last two decades. Furthermore, the implicit relationships between construction labour cost and its critical determinants might differ by time and region, because of many divergences exist in regions, industry development levels, and labour resources. This paper incorporates these diverse variations in regional construction market to examine construction labour cost across three regions, i.e. west region, central region, and east region, covering 31 provinces and cities in Mainland China, employing an advanced and combined econometric model, namely panel data analysis. The empirical results of this proposed method are compared for detailed discussions to identify regional differences of construction labour cost performance, for further references of construction enterprises and related policy makers.

3. Labor Cost Definition of Construction Industry

Labor cost refers to the total amount of money paid for employees who embark on construction industry during certain accounting period. As a main part of construction cost, labor cost consists of several components, i.e. wages and salaries, payroll taxes, and fringe benefits including paid leave, supplemental pay, insurance, retirement and savings, legally required benefits and so on. According to related on-site surveys, wages and salaries takes up over 80% of total cost of labor, sometimes even more than 90% among the site workers in China's construction industry. With this respect, labor compensation is universally interpreted as the total expenditure for construction worker, nearly equals to labor cost incurred during the construction process. Construction labor wage per hour worked (CLW) serves as a typical proxy for capturing the absolute variations of construction labor cost per unit time. But considering the extensive divergence of regional performance, project types and skill requirements of construction industry, it can hardly provide further detailed information, and diminish external disturbance that might not be conducive for comparative analysis.

Unit labor cost (ULC) is normally viewed as a broad measure of international price competitiveness. It is defined as the average cost of labor per unit of output produced, which can be expressed as the ratio of total labor compensation per hour worked to output per hour worked (labor productivity)^[35]. This indicator is measured in percentage changes and indices^[35]. ULC provides more specific information regarding the overall efficiency of construction labor input and final output per unit time. It can not only effectively capture the dynamic variations of labor cost, but also establish the implicit relationship with labor productivity for further implications. Meanwhile, selecting ULC as target variable

can automatically diminish the external differences caused by different levels of regional development and construction industry performance, facilitating multi-dimensional comparative analysis among different regions.

4. Labor Cost Variations and Driving Factors

With ever-increasing labor cost across China's construction industry over recent years, it has become the main concern of construction industry development, and even drawn widespread public attention. Previous studies have been focused on investigating critical factors affecting labor costs within China's construction industry, especially during the stage of rapid growth, from the perspective of life cycle development. First, gross domestic product (GDP) is a monetary measure of the market value of all final goods and services produced in certain periods of time^[36]. It is commonly used to determine economic performance of a whole country or region, and to make international or regional comparisons^[36]. Economic performance directly determines the level of labor cost. Over the past three decades, the general income of employees in construction industry has largely improved due to consecutive economic growth. Besides, with more contributions of construction sector towards the national economy, stable economic growth promotes the rapid development of construction industry, and then drives the fast increase of labor cost in construction industry^[2].

Second, as a pillar industry in national economy, the buoyant construction sector is also attributed to the huge amount of fixed asset investment. The sudden change of the amount of construction works created by central government broke original relative balance between market supply and demand, then impacted the level of labor remuneration. On the other hand, few newcomers have been attracted from labor pool due to the harsh working environment and unpromising career prospect. Although the income level for construction workers is much higher than before, most youngsters are prone to enter an industry with better working condition and higher social status instead. In terms of poor image of the construction industry, the decision makings for migrant workers might to some extent alter under different economic situations. In this sense, unemployment rate (UR) acts as a comprehensive indicator to describe the condition of economic landscape and job-seeking environment, which influences the direct recruitment of construction workers in terms of labor mobility, associated with labor cost management^[37, 38].

Third, faced with rising labor cost and limited skilled labor in construction industry, labor substituted by construction plants and equipment is thereby regarded as an irresistible trend in terms of acute labor shortage across the industry. Applying construction plants and equipment into the construction process rather than recruiting expensive skilled labor would simultaneously attain multiple objectives including labor-saving, cost-saving, and time-saving in the long term. Therefore, contractors have to adjust their market strategies to manage construction activities in a flexible manner according to market change. In this context, technical equipment ratio (TER), the total value of construction machines per worker, perform as an overall indicator to reflect the application of plants and equipment in construction industry. Higher rate of construction technical equipment implies more utilization of modern machinery and equipment during the construction process, with less labor input thus higher labor productivity. Accordingly, the amount of labor inputs required is associated with the level of labor cost within construction industry. Besides, construction labor productivity (CLP) can be thereby enhanced with close linkages of labor skillfulness, and the uniqueness of craftsmanship, interpreted as the possibility of being replaced by technical plants and equipment^[39-41]. Ultimately, both TER and CLP determine the level of construction labor cost via indirectly altering the amount of construction labor inputs.

Final, the internal proportion of construction cost varies with the development of construction industry, depicting different pictures at various stages. Therefore, how to balance the explicit relationship of each part of construction cost for the development need remains to be a critical issue for construction stakeholders to deal with. Some contractors attempt to bid for as many as construction projects to offset the decreasing profit rate in each working unit, while they do not fully understand the coming crisis and underlying message until the occurrence of labor shortage spread over the industry. Undoubtedly, maximizing the margin profits of construction project is the first thing that construction manager cares about. Once construction profit rate (PROF) is disturbed by external impacts, the responsive adjustments will be accordingly made to ensure the relative optimization for profit making. Increasing construction labor cost is bound to affect the space of profit gains, but how to tackle with this pressure based on corresponding strategies becomes quite important concerning whether both construction stakeholders and site workers can achieve the win-win situation.

5. Regional Labor Cost Data and Analysis

5.1. Data source

According to literature review above, potential factors affecting labour cost in construction industry including GDP, unemployment rate (UR), construction labour productivity (CLP), technical equipment ratio (TER), and construction profit rate (PROF) are therefore chosen for further investigation with labour cost variations across construction industry. The annual data of these indicators can be obtained from National Statistics Yearbooks over the past two decades, i.e. from 1996 to 2016, covering 31 provinces or cities in Mainland China^[42]. For regional division, 31 provinces and municipalities of Mainland China are categorized into undeveloped west region, developing central region, and developed east region, according to the administrative layout. West region includes 12 places, that is, Sichuan, Chongqing, Guizhou, Yun'nan, Shanxi, Guangxi, Inner Mongolia, Gansu, Ningxia, Xinjiang, Qinghai, and Tibet. Central region consists of 6 provinces, i.e. Hubei, Henan, Hunan, Anhui, Shanxi, and Jiangxi. East region incorporates mostly the coastal area, such as Hainan, Guangdong, Fujian, Zhejiang, Jiangsu, Shanghai, Shandong, Hebei, Tianjin, Beijing, Liaoning, Jilin, and Harbin.

5.2. Panel data analysis, tool, assumptions

Panel data analysis is used to model regional phenomena that other regional science methods are unable to handle, such as time dependent relationships among socio-economic variables. Apart from simply the time-series or cross-section regression, panel data modelling covers both horizontal and longitudinal dimension for overall examination. Besides, such models are often used to forecast or predict values of their dependent variables under various conditions. The basic model is the standard form of panel data analysis:

$$Y_{it} = \alpha_i + \beta * X_{it} + \mu_{it} \quad (i = 1, \dots, N; t = 1, \dots, T) \quad (1)$$

$$Y_{it} = \alpha_i + \beta * X_{it} + \delta_{it} + \lambda_i \quad (i = 1, \dots, N; t = 1, \dots, T) \quad (2)$$

Where Y is the dependent variable, the X_{it} are the independent or explanatory variables, subscript i represents the cross-section dimension, whereas t denotes the time-series dimension. Besides, the unobserved effects μ_{it} are captured including period individual-invariant effects λ_t and individual time-varying effects δ_{it} , characterized by structural parameter β and incidental parameter μ_{it} .

The effects of unobserved heterogeneity can either be assumed as random variables, referred to as the random effects model, or as the fixed parameters, referred to as the fixed effects model, or a mixture of both as the mixed effects model^[24]. The advantages of random effects (RE) specification are that it allows the derivation of efficient estimators that make use of both within and between group variation and the estimation of the impact of time-invariant variables, based on the assumption of the effects uncorrelated with X_{it} . Meanwhile, the advantages of fixed-effect model allow the individual-and/or time specific effects to be correlated with explanatory variables, supported by limited coefficients without time-invariant ones^[24]. RE specification and FE specification are mutually complementary patterns. To choose between two specifications, undertaking the Hausman test to determine RE versus FE pattern is an essential step before the modelling. Based on these criteria, panel data analysis is thereby conducted, model is initially specified by inputting all the listed variables, and results of Hausman test provide solid evidence for the selection of RE versus FE pattern, and statistical details are shown in the following tables below.

5.3. Model specification

The model specification is divided into several steps before conducting the panel data analysis. First, target variables and explanatory variables need to be determined respectively, and then the effects of modelling should be fixed via the Hausman test, whether the fixed effects or the random effects. Ultimately, the pattern of econometric modelling is therefore defined to see whether the likelihood ratio, i.e. F test, can be passed or not. For this modelling, panel data covers 31 provincial regions in Mainland China over past two decades from 1995 to 2015, during when experiencing the Asian Financial Turmoil, SARS, and the Global Mortgage Storm in 1997, 2003 and 2008, respectively. As is shown in Figure 1, the study period is accordingly divided into three stages according to the turning points and time spots of great events: 1995 - 2003 (Stage 1), 2004 - 2009 (Stage 2), and 2010 - 2015 (Stage 3). Detailed discussion will be then conducted from different stages, to obtain the reasonable and feasible findings.

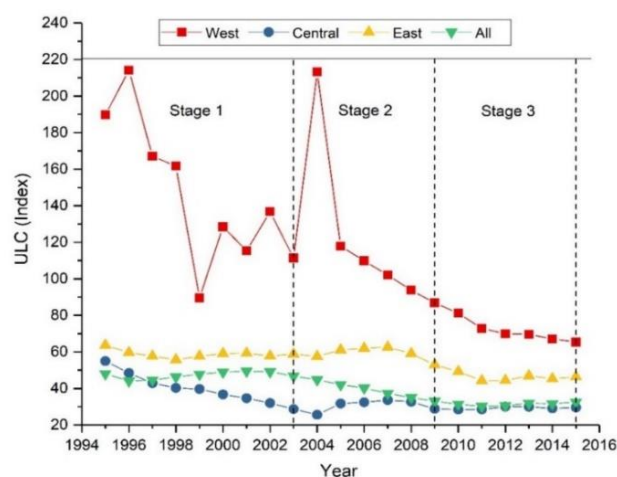


Figure 1 Regional Unit Labor Cost in China's Construction Industry (1995-2015)

6. Results and Discussions

According to the statistical tests of panel data analysis, established econometric models fit regional data well, and the adjusted R^2 shows a better fit for central and east regions, rather than west region, very close with the R^2 of all regions as a baseline. Besides, results of the Hausman Test suggest the fixed-effect model to be more appropriate than the random-effect model in representing the following cases (P-value less than 1%). Little autocorrelation problem for this panel is found according to Durbin-Watson statistics. GDP, CLP, and UR are found to be three common determinants of unit labor cost across various regions in Mainland China during entire study period. Positive coefficient of GDP is the biggest in west region, and gradually decreases from central region to east region, while the opposite condition for negative coefficients of CLP of these regions. Further, UR is positively associated with unit labor cost in both west and east regions, while negatively correlated with that in central region. The existing differences might be an overall result of diverse construction workforce strategies for meeting regional construction demands at different stages. This can be also evidenced by the significant coefficients of TER in central and east regions, which could indicate the application of construction plants and equipment in real practice, further reflect the reliance upon construction manpower.

Table 1 Panel Data Regression Analysis: Determinants of Unit Labor Cost in China's Construction Industry (1995 - 2015)

Independent Variables / Region	All Region	West Region	Central Region	East Region
GDP	0.001225 ^a	0.00425 ^b	0.000409 ^b	0.000265 ^a
CLP	-0.000557 ^a	-0.001077 ^a	-0.000232 ^a	-0.000178 ^a
TER	-0.001067 ^b	-0.000641	-0.000592 ^b	-0.000823 ^a
PROF	-5.498919 ^b	-8.795619	-0.409531	-1.367159
UR	17.55567 ^a	26.43122 ^a	-8.129785 ^a	6.288969 ^a
Constant	36.84578 ^b	39.67743	71.09039 ^a	49.39359 ^a
F-statistics	26.14	16.668	65.602	245.631
DW statistics	0.77	0.851	0.616	0.553
Adjusted R-squared	0.58	0.51	0.837	0.939

Note: DW = Durbin-Watson statistics.

^a Denotes significance at 1% level.

^b Denotes significance at 5% level.

^c Denotes significance at 10% level.

6.1. West region

Coefficients of GDP, CLP, and UR are statistically significant. Owing to the distinctive contributions from construction sector towards economic performance, the buoyant regional GDP promotes the incremental growth of construction labour cost, associated with the rising living standard. However, regional construction development in west region

shows more reliance upon cheap construction workforce, whereas surplus labour force in undeveloped area is relatively sufficient in contrast with other areas. Although the employment-generation potential of construction industry has been effectively utilized particularly during the economic recession^[43], the labour-intensive pattern of construction activity hinders efforts towards the improvement of construction labour productivity, also the rationalization of construction labour cost. To obtain as much as profit gains, contractors are inclined to reduce budget for construction manpower in early times, even delay payoffs to relieve the pressure of cash flow for cost management. All of these can be partly attributed to the low social status of construction workers themselves, and few barriers to entry into the industry^[44], especially when labour supply exceeds industry demand. Thus, regional construction profit gains are at the sacrifice of unit labour cost within a long period of time, making it hard return to a favorable level until the outbreak of labour shortage across the industry. Under this circumstance, construction profit rate will be largely affected in a tight construction labour market, previous pattern for profit gains depending on low labour cost might not be applicable to prevailing market competition in new period. Besides, the insecure employment, and negative aspects of working conditions largely influence the attractiveness of construction industry^[45]. Thus, construction contractors often have to pay disproportionally high wages in order to attract adequate numbers of workers, sometimes relying on untrained and little experienced workers, despite continued efforts to develop a core of local workers^[46]. Moreover, the inadequacy of training facilities and programs has resulted in an acute shortage of skilled personnel. The development and proper deployment of a well-trained and competent workforce is quite important for the well-being of construction industry, particularly for a pillar sector in national economy.

Table 2 Panel Data Regression Analysis: Determinants of Unit Labor Cost in West Region

West Region	1995 - 2015	1995 - 2003	2004 - 2009	2010 - 2015
GDP	0.00425 ^b	0.007499	0.034162	-0.000157
CLP	-0.001077 ^a	-0.000712	-0.00276	-0.0000049
TER	-0.000641	-0.002823 ^b	-0.0000108	0.000481
PROF	-8.795619	-14.07469 ^a	-61.49385 ^c	4.726488 ^b
UR	26.43122 ^a	15.60413 ^a	153.0494	22.93482 ^a
Constant	39.67743	88.52963 ^a	-399.2181	-30.16263
Adjusted R ²	0.51	0.95	0.45	0.964

^a Denotes significance at 1% level.
^b Denotes significance at 5% level.
^c Denotes significance at 10% level.

6.2. Central region

Unlike considerable fluctuations of construction labour cost in west region, labour cost performance in central region is much smoother with cyclic characteristics. Its turning points are easily captured in 2004 and 2009, respectively. The instability of construction labour cost is recognized as the result of fluctuations in the demand for investment, which usually gives a strong impetus to the development of construction industry^[47]. Construction is regarded as an important tool in government's management for regulating the economy, much more knowledge is required about the way that industry works especially as a major participant^[48]. Apart from those significant coefficients in west region, TER is identified to be negatively associated with ULC. In some regional centres, governments have used control over a certain segment of construction demands to promote the widespread adoption of new technology, aimed at reducing the reliance on labour inputs^[49]. In addition, UR is negatively correlated with ULC in the early stage, and then turns into positive relationship later. Considering that central region merely includes six provinces, construction industry performance in regional economy might be not so prominent compared with other places in developed area. The industry is generally operating below the capacity, and construction firms would take responsive measures to increase labour productivity. Meanwhile, there exist some mismatches between the levels of construction labour cost and construction development. This implies the urgent need to raise labour wage for attracting additional construction workforce, during when the industry still has the capability of meeting growing construction demands, and resolving the issue of social employment^[50]. As a labour-intensive sector, construction industry has absorbed massive surplus labour force not only from labour pool but also other related industries to satisfy the soaring needs, making the industry even more fragmented. With less available skilled labour in the construction market, plus limited new blood in young generation, labour substitution by construction technical plants and equipment will be an inevitable trend that must be reasonably considered and carefully treated, particularly during the successive construction booms. Otherwise, the negative effects are to emerge soon once the balance of market supply and demand is broken, due to external impacts

of international events or national policies.

Table 3 Panel Data Regression Analysis: Determinants of Unit Labor Cost in Central Region

Central Region	1995 - 2015	1995 - 2003	2004 - 2009	2010 - 2015
GDP	0.000409 ^b	-0.001589	-0.000559	0.0000882
CLP	-0.000232 ^a	-0.001036 ^c	0.00042	0.0000276
TER	-0.000592 ^b	-0.000261	-0.000899	0.0000644
PROF	-0.409531	0.167358	1.111548	2.355927 ^a
UR	-8.129785 ^a	-10.57576 ^a	12.73308	0.226393
Constant	71.09039 ^a	92.4512 ^a	-17.56982	19.56229 ^a
Adjusted R ²	0.837	0.87	0.879	0.985

^a Denotes significance at 1% level.

^b Denotes significance at 5% level.

^c Denotes significance at 10% level.

6.3. East region

Similar with the baseline trend of all regions, all explanatory variables including GDP, CLP, TER, and UR, except for PROF, are significantly correlated to construction labour cost in east region. However, the big differences lie in less dependence on cheap unskilled labour, and more reliance on technical plants and equipment, depicted in latter two stages with clear features. The dependence on causal labour hampers the creation of a pool of experienced workers and introduction of new techniques, then total investment in plant and equipment. Coupled with the uncertainty about the nature and size of construction workload, this has reinforced the unwillingness of contractors to acquire technical plant and equipment. Meanwhile, it is closely related to the exact stage that regional industry development lies in. No matter from the industry structure and industry pattern, east region is superior to other two regions in Mainland China. As the leadership of national economy and construction industry performance, regional construction development in east region has been seeking shifts from labour-intensive pattern towards technical-intensive pattern, via seizing the transition opportunities accompanied with the rapid development of real estate industry in 2003, and initiation of Four Trillion Fiscal Stimulus Package in 2009. From a holistic view, construction labour cost in east region stays at a moderate level, which is less subjected to the external shocks compared with west and central regions. Although there remain some slight ups and downs, regional construction labour cost has entered into a mature development process that is able to adapt to changing market environment within a short period. The maturation of construction labour cost can facilitate the efficient management of contractors, influence their alternative strategies over the recruitment and retainment of skilled labour. Moreover, it is also an epitome that does concern the final success of industry upgrade & transformation, then provide a paradigm how to deal with the critical conflict between rising labour cost and restricted available manpower under different conditions.

Table 4 Panel Data Regression Analysis: Determinants of Unit Labor Cost in East Region

East Region	1995 - 2015	1995 - 2003	2004 - 2009	2010 - 2015
GDP	0.000265 ^a	-0.000802	0.000597	0.000117
CLP	-0.000178 ^a	-0.000295	-0.000433	0.0000194
TER	-0.000823 ^a	0.000332	-0.001268 ^a	-0.000159
PROF	-1.367159	-0.893373	-1.160854	-2.646009
UR	6.288969 ^a	1.355822	-1.534906	10.52441 ^a
Constant	49.39359 ^a	61.55746 ^a	87.31229 ^a	20.03224
Adjusted R ²	0.939	0.978	0.979	0.972

^a Denotes significance at 1% level.

^b Denotes significance at 5% level.

^c Denotes significance at 10% level.

7. Conclusion and Implication

This study investigates the critical determinants of construction labour cost fluctuations at regional level in Mainland China via panel data analysis. GDP, construction labour productivity and unemployment rate are three common factors that affect regional construction labour cost; Besides, construction profit rate is found to be another dominant determinant of construction labour cost in west region, while construction technical equipment ratio acts as a significant

but negative factor in central and east regions, with incremental effects towards unit labour cost from west region to central region, then east region. Regional construction development in west region shows more reliance upon cheap labour, albeit industry has a high employment generating potentials to address social unemployment, labour-intensive pattern of construction development hinders efforts towards the improvement of construction labour productivity, and the rationalization of construction labour cost. Low labour cost can create high profit gains for contractors in the short term, however, have an adverse effect on the recruitment and retention of construction workers, particularly during the period of labour shortage in construction boom. This labour strategy enables construction productivity lag far behind most sectors in rest of the economy, which is not conducive to sharp core competition in construction market in the long term. For central region, the mismatch between the levels of labour cost and construction development implies the need to raise labour wage for construction workers especially when the industry still has the capacity of satisfying the persistent growing construction demands. The establishment and development of training facilities and programs for skilled workforce becomes quite important when facing with the large-scale labour shortage. New technologies for reducing the reliance on labour inputs, substituted by construction technical plants and equipment, are recommended to introduce and promote through gradual application in construction works. Final in east region, big differences lie in less dependence on cheap unskilled labour, and more reliance on technical plants and equipment. Owing to the superior industry structure and pattern, construction labour cost in east region stays at a moderate and reasonable level, which is more resilient to external shocks. Although there are some slight fluctuations around turning points, the level of regional labour cost become mature that facilitates the efficient management of contractors, alternative strategies over retention and training of skilled construction workforce. These are critical in shaping core competition of construction enterprises, determining final success of industry upgrade & transformation, and providing a paradigm to cope with conflict between rising labour cost and limited manpower, during the crossroads of construction industry development.

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