FACTORS AFFECTING CONSTRUCTION SAFETY PERFORMANCE IN CHINA DURING TRANSITION

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ABSTRACT
This paper adopted a macro perspective to evaluate factors affecting safety performance in China during the transition period. It addressed the limitation of previous studies that merely attempted to identify factors affecting safety performance from the micro perspective of project management, without questioning why those factors, such as lack of the top-management support and training, existed. Historical reasons explained why construction workers, consist of mainly “farmer workers”, always had little bargaining power with either developers or contractors. In addition, contractual arrangements in the construction industry failed to consider construction safety, making construction laws the only protection that farmer workers have. This paper used province-level construction safety records in China from 1994 to 2000 to investigate factors affecting construction safety in China. The implementation of construction safety laws and the rate of subcontracting were found to be relevant factors, while neither the extent of using temporary workers, nor the availability of resources, nor the level of per capita GDP has any effects.

Keywords: Construction safety, Farmer worker, Contractual arrangement, Safety laws, Subcontracting

INTRODUCTION
This paper adopted a macro perspective, which covers contractual arrangement, legal framework and governance structure in the industry, to evaluate factors affecting safety performance in China during the transition period. It contributes to the literature as few studies have concentrated on construction safety in China, except perhaps only studies on construction safety management by Cheng, et al. (2004), Fang, et al (2004), and Tam et al. (2004).


Although many factors that apparently affect construction safety have been identified, no one has asked why this was so. More sensible questions would be why construction safety management has never been “supported by top management,” why safety officers were not employed on site, and why “a safe environment/working conditions” were not provided.

This paper seeks to provide an answer by analyzing the issue from a macro perspective. The rest of the paper will be arranged as follows. First, the historical background of “farmer workers”, the major workforce in the construction industry, will be given. This will explain why farmer workers always have little bargaining power with either developers or contractors. Then contractual arrangements in the construction industry will be discussed to show that safety issues were
ignored by the parties to the construction contracts. The governance structure in the industry, in particular, the sub-contracting structure and the employment of temporary workers, will be discussed to give some clues on factors affecting safety performance. All the above analysis showed that the only protection the workers have is the relevant construction safety laws. The method of study will then be described followed by a discussion of the results. The last section concludes.

HISTORICAL BACKGROUND
Construction workers in China currently consist of mainly “farmer workers,” which is a concept unique to China. Farmer workers are those whose job category is registered in the Census Register as “farmer” and are mainly engaged in non-farming industries and earning wages as their main source of income.

Under the Residence Management and Registration Ordinance of the PRC enacted in 1958, the migration of rural residents to cities or towns was strictly prohibited unless they could find a job in a city/town or obtain admission by a university or special middle school. The industrialization process in the coastal cities since 1978 had created a large demand for labourers. At the same time, the reforms in agriculture greatly increased agricultural productivity, thereby freeing a lot of rural labourers. As a response to this situation, the authorities allowed “farmers” to work in the cities or towns without changing their registered residence category from “farmer” to “worker” (Drafting Group, 2006). The term, “farmer worker,” hence appeared and soon became popular.

Farmer workers often work for the lowest wages in the poorest working conditions. They do not have any of the social benefits that urban workers enjoy. Although they form the majority of work force in the construction industry, their safety problems have been largely ignored by scholars for many years except perhaps only Sha and Jiang (2003). These historical reasons explained why construction workers always had little bargaining power with either developers or contractors. First, most construction workers are farmer workers, historical arrangements have caused their low status in the society. Second, the education levels of farmers were generally low so that they were unaware of their rights. Thirdly, workers are not allowed to form unions in China.

Huang and Hinze (2006) concluded that owner’s involvement can favourably influence project safety performance and that contractual safety requirement is one important factor. Hence, the next section will inquire into the contractual arrangement in the construction industry to find whether safety issues have been considered by the parties to a construction contract.

CONTRACTUAL ARRANGEMENT IN THE CONSTRUCTION INDUSTRY
A construction contract is signed between a client and a contractor or between the main contractor and subcontractors. The provisions of a contract mainly deal with what the client requires. Time, cost, and quality are commonly recognized as the three most important measures of project management success, and they are normally all a client requires. In fact, the standard conditions of construction contracts deal mostly with these three matters. The selection of construction procurement strategies is also based primarily on these criteria. The difference of various procurement methods lies largely on the different level of emphasis placed on each of the factors. For instance, when time is more important, strategies facilitating an overlapping of the design and construction phases are often proposed. When cost is more important, lump sum contracts are proposed. Standard forms of contract have detailed provisions on controlling quality, including specifying, checking, and inspecting materials and workmanship.

The reason why time, cost, and quality are highly emphasized is that they directly affect developers who pay for construction projects. Time affects their cash flow. Cost directly affects their profits, which are their single most important goal if they are private and at least one of their most important goals if they are public. Quality affects the reputation of a developer and affects the selling prices of their properties. The overwhelming importance of these three matters attracts most of the attention of top management.
In contrast, safety matters rarely appear in minds of most contractors’ top management in China. The clients do not demand safety requirements, under the rule of winning by lowest price, the contractors will not increase costs by employing safety officers or by providing a safe environment / working conditions. Main contractors will not bother to demand safety performance from subcontractors as well. Only workers who risk their lives are most concerned with safety issues. Unfortunately, these people do not have a say in the preparation of construction contracts. In addition, there are no written contracts between the contractors and the workers at all. The most common way of dealing with safety in construction contracts, if any, is to ask contractors to satisfy the current safety laws and regulations.

In addition to the lack of attention in construction contracts, the governance structure in the construction industry, in particular the extensive use of sub-contracting and temporary workers, might impact the safety performance as well. This will be discussed below.

GOVERNANCE STRUCTURE IN THE CONSTRUCTION INDUSTRY
In the construction industry, the client (the developer) usually signs a main contract, which covers all or nearly all the works required for a project, with the main contractor. The main contractor, however, does not carry out all the construction works, but usually sub-lets a portion of it to subcontractors. The subcontractors may have their own sub-subcontractors. The client may select the subcontractors or suppliers through the provision of nominated subcontractor or suppliers in the conditions of contract. Alternatively, a contractor may select its own subcontractor, which will work as its domestic subcontractor if this is not forbidden in the conditions of contract.

Few scholars have empirically examined the relationship between subcontracting and construction safety. Although Lingard and Rowlinson (1994) believed that one reason for the poor safety performance in Hong Kong’s construction industry is the high level of subcontracting, they did not empirically test this statement. Intuitively, extensive subcontracting increases the difficulty of site management by the main contractor, and hence, will have a negative impact on safety.

In addition to subcontracting, China’s construction sector appears to have a habit of employing temporary workers. For instance, in 2000, 80.5% of the total construction workers in Hainan Province were temporary. The most obvious safety problem involved in the employment of temporary workers is a lack of training, which is considered by many researchers to be critical to safety (Cheng, et al 2004, Hinze and Gambatese 2003, Jannadi 1996, Jaselskis, et al 1996, Lee and Halpin 2003, Tam and Fung 1998).

As construction contracts do not make provisions on safety issues, and the governance structure of the industry might impact safety performance further, the only factor that might improve safety performance seems to be the legal framework, which will be discussed in the next section.

THE LEGAL FRAMEWORK ON CONSTRUCTION SAFETY
The Construction Law of the People’s Republic of China (The Construction Law) was the most important law shaping the legal framework of construction in China. Chapter 5 of The Construction Law makes a few provisions on safety matters. For instance, contractors are made responsible for construction site safety. However, the consequence of accidents was not made clear. One needs to refer to the Safe Production Law of the People’s Republic of China (the Safe Production Law) which is dedicated to safe production. Clause 48 of the Safe Production Law stipulates that workers who suffer from safety accidents, in addition to protection by casualty social insurance, have the right to claim compensation when the relevant civil laws provide for such. Clause 43 of the same law stipulates that production units shall buy casualty social insurance and pay the premiums for their employees. Clause 95 stipulates that production units shall be responsible for compensating accident victims when people are killed/injured or others’ properties are damaged.

1 Source: China Building Industry Year-Book 2001.
2 Clause 45 of Construction Law.
The Safe Production Law does not specify the amount of compensation to be paid, but the provisions in the Work Injury Insurance Ordinance may be indicative of what should be paid. Clause 37 of this ordinance stipulates that the standard of the one-off compensation for a work fatality is about 48 to 60 months of the average wage of the affected worker in the relevant area for the previous year.

Apart from the responsibilities mentioned above, the laws also make provisions on the responsibilities of the client, designer, contractor, and construction supervisor.\(^3\) In addition, the laws further aim to reduce the possibility of accidents. Examples are:

(a) Allowance of construction costs for safety matters,\(^4\)
(b) a safety licensing system for contractors,\(^5\)
(c) reporting and investigating "serious accidents" in construction,\(^6\)
(d) the authority's supervision and administration,\(^7\)
(e) the employment of safety officers,\(^8\) and
(f) the adoption of a mandatory construction supervising system (Yung and Lai 2008).

The laws were mostly enacted during the 1990s and early 2000s. Although their application may not be perfect, it should be possible to observe gradual improvements on construction safety over the course of the study period.

The following section will develop testable hypotheses to evaluate the above factors.

**HYPOTHESES**

Under the current institutional arrangements, the market fails to properly consider construction safety, as evidenced by the contractual arrangements in the industry. Hence, improvements in construction safety could be observed when construction safety laws favouring construction workers have been implemented. Since various laws and ordinances were enacted and implemented during the study period (1994-2000), the effects on improvements in construction safety should have been observed gradually during the period. Thus, the following hypothesis has been developed:

**Hypothesis 1**

The gradual implementation of safety laws will improve safety performance gradually over the years.

Extensive subcontracting increases the difficulty of site management by the main contractor, and hence, will have a negative impact on safety. Meanwhile, the extensive use of temporary workers will reduce the overall level of training in the labour force, thereby making them vulnerable to safety hazards. Hence, a few more hypotheses were developed:

**Hypothesis 2A**

Higher rates of sub-contracting will negatively impact construction safety.

**Hypothesis 2B**

Higher rates of temporary workers will negatively impact construction safety.

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\(^3\) Relevant provisions could be found in the Construction Project Safe Production Administration Ordinance, which was enacted on 24 November 2003 by Order No. 393 of the State Council and became effective on 1 February 2004.

\(^4\) Clause 18 of the Safe Production Law.

\(^5\) Clause 2 of the Safe Production Licensing Ordinance.

\(^6\) This is stated in the Provisions on the Procedures of Reporting and Investigating Serious Construction Accidents.

\(^7\) This is stated in the Provisions on Supervision and Administration of Safe Production in Construction, which was enacted on 9 July 1991 by Order No. 13 of the Ministry of Construction of China.

\(^8\) Clause 23 of the Construction Project Safe Production Administration Ordinance.
The author has shown elsewhere (Yung and Lai 2008) that the availability of resources, human and non-human alike, could affect construction quality. The availability of resources could also affect safety performance. Cheng, et al (2004) showed that the “poor quality of construction materials and equipment” is one of the most important factors that affect construction safety.

This paper uses five measures of availability for both man-made resources, in particular the machinery and equipment for construction, and human resources, in particular construction workers. Hence, the following five null hypotheses were developed:

**Hypothesis 3A:**
The number of labourer per unit area of floor space has no effect on construction safety.

**Hypothesis 3B:**
The power of the machinery owned by contractors per labourer has no effect on construction safety.

**Hypothesis 3C:**
The power of the machinery per unit area of floor space has no effect on construction safety.

**Hypothesis 3D:**
The value (at constant prices) of the machinery owned by contractors per labourer has no effect on construction safety.

**Hypothesis 3E:**
The amount (at constant prices) of the machinery per unit area of floor space has no effect on construction safety.

As mentioned, the compensation for work fatalities could be based on 48 to 60 months of the average worker’s wages in the relevant area over the previous year. As China’s economy develops, the average worker’s wages have increased. Hence, the burden of compensation has also increased. In addition, as the economy develops, people begin to treasure their lives more. Hence, the following hypothesis was developed:

**Hypothesis 4:**
Construction safety will improve as the per capita Gross Domestic Product (GDP) at constant prices increases.

**DATA AND METHOD**
The mandatory reporting of “serious accidents” started in 1989 when the *Provisions on the Procedures of Reporting and Investigating Serious Construction Accidents* came into effect. “Serious accidents” are classified into four categories as shown in Table 1.

<table>
<thead>
<tr>
<th>Class</th>
<th>Fatalities</th>
<th>Injuries</th>
<th>Economic Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>≥ 30</td>
<td></td>
<td>≥ RMB 3 million</td>
</tr>
<tr>
<td>2</td>
<td>10 - 29</td>
<td></td>
<td>RMB 1 – 3 million</td>
</tr>
<tr>
<td>3</td>
<td>3 - 9</td>
<td>≥ 20</td>
<td>RMB 0.3 – 1 million</td>
</tr>
<tr>
<td>4</td>
<td>≤ 2</td>
<td>3 - 19</td>
<td>RMB 0.1 – 0.3 million</td>
</tr>
</tbody>
</table>

These were enacted on 30 September 1989 by Order No. 3 of the Ministry of Construction of China, effective from 1 December 1989.
There will be two measures of safety performance, namely the number of serious accidents (of Class 4 and above) and the number of casualties (including fatalities and serious injuries) per 10,000 workers in a particular year. The data on dependent variables, rates of subcontracting, and the rate of temporary workers were collected from the China Building Industry Yearbook and that on the five measures of the availability of resources and per capita GDP from the China Statistical Yearbook. Unfortunately, the former did not consistently publish safety data. Only six years of data (1994, 1996-2000), consisting of 211 province level entries, were available.

The purpose of this paper is to study how institutional arrangements affect construction safety. This type of study is best conducted during the transition period. The years from 1994 to 2000 best fit into this study. The fact that the authority stopped publishing these data showed that construction safety was a sensitive and political issue. This made the set of data even more valuable.

Although the formal laws were enacted in 1998 or later, it does not mean that the rules were suddenly established in 1998 or later. In China, the common practice is that the rules will appear in the form of ministry regulations before formal enactment of laws. There will be a few years of “trial” period. This does not mean that practitioners could choose not to comply with ministry regulations. The most persuasive example is the implementation of mandatory supervising arrangement. The requirement of mandatory supervising appeared as early as 1988, ten years before the formal inclusion in the Construction Law which was enacted in 1998. Hence, it makes perfect sense to expect that the implication of rules happened in the study period.

There is also a lot of missing information on the number of workers employed by subcontractors and the number of temporary workers in those data, as a result, 98 province-level entries were left. Nevertheless, the number of data is still enough for our regression analysis.

Table 2 shows the description of the dependent variables and independent variables. Nominal values have been discounted with appropriate indices to obtain constant prices in 1993. In particular:

a. The “Value of Machinery” was discounted with the “purchase of equipment, tools and instruments” index (one component index for Price Index of Investment in Fixed Assets) for each province published in the China Statistical Yearbook (available from 1991 only);
b. the “Gross Domestic Product” was discounted with the Price Index of Investment in Fixed Assets); and
c. when the entry for a particular province in a particular year was unavailable, the national average data in that year was used.

Table 2 Description of Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Meaning</th>
<th>Unit</th>
<th>Min.</th>
<th>Max.</th>
<th>Mean</th>
<th>Stad. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dependent Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Acc_rate</strong></td>
<td>No. of accidents rated Class 4 or above per 10,000 workers in a year.</td>
<td></td>
<td>0.000</td>
<td>4.456</td>
<td>0.656</td>
<td>0.629</td>
</tr>
<tr>
<td><strong>Cas_rate</strong></td>
<td>No. of casualties in the accidents per 10,000 worker in a year.</td>
<td></td>
<td>0.000</td>
<td>7.073</td>
<td>1.179</td>
<td>1.148</td>
</tr>
<tr>
<td><strong>Independent Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothesis 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Year</strong></td>
<td>The year of the observation</td>
<td></td>
<td>1994</td>
<td>2000</td>
<td>1997.5</td>
<td>1.933</td>
</tr>
<tr>
<td><strong>Hypotheses 2A &amp; 2B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SC_rate</strong></td>
<td>No. of workers employed by subcontractors as a percentage of the total no. of workers</td>
<td>%</td>
<td>0.28%</td>
<td>65.63%</td>
<td>14.49%</td>
<td>0.134</td>
</tr>
</tbody>
</table>
### RESULTS AND DISCUSSION

Table 3 shows the empirical results of the multiple regressions. It is clear that the results of the two measures of safety performance (the accident rate and casualty rate) are quite similar. The variable, “Year,” is very significant in both equations and has a negative sign. This confirms our hypothesis that as safety laws were gradually implemented from 1994 to 2000, safety performance over the years improved. Both the accident rate and casualty rate decreased over the years. Hence, Hypothesis 1 is not refuted.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Acc_rate</th>
<th>Cas_rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of observations</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Independent Variable</td>
<td>Coefficient</td>
<td>Prob. of t-test</td>
</tr>
<tr>
<td>Constant</td>
<td>261.59</td>
<td>0.0000</td>
</tr>
<tr>
<td>Year (Hypothesis 1)</td>
<td>-0.1309</td>
<td>0.0000*</td>
</tr>
<tr>
<td>SC_rate (Hypothesis 2A)</td>
<td>0.9879</td>
<td>0.0291**</td>
</tr>
<tr>
<td>Temp_rate (Hypothesis 2B)</td>
<td>-0.0475</td>
<td>0.8282</td>
</tr>
<tr>
<td>Lab_m² (Hypothesis 3A)</td>
<td>-0.0004</td>
<td>0.3732</td>
</tr>
<tr>
<td>Power_lab (Hypothesis 3B)</td>
<td>0.0247</td>
<td>0.6643</td>
</tr>
<tr>
<td>Power_m² (Hypothesis 3C)</td>
<td>-0.0171</td>
<td>0.6974</td>
</tr>
<tr>
<td>VM_lab (Hypothesis 3D)</td>
<td>0.0323</td>
<td>0.5483</td>
</tr>
<tr>
<td>VM_m² (Hypothesis 3E)</td>
<td>0.0042</td>
<td>0.3167</td>
</tr>
</tbody>
</table>
The variable, “SC_rate,” is significant at the 5% level in both equations. Its positive sign indicates that the higher the subcontracting rate, the higher the accident rate and casualty rate, thereby confirming Hypothesis 2A. This may because there are too many subcontractors in a project. Many facilities are provided by the main contractor. Each subcontractor has only a short time to familiarize the conditions of the site.

Researchers have diversified views on the question why subcontracting appears. As subcontracting arrangements are not mandated by the government, hence, it must have appeared because the market thinks it fit. It was found that higher subcontracting rate is associated with poorer safety performance. However, without clear understanding on the question why subcontracting appears, it seems too hasty to make any recommendations now. This remains an interesting area for further study.

However, the variable, “Temp_rate,” is not significant, indicating that the level of temporary workers did not have any impact on construction safety. Thus, our previous intuition of the lower training level of temporary workers may not be true. A possible answer to this may be that “temporary” or “permanent” is merely a measure of the nature or term of an employment contract; it does not relate to the experience level or skills of a worker.

None of the five measures of availabilities of resources is significant in either equation, indicating that the availabilities of plants and equipment and labour have no relation to construction safety. Hence, all five null hypotheses 3A – 3E are refuted.

The results of the variable, “GDP_cap,” are mixed. It is not significant in the equation for the accident rate, but significant at the 10% level in the equation for the casualty rate. Since 5% was chosen as the cut-off point, the variable will be regarded as not significant here. Hence, Hypothesis 4 is rejected. Although the compensation of fatalities is based on 48 to 60 months of an average worker’s wage over the previous year, the deterrence effects might be too small to generate obvious effects on safety.

The adjust $R^2$ of the two equations is about 39%, meaning that about 40% of the variations in the dependent variables could be explained by the independent variables. The other part of the variations should relate to the actual site management issues, probably identified in previous studies from the micro perspective of project management.

**CONCLUSION**

Unlike the literature on construction safety that approached the issue from the micro perspective of project management, this paper adopted a macro perspective of institutional arrangements. The institutional perspective covers the aspects of the historical contexts of farmer workers, contractual arrangements, the governance structure, and the legal framework in China’s construction industry. Publicly available “hard” data, ranging from 1994 to 2000, were tested with the multiple regression method. The major findings were:

(a) The gradual implementation of construction safety laws has gradually improved construction safety in China over the years;
(b) the extensive rate of subcontracting has had a negative impact on construction safety;
(c) the extent of using temporary workers did not have any impact on construction safety;
(d) the availability of resources did not have an impact on construction safety; and
(e) an increase in the level of per capita GDP did not have significant impact on construction safety.
Hence, there are obviously two ways to improve construction safety. First, the safety laws should be well developed and fully implemented. Second, extensive subcontracting should be avoided.

REFERENCES


