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Research on the mobility behaviour of Chinese construction workers based on evolutionary game theory

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ABSTRACT
The Chinese construction industry is characterised by the frequent job changes of lower-level workers, which has been identified as one of the principal causes of poor performance, quality and safety accidents, and high technology loss in the construction industry. Assuming that each party has incomplete market information about the other, we can thus define a dynamic game relationship between employers' incentives to retain workers and workers' mobility behaviour. By using evolutionary game theory, in this study we analyse various conditional evolutionary stable strategies and explore how employer behaviour influences the mobility of the workers in this industry in China. The results show that under the prevailing employment model, construction workers are bound to change jobs regardless of whether their employers adopt incentives to retain them or not. This finding suggests that the government, as the market regulator, should reform its employment model to ensure that construction workers switch jobs in an orderly and rational manner.

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1. Introduction

With rising urbanisation and the modernisation of rural areas, many surplus rural workers have been liberated and they are rushing into cities to find work (Wang, Wang, & Wu, 2010). Because Chinese construction is still labour-intensive (Dixit, Culp, & Fernández-Solís, 2013) and its entry barriers remain extremely low, potential incomes are large and many rural migrant workers give priority to construction because of their minimal skill levels (Deng, Liu, & Jin, 2012).

In 1984, the Chinese government began to reform its construction employment model to adjust to the country's new economic situation (Meng, 2012). The model is composed of project management and labour services; construction enterprises are then divided into general contractors, specialist contractors, and labour subcontractors (Tarziján & Brahm, 2014), which constitutes a 'three-level pyramid'. Having won the bidding contract, general contractors subcontract work to labour subcontractors, which then organise rural workers to finish the field operations. However, labour subcontractors employ few construction

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workers. As rural migrant workers aim to increase their economic incomes and have some job and location flexibility, they always move toward well-paid employers (Chiang, Hannum, & Kao, 2015). Bai and Li's (2009) field survey showed that 73.3% of construction workers have moved between employers, the highest among all industries examined, while the survey of Sun, Nie, and Shen (2015) found that 82% of construction workers have changed employers.

Job mobility in this study refers to situations where workers plausibly change employers within the construction industry. Compared with manufacturing, construction projects are temporary and immovable (Mitropoulos & Memarian, 2012), a characteristic that naturally leads to construction workers' mobility. We distinguish between natural mobility, where workers move away after their construction tasks are complete, and the abnormal mobility caused by the external environment or personal factors that entice workers away from employers arbitrarily, whether or not the construction project is finished. This study focuses on the latter.

As for enterprises and industries, Meier and Hicklin (2008) proposed that moderate levels of mobility may positively affect organisational and industry performance, although they found that overly high mobility was harmful. Construction workers' frequent job mobility makes it difficult to secure a workforce and costs construction companies enormous expenses to recruit, hire, and train new personnel (Vitharana & De Silva, 2015). As a result, there is a consensus that workers' frequent job mobility is one of the principal causes of poor performance, low quality, and accidents in the construction industry (Ismail, Doostdar, & Harun, 2012; Tomić, 2014). Kumar (2013) found construction workers to be vulnerable and have fragile employer–employee relationships. Yu, Ding, Zhou, and Luo (2014) found that fatal accidents occurred more than 20 times from 2008 to 2012 in China and verified that workers' high mobility is one of the main reasons. Siddiqui (2014) pointed out that more than 21,000 construction workers in the US lost their lives from occupational injuries between 1992 and 2010, because high mobility prevents workers from accumulating experience and specific knowledge in the job. Therefore, there is an increasing need to understand the major critical variables affecting the job mobility of Chinese construction workers.

Nowadays, awareness about the rights of Chinese construction workers is low, and low-skilled workers have flooded the market (Knight, Deng, & Li, 2011), weakening the position of construction workers and encouraging them to quit to deal with employers' unfair treatment. On the contrary, high-skilled construction workers are in high demand in the labour market. Nevertheless, the flexibility of such workers can lead many employers to delay wages; therefore, it is no surprise that construction workers have a high willingness to switch jobs to raise or protect their interests. Under the condition of incomplete information, this scenario thus presents a dynamic game relationship between employers and construction workers. Finally, in a game relationship, Rabin (1993) pointed out that a player's utility depends mainly on his or her monetary income in the employment relationship.

Few studies have examined the mobility of Chinese construction workers. This study bridges this gap in the body of knowledge on this topic by examining the dynamic evolutionary effect on the mobility behaviour of construction workers, using evolutionary game theory (Basar & Olsder, 1999; Cressman, 2013). Evolutionary game theory requires two groups rather than individuals and is dynamic as opposed to static, while evolutionary stability requires that no mutant strategy persists in the sense of earning an equal or higher payoff (Weibull, 1997).

2. Literature review

Employee mobility behaviours are an important research topic in the fields of organisational behaviour, human resource management, and labour economics. Many researchers have explored the factors influencing workers' mobility from different perspectives. The construction industry has often been described in terms of its distinctive features, such as its industrial organisation, the specificity of its workforce, the nature of its work processes, and its labour relations system (Farina, Bena, Pasqualini, & Costa, 2013). Another important feature of the industry is its unstable employment and the resulting high level of workforce mobility.

Sorokin (1927), an American sociologist, offered the first definition of social mobility and pioneered related research. Over time, researchers found that mobility exists in some occupations and is a form of social mobility. Blau and Duncan (1967) proposed that social mobility (e.g., income, class, and power) are based on occupational mobility. Since then, occupational mobility has drawn significant research interest and controversy. Exploring the factors influencing workers' mobility from different perspectives has become a prevailing research topic in the fields of organisational behaviour, human resource management, and labour economics.

In terms of job mobility in the construction industry, by exploring burnout among civil engineers in Australia, Lingard (2003) found that burnout is attributed not only to emotional exhaustion, cynicism, and a diminished sense of personal accomplishment, but also occurs as a result of the complex interaction among individual characters and issues in the work environment.

Charest (2008) verified that mobility is more often correlated with low initial gains for workers and that the logical consequence is that mobility reflects workers' desire to improve their economic situations. By controlling for age, occupational, and demographic factors, Kim and Philips (2010) demonstrated that both portable union and non-portable non-union employer-provided health insurance increase the probability of retaining blue collar workers in the construction industry. In addition, in the union sector of construction where health insurance is portable across signatory contractors, the problem of job-lock inefficiencies is reduced.

By examining the occupational mobility of Queensland's civil construction workers, Haukka (2011) found that workers who are younger, less qualified, and lower skilled are likely to move and that their turnover intention is motivated by income-related reasons and because they can apply and develop skills at work.

By investigating the effect of job embeddedness (fit, links, sacrifice) and work satisfaction on mobility willingness in small- and medium-sized construction firms, Cho and Son (2012) found that the greater the sacrifice, the higher the career satisfaction, and the higher the job satisfaction of employees, the lower is their turnover intention, the higher is their fit and links, and the lower is their turnover intention.

This review of the literature reveals that the majority of factors affecting workers' mobility behaviours can be grouped into income-related, job satisfaction, and organisational commitment. Scarce research has, however, been conducted to study how income-related factors affect Chinese construction workers' mobility.

3. Evolutionary game model between employers and workers

3.1. Assumptions

According to the National Bureau of Statistics in China, the proportion of subcontractors among construction workers is rising rapidly (see Table 1). Since 2001, promoted and institutionalised by the government, labour subcontracts have gradually become the dominant employment model in the construction industry. The government intentionally passed a regulation that only labour subcontractor firms with an approved licence can bid for labour service, and construction workers should be absorbed by those approved firms. Consequently, the increasing labour subcontractor firms were founded, and attracted a growing number of construction workers.

Catering to the schedules and requirements of general contractors, labour subcontractors supply workers to construction projects as well as dispatch site administrators and technicians. Based on the above employment model and ensuring that evolutionary game preconditions are confined to a realistic labour market situation, we propose the following hypotheses:

Assumption 1. Game players are employers' groups and workers' groups. Employers and construction workers are rational homo economicus and are players. Employers aim to maximise total profits, while construction workers aim to maximise personal earnings.

Assumption 2. *Construction workers' mobility strategy is Ω_1={yes, no}. Similarly, employers' retention strategy is Ω_2={yes, no}, including providing an attractive salary, promotion opportunities, free training, and personal insurance for construction workers). The above retention strategy is implemented before construction workers plan to change jobs or when they are about to leave. Usually, before making a decision, they do not know what the counterpart has decided.*

Assumption 3. Employers and construction workers not only desire higher earnings, but also pay close attention to interpersonal relationships in order to balance these two factors.

Assumption 4. Employers and construction workers seek to maximise the long-run benefits and can overlook moderate gains and losses in the short-term.

Assumption 5. Employers set roughly equivalent basic wages for the same jobs. However, benefits such as bonuses depend on employers' policies, which influence the willingness of construction workers to move jobs.

Assumption 6. For different construction workers, the same employer may provide different benefits. Employers always prioritise their incentives and provide more benefits to workers that are more profitable to them. Consequently, the more construction workers make profits, the more benefits the employer provides.

Assumption 7. Construction workers move toward well-paid jobs and high-performing employers before deciding to change jobs.

Table 1. Construction subcontractors in China, 2002–2014.

Year	Number	Registered construction workers
2002	1193	340,000
2005	2984	870,000
2008	4357	147,860,000
2011	8000	244,690,000
2014	16,099	460,370,000

Source: Data from China Statistical Yearbook 2002–2014 in National Bureau of Statistics of the People's Republic of China.

Assumption 8. Through social networks, construction workers can find a lot of employment information on earnings and employer performance.

Assumption 9. When employers reduce payments or break their promises, construction workers rarely resort to legal measure; instead, they quit then wait patiently to be paid.

Assumption 10. Every construction worker has a different perception and evaluation of the employer's performance and this influences their effort and mobility behaviour.

Assumption 11. If construction workers plan to move away, their employers suffer a loss; if employers intend to retain workers, they will pay for their retention.

Assumption 12. If employers decide to retain a construction worker, they will ask them to pay a penalty for their mobility behaviour.

Assumption 13. According to job search theory, if construction workers switch jobs, they incur mobility costs including removal costs, traffic costs, and living costs. Similarly, after construction workers have moved away, employers incur the costs of recruiting new workers.

3.2. Parameters

The vast majority of construction sites across China are dangerous. In addition, the social security mechanism is incomplete in the construction industry, and the government has not ruled that subcontractors must pay social insurance for construction workers. Subcontractors are reluctant to implement safety precautions or social security mechanisms to safeguard workers' lives and health; hence, social security and welfare are not the focuses of the game. In this game, workers focus on basic wages, mobility costs, income rises, and default penalties to decide whether they move away, while employers focus on profits, retention costs, mobility loss, and recruitment costs to decide whether they retain workers. By combining with the above assumptions, we set the following parameters (every parameter is greater than 0).

- If employers do not intend to retain construction workers and construction workers do not plan to change jobs, employer' incomes are P that constructions workers make profits to employers. Construction labour' incomes are S that employer pay basic wages for them.
- If employers do not intend to retain construction workers and construction workers plan to change jobs, the employer's loss is L_1; construction workers' incomes increase by A compared with before, and their mobility costs are $Mc1$.
- If employers intend to retain construction workers and construction workers plan to change jobs, the employer will pay C as a retention cost and suffer L_2 (i.e., the gross loss to employers because of the construction worker's mobility); construction workers thus pay $Mc2$ for mobility, including penalty ΔC and $Mc1$.
- If employers intend to retain workers and workers do not plan to change jobs, construction workers' income increases by Ei including tangibles and intangibles.
- After construction workers have moved away, the employer pays Rc to recruit new workers.

Based on the above assumptions and variables, we establish a pay-off matrix between construction workers and employers (see Table 2).

Table 2. Pay-off matrix between workers and employers.

Construction worker		Yes		No	
Employer	Yes	$P-C-L2-Rc$	$S+A-Mc2$	$P-C$	$S+Ei$
	No	$P-L1-Rc$	$S+A-Mc1$	P	S

Source: Authors' logical inference based on the parts of "*Assumptions*" and "*Parameters*".

We assume that the probability that construction workers plan to change jobs is x ($0 \leq x \leq 1$), whereas the probability that they do not is $1-x$. Similarly, we assume that the probability that employers intend to retain construction workers is y ($0 \leq y \leq 1$), while the probability that employers do not is $1-y$.

According to the fitness function of evolutionary game theory (Cheung & Friedman, 1998), we assume that expected revenue when construction workers plan to change jobs is $Ud1$, expected revenue when they do not is $Ud2$, and average expected revenue whether construction workers plan to change jobs or not is Ud. Then, we can formulate the following equations:

$$Ud1 = y(S + A - Mc2) + (1 - y)(S + A - Mc1) = S + A - Mc1 + y(Mc1 - Mc2) \quad (1)$$

$$Ud2 = y(S + Ei) + (1 - y)S = S + yEi \quad (2)$$

$$Ud = xUd1 + (1 - x)Ud2 = S + x(A - Mc1) + yEi + xy(Mc1 - Mc2 - Ei) \quad (3)$$

Similarly, we assume that expected revenue when employers intend to retain construction workers is $Ut1$, expected revenue when employers do not is $Ut2$, and average expected revenue whether employers intend to retain construction workers or not is Ut. Then:

$$Ut1 = x(P - C - L2 - Rc) + (1 - x)(P - C) = P - C - x(L2 + Rc) \quad (4)$$

$$Ut2 = x(P - L1) + (1 - x)P = P - xL1 \quad (5)$$

$$Ut = yUt1 + (1 - y)Ut2 = P - xL1 - yC + xy(L1 - L2 - Rc) \quad (6)$$

This leads to the following replicator dynamics equation about x and y (Pelillo, 1999):

$$F(x) = \frac{dx}{dt} = x(Ud1 - Ud) \quad (7)$$

$$F(y) = \frac{dy}{dt} = y(Ut1 - Ut) \quad (8)$$

By substituting equations (1), (3), (4), and (6) into equations (7) and (8), we get:

$$F(x) = x(1 - x)[(A - Mc1) + y(Mc1 - Mc2 - Ei)] \quad (9)$$

$$F(y) = y(1 - y)[-C + x(L1 - L2 - Rc)] \quad (10)$$

4. Game result

According to the above assumptions and parameters, we assume that $\Delta A = A - Mc1$, $\Delta L = L1 - L2$, and $\Delta C = Mc2 - Mc1$. In the above assumptions, we stated that construction workers always move toward well-paid employers and plan to change jobs only when A is greater than $Mc1$, where ΔA is greater than 0. Employers rarely pass on the retention costs to individual construction workers. Hence, the loss that the mobility of construction workers causes the employer when it intends to retain them is less than when the employer does not, because employers ask construction workers to pay a penalty and thus ΔL is greater than 0. The mobility costs when employers intend to retain such workers are greater than those when employers do not, because construction workers need to pay a penalty to employers, i.e.: $\Delta C = Mc2 - Mc1$. Therefore, we can transform equations (9) and (10) into

$$F(x) = x(1-x)[\triangle A - y(\triangle C + Ei)] \tag{11}$$

$$F(y) = y(1-y)[-C + x(\triangle L - Rc)] \tag{12}$$

Hirshleifer (1977) pointed out that in the dynamic evolutionary system, the trajectory from an arbitrarily small neighbourhood will evolve toward a certain balance point, which is asymptotic stable. This is called the evolutionary stable strategy (ESS). If the population share of mutants is sufficiently small, a certain strategy is said to remain evolutionarily stable (Smith, 1974).

When functions $F(x)$ and $F(y)$ equal 0, we obtain $x1$=0, $x2$=1, and $x3 = \frac{C}{\Delta L - Rc}$ as well as $y1 = 0$, $y2$=1, and $y3 = \frac{\Delta A}{Ei + \Delta C}$ Correspondingly, we obtain five evolutionary equilibrium points: $E1$ (0, 0), $E2$ (0, 1), $E3$ (1, 0), $E4$ (1, 1), and $E5$ $\left(\frac{C}{\Delta L - Rc}, \frac{\Delta A}{Ei + \Delta C}\right)$

In equation (11), if $y = \frac{\Delta A}{Ei + \Delta C}$, all x are ESS; if $y \neq \frac{\Delta A}{Ei + \Delta C}$, only x^*=0 and x^*=1 are ESS. If $0 < y < \frac{\Delta A}{Ei + \Delta C}$, x^*=1 is ESS, which means that construction workers should choose to change jobs when the probability that employers intend to retain them is below a certain value. If $\frac{\Delta A}{Ei + \Delta C} < y < 1$, x^*=0 is ESS, which means that construction workers may not plan to change jobs when the probability that the employer intends to retain them is above a certain value.

In equation (12), if $x = \frac{C}{\Delta L - Rc}$, all y are ESS; if $x \neq \frac{C}{\Delta L - Rc}$, only y^*=0 and y^*=1 are ESS. If $0 < x < \frac{C}{\Delta L - Rc}$ y^*=1 is ESS, which means employers may not intend to retain construction workers when the probability that they plan to change jobs is below a certain value. If $\frac{C}{\Delta L - Rc} < x < 1$, y^*=0 is ESS, which means employers intend to retain them when the probability that construction workers plan to change jobs is above a certain value.

Friedman (1991) pointed out that the Jacobian matrix helps demonstrate whether a dynamic evolutionary system is stable or not. As for discrete systems, the evolutionary equilibrium point reaches stability only when the Jacobian matrix $DetJ > 0$ and $TrJ < 0$. After working out the x and y partial derivatives, we can establish the following Jacobian matrix:

$$J = \begin{pmatrix} (1-2x)[(A - Mc1) + y(Mc1 - Mc2 - Ei)] & x(1-x)(Mc1 - Mc2 - Ei) \\ y(1-y)(L1 - L2) & (1-2y)[x(L1 - L2 - Rc) - C] \end{pmatrix}$$

From this matrix, we see that the stability of the evolutionary equilibrium depends on $[\Delta A - (Ei + \Delta C)]$ and $[C - (\Delta L - Rc)]$. $(Ei + \Delta C)$ is the net earnings when construction workers do not plan to change jobs, including the saved mobility costs and direct benefits of employers retaining them. $(\Delta C - Rc)$ is the net profit that employers do not intend to retain construction workers. By capturing the penalty, employers incur costs for recruitment. Now, according to $[\Delta A - (Ei + \Delta C)]$ and $[C - (\Delta L - Rc)]$, we can combine these four cases to analyse the system's stability and draw its corresponding evolutionary phase diagram (Szabó & Fath, 2007).

Case 1: $\Delta A < Ei + \Delta C$ ***and*** $C < \Delta L - Rc$

If employers intend to retain construction workers, the net earnings when construction workers do not plan to change jobs are greater than those when construction workers do; the penalty is sufficient to compensate for the individual retention and recruitment costs. Under these circumstances, employers would strengthen their incentives and ask construction workers to pay a large penalty, which meets $\Delta A < Ei + \Delta C$ and $\Delta L > C + Rc$. The result is that the net earnings when construction workers do not plan to change jobs are greater than those when they do, while the net profits when employers intend to retain construction workers are greater than those when they do not. We can draw five evolutionary equilibrium points: $E1$, $E2$, $E3$, $E4$, and $E5$. Table 3 shows the analysis results of the equilibrium local stability of the Jacobian matrix.

From Table 3, we can draw an evolutionary phase diagram (see Figure 1). This figure shows that the dynamic evolutionary system cannot converge toward any point. Regardless of the initial proportion from which construction workers and employers adopt their respective strategies, $E5$ always evolves toward $E1$, $E2$, $E3$, or $E4$; then, $E1$, $E2$, $E3$ and $E4$ always evolves toward each other. As a result, the whole system remains unstable.

Table 3. Analysis of the stability of the local equilibrium.

Equilibrium	Plus or minus of *DetJ*	Plus or minus of *TrJ*	Results
$E1$ (0, 0)	–	uncertain	saddle point
$E2$ (0, 1)	–	uncertain	saddle point
$E3$ (1, 0)	–	uncertain	saddle point
$E4$ (1, 1)	–	uncertain	saddle point
$E5$ $\left(\frac{C}{\Delta L - Rc}, \frac{\Delta A}{Ei + \Delta C}\right)$	+	0	unstable point

Source: Authors' calculation based on the Jacobian matrix.

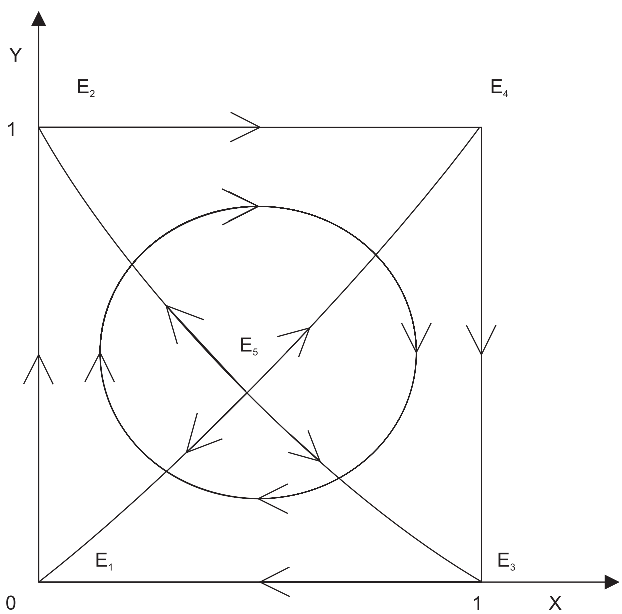

Figure 1. Case 1: evolutionary phase diagram. Source: Authors' processing based on result of Table 3.

Table 4. Analysis of the stability of the local equilibrium.

Equilibrium	Plus or minus of *DetJ*	Plus or minus of *TrJ*	Results
*E*1 (0, 0)	–	uncertain	saddle point
*E*2 (0, 1)	+	+	unstable point
*E*3 (1, 0)	+	–	stable point
*E*4 (1, 1)	–	uncertain	saddle point

Source: Authors' calculation based on the Jacobian matrix.

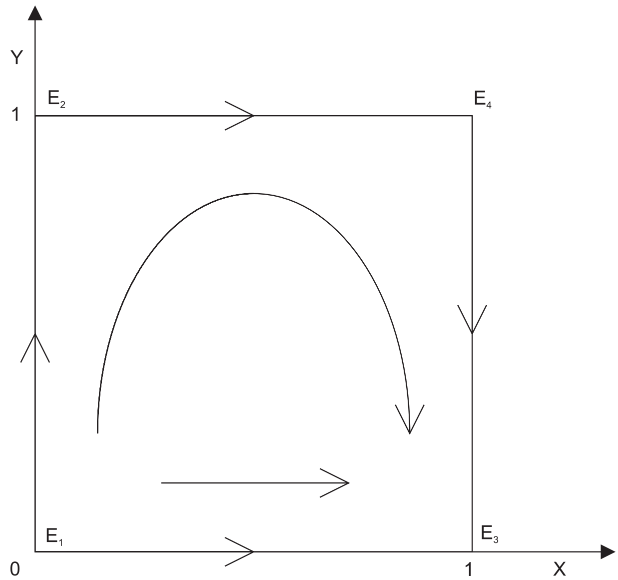

Figure 2. Case 2: evolutionary phase diagram. Source: Authors' processing based on result of Table 4.

Case 2: $\Delta A > Ei + \Delta C$**and** $C > \Delta L - Rc$
If employers intend to retain construction workers, the net earnings when construction workers do not plan to change jobs are less than those when workers do; the individual retention costs plus recruitment costs are thus greater than the penalty that construction workers pay. Under these circumstances, we can draw four evolutionary equilibria: *E*1, *E*2, *E*3, and *E*4. Table 4 presents the analysis results for this case and Figure 2 illustrates the evolutionary phase diagram.

Figure 2 shows that the dynamic evolutionary system converges toward *E*3, indicating that *E*3 is ESS. In this case, although employers adopt incentives to retain their workers, they cannot attract workers, who decide to move toward well-paid employers. Consequently, employers should strengthen their incentives to change workers' decisions.
Case 3: $\Delta A > Ei + \Delta C$ **and** $C < \Delta L - Rc$
If employers intend to retain construction workers, the net earnings when workers do not plan to change jobs are less than those when workers do; again, the individual retention costs plus recruitment costs are less than the penalty that construction workers pay. Under these circumstances, we can draw four evolutionary equilibria: *E*1, *E*2, *E*3, and *E*4.

According to the analysis results in Table 5, we can draw the evolutionary phase diagram (see Figure 3). Here, the dynamic evolutionary system converges toward *E*4, indicating *E*4

Table 5. Analysis of the stability of the local equilibrium.

Equilibrium	Plus or minus of *DetJ*	Plus or minus of *TrJ*	Results
*E*1 (0, 0)	–	uncertain	saddle point
*E*2 (0, 1)	+	+	unstable point
*E*3 (1, 0)	–	uncertain	saddle point
*E*4 (1, 1)	+	–	stable point

Source: Authors' calculation based on the Jacobian matrix.

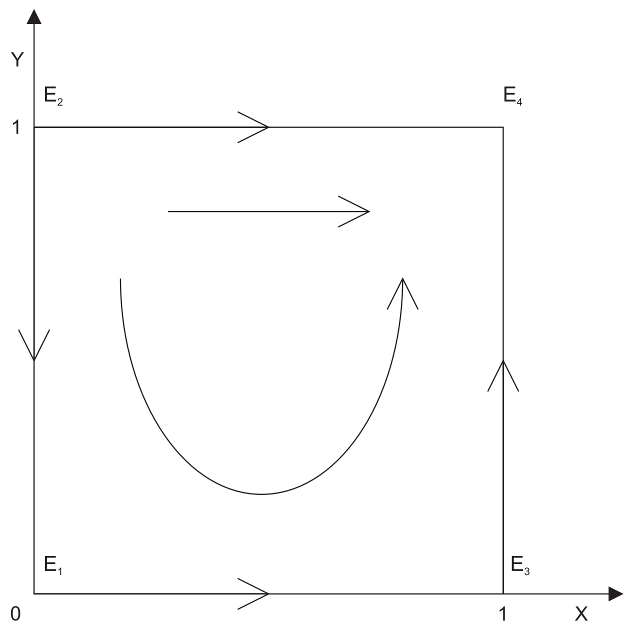

Figure 3. Case 3: evolutionary phase diagram. Source: Authors' processing based on result of Table 5.

is ESS. In this case, construction workers do nothing about the penalty and are determined to move toward well-paid employers, because they think the earnings of the new job would be greater than those when do not plan to change jobs plus the penalty. Moreover, the penalty compensates them for the individual retention costs and recruitment costs. Hence, the employer may be willing to adopt incentives.

Case 4: $\Delta A < Ei + \Delta C$ ***and*** $C > \Delta L - Rc$

If employers intend to retain construction workers, the net earnings when workers do not plan to change jobs are greater than those when they do; then, the individual retention costs plus recruitment costs are greater than the penalty. Under these circumstances, we can draw four evolutionary equilibria: *E*1, *E*2, *E*3, and *E*4.

From Table 6, we can draw the evolutionary phase diagram (see Figure 4). Figure 4 shows that the dynamic evolutionary system converges toward *E*3, indicating *E*3 is ESS. In this case, the penalty cannot compensate for the individual retention costs and recruitment costs, and thus employers are reluctant to adopt incentives. In turn, by not obtaining any incentives, construction workers try to move toward other well-paid employers.

Table 6. Analysis of the stability of the local equilibrium.

Equilibrium	Plus or minus of *DetJ*	Plus or minus of *TrJ*	Results
*E*1 (0, 0)	–	uncertain	saddle point
*E*2 (0, 1)	–	uncertain	saddle point
*E*3 (1, 0)	+	–	stable point
*E*4 (1, 1)	+	+	unstable point

Source: Authors' calculation based on the Jacobian matrix.

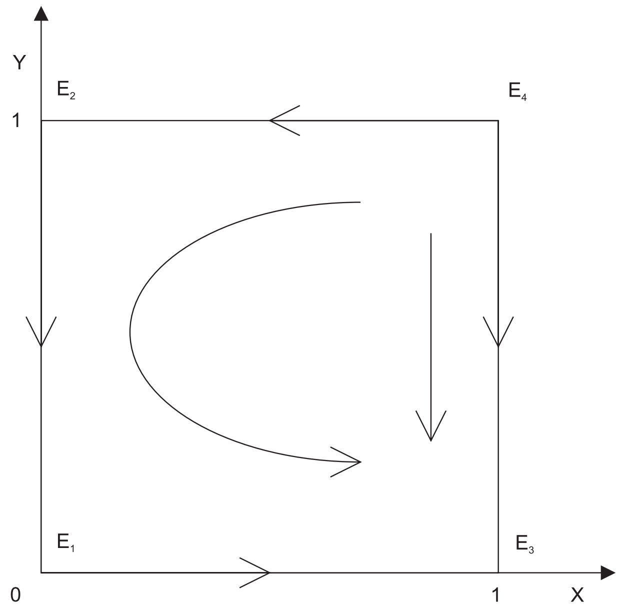

Figure 4. Case 4: evolutionary phase diagram. Source: Authors' processing based on result of Table 6.

5. Discussion

According to the above analysis, only *case 1* has no stable point; both *case 2* and *case 4* have stable points at *E*3 and *E*4, while *case 3* has a stable point at *E*4. As shown in Figure 1, regardless of the initial proportion from which players adopt their respective strategies the dynamic game system cannot converge toward any point. Usually, an employer's strategy depends on the behaviour of construction workers. Employers may adopt incentives to retain construction workers as job mobility increases. However, employers may not incentivise workers in such a way when they realise that construction workers are not moving jobs to reduce employment costs. If things continue this way, both employers and construction workers always change their minds, making the system unstable. Because the game is endless, the stable points *E*1, *E*2, *E*3, and *E*4 exist simultaneously. As shown in Figures 2–4, the system then converges toward *E*3 or *E*4.

Stable point *E*3 reveals the phenomenon that construction workers are frequently changing jobs and that employers do not intend to adopt incentives to retain them. Evolutionary game theory can thus explain why construction workers continue to move jobs frequently. In view of the freedom of job movement by workers in the Chinese construction industry, employers are reluctant to implement any incentives. If things continue in this vein, the above phenomenon will not change.

The stable point $E4$ reveals that employers actively incentivise workers to remain, while construction workers still have great freedom of mobility. However, this status cannot be sustained in the long-term. Once construction workers seek better paying employers, they are determined to move away – and the penalty is sufficiently negligible not to change their decision. Although the penalty can compensate for employers' loss, they gain no benefit in the long run.

Stable points $E3$ and $E4$ suggest that the probability that construction workers plan to change jobs is 1, while the probability that employers adopt incentives is 1 or 0. Hence, under the current employment model, construction workers always choose to move toward well-paid employers regardless of whether employers implement incentives to retain them.

Since these parameters are variable, for their own interests, employers, workers, and policymakers can change their values to reach the desired stable points. Workers know the parameter value of employers intimately, allowing them to understand when the game would reach which stable point and thus whether to move. Employers identify workers' needs to assign the parameter value, allowing them to understand when the game would reach which stable point and thus whether to retain workers. Policymakers can retain or introduce employers and construction workers by creating relevant rules, driving the game to reach the desired stable point, which achieves harmonious labour relations and promotes the sustainable development of the industry.

6. Summary

6.1. Conclusion

By using evolutionary game theory, and from an economics perspective, this study analyses how employers and workers make decisions on job choices under the condition of incomplete information. We find that the probability that construction workers plan to change jobs is 1, while the probability that employers adopt incentives is 1 or 0. Hence, under the current employment model in the Chinese construction industry, workers always choose to move toward well-paid employers regardless of whether employers implement incentives to retain them. Because it is difficult for employers and construction workers, as players, to change the game rules, the government – as the market regulator – must gradually abolish the old rules and reform the current employment model. This approach would guide construction workers to change jobs in an orderly and rational manner as well as award employers that offer incentives to retain workers.

6.2. Policy implications

It takes a long time to reform employment models because the government and related institutes face a number of tough trade-offs. Nevertheless, the results of the presented analysis suggest two ways in which to relieve the current high level of job mobility in China. First, the government should improve employment contracts. Specifically, it should guide employers and construction workers to sign a contract that specifies the responsibilities and obligations of both parties. Under such a contract, construction workers would face high costs if they moved away discretionarily. Second, the government should encourage employers to purchase personal insurance for workers. Construction workers not only focus on wages, but also attach importance to personal insurance because construction sites are full of potential safety hazards. Meanwhile, for employers that provide such insurance and other benefits, the government should enact corresponding preferential policies such as economic subsidies and tax relief to reduce employers' costs.

6.3. Limitations and future research

There are three limitations in this study. First, the micro-level factors included in this study to analyse how to influence construction workers' decisions to move are not comprehensive. Future studies could examine workers' individual variables (i.e., age, education, family, skill level, attitude toward mobility), mobility psychological costs, interpersonal relationships, contracts, and so on. Second, this study excluded macro-level factors such as national economic status, labour supply and demand, construction industry characteristics, employment culture, social security, and public welfare. Finally, this study revealed a single income or earnings variable in terms of the mobility variable, although it did not explain situations where the above micro-level and macro-level factors have a combined effect on the dependent variable. We aim to prioritise these limitations in future research by including more micro- and macro-level factors. By conducting an analysis that includes more than a single factor to examine the combined effects and investigating all potential factors, it would be possible to propose an optimal mobility rate as well as illustrate and rank the marginal contribution of each variable.

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