WORKING PAPER No. 03

Skill Complementarity within Firms

By

Wenquan Liang

Jinan University

and

Ming Lu

Shanghai Jiao Tong University

June 2021

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Skill Complementarity within Firms

Wenquan Liang, *College of Economics, Jinan University*

Ming Lu(*), *Department of Economics and China Institute for Urban Governance, Shanghai Jiao Tong University*[1]

Abstract

This paper builds a theoretical model for skill complementarities within firms and shows how migration restriction, especially on low-skilled labors, undermines skill complementarities within firms. Using China's Second Economy Census (CSEC) data in 2008, which contains within-firm education composition of employees, we find that skill complementarities within firms only exist when the firm size exceeds a threshold, below which employees are substitutes. The threshold is not found to decrease along with the city size, which means the larger cities do not promote skill complementarities within firms. Furthermore, after controlling for an index of Household Registration System (HRS), which hinders labor mobility and is usually stricter in large cities, the threshold for within-firm skill complementarities decreases significantly. In other words, labor mobility barriers harm the efficiency and development of large cities.

JEL Classification: J24, R23

Keywords: Skill Complementarities; Knowledge Spillover; Urban Labor Market; Household Registration System

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[1] *Corresponding author.

Email address: *liang.wenquan@jnu.edu.cn* (Wenquan Liang), *luming1973@sjtu.edu.cn* (Ming Lu)

Skill Complementarity within Firms

Abstract

This study builds a theoretical model for skill complementarities within firms and shows how migration restrictions, especially on low-skilled labors, undermine these complementary relationships of skills. Using China's Second Economy Census (CSEC) data from 2008, which contains within-firm education composition of employees, we found that skill complementarities within firms only exist when the firm size exceeds a threshold, below which high- and low-skill employees can be mutually substituted. The threshold was not found to decrease along with the city size, which means that larger cities do not necessarily promote such skill complementarities within firms. Furthermore, after controlling for an index of the Household Registration System (HRS), which hinders labor mobility and is usually stricter in large cities, the threshold for within-firm skill complementarities decreased significantly. In other words, labor mobility barriers harm the efficiency and development of large cities.

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I. Introduction

Contemporary firm composition can be described by the specialization into different positions of workers, which enhances learning-by-doing, knowledge spillover, and, consequently, the growth of

productivity (Smith, 1776; Lucas, 1988). In line with the classic idea that market expansion deepens specialization (Young, 1928; Stigler, 1951; Smith, 1776), recent studies argue that cities–especially the large ones–tend to promote the sorting, matching and learning of workers in the urban labor market (Duranton and Puga, 2004; Rosenthan and Strange, 2004). Large cities enjoy skill complementarities more than smaller ones, so both low- and highly skilled laborers agglomerate in large cities, which consequently also leads to greater income inequality in large cities (Eeckhout et al., 2014). However, we still lack evidence, indicating whether there exist skill complementarities at the firm level, and, if so, whether these complementarities vary across cities of different sizes. Knowledge about the manner in which a city's scale affects skill complementarities between high- and low-skilled workers is crucial to understanding the skill composition between one city and another.

This paper studies skill complementarities within firms and their relationship with firm and city size. First, we used a simple theoretical framework to investigate the relationship between skill complementarities and firm size. We found that the within-firm skill complementarities increase with firm size if there exist knowledge spillovers. As a guidance for empirical studies, a labor mobility obstacle was added to the model and some of the firms were protected. The model revealed that those protected firms tend to employ more local unskilled labor as a substitute for high-skilled labor from other cities. Thus, the protected firms enjoy fewer skill complementarities, especially in the large cities where labor market institutions favor local residents more.

More importantly, we seek to provide micro-evidence for skill complementarities within firms. China's Second Economy Census (CSEC) data in 2008, which contains within-firm education composition of employees, was used to test the relationship between skill complementarities, firm size and city size. We obtained three major findings as follows: first, there exist complementarities between

workers with different skill levels, but only when the firm size exceeds a certain threshold, below which employees can be substituted. Broadly speaking, 32% of workers from the sample were employed by the firms with skill complementarities. Second, the state-owned-enterprises (SOEs),[2] which are more protected by the labor market institutions, enjoyed fewer skill complementarities, especially in the large cities, as the theoretical framework indicates. Third, large cities did not show stronger within-firms skill complementarities. However, after controlling for an index of Household Registration System (HRS), which hinders labor mobility and is usually stricter in large cities, the scale threshold for within-firm skill complementarities became lower in large cities. In other words, labor mobility barriers undermine the efficiency of labor distribution and the development of large cities.

The rest of this study is organized as follows: Section 2 reviews the related literature; Section 3 presents a theoretical model to investigate the relationship between skill complementarities, firm size and city size, and sets up two testable hypotheses; Section 4 constructs the econometric models to test the hypotheses; Section 5 introduces the data we use in the empirical analysis; Section 6 and 7 report the empirical results including the heterogeneities of skill complementarities; Section 8 presents the conclusions of this research.

II. Literature Review

Skill complementarity is a relationship between workers with different skills, if they can mutually improve each other's productivity. In other words, skill complementarity exists if the marginal productivity of highly skilled workers depends on the quantity of low-skilled ones in a positive way and, similarly, the marginal productivity of low-skilled workers depends positively on the quantity of highly skilled ones. Otherwise, the high- and low-skilled workers may be seen as substitutes if one group's

productivity depends negatively on the quantity of workers in another group. Given the number of workers, if there exists a complementary relationship between workers of different skills, the firms will gain productivity by employing a mixture of both high- and low-skilled workers.

Skill complementarity is one of the sources of agglomeration effects in urban development. It results mainly from two channels: specialization and knowledge spillover. Knowledge spillover has attracted much scholarly attention (Marshall, 1890; Duranton and Puga, 2004; Rosenthan and Strange, 2004; Moretti, 2011). In theory, the communication and interaction between workers induce knowledge and improve productivity (Fujita and Ogawa, 1982; Lucas and Rossi-Hansberg, 2002). In empirics, wages and production are used to identify knowledge spillover indirectly because it is difficult to identify the existence of knowledge spillover, which cannot be observed directly. However, the study by Jaffe et al. (1993) is an exception. They used patent citations to measure knowledge flows and found them to be highly geographically localized: citations were five to ten times as likely to come from the same Standard Metropolitan Statistical Area (SMSA), which reflected the pre-existing concentration of related research activity. Additionally, they were three to four times as likely to come from the same state as the originating patents. Papers by Jaffe (1989) and Acs et al. (1992) identified knowledge spillover in a similar way. Innovation has also been used as an indicator to reflect the presence of knowledge spillover. Audretsch and Feldman (1996) studied agglomeration of innovation in firms. They regressed the indicator of innovation agglomeration on the industry-level variables, such as the share of skilled workers with industry employment and university expenditures on research relevant to industry, in order to investigate the source of knowledge spillover. They concluded that the knowledge-intensive industries were more likely to agglomerate, which is the result of knowledge spillover effect.

The existence of knowledge spillover means increasing knowledge not only increases one's own

wage but also contributes to increasing the wages of others. Knowledge spillover can also improve the marginal productivity of each worker within a firm and, consequently, the total production of the firm. Previous studies use two indicators to identify the existence of knowledge spillovers: one is wage (Rauch, 1993; Moretti, 2004a,b; Rosenthal and Strange, 2008); the other is the total production of firm (Moretti, 2004c; Greenstone et al., 2010). In our study, we use production as the indicator to identify knowledge spillover because wage does not necessarily reflect productivity.

The communication between workers in the firm is one mechanism to improve firm production. Charlot and Duranton (2004) used a unique survey data that recorded workplace communication of individual workers and found that workers tend to communicate more frequently in large cities, but the influence of this communication is limited. One reason behind this observation is that the survey data may only identify part of the total knowledge spillover. Serafinelli (2019) used the turnover of highly skilled workers to identify the effect of knowledge spillover on the productivity of firms located near other highly productive firms, but worker flows can only explain 10%–20% of the agglomeration advantage. The reason may be that the turnover of highly skilled workers between firms is scarce, and the turnover of highly skilled workers is more likely to be across regions; thus, the impact of knowledge spillover is constrained (Davis and Dingel, 2019). Even if the turnover of highly skilled workers led to knowledge spillover, it can only explain the knowledge spillover between but not within firms.

Based on this existing body of literature, our study formally tests whether larger firms enjoy greater positive interdependence of marginal productivity between workers of different skills. We observe the existence of complementary relationships between workers of different skills, but only when the firm size is larger than some threshold values and when the effect of knowledge spillover plays the dominant role, in comparison with the cost of communication.

We further investigate the relationship between city size and skill complementarity within firms. Large cities promote the growth of firms that enjoy knowledge spillover, but they also suffer from the congestion effect. Thus, it is difficult to predict a clear pattern about the effect of city size on skill complementarity within firms. The *Hukou* system, also known as the Household Registration System (HRS), provides a good quasi-natural experiment to test how city size and labor mobility barriers affect skill complementarity within firms.

The *Hukou* system was enacted to provide population statistics and to identify personal status since 1953, when the central government implemented a food rationing program to resolve the widespread problem of food shortages. The *Hukou* system can be viewed as the cornerstone of the Chinese industrialization process and the planned system by prohibiting the migration of workers from rural to urban areas. Economic reform initiated in the late 1970s not only released millions of rural laborers from agricultural production but also increased the demand for workers in the cities. As a result, more and more laborers migrated from rural to urban areas, which pushed the central and local governments to relax restrictions on rural-urban migration. Lots of reforms have since been instituted to relax the *Hukou* system, but these have only had only limited impact: "The *Hukou* system, directly and indirectly, continues to be a major wall in preventing China's rural population from settling in the city and in maintaining the rural-urban 'apartheid'" (Chan and Buckingham, 2008).

The *Hukou* system gives each Chinese citizen a registration identity (*Hukou*) designated as local or migrant, which is usually inherited from parents and is also usually hard to change. Workers who are identified as migrants (not local) do not enjoy equal opportunities in employment, wages, social security, children education and other public services (Chan and Buckingham, 2008; Fields and Song, 2013; Lu et al., 2013). The *Hukou* system increases the cost of interregional migration and hinders labor mobility,

and is usually stricter in large cities. Production in large cities benefits from strong economies of scale and is reliant on freedom in labor migration so as to form high population density to exert the advantages of agglomeration. However, the *Hukou* system restricts migration, hinders workers from migrating to more productive cities, resulting in restrictions to the large cities' sizes (Au and Henderson, 2006a, b) and causing the urban system to deviate from a core and periphery structural patterns (Bosker et al., 2012). However, existing studies have ignored the effect of *Hukou* on firm production. We found that after controlling for the *Hukou* index, the threshold values of firm size to the presence of skill complementarities decreases substantially. This adds a new evidence that cities only hurt themselves if they protect local workers by discriminating against migrants since migrants contribute to the cities through skill complementary relationships with native workers (Combes, et al., 2015), agglomeration effects (Combes, et al., 2015) and consumption (Liang and Lu, 2019; Olney, 2015). In developed countries that attract immigrants, this study has a general implication that restrictions imposed on immigration might hurt within-firm skill complementarities as a source of economic growth.

Our study is different from previous studies in two respects. First, we use firm-level census data, which contain education composition of employees to identify within-firm skill complementarities directly. Second, and based on the institutional background of China, we also test whether barriers to migration may undermine skill complementarities and consequently firms' productivity. To the best of our knowledge, this study is among the first studies using firm-level data to provide micro-evidence for skill complementarity and how it varies with firm and city size.

III. Theoretical Framework

In this section, we use a simple theoretical framework to guide our later empirical analyses. The relationship between skill complementarity, firm size and city size will be established. How labor

mobility barriers reduce skill complementarity will also be discussed.

3.1 Workers

Suppose the population in a city is N. There are two types of labor: local N^U and migrant N^M:

$$N = N^U + N^M. \tag{1}$$

To simplify the model, we assume that all local laborers only take jobs in the protected sector with high wages, and the low-wage jobs are filled by migrant laborers. For each type of labor, there are two types of workers: those who are defined as highly skilled and those who are low-skilled, denoted by subscripts, *H* and *L*, respectively:

$$\begin{aligned} N^U &= N_H^U + N_L^U \\ N^M &= N_H^M + N_L^M. \end{aligned} \tag{2}$$

3.2 Firms

There are two representative firms, G and P, which have the same production functions. To incorporate labor market distortion, we assume that firm G is under the protection of government, which means that the wage and the quantity of workers are set by the government. Here, we suppose the wage of highly skilled workers in firm G is $\overline{W}_H$, and the wage of low-skilled workers is $\overline{W}_L$; the quantity of workers is $\bar{n}_G$. Both wages are higher than the market competitive levels in the unprotected sector. Because the protected sector is required to favor the local residents, they have to spend a cost of $C(N)$ to employ *N* migrants. Larger cities have higher labor demand and attract more migrants, which means that the cost $C(N)$ increases with the city size. This assumption is consistent with the Chinese situation that larger cities have stricter discrimination against migrants. Therefore, firm G maximizes its profit.

We suppose the production function is in an expanded Cobb-Douglass format as follows:

$$\mathrm{F(n,k)} = N_H^{\delta} n^{\alpha} k^{1-\alpha}, \delta \geq 0; \text{where } \mathrm{n} = \{[N_H]^{\rho} + \beta[N_L]^{\rho}\}^{\frac{1}{\rho}}, 0 < \rho < 1, 0 < \beta < 1,$$

where n_H^{δ} represents the technology, a function of the number of high-skilled workers. Insert the formula of n into the production function, we obtain:

$$\mathrm{F}(N_H, N_L) = N_H^{\delta}\{[N_H]^{\rho} + \beta[N_L]^{\rho}\}^{\frac{\alpha}{\rho}} k^{1-\alpha}.$$

In this production function, the human capital externality within the firm is represented by n_H^{δ}. The greater the number of highly skilled workers and the externality parameter δ, the greater the human capital externality is. We assume that $\alpha > \rho$.[3] The substitution elasticity between workers of high- and low-skilled workers is $\frac{1}{1-\rho}$. In our model, we do not consider the unemployment in the city. All the workers who do not work in firm G can always be employed by firm P. Firm P can set their wage to clear the labor market.

3.3 Equilibrium

For firm G, the marginal product of highly skilled workers is higher than that of low-skilled ones, so it hires all the highly skilled local workers and does not hire any low-skilled migrants. Although the marginal product of highly skilled migrants is higher than low-skilled local workers, the firm has to spend the additional cost $C(N)$ to employ migrants. Thus, firm G needs to identify a trade-off between hiring highly skilled migrants or low-skilled local workers by solving the following maximization problem:

$$\underset{\{N_{HG}^R, N_{LG}^U\}}{Max} \; F(N_H, N_L) - \bar{W}_H(N_H^U + N_{HG}^R) - \bar{W}_L N_{LG}^U - C(N)N_{HG}^R$$

$$\text{s.t. } N_H^U + N_{HH}^R + N_{LG}^U = \bar{N}_G. \tag{3}$$

From the above assumption, all the highly skilled local workers, but no low-skilled migrants work in firm G, so the production function can be written as follows:

$$\mathrm{F}(N_H, N_L) = N_H^{\delta}\{[N_H]^{\rho} + \beta[N_L]^{\rho}\}^{\frac{1}{\rho}} = [N_H^U + N_{HG}^R]^{\delta}\{[N_H^U + N_{HG}^R]^{\rho} + \beta[N_{LG}^U]^{\rho}\}^{\frac{\alpha}{\rho}} k^{1-\alpha}.$$

[3] Katz and Murphy (1992) who estimates an elasticity of substitution between college and high school labor of about 1.4, which means that $\rho = 2/7$. In general, the labor income share in different countries is greater than ½, so we can suppose that $\alpha > \rho$, although in reality α is a little different from the labor income share.

(4)

According to (1)–(4), we can solve to obtain:

$$(\alpha+\delta)(n_H^U+n_{HG}^R)^{\rho-1}(n_{LG}^U)^{1-\rho}+\delta\beta(n_H^U+n_{HG}^R)^{-1}n_{LG}^U=\alpha\beta\frac{\bar{W}_H+C}{\bar{W}_L} \quad (5)$$

For the sake of analysis, we define the ratio of highly skilled workers in firm G as $\eta=(n_H^U+n_{HG}^R)/\bar{n}_G$. From this, we obtain:

$$(\alpha+\delta)(\tfrac{1-\eta}{\eta})^{1-\rho}+\delta\beta\frac{1-\eta}{\eta}=\alpha\beta\frac{\bar{W}_H+C}{\bar{W}_L}. \quad (6)$$

From (6), we can obtain η, which is a function of $(\bar{W}_H+C)/\bar{W}_L$, independent of the total labor demand in sector G.

3.4 Skill Complementarities, Firm Size and City Size

3.4.1 Skill complementarities and firm size

From the definition of skill complementarities in previous section, we can find that:

$$SC=\frac{\partial^2 F}{\partial N_H\partial N_L}=\alpha\beta\bar{n}_A^{\delta+\alpha-2}\eta^{\alpha+\delta-2}(\tfrac{1-\eta}{\eta})^{\rho-1}[1+\beta(\tfrac{1-\eta}{\eta})^{\rho}]^{\frac{\alpha-2\rho}{\rho}}\left\{\delta\left[1+\beta\left(\tfrac{1-\eta}{\eta}\right)^{\rho}\right]+(\alpha-\rho)\right\}k^{1-\alpha}.$$

Then, we can obtain:

$$\frac{\partial SC}{\partial k}=(1-\alpha)\alpha\beta\bar{n}_A^{\delta+\alpha-2}\eta^{\alpha+\delta-2}\left(\tfrac{1-\eta}{\eta}\right)^{\rho-1}\left[1+\beta\left(\tfrac{1-\eta}{\eta}\right)^{\rho}\right]^{\frac{\alpha-2\rho}{\rho}}\left\{\delta\left[1+\beta\left(\tfrac{1-\eta}{\eta}\right)^{\rho}\right]+(\alpha-\rho)\right\}k^{-\alpha} \quad (7)$$

As long as $\left\{\delta\left[1+\beta\left(\tfrac{1-\eta}{\eta}\right)^{\rho}\right]+(\alpha-\rho)\right\}>0$, then $\partial SC/\partial k>0$, which means that the within-firm skill complementarities will increase with the size of the firm. This inequality condition, $\delta>(\rho-\alpha)/\left[1+\beta\left(\tfrac{1-\eta}{\eta}\right)^{\rho}\right]$, is easy to satisfy because its right-hand side is less than $(\rho-\alpha)<0$. The intuition behind this is that if the human capital externality exists or the congestion effect is not strong enough, as the firm size increases, more highly skilled workers will be employed and the productivity of the low-skilled workers will be improved, in line with the definition of skill complementarities.

Furthermore, from the model setting, we know that $\alpha>\rho$, which means that even if there are very limited or no human capital externalities, as an extreme case when $\delta=0$, skill complementarities

will increase with the size of the firm. By definition, ρ is the parameter to denote the substitution between high- and low-skilled workers. A smaller ρ means lower substitution and greater specialization, so that skill complementarities increase with firm size.

3.4.2 Skill complementarities and city size

We conducted the analysis in two steps in order to identify the relationship between skill complementarities and city size.

First, based on equation (5), we analyzed how the ratio of highly skilled workers to the total number of workers in the firm, denoted by η, changed with the city population N. We obtained the following:

$$\frac{d\eta}{dN} = -\frac{\alpha\beta C'(N)\eta^2}{\bar{W}_L\left[(\alpha+\delta)(1-\rho)\left(\frac{1-\eta}{\eta}\right)^{-\rho}+\delta\beta\right]} < 0. \tag{8}$$

The ratio of highly skilled workers to the total number of workers in the firm, η, decreased with the city population. The intuition is that as the city population increases, the cost of employing migrants, $C(N)$, also increases. Given the marginal product difference, the firm would hire more low-skilled local workers to substitute highly skilled ones.

Second, we deduced how the skill complementarities would change with η:

$$\frac{\partial SC}{\partial \eta} = \underbrace{\alpha\beta\bar{n}_A^{\delta+\alpha-2}k^{1-\alpha}\eta^{\delta+\alpha-3}\left(\frac{1-\eta}{\eta}\right)^{\rho-1}\left[1+\beta\left(\frac{1-\eta}{\eta}\right)^{\rho}\right]^{\frac{\alpha-3\rho}{\rho}}}_{+} \cdot \{\left[1+\beta\left(\frac{1-\eta}{\eta}\right)^{\rho}\right]^2\delta^2$$
$$+\left[\left(\alpha+\frac{1-\alpha}{1-\eta}-2\right)\left(1+\beta\left(\frac{1-\eta}{\eta}\right)^{\rho}\right)+(\alpha-\rho)\frac{2-\eta}{1-\eta}\right]\delta+(\alpha-\rho)[\alpha+(\alpha-2$$
$$+\frac{1-\alpha-\rho}{1-\eta})(1+\beta\left(\frac{1-\eta}{\eta}\right)^{\rho})]\} \tag{9}$$

As long as δ is larger than some particular value, then $\partial SC/\partial\eta > 0$, which means that the within-firm skill complementarities will increase with the ratio of high skill. Combining (8) and (9), we obtain:

$$\frac{\partial SC}{\partial N} = \underbrace{\frac{\partial SC}{\partial \eta}}_{+}\underbrace{\frac{\partial \eta}{\partial N}}_{-} < 0. \tag{10}$$

Thus, we can infer that skill complementarities decrease with the city population under the labor market regulation. In a large city, the ratio of low-skilled workers in firm G would become greater, following which it would lose within-firm skill complementarities. This loss in productivity is a negative consequence of policies enacted to protect local workers. In contrast, since firm P is not regulated by the government, and as $C(N)$ is reduced to 0, its wage and employment is then determined by the relative productivity of the high- and low-skilled workers. Since the high-skilled workers' ratio in firm P rises with city size, it is expected to cause strong human capital externalities within the firm.

To conclude, protectionary measures for local workers may encourage firms to employ more low-skilled local workers as a substitute for highly skilled migrants and thus may reduce their skill complementarities and productivity.

IV. Econometric Model

In the empirical sections, we tested whether the productivity of high- and low-skilled workers is positively interdependent and how this interdependency changes with firm size and city size. Our econometric model was based on an extended production function. We divided labor into two groups, highly skilled and low-skilled; the highly skilled workers affected the marginal product of low-skilled workers and vice versa. We assumed the production function to be $Y = A \cdot F(K, H, L, H \cdot L)$.

Whether the high- and low-skilled workers are substitutes or complementarities is described by the following formula, which describes the dependence of one group's productivity on another group's number of employees:

$$\frac{\partial(\partial Y/\partial L)}{\partial H} = \frac{\partial(\partial Y/\partial H)}{\partial L} = \frac{\partial^2 Y}{\partial H \partial L} = \theta.$$

If θ is negative, high- and low-skilled workers can be substitutes; otherwise, they are complementary. As the theoretical model predicts, skill complementarities may depend on the scale of

firms, so we obtain:

$$\frac{\partial^2 Y}{\partial H \partial L} = \theta_1 + \theta_2 Scale.$$

If $\theta_2 > 0$, then the larger firms enjoy greater skill complementarities. If $\theta_1 < 0$, but $\theta_2 > 0$, the skill complementarities exist only when the scale of firms exceeds a certain critical value: θ_1/θ_2. Otherwise, workers of different skills can be substitutes in small firms. Therefore, we set up the econometric model as follows:

$$\begin{aligned} lny_i = \beta_1 + \beta_2 \ln capital_i + \beta_3 lnhigh_i + \beta_4 lnmiddle_i + \beta_5 lnlow_i + \beta_6 \ln capital_i \cdot lnhigh_i \\ + \beta_7 \ln capital_i \cdot lnlow_i + \beta_8 lnhigh_i \cdot lnlow_i \\ + \beta_9 \ln capital_i \cdot lnhigh_i \cdot lnlow_i + \varepsilon_{i,} \end{aligned} \tag{11}$$

where y_i is the annual sales revenue of firm i; $capital_i$ is the reported total assets of firm i; $high_i$ and low_i represent the quantity of high- and low-skilled workers, respectively, while $middle_i$ denotes middle-skilled workers if they have educational level between high and low skills. To make sure that our findings were robust, we ran the model repeatedly with different definitions of skill, which are listed in Table 3.

The sign of β_8 demonstrates the relationship between workers of different skills: a positive coefficient indicates that the high- and low-skilled workers will improve the marginal product of each other, i.e. there exist complementarities between high- and low-skilled workers; a negative coefficient indicates a substitution relationship between the two groups.

In general, for large firms, the incremental heterogeneity of workers results in increase to the cost of communication. At the same time, their division of labor is deep by assigning workers of different skills in different positions. More importantly, worker diversity promotes knowledge spillovers. Skill complementarities exist within firms when labor specialization and knowledge spillovers are strong

enough to offset the cost of communication (Fujita and Ogawa, 1982; Lucas and Rossi-Hansberg, 2002). Therefore, we interacted the variables of highly skilled workers, low-skilled workers and firm size to form a triple interaction term whose coefficient, β_9, was expected to be positive.

In the regression model, if both β_8 and β_9 were to be positive, then we could determine that skill complementarities exist and that they are promoted by firm size. If β_8 was found to be negative, but β_9 was positive, then the complementary relationship would only exist when the firm size exceeds some critical value.

Under the conditions of free labor mobility, when the population of a city increases, the labor market becomes thicker and the matching between worker and firm improves (Helsley and Strange, 1990; Harmon, 2013). This not only helps the labor force to more easily find jobs (Wheeler, 2008) but also enables workers to find better-matched jobs (Jovanovic, 1979; Petronogolo and Pissariders, 2006; Bleakley and Lin, 2012; Harmon, 2013) and increases wages (Harmon, 2013). In a word, when the size of a city increases, the labor market pooling and the knowledge spillover effect promote complementarities between workers of different skill levels.

However, during China's urbanization, the migration of laborers is controlled by the *Hukou* system, which has not only depressed city sizes – especially the bigger cities (Au and Henderson, 2006a, b) – but also impacted the destination of migrating workers and affected the skill composition of workers employed by firms. Fields and Song (2013) concluded that SOEs, which enjoy state protection, prefer to employ the workers with local *Hukou*. Meng (2012) found that the percentage of migrants employed by SOEs to be only 7.3% of total employment, but the proportion of workers who have local *Hukou* is 49.4% of the total. In our theoretical model, firm G (a Chinese SOE) is regulated by the government and should pay for additional costs to employ migrants at the expense of $C(N)$. In a large city, the

increased costs to employ migrants result in a higher ratio of low-skilled workers in the SOE, compared to non-SOE, the unregulated sector. As a result, large city SOEs are predicted to hire too many local low-skilled workers under the *Hukou* system, and therefore, lose the complementarities between workers of different skill levels.

Therefore, we have added the city level variables to equation (1) and interact the high- and low-skilled workers with the city variables:

$$lny_i = \beta_1 + \beta_2 \ln capital_i + \beta_3 lnhigh_i + \beta_4 lnmiddle_i + \beta_5 lnlow_i + \beta_6 \ln capital_i \cdot lnhigh_i + \beta_7 \ln capital_i \cdot lnlow_i + \beta_8 lnhigh_i \cdot lnlow_i + \beta_9 \ln capital_i \cdot lnhigh_i \cdot lnlow_i + \beta_{10} lncity_i + \beta_{11} lnhigh_i \cdot lncity_i + \beta_{12} lnlow_i \cdot lncity_i + \beta_{13} lnhigh_i \cdot lnlow_i \cdot lncity_i + \varepsilon_i, \quad (12)$$

where $lncity_i$ is a vector of city level variables. Of concern here is the change of threshold value of capital to have positive skill complementarities after controlling for the city level variables. When the size of city increases, the labor market pooling and the knowledge spillover effects would promote skill complementarities within firms, so we expect the critical value to decrease.

However, larger cities usually enact stricter local-biased policies under the *Hukou* system to protect local workers, a condition that encourages regulated firms to employ local low-skilled workers in lieu of highly skilled migrants, which leads to reductions in within-firm skill complementarities. If this is not considered, within-firm skill complementarities in larger cities would be underestimated. To avoid this bias, we constructed a variable to measure the strictness of the *Hukou* system at the city level. We expected that this *Hukou* index and its interaction between high- and low-skilled labors would have a negative sign, indicating restrictions to the labor inflow hindering skill complementarities. However, after controlling for this triple interaction term, the interaction terms between city size and the quantity

of high- and low-skilled workers will have a greater positive coefficient, indicating that larger cities should have stronger within-firm skill complementarities, if there are no restrictions on labor inflow.

V. Data Description

For the empirical analysis, we used firm-level data of the China Second Economy Census (CSEC) from 2008. The 2008 CSEC covers all of the economic units such as government agencies, enterprises, and self-employed businesses in the tertiary industry. It contains 19 one-digit industries, 90 two-digit industries of, 378 three-digit industries and 875 four-digit industries. The data provide firm-level observations on a wide range of economic and accounting information, including industry, registration type, capital structure, and so on, that reflect the nature of firms; the time of establishment, the operating status, and so on that reflect the status of firms, as well as the balance indicator, profit and loss indicators, etc. that reflect the accounting status of firms. The data we used comprise about 5 million observations. The most valuable information for this study is, in addition to the total number of workers of each firm, the number of workers of different educational levels, which we used to estimate the relationship between workers of different skills.

Since we focused on the relationship between workers in firms, we chose to eliminate samples from government agencies. We constructed the ownership status variable based on two indicators in the data: registration status and capital structure. We report the results using both measurements.

There are five types of educational background present in the data: graduate and above, undergraduate, college, senior middle school, junior middle school and less. For this study, we defined workers with 'graduate and above' and 'undergraduate' as the highly skilled workers, 'college' and 'high school' as middle-skilled workers and 'middle school' and 'less' as low-skilled workers. We also considered other definitions of skill in order to avoid possible impacts caused by limitations to the

definition of skill and compared the differences among them. Additionally, we found zero values of workers with one or more types of skill groups in the firms; we also compared the results, including and excluding those samples with zeroes. The statistical descriptions of the data are listed in Table 1.

『Insert Table 1 here』

From the theoretical framework, we predicted that some differences in the ratio of workers of different skill levels. Because in China, SOEs are the protected and regulated sector, we showed the ratio of highly skilled and low-skilled workers by ownership based on the registration type in Table 2. We observe that the SOEs have 0.9% fewer highly skilled workers than non-SOEs, 1.7% fewer middle-skilled workers and 2.7% more low-skilled workers.

『Insert Table 2 here』

We were also interested in the skill composition difference between SOEs and non-SOEs in different sized cities. We divided the whole samples into three groups according to the cities' populations, and then calculated the mean of the ratio of highly skilled workers in SOEs and non-SOEs. The results are reported in Table 3.

『Insert Table 3 here』

From Table 3, we see that the ratios of highly skilled workers in SOEs are 8.724%, 18.282% and 19.622% in small, medium and large cities, respectively; in non-SOEs the corresponding ratios are 7.808%, 17.821% and 20.282%. As a general rule, the ratios increase with city size. The last column lists the differences in the mean values, which are significant at the 1% level. In small- and medium-sized cities, the share of highly skilled workers in the SOEs is higher than non-SOEs by 0.916 and 0.421 percentage points, respectively. In large cities, however, the ratio in SOEs is less than in non-SOEs by 0.28 percentage points.

From the observed differences in the ratio of highly skilled workers in SOEs and non-SOEs in

different cities, we can conclude that SOEs will hire fewer highly skilled workers in large cities where SOEs are required to protect local workers. This finding is in line with the theoretical prediction in the previous section. Another implication of the result is that SOEs will substitute highly skilled migrants with more low-skilled local workers. This loss in skill complementarities is tested in the following sections.

VI. Empirical Results

6.1 Baseline Regressions

Table 4 reports the baseline regressions for skill complementarities within firms. Different estimations use different definitions of high-, middle- and low- skilled workers. All of the regressions control for the city and four-digit industry fixed effects. In columns 1−3, we divided the workers into two groups. All of the interaction terms of high- and low-skilled workers have negative coefficients and are statistically significant at the 1% level, which means that skill complementarities are not present in small firms. However, all of the coefficients of the interaction terms of highly skilled workers, low-skilled workers and firm size, measured by total capital of the firm, are positive. This means that the skill complementarities within firms appear when the scale of the firms exceeds some threshold value. With the coefficients of the interaction terms, we calculated the threshold values for skill complementarities, which are 12.773, 14.497 and 14.659 for models in the first three columns, respectively. We also calculated the proportion of firms whose scale is larger than the threshold value. The percentage is 0.324, 0.000 and 0.000 for models in the first three columns, respectively. As a whole, the percentage is so small that almost no skill complementarity exists within these firms. The firms whose sizes are larger than the threshold value have more workers, so we also calculated the percentage of workers who enjoy skill complementarities within the firms at 4.583, 0.000 and 0.000, respectively.

The differences in threshold value from column 1 to column 3 may be ascribed to two reasons: firm characteristics (such as ownership, etc.) and industry and the definition of high-, middle-, and low-skilled workers. Since college graduates and high school graduates may have similar years of education, but are divided into two different skill groups, this may result in fewer skill complementarities within firms. To avoid this problem, we divided the workers into three groups from column 4 and constructed the interaction terms only using high- and low-skilled workers. In column 4, we categorized high school as a medium-skilled workers group. In column 5, we added college into the medium-skilled workers group. In column 6, we added undergraduate into the medium-skilled workers. After these adjustments were made, we found that the coefficients of the interaction terms between high- and low-skilled workers all became negative and statistically significant at the 1% percent level, but the coefficients of triple interaction terms between high- and low-skilled workers and firm size all remained positive and statistically significant at the 1% level. The threshold values were 13.308, 12.254 and 11.285, and the percentages of firms whose scale is larger than the threshold values were 0.000, 0.628 and 1.776, respectively. The corresponding percentages of workers in these firms were 0.000, 8.252 and 19.630, respectively. Similarly, we added the high school graduates to the low-skilled group and change the definition of highly skilled correspondingly in columns 7 and 8. Again, we found that the skill complementarities only exist when the scale of firms becomes larger than some threshold value.

『Insert Table 4 here』

When the number of workers in one skill group equals zero, it may mean that the firms do not have a need for this particular skill group, or that this skill group may be substituted by workers of another skill level. Therefore, when we did not use the samples in which some skill group is null – usually no college graduates – the threshold values for skill complementarities may decrease, which

means skill complementarities were more likely to exist. The results are reported in Table 5. We can find that the coefficients of double interaction terms were all significantly negative, while the coefficients of triple interaction terms were all significantly positive. We report the changes of threshold values for skill complementarities under each circumstance in Table 6. In most of the situations, the threshold values decreased, as expected, although not much. Therefore, in all the following regressions, we included the samples with zero values and defined the workers with at least a bachelor's degree as highly skilled, and the workers with less than high school diplomas as low-skilled.

『Insert Table 5, and 6 here』

6.2 Regressions by City

When the city size increases, the labor market becomes thicker, and the matching between workers and firms is predicted to improve (Helsley and Strange, 1990; Harmon, 2013). This not only helps the labor force to more easily to find jobs (Wheeler, 2008) but it also enables workers to find better jobs (Jovanovic, 1979; Petronogolo and Pissariders, 2006; Bleakley and Lin, 2012; Harmon, 2013), and increase wages (Harmon, 2013). Additionally, the workers of the firm would be better matched and promote skill complementarities within firms. Therefore, we divided the cities into three groups according to their population, and then ran the regression for Equation (1) for each group separately. The results are shown in Table 7. As above, the coefficients of double interaction terms were all statistically negative, while the coefficients of triple interaction terms were all significantly positive. The threshold values for skill complementarities were almost the same in the small and medium cities, but much higher in large cities, a finding which seems inconsistent with theory(Eeckhout et al., 2014) . Before exploring the situation in the large cities, we calculated the percentage of firms which are larger than the threshold value and the percentage of workers in these firms. The percentages of firms that are larger than the threshold value in the small and medium cities were 0.917 and 1.325, respectively.

The corresponding percentages of workers were 11.365 and 16.739, respectively. However, for the large cities, the percentage of firms with skill complementarities decreased to only 0.755, and the percentage of workers was 10.542, smaller than that in the small and medium-sized cities. These results suggest that the large cities do not in fact have greater skill complementarities within firms. According to the theoretical model, there must be some institutional barriers hindering labor mobility, and thus reducing skill complementarities within firms in China's large cities, considerations that motivated us to conduct the following analysis.

『Insert Table 7 here』

6.3 Regression by Ownership of Firms

In China, firm ownership matters. National policy dictates that SOEs enjoy many structural or economic privileges, such as low-interest loans and special preference for government procurement. In the labor market, policy specific to SOEs encourages the hiring of more local workers rather than migrants (Fields and Song, 2013). According to the above theoretical analysis, protected firms would substitute migrants by employing more local workers at the expense of skill complementarities. There are two primary ways to distinguish SOE from non-SOE: register status and capital structure. Table 8 reports the results using these two definitions of ownership. We found that the coefficients of double interaction terms were all significantly negative, while the coefficients of triple interaction terms remained significantly positive. When using register status to define ownership, the threshold values of SOE and non-SOE were 14.085 and 12.222, respectively. The corresponding percentages of firms having skill complementarities were 0.032 and 2.482, respectively; the percentages of workers were 0.168 and 14.558, respectively. There were no skill complementarities in SOEs when using capital structure to define ownership. These comparisons support the hypothesis that SOEs are more likely to hire local workers and have a higher ratio of low-skilled workers and, as a result, SOEs lose within-firm

skill complementarities.

『Insert Table 8 here』

Although heterogeneity of skill complementarities exists in firms of different ownership and in cities of different size, we wanted to know whether heterogeneity exists if we ran regressions using sub-samples in different ownership types and in different groups of cities. To do so, we first divided the cities into three groups and then categorized samples as SOEs and non-SOEs. The regression results are reported in Tables 9 and 10. Table 11 reports the threshold values and the corresponding percentages of firms and workers that enjoy skill complementarities. We found that the threshold values in SOEs were always larger than non-SOEs in each group. This result suggests that SOEs are less likely to see skill complementarities within firms, especially in the larger cities. The institutional reasons behind this finding are investigated in the next section.

『Insert Table 9, 10, and 11 here』

VII. Labor Market Discrimination Limits Within-firm Skill Complementarities: The *Hukou* System as a Quasi-Natural Experiment

As the above results show, SOEs are less likely to enjoy skill complementarities within firms, especially in the larger cities. The model we built tells us that labor market protection enjoin the favored enterprises to employ more local unskilled workers to substitute skilled migrants, leading to reductions in skill complementarities. The *Hukou* system that hinders labor mobility across regions constitutes a quasi-natural experiment of labor market discrimination against migrants. We hypothesize that, after controlling for a measure of the effectiveness of *Hukou* system, the skill complementarities in large cities will increase, especially in SOEs.

7.1 Regressions by City

The *Hukou* system does not restrict migration equally across the cities. Usually, large cities have a much more restrictive *Hukou* system for the migrants who wish to change their household registration to local. Wu and Zhang (2010) made great efforts to construct an index of *Hukou* threshold for 45 cities by applying the projection pursuit model as well as the techniques of factor analysis and cluster analysis. The index is a measurement of the difficulty to obtain local urban *Hukou* through four channels: investment, job status, family reunion and major contribution to the local city. The higher the index is, the more restrictive the *Hukou* system is. The results, after controlling for the *Hukou* index and its interaction with the number of high- and low-skilled workers, are reported in Table 12. As expected, the coefficients of the triple-interaction terms between highly skilled workers, low-skilled workers and the *Hukou* index were all significantly negative. This means the *Hukou* system depresses the skill complementarities within firms. After controlling for the *Hukou* index, the coefficients of double interaction between high- and low- skilled workers were all found to be negative, while the triple interaction terms with firm size were all positive and statistically significant at the 1% level. Similarly, we calculated the percentage of firms whose sizes were larger than the threshold values for skill complementarities. We found that the percentage of firms that enjoy skill complementarities in small, medium and large cities to be 9.870, 11.993 and 10.408, respectively. The percentage in the larger cities was a little smaller than that in the medium cities, but larger than that in the small cities. Furthermore, we also found all the percentages of workers in these firms to be larger than corresponding results in Section 6 without controlling for the *Hukou* index. Therefore, we can conclude that the *Hukou* system has depressed the skill complementarities within firms.

『Insert Table 12 here』

The *Hukou* index itself may contain the factors that affect the skill complementarities within firms,

such as city population. To avoid this problem, we regressed the *Hukou* index on the city population, then used the residuals to form a new *Hukou* index, denoted as *Hukou2*, which was not correlated with city population. The regression results using *Hukou2* are presented in the Appendix, but we make a comparison in Table 13. After controlling for the *Hukou* index, we can see that the threshold values were all lower, to some extent, and the percentage of firms and workers which enjoy skill complementarities were all increased, correspondingly.

『Insert Table 13 here』

7.2 Regressions by Ownership of Firms

The *Hukou* system mainly protects SOEs, encourages them to employ more low-skilled local workers and hinders their skill complementarities. The results of regressions by ownership of firms are reported in Table 14. We find that after controlling for the *Hukou* index, the coefficients of the double interaction terms between high- and low-skilled workers were all negative, while the coefficients of triple interaction terms with firm size were all positive and statistically significant at the 1% level. As expected, all the coefficients of interaction among highly skilled workers, low-skilled workers and the *Hukou* index were again negative and significant at least at the 5% level. Similarly, we calculated the percentage of firms whose size was larger than the threshold values and the percentage of workers in these firms. We found that the threshold values were 12.092 and 10.581 for SOEs and non-SOEs, respectively; the percentages of firms were 4.001 and 12.263, respectively, and the percentages of workers were 22.308 and 49.523, respectively. This shows that there are more skill complementarities within firms after controlling for the *Hukou* index. Similar results are also presented using the ownership definition by capital structure.

『Insert Table 14 here』

As before, we compare the results containing the *Hukou* index and *Hukou2* in Table 15. We again found that, after controlling for these *Hukou* indexes, more firms enjoy skill complementarities within firms.

『Insert Table 15 here』

7.3 Regressions by Ownership of Firms and City Size

Based on the previous two sub-sections, we hypothesized that the change in percentages of firms and workers that enjoy skill complementarities should be greater for SOEs relative to non-SOEs. To test this, we ran regressions by firm ownership and city size. The results, based on the definition of registered ownership status, are presented in Table 16. The comparisons between the results before and after controlling for the *Hukou* index are listed in Table 17. The signs of coefficients are similar to previous results: thresholds for skill complementarities within firms decrease, especially for SOEs in the larger cities. The results based on the ownership definition by capital structure are similar, though the SOEs still do not enjoy any skill complementarities after controlling for the *Hukou* index. The reason may be that all 45 large cities with a *Hukou* index may be subject to other unobserved institutional barriers against migrant workers.

『Insert Table 16-19 here』

VIII. Conclusions

This study builds a model of skill complementarities within firms. Larger firms may enjoy stronger skill complementarities. However, when migration is hindered, protected firms tend to employ more local unskilled workers, undermining skill complementarities within the firms.

We also provide evidence to test the relationship between skill complementarities, firm size and city size. Using firm-level micro-data from the 2008 China Economy Census, we found the following

empirical results: First, skill complementarities within firms exist only when the scale of firm exceeds some threshold value. Second, the skill complementarities demonstrate vast heterogeneity between firm ownership and city size. Specifically, the threshold value for skill complementarities is larger in SOEs than in other firms, which means that the skill complementarities are less likely to exist in SOEs. Third, the threshold values of firm size to have skill complementarities increases with city size, showing that large cities in China do not necessarily enjoy stronger skill complementarities within firms.

However, using the quasi-natural experiment of the *Hukou* system in China, which hinders labor migration, especially in large cities, we found that, after controlling for the *Hukou* index, the threshold values of firm size to have skill complementarities decrease significantly. This indicates that the cities sacrifice skill complementarities if they want to protect local workers by discriminating against migrant laborers. However, the threshold values did not decrease with the city size, meaning that larger cities do not have stronger skill complementarities within firms.

Based on the findings of this study, we argue that free mobility of labor is necessary for firms, especially for large firms and in large cities, to enjoy skill complementarities within the firm. The findings also have general implications for cross-country migration and its effects on skill complementarities within firms. Our research findings can serve as a caution to policymakers that restricting migration may undermine firm-level productivity.

Table 1 Statistical Description

Variable	Obs	Mean	Std. Dev.	Min	Max
Sale	2473358	10060	51754	1	1684760
Capital	2473358	7998	44605	1	1375407
Worker	2473358	25.52	100.6	1	2352
High	2473358	2.845	16.40	0	2076
Middle	2473358	13.68	53.66	0	2300
Low	2473358	8.987	57.02	0	2310

Notes: Sale is the annual sale value of firms, units: thousand yuan; Capital is the capital value of the firms, units: thousand yuan; Worker is the number of workers in the firms; high, middle and low are high-, middle- and low-skilled workers in the firms respectively.

Table 2 Skill structure of worker' between different ownership

	Firm	Sample	Mean	Sd	Difference between Mean
High-skilled share	SOE	254840	13.670	24.266	**-0.972*****
	Non-SOE	2218518	14.642	25.864	
Mid-skilled share	SOE	254840	61.962	31.512	**-1.766*****
	Non-SOE	2218518	63.728	32.759	
Low-skilled share	SOE	254840	24.366	30.695	**2.738*****
	Non-SOE	2218518	21.630	30.742	

Notes: The high-skilled is defined as those who have bachelor degree; Mid-skilled defined as those who have the high school degree or vacation school degree; Low-skilled defined as those at most have the middle school degree; * $p <.10$, ** $p <.05$, *** $p <.01$.

Table 3 High-skilled percentage between firm of different city and ownership

City	firm	Sample	Mean	Sd	Difference between Mean
Small	SOE	132966	**8.724**	18.526	**0.916*****
	Non-SOE	883966	**7.808**	18.154	
Medium	SOE	50641	**18.282**	27.294	**0.421****
	Non-SOE	604321	**17.821**	27.445	
Large	SOE	71233	**19.622**	28.985	**-0.28*****
	Non-SOE	730231	**20.283**	30.221	

Notes: The high-skilled definition is the same as Table 2; Small: $\text{pop} \leq 1$ million; Medium: $1 < pop \leq 2$ million; Large: $2 \text{ million} < pop$; * $p <.10$, ** $p <.05$, *** $p <.01$.

Table 4 Benchmark Models [With Zero Values]

Lnsales	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lncapital	0.576***	0.567***	0.589***	0.560***	0.563***	0.563***	0.583***	0.606***
	(0.0266)	(0.0316)	(0.0318)	(0.0195)	(0.0163)	(0.0143)	(0.0222)	(0.0207)
Lnhigh	1.076***	0.970***	0.841***	0.578***	0.499***	0.475***	0.699***	0.644***
	(0.131)	(0.138)	(0.145)	(0.0760)	(0.0666)	(0.0768)	(0.0888)	(0.0894)
Lnmiddle				0.350***	0.490***	0.586***	0.318***	0.396***
				(0.0163)	(0.0214)	(0.0360)	(0.0223)	(0.0369)
Lnlow	1.602***	1.440***	1.334***	1.102***	0.978***	0.916***	1.098***	0.978***
	(0.165)	(0.123)	(0.116)	(0.133)	(0.115)	(0.107)	(0.0926)	(0.0892)
Lnhigh×Lnk	-0.0316**	-0.0175	-0.0144	-0.00912	-0.0175***	-0.0278***	-0.0177*	-0.0289***
	(0.0137)	(0.0166)	(0.0185)	(0.00847)	(0.00642)	(0.00643)	(0.0106)	(0.00840)
Lnlow×Lnk	-0.118***	-0.0815***	-0.0696***	-0.0858***	-0.0836***	-0.0819***	-0.0676***	-0.0671***
	(0.0174)	(0.0106)	(0.0109)	(0.0141)	(0.0124)	(0.0119)	(0.00859)	(0.00935)
Lnhigh×Lnlow	-0.456***	-0.461***	-0.387***	-0.350***	-0.348***	-0.448***	-0.385***	-0.426***
	(0.0485)	(0.0485)	(0.0509)	(0.0402)	(0.0403)	(0.0601)	(0.0399)	(0.0547)
Lnhigh×Low×Lnk	0.0357***	0.0318***	0.0264***	0.0263***	0.0284***	0.0397***	0.0267***	0.0331***
	(0.00410)	(0.00398)	(0.00443)	(0.00338)	(0.00346)	(0.00546)	(0.00301)	(0.00445)
Cons	0.439	0.408	0.191	1.042***	0.995***	0.876***	0.742***	0.737***
	(0.269)	(0.290)	(0.290)	(0.213)	(0.195)	(0.198)	(0.228)	(0.230)
N	2473358	2473358	2473358	2473358	2473358	2473358	2473358	2473358
adj. R^2	0.621	0.622	0.622	0.610	0.611	0.611	0.615	0.609
Threshold value	12.773	14.497	14.659	13.308	12.254	11.285	14.419	12.870
Percentage 1	0.324	0.000	0.000	0.000	0.628	1.776	0.000	0.285
Percentage 2	4.583	0.000	0.000	0.000	8.252	19.630	0.000	4.074

Notes: Standard errors clustered at city level are presented in parentheses,* $p <. 10$, ** $p <. 05$, *** $p <. 01$. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value. In column 1, the high-skilled workers include high school, college, undergraduate, graduate and above, the low-skilled workers include middle school and less. In column 2, the high-skilled workers include college, undergraduate, graduate and above, the low-skilled workers include high school, middle school and less. In column 3, the high-skilled workers include undergraduate, graduate and above, the low-skilled workers include college, high school, middle school and less.

Table 5 Benchmark Models [Without Zero Values]

Lnsales	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lncapital	0.639***	0.639***	0.616***	0.593***	0.607***	0.582***	0.607***	0.579***
	(0.0208)	(0.0252)	(0.0309)	(0.0266)	(0.0395)	(0.0268)	(0.0379)	(0.0303)
Lnhigh	0.820***	0.962***	1.017***	0.441***	0.540***	0.429***	0.697***	0.530***
	(0.0552)	(0.0741)	(0.0884)	(0.0415)	(0.0975)	(0.126)	(0.0654)	(0.114)
Lnmiddle				0.238***	0.346***	0.506***	0.265***	0.471***
				(0.00744)	(0.00987)	(0.0128)	(0.00808)	(0.0156)
Lnlow	1.289***	1.374***	1.266***	0.948***	0.862***	0.582***	0.926***	0.701***
	(0.0713)	(0.0882)	(0.0987)	(0.0452)	(0.0672)	(0.0585)	(0.0518)	(0.0494)
Lnhigh×Lnk	-0.0294***	-0.0322***	-0.0372***	-0.00819**	-0.0240**	-0.0292**	-0.0277***	-0.0309**
	(0.00425)	(0.00555)	(0.00547)	(0.00328)	(0.00928)	(0.0125)	(0.00668)	(0.0132)
Lnlow×Lnk	-0.0991***	-0.0850***	-0.0613***	-0.0699***	-0.0621***	-0.0409***	-0.0516***	-0.0391***
	(0.00673)	(0.00789)	(0.00833)	(0.00419)	(0.00670)	(0.00551)	(0.00514)	(0.00505)
Lnhigh×Lnlow	-0.259***	-0.340***	-0.332***	-0.188***	-0.218***	-0.190***	-0.248***	-0.229***
	(0.0217)	(0.0313)	(0.0389)	(0.0135)	(0.0231)	(0.0363)	(0.0172)	(0.0316)
Lnhigh×Low×Lnk	0.0216***	0.0248***	0.0225***	0.0144***	0.0168***	0.0148***	0.0169***	0.0158***
	(0.00177)	(0.00254)	(0.00293)	(0.00106)	(0.00204)	(0.00320)	(0.00135)	(0.00273)
Cons	0.705***	0.271	0.176	1.594***	1.371***	1.530***	1.102***	1.351***
	(0.234)	(0.253)	(0.304)	(0.253)	(0.365)	(0.277)	(0.336)	(0.282)
N	986978	1337757	879286	587939	281409	47480	577884	101117
adj. R^2	0.658	0.636	0.643	0.658	0.686	0.722	0.649	0.679
Threshold value	11.991	13.710	14.756	13.056	12.976	12.837	14.675	14.494
Percentage 1	1.232	0.0877	0.000	0.484	1.127	5.352	0.000	0.000
Percentage 2	12.25	0.999	0.000	3.929	5.662	16.833	0.000	0.000

Notes: Standard errors clustered at city level are presented in parentheses, $^{*}p<.10$, $^{**}p<.05$, $^{***}p<.01$. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals are larger than the threshold value.

Table 6 Comparison between results with and without zero value

	Low-skilled workers	Medium skilled workers	High-skilled workers	With zero value samples	Without Zero value samples
1	middle school and less		high school, college, undergraduate, graduate and above	12.77	11.06
2	middle school and less, high school		college, undergraduate, graduate and above	14.50	12.66
3	middle school and less, high school, college		undergraduate, graduate and above	14.66	13.61
4	middle school and less	high school	college, undergraduate, graduate and above	13.31	12.01
5	middle school and less	high school, college	undergraduate, graduate and above	12.25	12.73
6	middle school and less	high school, college, undergraduate	graduate and above	11.28	12.94
7	middle school and less, high school	College	undergraduate, graduate and above	14.42	14.00
8	middle school and less, high school	college, undergraduate	graduate and above	12.87	14.12

Table 7 Results for different cities

Lnsales	Small	Medium	Large
Lncapital	0.522***	0.541***	0.581***
	(0.0118)	(0.0114)	(0.0221)
Lnhigh	0.445***	0.434***	0.636***
	(0.0287)	(0.0411)	(0.100)
Lnmiddle	0.414***	0.412***	0.551***
	(0.0109)	(0.0241)	(0.0289)
Lnlow	0.587***	0.700***	1.221***
	(0.0339)	(0.0512)	(0.151)
Lnhigh×Lnk	-0.0279***	-0.0239***	-0.0275***
	(0.00372)	(0.00483)	(0.00986)
Lnlow×Lnk	-0.0447***	-0.0565***	-0.105***
	(0.00393)	(0.00527)	(0.0172)
Lnhigh×Lnlow	-0.219***	-0.262***	-0.444***
	(0.0142)	(0.0194)	(0.0514)
Lnhigh×Low×Lnk	0.0187***	0.0225***	0.0362***
	(0.00138)	(0.00164)	(0.00474)
cons	1.939***	1.676***	0.622**
	(0.104)	(0.160)	(0.231)
N	512733	504199	1456426
adj. R^2	0.655	0.634	0.598
Threshold value	11.711	11.644	12.265
Percentage 1	0.917	1.325	0.755
Percentage 2	11.365	16.739	10.542

Notes: Standard errors clustered at city level are presented in parentheses, * p <. 10, ** p <. 05, *** p <. 01. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Small: $\text{pop} \leq 1$ million; Medium: $1 < pop \leq$ 2 million; Large: $2 \text{ million} < pop$; Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 8 Results for different ownerships

Lnsales	All	Registration Status		Capital Structure	
	Sample	SOE	NonSOE	SOE	NonSOE
Lncapital	0.563***	0.458***	0.571***	0.477***	0.572***
	(0.0163)	(0.0139)	(0.0159)	(0.0152)	(0.0158)
Lnhigh	0.499***	0.437***	0.494***	0.446***	0.492***
	(0.0666)	(0.0305)	(0.0714)	(0.0280)	(0.0767)
Lnmiddle	0.490***	0.432***	0.501***	0.434***	0.504***
	(0.0214)	(0.00852)	(0.0233)	(0.00852)	(0.0245)
Lnlow	0.978***	0.555***	1.019***	0.560***	1.033***
	(0.115)	(0.0346)	(0.126)	(0.0372)	(0.132)
Lnhigh×Lnk	-0.0175***	-0.0111***	-0.0163**	-0.00961***	-0.0162**
	(0.00642)	(0.00360)	(0.00714)	(0.00344)	(0.00804)
Lnlow×Lnk	-0.0836***	-0.0360***	-0.0879***	-0.0365***	-0.0899***
	(0.0124)	(0.00389)	(0.0138)	(0.00414)	(0.0147)
Lnhigh×Lnlow	-0.348***	-0.200***	-0.374***	-0.200***	-0.386***
	(0.0403)	(0.0113)	(0.0454)	(0.0102)	(0.0496)
Lnhigh×Low×Lnk	0.0284***	0.0142***	0.0306***	0.0139***	0.0318***
	(0.00346)	(0.00106)	(0.00402)	(0.000950)	(0.00448)
Cons	0.995***	2.264***	0.871***	2.188***	0.843***
	(0.195)	(0.110)	(0.199)	(0.123)	(0.201)
N	2473358	195157	2278201	254840	2218518
adj. R^2	0.611	0.643	0.609	0.655	0.605
Threshold value	12.254	14.085	12.222	14.388	12.138
Percentage 1	0.628	0.032	2.482	0.000	0.414
Percentage 2	8.252	0.168	14.558	0.000	6.052

Notes: Standard errors clustered at city level are presented in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 9 Results for different cities and ownerships [Registration Status]

Lnsales	SOE			Non-SOE		
	Small	Medium	Large	Small	Medium	Large
Lncapital	0.445***	0.450***	0.471***	0.536***	0.553***	0.587***
	(0.0117)	(0.0161)	(0.0276)	(0.0132)	(0.0117)	(0.0211)
Lnhigh	0.517***	0.401***	0.501***	0.423***	0.441***	0.632***
	(0.0478)	(0.0610)	(0.0600)	(0.0319)	(0.0407)	(0.105)
Lnmiddle	0.429***	0.407***	0.449***	0.415***	0.419***	0.563***
	(0.0109)	(0.0188)	(0.0137)	(0.0119)	(0.0260)	(0.0312)
Lnlow	0.442***	0.494***	0.672***	0.606***	0.719***	1.262***
	(0.0271)	(0.0446)	(0.0575)	(0.0388)	(0.0540)	(0.164)
Lnhigh×Lnk	-0.0286***	-0.0139*	-0.0126*	-0.0268***	-0.0253***	-0.0266**
	(0.00529)	(0.00760)	(0.00655)	(0.00433)	(0.00486)	(0.0105)
Lnlow×Lnk	-0.0266***	-0.0315***	-0.0453***	-0.0470***	-0.0587***	-0.110***
	(0.00334)	(0.00484)	(0.00721)	(0.00448)	(0.00557)	(0.0191)
Lnhigh×Lnlow	-0.183***	-0.191***	-0.229***	-0.227***	-0.272***	-0.476***
	(0.0172)	(0.0227)	(0.0182)	(0.0172)	(0.0213)	(0.0564)
Lnhigh×Low×Lnk	0.0140***	0.0147***	0.0160***	0.0196***	0.0234***	0.0391***
	(0.00156)	(0.00227)	(0.00184)	(0.00168)	(0.00177)	(0.00537)
Cons	3.274***	2.794***	2.000***	1.579***	1.871***	0.518**
	(0.102)	(0.118)	(0.168)	(0.113)	(0.168)	(0.235)
N	62691	46288	86178	450042	457911	1370248
adj. R^2	0.656	0.639	0.643	0.657	0.635	0.595
Threshold value	13.071	12.993	14.313	11.582	11.624	12.174
Percentage 1	0.571	1.442	0.000	0.800	1.113	0.640
Percentage 2	3.466	8.590	0.000	11.226	15.078	9.565

Notes: Standard errors clustered at city level are presented in parentheses, * p <. 10, ** p <. 05, *** p <. 01. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Small: $pop \leq 1$ million; Medium: $1 < pop \leq 2$ million; Large: $2 \text{ million} < pop$; Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 10 Results for different cities and ownerships [Capital Structure]

Lnsales	SOE			Non-SOE		
	Small	Medium	Large	Small	Medium	Large
Lncapital	0.450***	0.480***	0.491***	0.540***	0.552***	0.588***
	(0.0109)	(0.0253)	(0.0279)	(0.0135)	(0.0117)	(0.0208)
Lnhigh	0.490***	0.464***	0.520***	0.433***	0.439***	0.635***
	(0.0392)	(0.0600)	(0.0601)	(0.0353)	(0.0396)	(0.111)
Lnmiddle	0.434***	0.406***	0.451***	0.413***	0.421***	0.567***
	(0.0109)	(0.0184)	(0.0130)	(0.0120)	(0.0267)	(0.0329)
Lnlow	0.427***	0.512***	0.669***	0.613***	0.722***	1.284***
	(0.0247)	(0.0492)	(0.0594)	(0.0396)	(0.0553)	(0.173)
Lnhigh×Lnk	-0.0250***	-0.0204**	-0.0118*	-0.0286***	-0.0255***	-0.0269**
	(0.00433)	(0.00813)	(0.00591)	(0.00492)	(0.00526)	(0.0114)
Lnlow×Lnk	-0.0247***	-0.0342***	-0.0451***	-0.0481***	-0.0593***	-0.112***
	(0.00296)	(0.00559)	(0.00721)	(0.00459)	(0.00579)	(0.0204)
Lnhigh×Lnlow	-0.178***	-0.197***	-0.226***	-0.230***	-0.278***	-0.495***
	(0.0151)	(0.0197)	(0.0161)	(0.0190)	(0.0222)	(0.0629)
Lnhigh×Low×Lnk	0.0134***	0.0154***	0.0154***	0.0201***	0.0241***	0.0410***
	(0.00132)	(0.00213)	(0.00166)	(0.00190)	(0.00185)	(0.00613)
Cons	2.739***	2.686***	1.964***	1.785***	2.323***	0.472*
	(0.0809)	(0.178)	(0.173)	(0.118)	(0.164)	(0.239)
N	75011	57955	121874	437722	446244	1334552
adj. R^2	0.667	0.651	0.656	0.653	0.632	0.589
Threshold value	13.284	12.792	14.675	11.443	11.535	12.073
Percentage 1	0.499	2.164	0.000	0.760	1.010	0.529
Percentage 2	3.334	12.927	0.000	10.916	13.846	7.823

Notes: Standard errors clustered at city level are presented in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Small: $pop \leq 1$ million; Medium: $1 < pop \leq 2$ million; Large: $2 \text{ million} < pop$; Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 11 Comparison of threshold values between the firm of different cities and

ownerships

		SOE			Non-SOE		
		Small	**Medium**	**Large**	**Small**	**Medium**	**Large**
Registration Status	Threshold value	13.071	12.993	14.313	11.582	11.624	12.174
	Percentage of firms	0.571	1.442	0.000	0.800	1.113	0.640
	Percentage of workers	3.466	8.590	0.000	11.226	15.078	9.565
Capital Structure	Threshold value	13.284	12.792	14.675	11.443	11.535	12.073
	Percentage of firms	0.499	2.164	0.000	0.760	1.010	0.529
	Percentage of workers	3.334	12.927	0.000	10.916	13.846	7.823

Notes: Percentage of firms is the percentage of firms whose capitals are greater than the threshold value, percentage of workers is the percentage of workers in the firms whose capitals are greater than the threshold value.

Table 12 Results for different cities [with *Hukou* Index]

Lnsale	Small	Medium	Large
Lncapital	0.515***	0.579***	0.584***
	(0.0291)	(0.0157)	(0.0332)
Lnhigh	0.297***	0.498***	0.406***
	(0.0829)	(0.0538)	(0.115)
Lnmiddle	0.581***	0.538***	0.572***
	(0.0750)	(0.0254)	(0.0482)
Lnlow	0.574***	0.875***	1.242***
	(0.105)	(0.0694)	(0.200)
Lnhigh×Lncapital	-0.0274***	-0.0357***	-0.0335*
	(0.00842)	(0.00401)	(0.0171)
Lnlow×Lncapital	-0.0607***	-0.0711***	-0.126***
	(0.0125)	(0.00640)	(0.0219)
Lnhigh×Lnlow	-0.228***	-0.331***	-0.434***
	(0.0425)	(0.0240)	(0.0700)
Lnhigh×Lnlow	0.0231***	0.0276***	0.0417***
×Lncapital	(0.00397)	(0.00228)	(0.00627)
Hukou	-0.449***	-0.153***	-0.426***
	(0.0701)	(0.0379)	(0.0422)
Lnlow×Hukou	0.316***	0.0381	0.0830*
	(0.0513)	(0.0284)	(0.0385)
Lnhigh×Hukou	0.332***	0.108***	0.167***
	(0.0478)	(0.0298)	(0.0442)
Lnhigh×Lnlow×Hukou	-0.0974***	-0.0161**	-0.0340*
	(0.0143)	(0.00618)	(0.0172)
Cons	1.497***	0.913***	1.681***
	(0.387)	(0.159)	(0.283)
N	103827	528110	801464
adj. R^2	0.629	0.599	0.589
Threshold value	9.870	11.993	10.408
Percentage 1	7.04	0.964	4.237
Percentage 2	45.051	13.456	35.422

Notes: Standard errors clustered at city level are presented in parentheses, * p <. 10, ** p <. 05, *** p <. 01. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Small: $pop \leq 1$ million; Medium: $1 < pop \leq 2$ million; Large: $2 \text{ million} < pop$; Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 13 Comparison of threshold values for skill complementarities between firms across cities

City size		Small	Medium	Large
Threshold value	Without control Hukou	12.857	12.810	12.249
	Control Hukou 1	9.870	11.993	10.408
	Control Hukou 2	12.756	12.563	11.611
Percentage of firms	Without control Hukou	0.316	0.362	0.771
	Control Hukou 1	7.04	0.964	4.237
	Control Hukou 2	0.367	0.499	1.461
Percentage of workers	Without control Hukou	3.947	5.707	10.781
	Control Hukou 1	45.051	13.456	35.422
	Control Hukou 2	4.497	7.624	17.872

Notes: *Hukou1* is the *Hukou* index quoted from Wu and Zhang (2010) for 45 cities, *Hukou2* is the residuals of regression of *Hukou1* on city population.

Table 14 Results for firm of different ownerships

Lnsales	All	Registration Status		Capital Structure	
	Sample	SOE	NonSOE	SOE	NonSOE
Lncapital	0.577***	0.468***	0.584***	0.490***	0.585***
	(0.0212)	(0.0279)	(0.0202)	(0.0298)	(0.0198)
Lnhigh	0.424***	0.355***	0.426***	0.366***	0.430***
	(0.0544)	(0.0526)	(0.0573)	(0.0540)	(0.0608)
Lnmiddle	0.559***	0.450***	0.571***	0.451***	0.575***
	(0.0282)	(0.0147)	(0.0305)	(0.0139)	(0.0323)
Lnlow	1.090***	0.575***	1.137***	0.568***	1.157***
	(0.158)	(0.0449)	(0.176)	(0.0466)	(0.188)
Lnhigh×Lncapital	-0.0331***	-0.0131*	-0.0334***	-0.0150**	-0.0341***
	(0.0103)	(0.00721)	(0.0109)	(0.00700)	(0.0116)
Lnlow×Lncapital	-0.106***	-0.0449***	-0.110***	-0.0455***	-0.112***
	(0.0183)	(0.00638)	(0.0203)	(0.00622)	(0.0217)
Lnhigh×Lnlow	-0.385***	-0.185***	-0.419***	-0.181***	-0.438***
	(0.0471)	(0.0169)	(0.0538)	(0.0140)	(0.0620)
Lnhigh×Lnlow	0.0363***	0.0153***	0.0396***	0.0152***	0.0417***
×Lncapital	(0.00494)	(0.00172)	(0.00566)	(0.00154)	(0.00651)
Hukou	-0.335***	-0.193***	-0.142***	-0.180***	-0.141***
	(0.0261)	(0.0289)	(0.0409)	(0.0288)	(0.0411)
Lnlow×Hukou	0.0851***	0.0644***	0.0823***	0.0685***	0.0821**
	(0.0269)	(0.00870)	(0.0294)	(0.00852)	(0.0308)
Lnhigh×Hukou	0.158***	0.107***	0.159***	0.122***	0.159***
	(0.0340)	(0.0272)	(0.0347)	(0.0245)	(0.0350)
Lnhigh×Lnlow×Hukou	-0.0359***	-0.0242***	-0.0359***	-0.0270***	-0.0366**
	(0.0121)	(0.00502)	(0.0132)	(0.00478)	(0.0139)
Cons	1.423***	2.446***	0.843***	2.326***	0.800***
	(0.190)	(0.147)	(0.175)	(0.153)	(0.181)
N	1433401	85857	1347544	120654	1312747
adj. R^2	0.597	0.646	0.593	0.658	0.587
Threshold value	10.606	12.092	10.581	11.908	10.504
Percentage 1	3.631	4.001	12.263	5.699	2.902
Percentage 2	32.613	22.308	49.523	28.960	27.568

Notes: Standard errors clustered at city level are presented in parentheses, * $p < .10$, ** $p < .05$, *** $p < .01$. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 15 Comparison of threshold values for skill complementarities between firms of different ownerships

		All Sample	Registration Status		Capital Structure	
			SOE	NonSOE	SOE	NonSOE
Threshold value	Without control Hukou	12.314	14.600	12.208	14.932	12.101
	Control Hukou 1	10.606	12.092	10.581	11.908	10.504
	Control Hukou 2	11.831	13.961	11.729	13.987	11.623
Percentage of firms	Without control Hukou	0.693	0.000	3.655	0.000	0.518
	Control Hukou 1	3.631	4.001	12.263	5.699	2.902
	Control Hukou 2	1.157	0.161	5.394	0.157	0.902
Percentage of workers	Without control Hukou	9.796	0.000	20.719	0.000	7.668
	Control Hukou 1	32.613	22.308	49.523	28.960	27.568
	Control Hukou 2	14.817	1.029	28.130	0.996	12.283

Note: *Hukou1* is the *Hukou* index quoted from Wu and Zhang (2010) for 45 cities, *Hukou2* is the residuals of regression of *Hukou1* on city population.

Table 16 Results for different cities and ownerships [registration status]

Lnsales	SOE			Non-SOE		
	Small	Medium	Large	Small	Medium	Large
Lncapital	0.397***	0.472***	0.472***	0.525***	0.583***	0.592***
	(0.0245)	(0.0232)	(0.0453)	(0.0315)	(0.0159)	(0.0312)
Lnhigh	0.133	0.429***	0.336***	0.311***	0.497***	0.411***
	(0.156)	(0.0715)	(0.0819)	(0.0755)	(0.0537)	(0.120)
Lnmiddle	0.470***	0.426***	0.463***	0.598***	0.548***	0.584***
	(0.0559)	(0.0233)	(0.0192)	(0.0772)	(0.0254)	(0.0529)
Lnlow	0.306**	0.585***	0.593***	0.592***	0.892***	1.307***
	(0.104)	(0.0659)	(0.0631)	(0.116)	(0.0720)	(0.221)
Lnhigh×Lncapital	-0.00491	-0.0203**	-0.00851	-0.0291***	-0.0352***	-0.0344*
	(0.0141)	(0.00725)	(0.0116)	(0.00743)	(0.00422)	(0.0178)
Lnlow×Lncapital	-0.0247**	-0.0445***	-0.0474***	-0.0628***	-0.0703***	-0.132***
	(0.00871)	(0.00698)	(0.0103)	(0.0134)	(0.00681)	(0.0238)
Lnhigh×Lnlow	-0.132***	-0.204***	-0.177***	-0.238***	-0.349***	-0.481***
	(0.0429)	(0.0246)	(0.0250)	(0.0490)	(0.0268)	(0.0766)
Lnhigh×Lnlow	0.0124***	0.0172***	0.0144***	0.0239***	0.0286***	0.0461***
×Lncapital	(0.00389)	(0.00195)	(0.00262)	(0.00428)	(0.00260)	(0.00680)
Hukou	-0.695***	0.0712	-0.175***	-0.425***	-0.151***	-0.440***
	(0.159)	(0.0971)	(0.0330)	(0.0651)	(0.0358)	(0.0431)
Lnlow×Hukou	0.232**	0.0633	0.0585***	0.325***	0.0271	0.0791*
	(0.102)	(0.0485)	(0.0129)	(0.0469)	(0.0271)	(0.0428)
Lnhigh×Hukou	0.368***	0.0973**	0.0902**	0.326***	0.104***	0.168***
	(0.0784)	(0.0401)	(0.0336)	(0.0459)	(0.0292)	(0.0452)
Lnhigh×Lnlow×Hukou	-0.0683*	-0.0244*	-0.0228***	-0.102***	-0.0140**	-0.0327
	(0.0346)	(0.0123)	(0.00669)	(0.0119)	(0.00598)	(0.0188)
Cons	3.212***	2.182***	2.358***	1.318***	0.813***	1.615***
	(0.283)	(0.179)	(0.187)	(0.411)	(0.163)	(0.291)
N	8600	27705	49552	95227	500405	751912
adj. R^2	0.629	0.640	0.652	0.629	0.596	0.584
Threshold value	10.645	11.860	12.292	9.958	12.203	10.434
Percentage 1	10.616	5.014	3.503	5.585	0.610	3.553
Percentage 2	43.430	26.230	20.711	40.383	9.420	32.029

Notes: Standard errors clustered at city level are presented in parentheses, * p <. 10, ** p <. 05, *** p <. 01. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Small: $pop \leq 1$ million; Medium: $1 < pop \leq 2$ million; Large: $2 \text{ million} < pop$; Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 17 Comparison of threshold values for skill complementarities between firms of different cities and ownerships [registration status]

		SOE			Non-SOE		
		Small	Medium	Large	Small	Medium	Large
Threshold value	Without control Hukou	15.040	13.452	15.652	12.928	12.852	12.084
	Control Hukou 1	10.645	11.860	12.292	9.958	12.203	10.434
	Control Hukou 2	14.298	13.237	14.483	12.888	12.683	11.503
Percentage of firms	Without control Hukou	0.000	0.798	0.000	0.185	0.256	0.708
	Control Hukou 1	10.616	5.014	3.503	5.585	0.610	3.553
	Control Hukou 2	0.000	1.191	0.000	0.198	0.323	1.303
Percentage of workers	Without control Hukou	0.000	4.604	0.000	2.973	4.328	10.361
	Control Hukou 1	43.430	26.230	20.711	40.383	9.420	32.029
	Control Hukou 2	0.000	6.897	0.000	3.089	5.403	16.856

Note: *Hukou1* is the *Hukou* index quoted from Wu and Zhang (2010) for 45 cities, *Hukou2* is the residuals of regression of *Hukou1* on city population.

Table 18 Results for different cities and ownerships [capital structure]

Lnsales	SOE			Non-SOE		
	Small	Medium	Large	Small	Medium	Large
Lncapital	0.397***	0.486***	0.500***	0.527***	0.585***	0.593***
	(0.0199)	(0.0230)	(0.0473)	(0.0332)	(0.0160)	(0.0307)
Lnhigh	0.171	0.435***	0.332***	0.303***	0.499***	0.420***
	(0.133)	(0.0610)	(0.0868)	(0.0719)	(0.0538)	(0.125)
Lnmiddle	0.487***	0.442***	0.455***	0.599***	0.551***	0.591***
	(0.0567)	(0.0214)	(0.0196)	(0.0778)	(0.0260)	(0.0565)
Lnlow	0.238**	0.580***	0.568***	0.603***	0.895***	1.338***
	(0.0980)	(0.0720)	(0.0674)	(0.118)	(0.0721)	(0.236)
Lnhigh×Lncapital	-0.0110	-0.0222***	-0.0102	-0.0273***	-0.0356***	-0.0356*
	(0.0118)	(0.00617)	(0.0113)	(0.00716)	(0.00464)	(0.0189)
Lnlow×Lncapital	-0.0198**	-0.0462***	-0.0476***	-0.0637***	-0.0702***	-0.136***
	(0.00762)	(0.00714)	(0.0101)	(0.0139)	(0.00697)	(0.0254)
Lnhigh×Lnlow	-0.115**	-0.202***	-0.165***	-0.244***	-0.357***	-0.511***
	(0.0420)	(0.0220)	(0.0196)	(0.0526)	(0.0296)	(0.0895)
Lnhigh×Lnlow	0.0120***	0.0176***	0.0138***	0.0241***	0.0290***	0.0494***
×Lncapital	(0.00352)	(0.00189)	(0.00243)	(0.00480)	(0.00285)	(0.00808)
Hukou	-0.758***	-0.0658	-0.298***	-0.412***	-0.148***	-0.442***
	(0.148)	(0.0706)	(0.0419)	(0.0633)	(0.0350)	(0.0432)
Lnlow×Hukou	0.269**	0.0857**	0.0656***	0.321***	0.0242	0.0781
	(0.0942)	(0.0378)	(0.0120)	(0.0462)	(0.0269)	(0.0450)
Lnhigh×Hukou	0.408***	0.129***	0.109***	0.318***	0.102***	0.168***
	(0.0863)	(0.0320)	(0.0291)	(0.0456)	(0.0290)	(0.0460)
Lnhigh×Lnlow×Hukou	-0.0921**	-0.0334***	-0.0248***	-0.0981***	-0.0117*	-0.0334
	(0.0325)	(0.0101)	(0.00599)	(0.0111)	(0.00575)	(0.0200)
Cons	3.135***	2.077***	2.603***	1.305***	0.782***	1.567***
	(0.251)	(0.185)	(0.207)	(0.412)	(0.165)	(0.301)
N	10579	38842	71233	93248	489268	730231
adj. R^2	0.625	0.649	0.668	0.626	0.592	0.576
Threshold values	9.583	11.477	11.957	10.124	12.310	10.344
Percentage 1	23.131	8.311	5.559	4.427	0.413	3.271
Percentage 2	67.664	37.180	29.160	34.711	6.759	29.332

Notes: Standard errors clustered at city level are presented in parentheses, * p <. 10, ** p <. 05, *** p <. 01. All regressions control for the city fixed effects, industry fixed effects (4-digit industries). Small: $pop \leq 1$ million; Medium: $1 < pop \leq 2$ million; Large: $2 \text{ million} < pop$; Percentage 1 is the percentage of firms whose capitals are larger than the threshold value; Percentage 2 is the percentage of workers in the firms whose capitals larger than the threshold value.

Table 19 Comparison of threshold values for skill complementarities between firm of different cities and ownerships [capital structure]

		SOE			Non-SOE		
		Small	Medium	Large	Small	Medium	Large
Threshold value	Without control Hukou	15.678	13.625	16.094	12.862	12.882	11.929
	Control Hukou 1	9.583	11.477	11.957	10.124	12.310	10.344
	Control Hukou 2	14.741	13.315	14.779	12.906	12.715	11.362
Percentage of firms	Without control Hukou	0.000	0.615	0.000	0.157	0.182	0.624
	Control Hukou 1	23.131	8.311	5.559	4.427	0.413	3.271
	Control Hukou 2	0.000	1.050	0.000	0.193	0.310	1.516
Percentage of workers	Without control Hukou	0.000	3.512	0.000	2.323	3.089	8.939
	Control Hukou 1	67.664	37.180	29.160	34.711	6.759	29.332
	Control Hukou 2	0.000	6.101	0.000	2.991	5.162	18.745

Note: *Hukou1* is the *Hukou* index quoted from Wu and Zhang (2010) for 45 cities, *Hukou2* is the residuals of regression of *Hukou1* on city population.

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