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Body shape and labor market dynamics: analyzing salary information asymmetry and bargaining power

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Research extensively explores inequalities in employment opportunities, wages, and prices related to body shape. However, there's a gap in understanding how body shapes affect salary information and bargaining dynamics. Using 2020 China Family Panel Studies (CFPS), this study employs a two-tier stochastic frontier model to analyze shifts in salary information and bargaining power among employees (university graduates) and employers of various body types. Key findings include: (1) Information asymmetry significantly influences price, favoring employers with more information. (2) Normal-range BMI employees tend to receive more salary information and have stronger bargaining power, while severely obese employees receive less information and experience greater net surplus depletion. (3) Height correlates positively with information acquisition and net surplus. (4) Women generally experience lower surplus gains compared to men across BMI levels. (5) Contracted employees, regardless of BMI, tend to have higher average salary information than non-contracted employees.

Keywords Salary information, Body shape, BMI, Two-tier stochastic frontier

Recently, the New York City Council passed a bill that would prohibit discrimination against someone on the basis of their weight at work, in housing, or in public places. Clearly, discrimination based on body size, particularly obesity, has garnered significant societal attention. This bias can result in adverse outcomes, such as reduced wages in the labor market, particularly affecting women[1,2]. Most individuals in the labor market are familiar with wage dispersion[3]. Price dispersion is observed at the outset of trading, whether in product or labor markets. The labor market's functionality reflects market competition levels. According to human capital and search theory, in the absence of discrimination, employees' human capital dictates their wages. Under this scenario, workers with equal human capital may receive identical wages. If an employer offers wages below a worker's reservation wage, they may remain unemployed. In situations of information symmetry, individuals tend to favor companies offering higher salaries. Employers may prefer hiring individuals willing to accept lower wages. However, this is subject to the absence of discrimination and sufficient information for both parties. Without shared information, job seekers lack insights into potential employers, while employers may offer wages exceeding workers' reservation wages due to incomplete information.

The influence of information asymmetry on salaries can be illustrated in Fig. 1. In Fig. 1, the vertical axis represents the salary level, and the horizontal axis represents the number of salary negotiations. Based on profit maximization, employers have an incentive to offer lower salary levels. Hence, the employers' expected salary locates below the frontier curve. On the other hand, for the purpose of maximizing the employee's income, the expected salary of employees is located above the frontier line. At this time, the greater the effect of the bargaining power of both parties on the final transaction, the smaller the deviation of the frontier curve from the expected salary level. Employees and employers try to adjust the degree of bias in the information they have.

In the economics literature, numerous studies have established body size as a crucial factor influencing success in the labor market. Some investigations have concentrated on the correlation between height and wages[6–8], often revealing a positive association between height and wages for men and women. Others have

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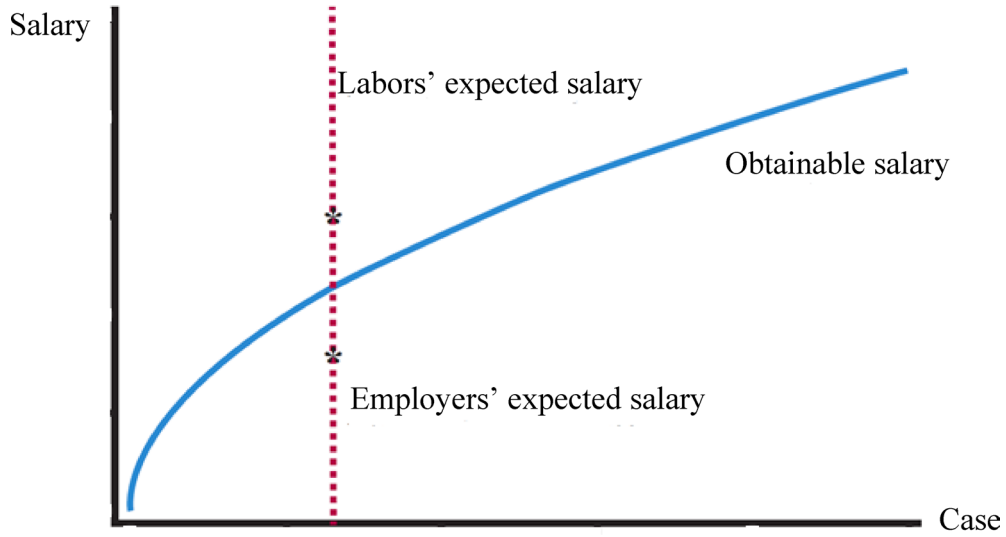

Fig. 1. The Frontier of Information Asymmetry in Salary Negotiations. Source: Pu et al.[4] and Shao et al.[5]

explored the relationship between obesity and employment and income[9–12], consistently finding that individuals who are overweight or obese are less likely to be employed and tend to earn lower incomes. However, few studies have examined how observable body size (appearance) characteristics influence access to salary information and wage bargaining outcomes in the labor market.

As obesity patterns in developing countries increasingly resemble those in developed countries[13], social inequalities stemming from obesity are proliferating globally, particularly within the employment sphere[14]. According to the latest report from The Lancet, by 2022, China is projected to have the largest absolute number of obese adults after the United States[13]. Hence, this study focuses on men and women in the Chinese labor market as research subjects.

In this study, we employ a two-tier stochastic frontier model to examine wage information disparities between employees (university graduates) and employers in China, aiming to assess the influence of body mass index (BMI) and individual height on wage dispersion. The empirical findings indicate that body size significantly impacts workers' wages. When employees' BMI is near the normal level, they tend to receive more salary information or possess greater bargaining power during salary negotiations. Conversely, severely obese employees receive less salary information and experience greater depletion of net surplus. Additionally, taller employees tend to acquire more information and consequently, obtain a higher net surplus.

This article offers numerous potential contributions. Firstly, it constructs a measurement model for assessing the degree of information asymmetry in China's labor market, presenting a novel approach for quantitatively estimating information disparities between transaction parties. Secondly, it utilizes microdata to empirically gauge the degree of information asymmetry manifested in wage prices within China's labor market. Through comparative analysis of variations in bargaining power and residual distribution across different body shapes and heights, this study effectively illustrates the impact of BMI and height on employee salaries. Finally, it substantiates gender discrimination within China's labor market and sheds light on the adverse effects experienced by workers who do not sign contracts.

The remainder of this study is organized as follows. We first review the relevant literature in Section "Literature review". Section "Materials and methods" introduces the research methodology. Section "Empirical results" covers the empirical data and explains the empirical results. In Section "Conclusion", a brief conclusion and some recommendations are provided.

Literature review

Wage fairness, salary dispersion, or discrimination exist in the labor market and has been discussed in the literature[15]. The empirical analysis of previous studies on various industries has paid more attention to the price differences among commodities, labor, and the environment[16]. Early studies such as Polachek and Yoon[17] and Murphy and Strobl[18] emphasized that wage differentials often persist even among workers with similar qualifications, a phenomenon largely driven by asymmetric access to salary information between employees and employers[17,18]. This aligns with findings from Bayer et al.[19], who argue that increased price dispersion—whether in product or labor markets—is frequently a symptom of incomplete or unevenly distributed market information. Theoretically, greater transparency in market information should reduce wage dispersion, as workers and firms make more informed decisions[20]. Empirical studies further support this, showing that price and wage volatility often increases when search costs are high or when market signals are obscured. In the context of developing countries, Hinsch et al.[21] highlight how improved information transparency in healthcare markets contributes to more equitable access—paralleling similar dynamics in labor markets where information asymmetry may distort salary outcomes. This also means that the more transparent market information, the less price dispersion of commodities. The main reason is because of the insufficient market information of employees and employers

in the labor market since non-parametric and semi-parametric approaches to the functional form of production relations are proposed in the literature[17,22,23].

Weight and, to some extent, height represent crucial aspects of healthy human capital and are shaped by early-life nutritional and healthcare investments by families and society[7,24,25]. Previous studies which discussed the influence of body size on labor's salary found that personal appearance figure and height have an impact on salary and income[26,27]. Mobius and Rosenblat (2006) found that attractive workers are more confident and earn higher wages; furthermore, employers may interpret physical appearance as a signal of unobservable productivity attributes[24,28]. Based on data from Finland, Johansson et al.[29] discovered a negative correlation between waist circumference and women's wages. However, the obesity indicator did not demonstrate significance in a linear wage model for men. Hamermesh[30] considered the influence of appearance on labor income as beauty economics and analyzed whether there is a problem of appearance discrimination in the labor market.

A growing body of empirical work examines how body size—especially obesity—affects wages and employment outcomes. Studies conducted in high-income developed countries indicate that weight typically exerts a negative influence on wages, particularly for women[31]. Conversely, in developing countries, taller stature generally signifies greater physical strength and improved health, correlating with higher wages[32]. Averett and Korenman[33] studied the influence of obesity on wages and personal performance in the marriage market. Harper[34] applied the data from the National Child Development Study (NCDS) to study the impact of appearance, height, and weight on salary, and marriage probability. He found that in the labor market, unattractive men (women) earn 15% (11%) lower than the average salary. In addition, some studies discussed the impact of body size on labors in the porn industry[35]. For example, Chang and Weng[36] found that the price of prostitutes is related to weight, the overweight prostitutes charge less for their services in the market of Taiwan.

From the perspective of labor economics and health economics, obesity can also reduce workplace productivity through presenteeism and absenteeism[37,38]. These effects translate into lower wages either through reduced performance or employer discrimination. In this sense, body shape may not only reflect innate characteristics or consumption preferences but also interact with labor market structures in determining wage outcomes.

Within the framework of information asymmetry, few studies explicitly examine how body shape affects wage negotiations. Polachek and Yoon[17] proposed a two-tier stochastic frontier model to disentangle the role of asymmetric information in wage setting. Martín-Román and Moral[39] and Martín et al.[40] extended this framework to show how opportunistic behaviors under asymmetric information vary by gender and income, using sick-leave duration as an outcome. These studies highlight that the labor market operates under incomplete information and that visible traits (such as body size) can act as imperfect but salient signals of unobservable productivity.

Nevertheless, most extant research focuses on direct wage penalties associated with obesity or beauty premiums, often neglecting the underlying mechanisms—such as salary information asymmetry and bargaining power—through which these outcomes are realized. For instance, while Mobius and Rosenblat[28] identify a "beauty premium" in labor markets through a signaling mechanism, fewer studies quantify how differences in BMI or height might affect the volume and quality of salary information received or the net surplus extracted during wage negotiations.

Despite a growing literature on labor market inequality, few studies have systematically examined the determinants of bargaining power between employees and employers under conditions of information asymmetry. This paper contributes to the literature in several ways. First, we integrate body shape variables (BMI and height) into a two-tier stochastic frontier model, allowing us to separate wage gaps due to differences in salary information from those due to bargaining outcomes. Second, we apply this framework to Chinese microdata, filling a regional and methodological gap in the literature. Finally, our study adds to the emerging discussion on non-contractual employment and gender disparities, which remain underexplored in information asymmetry contexts in developing labor markets.

Materials and methods

Participants and dataset

The data for this study are sourced from the 2020 China Family Panel Studies (CFPS). CFPS is a nationally representative, biennual longitudinal survey of Chinese communities, families, and individuals which first started in 2010 by the Institute of Social Science Survey (ISSS) of Peking University, China. The CFPS is designed to collect individual-, family-, and community-level longitudinal data in contemporary China. The studies focus on the economic, as well as the non-economic, wellbeing of the Chinese population, with a wealth of information covering such topics as economic activities, education outcomes, family dynamics and relationships, and migration. The CFPS is funded by the Chinese government through Peking University. In this study, we collect the empirical database which employs a multi-stage stratified size-proportional random sampling method to encompass all 31 provinces across the country, yielding a total of 12,582 observations. The Ethical Review of Biomedical Research Involving Humans at Peking University of China granted ethical approval for the survey (the approval number: IRB00001052-14,010, also see the website: https://www.isss.pku.edu.cn/cfps/cjwt/fbxg/1379028.html). Trained research assistants from local cooperatives oversaw the data collection process. Before administering the surveys, informed consent was obtained from all the participants. All information gathered through the questionnaires was treated with strict confidentiality in accordance with the Statistical Law of the People's Republic of China. Additional details on the questionares are provided at https://www.isss.pku.edu.cn/cfps/wdzx/tcwj/index.html.

Adhering to the principles of data authenticity and scientific rigor, this article rigorously filters out missing and invalid data (such as missing values of related variables and extreme outliers) in line with the research objectives and variable selection criteria. The dependent variable in this study is annual income (income), representing the "base salary" $\mu(x_i)$ in formula (3). Control variables encompass the labor force's years of work experience (Exp),

tenure in the current occupation (Tenure), gender (Gender), years of education (Edu), household size (People), labor's weight divided by the height square (BMI), and interviewee height (Height).

The choice of variable comes from the aspect of labor economics. The Mincer equation emphasized that human capital accumulation, working experience and family burden could have an influence on salaries. Therefore, first we collect the year of education to represent human capital accumulation. Second, the working year usually brings a positive effect on salary and family burden may increase the care time of family members and thus reduce work productivity. Third, occupation working year represents another kind of human capital accumulation in the era of post school because labor can learn the culture or technology of firm in the occupation, therefore we collect the data of variable Tenure. Other variables such as BMI and Height depict the appearance and body shape of research objects. The variable Contract is a binary indicator coded as 1 if the worker has signed a formal labor contract, and 0 otherwise. In China, the Labor Contract Law (effective since 2008) mandates written contracts for formal employment relationships. Nevertheless, informal employment—where no contract is signed—remains prevalent in practice. Formal contracts provide workers with legal protections, including access to pensions, annual allowances, and social welfare benefits. As such, employees with signed contracts are more likely to enjoy better working conditions and institutional safeguards. Finally, variable Register demonstrates the location of household registration and we apply this variable for robust check in the subsequent empirical estimation. Detailed variable assignments and descriptive statistics are presented in Table 1.

Methods

The frontier function estimation basically the empirical evaluation introduced a dichotomy in the error term, distinguishing between a random error term conforming to a normal distribution and a random variable with a unilateral distribution. Extending this framework, Kumbhakar and Parmeter[23] further subdivided the error term into three components: random error, downward error, and upward error, leading to the refined application of the bilateral stochastic frontier method. Since 2010, there has been a proliferation of the two-tier frontier method worldwide[41]. However, its full utilization in the analysis of wage determination based on body shape remains limited.

Building on prior studies[4,5,23], we assume a market characterized by numerous wage suppliers and labor forces, all motivated to acquire and leverage wage information for their benefit. Consequently, both parties in transactions actively seek information to negotiate wages aligned with their respective interests. Thus, the equilibrium wage level (S) can be expressed as:

$$S = \underline{S} + \eta\left(\overline{S} - \underline{S}\right) \tag{1}$$

In Eq. (1), $\underline{S}$ is the minimum salary that an employee can accept and $\overline{S}$ is the maximum salary an employer is willing to pay. η is the estimator of market information in the process of deciding the salary, and it ranges from 0 to 1. Therefore, $\eta(\overline{S} - \underline{S})$ reflects the surplus of profits earned by the employees in the process of determining salary level.

Given employees' characteristics x, the fair salary is expressed as $\mu(x) = E(\theta|x)$, where θ refers to actual presence, $\underline{S} \leq \mu(x) \leq \overline{S}$. Among which, $\overline{S} - \mu(x)$ denotes the employees' expected surplus in the salary transaction; $\mu(x) - \underline{S}$ denotes the employers' expected surplus. Whether employees or employers achieve higher surpluses depends on their bargain power and information gathering ability[18]. By concurrently adding and subtracting $\mu(x)$ on the right-hand side of Eq. (1), we derive:

$$S = \mu(x) + \eta\left[\overline{S} - \mu(x)\right] - (1-\eta)\left[\mu(x) - \underline{S}\right] \tag{2}$$

In Eq. (2), $\eta\left[\overline{S} - \mu(x)\right]$ illustrates that employees can elevate their salary level, by leveraging their informational advantages. This augmentation relies on the degree of information held by employees η and the employer's expected surplus $\overline{S} - \mu(x)$, indicating the surplus extracted by employees from the employer's surplus due to their informational edge. Similarly, the employer can impact the salary price by utilizing its informational advantage, thereby diminishing it by $(1-\eta)\left[\mu(x) - \underline{S}\right]$. This reduction is contingent upon the information

Variables	Definition	Sample	Mean	SD	Min	Max
Income	Yearly salary (Unit: RMB)	12,369	40,293	245,563	0	4,400,000
Edu	Years of education	12,582	7.7667	3.8168	0	18
Exp	Accumulated years of working in the workplace	11,952	6.2587	10.4816	0	72
Tenure	Accumulated years of working in the current position	11,911	3.6361	7.4486	0	69
Gender	Dummy variable, 1 = male; others = 0	12,582	0.4717	0.4992	0	1
People	The number of family member living with the interviewees	12,582	2.9010	3.2279	1	23
BMI	$\mathrm{Weight(Kg)}/Height^2(m^2)$	12,445	22.7403	3.6866	6.7319	45
Height	Height of interviewees (Unit: cm)	12,506	163.8815	8.1730	101	193
Contract	Dummy variable, 1 = interviewee has work contract; others = 0	3255	0.3465	1.2428	0	1
Register	Dummy variable, 1 = interviewee's household registration in city; others = 0	12,582	0.8354	0.3708	0	1

Table 1. Variable specifications and descriptive statistics.

$1-\eta$ possessed by the employer and the expected surplus of employees $\mu(x)-\underline{S}$, thereby reflecting the surplus extracted by the employer from employee surplus due to its informational advantage. The disparity in surplus earned by employers and employees, referred to as net surplus, quantifies the variance between actual wages and wages under perfect information symmetry. A positive value denotes an informational advantage held by the employee, leading to an increase in the final negotiated salary. Conversely, a negative value indicates an informational advantage held by the employer, resulting in a decrease in the negotiated salary. Moreover, we model it as a linear function of individual characteristic variables that facilitates empirical analysis:

$$S_i = \mu(x_i) + \varepsilon_i,\ \varepsilon_i = w_i - u_i + v_i \tag{3}$$

Among which, $\mu(x_i) = x_i'\beta$, where x_i represents the individual characteristics of employees and other factors, and β is the parameter vector to be estimated. ε_i is the composite interference term. $w_i = \eta_i\left[\overline{S}_i - \mu(x_i)\right] \geq 0$ measures the extent of upward salary deviation and represents the surplus obtained by employees, while $u_i = (1-\eta_i)\left[\mu(x_i) - \underline{S}_i\right] \geq 0$ measures the extent of downward wage deviation, indicating the surplus obtained by the employer. v_i represents the random error term.

In Eq. (3), when both w_i and u_i are 0, Eq. (3) reduces to a general Ordinary Least Squares (OLS) model, indicating that the final actual salary is on the "base salary" boundary. However, if they are not simultaneously 0, traditional OLS estimation may become biased. Hence, by reviewing past literature and considering the influence of information acquisition capabilities of both parties on salary levels, this study assumes $w > 0$ and $u > 0$, selecting Maximum Likelihood Estimation (MLE) to estimate model (4). Based on the reference[4,5,23], the use of an exponential distribution is commonplace in single-tier stochastic frontier studies when MLE is used. The reason for exponential distribution applied in two-tier stochastic frontier is because the exponential distributions for surpluses extracted by the employee and the employer is that the likelihood function can be expressed in a closed form and identification of the variance parameters is trivial. Considering that both w_i and u_i follow unilateral distribution characteristics, assuming they both obey exponential distribution, in Eq. (3), v_i serves as the error term, w_i reflects the surplus deprived by employees through information collection, and u_i reflects the surplus deprived by the employer through information collection. The net surplus, $\eta\left[\overline{P} - \mu(x)\right] - (1-\eta)\left[\mu(x) - \underline{P}\right]$, describes the overall impact of information asymmetry on wages during the transaction process. Maximum Likelihood Estimation (MLE) is utilized to estimate the parameters β, employee surplus, and employer surplus. Assuming w_i and u_i follow exponential distribution, $w_i \sim i.i.d.Exp\left(\sigma_w, \sigma_w^2\right)$, $u_i \sim i.i.d.Exp\left(\sigma_u, \sigma_u^2\right)$, and v_i follows normal distribution, $v_i \sim i.i.d.N\left(0, \sigma_v^2\right)$. w_i, u_i and v_i are mutually independent. The probability density function is listed in Eq. (4):

$$\begin{aligned} f(\varepsilon_i) &= [\sigma_w + \sigma_u]^{-1}\left[\exp(a_i)\,\Phi(c_i) + \exp(b_i)\int_{-h}^{\infty}\phi(z)\,d(z)\right] \\ &= [\sigma_w + \sigma_u]^{-1}\left[\exp(a_i)\,\Phi(c_i) + \exp(b_i)\,\phi(h_i)\right] \end{aligned} \tag{4}$$

where $\Phi(\bullet)$ and $\phi(\bullet)$ are cumulative distribution function and probability density function of the standard normal distribution, respectively. The specific parameter settings are as follows:

$$\begin{aligned} &a_i = \sigma_u^{-1}\left[\varepsilon_i + \sigma_v^2(2\sigma_u)^{-1}\right];\ b_i = \sigma_w^{-1}\left(-\varepsilon_i + \sigma_v^2(2\sigma_w)^{-1}\right); \\ &h_i = \varepsilon_i\sigma_v^{-1} - \sigma_v\sigma_w^{-1};\ c_i = -\varepsilon_i\sigma_v^{-1} - \sigma_v\sigma_u^{-1} \end{aligned}$$

The log-likelihood function for maximum likelihood estimation with a sample of n observations is expressed as follows:

$$\ln L(X;\theta) = -n\ln(\sigma_w + \sigma_u) + \sum_1^n \ln[e^{a_i}\Phi(c_i) + e^{b_i}\Phi(h_i)] \tag{5}$$

where $\theta = [\beta,\ \sigma_v,\ \sigma_u,\ \sigma_w]'$. Therefore, we can estimate the parameters by solving the maximization of the log-likelihood function. The conditional distribution of u_i and w_i are $f(u_i|\varepsilon_i)$, $f(w_i|\varepsilon_i)$;

$$(u_i/\sigma_v + h_i)\left[\Phi(h_i) + \exp(a_i - b_i)\,\Phi(c_i)\right]^{-1} \tag{6a}$$

$$f(u_i|\varepsilon_i) = \lambda\exp(-\lambda w_i)\,\Phi(w_i/\sigma_v + c_i)\exp(b_i - a_i)\left\{\Phi(h_i) + \exp(a_i - b_i)\,\Phi(c_i)\right\}^{-1} \tag{6b}$$

where $\lambda = 1/\sigma_u + 1/\sigma_w$. We can furtherly estimate the conditional expectations of u_i and w_i through Eq. (6):

$$E(u_i|\varepsilon_i) = \lambda^{-1} + \exp(a_i - b_i)\,\sigma_v\left[\phi(-c_i) + c_i\Phi(c_i)\right]\left[\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)\right]^{-1} \tag{7a}$$

$$E(w_i|\varepsilon_i) = \lambda^{-1} + \sigma_v\left[\phi(-h_i) + h_i\Phi(h_i)\right]\left[\Phi(h_i) + \exp(a_i - b_i)\Phi(c_i)\right]^{-1} \tag{7b}$$

Finally, the net surplus (NS) is derived using Eqs. (7) and (8) as follows:

$$NS = E\left(1 - e^{-w_i}|\varepsilon_i\right) - E\left(1 - e^{-u_i}|\varepsilon_i\right) = E(e^{-u_i} - e^{-w_i}|\varepsilon_i) \tag{8}$$

As the parameter σ_u only appears in a_i and c_i, and σ_w only appears in b_i and $\mathrm{h_i}$, they are both identified. Therefore, the results depend on the subsequent model tests, there is no need to assume in advantage of the salary information of employees or employers.

Empirical results

Based on the above labor market bargaining power measurement model, we analyze the bargaining power effect of both employers and employees in the salary negotiation process. Table 2 use the concept of Mincer equation, Ordinary Least Squares (OLS) estimation was applied in column 1 to column 3, and the empirical results showed that variables Edu, Exp, Exp Square, Tenure, Tenure Square, Gender, and People all were significant.

Although the coefficients of the independent variables were all significant, there is still the risk of endogeneity due to the omitted variable or other possible reasons. In order to test whether there is an endogeneity problem in the process of estimation, the 4th column applies 2 stage least square estimation (2SLS). In the estimation of 2SLS we need to find an instrumental variable which is unrelated with the dependent variable but affects the independent variable. In the case of this study, the omitted variable may be work ability or earning ability. In other words, apart from the accumulation of human capital through education, the interviewees' earning ability may also affect their personal salary level. However, the number of years of education is closely related to the earning ability and then endogeneity occurs. To check the endogeneity we use household registration (Register) as an instrument variable because the region of household registration may affect the educational resources or educational time accumulated by interviewees, but has no relationship with their earning ability. The results of the 4th column are consistent with the third column in Table 2, and the *p*-value of the Hausment test is insignificant. This outcome means there is no significant systematic difference between the 2SLS estimator and the OLS estimator (Null hypothesis: difference in coefficients not systematic), that is, all independent variables are exogenous.

In view of the consistency of the empirical results, the subsequent analyses are mainly based on the MLE estimation of column 5. The outcomes indicate that the higher the number of years of education, the longer the cumulative years of work in the workplace, the longer the cumulative years of current employment, and whether they are male make labors more advantageous in the market. In addition, the cumulative working experience (tenure) also had a positive impact on their salaries, albeit with negative marginal influences. The quadratic terms of Exp and Tenure capture the negative effect of cumulative working experience (tenure), which indicates that the positive impact of work experience on salary has a depreciation effect that increases over time and brings a marginal diminishing effect. The negative coefficient of variable People means that the more living people with the interviewees, the less stress in their life, and the lower annual income tend to be. In order to interpret the economic significance of the quadratic terms, we calculate the turning points of the relevant variables in column 5. For the variable Experience, the turning point is estimated at 24.33 years, indicating that salary increases with experience up to this point, after which additional experience is associated with a decline in income. Similarly, for Tenure, the turning point is 17.67 years, reflecting diminishing marginal returns to tenure beyond this threshold. These turning points lie within a plausible range and support the concave functional form

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS 1	**OLS 2**	**OLS 3**	**2SLS**	**MLE 1**	**MLE 2**
Edu	0.1412***	0.1383***	0.1260***	0.1294***	0.1031***	0.1016***
	(0.0072)	(0.0073)	(0.0073)	(0.0205)	(0.0030)	(0.0034)
Exp	0.2478***	0.2077***	0.2008***	0.2100***	0.0438***	0.0412***
	(0.009)	(0.0134)	(0.0132)	(0.0139)	(0.0042)	(0.0045)
Exp Square	−0.048***	−0.0040***	−0.0042***	−0.0042***	−0.0009***	−0.0008***
	(0.0002)	(0.0003)	(0.0003)	(0.0004)	(0.0001)	(0.0001)
Tenure		0.0745***	0.0726***	0.0718***	0.0212***	0.0207***
		(0.0178)	(0.0175)	(0.0181)	(0.0049)	(0.0039)
Tenure Square		−0.0019***	−0.0019***	−0.0019***	−0.0006***	−0.0007***
		(0.0005)	(0.0005)	(0.0005)	(0.0001)	(0.0001)
Gender			1.0365***	1.0334***	0.2312***	0.2133 ***
			(0.0664)	(0.0687)	(0.0236)	(0.0277)
People			−0.0928***	−0.0927***	−0.0094***	−0.0089***
			(0.0121)	(0.0122)	(0.0038)	(0.0045)
Constant	Yes	Yes	Yes	Yes	Yes	Yes
R square	0.1695	0.1705	0.1933	0.1923		
Hausman test (*p*-value)				0.8596		
Log likelihood					−2485.8150	−2167.3495
Sample	11,314	11,223	11,123	11,223	11,223	11,223

Table 2. Results of OLS, Two Stage Least Squares model and Maximum Likelihood Estimation model regressing on employees' income on the variables that affect salary changes. Standard errors in parentheses. $^{*}p<.1$, $^{**}p<0.05$, $^{***}p<0.01$.

assumption. Finally, column 6 lists the robust test of the two-tier stochastic frontier estimation. According to the research of Lian et al.[42], the sftt command in the Stata software allows for the specification of explanatory variables and the estimation of the coefficients of each independent variable with MLE, which we further use to compare with our estimations. The results in column 6 show that the directions of the effect of the explanatory variables on the dependent variable are the same as the results of MLE 1, indicating that the empirical results are consistent.

Table 3 lists the outcomes of the mastery of salary information of employers and employees (labors), respectively expressed as $\widehat{E}(1-e^{-u}|\varepsilon)$ and $\widehat{E}(1-e^{-w}|\varepsilon)$. This is the surpluses earned by both the employees and employers relative to the estimated change in base wage. On average, the surplus of employees will increase their salary by 32.43% above the base level in salary negotiation, while the surplus of employers' wage will decrease by 69.06%. The information asymmetry between employees and employers makes the actual salary 36.63% (i.e., 32.43%-69.06%) lower than the baseline salary. In other words, in a fair market with a return of \$100, due to the discrepancy in the information of salary, employee only gets \$63.37 for payments. Table 3 further analyzes the surplus distribution of the employees and employers in the process of salary negotiation from gender. The results show that the net surplus of males (-34.75) is higher than females (-38.35), indicating male employees are more likely to get a fairer market salary during salary negotiations.

Table 4 compares the impact of obesity on the net surplus during salary negotiation. Taking into account the different definitions of obesity in different countries or areas (for example, the World Health Organization defines BMI greater than 30 as obesity, but Japan, Hong Kong and Taiwan define BMI greater than 25 or 27 as obesity), According to the definition of obesity in National Health Commission of the People's Republic of China, Adults over 18 years old are divided into six body types: underweight ($BMI<18.5$), normal ($18.5\le BMI<24$), overweight ($24\le BMI<27$), mild obese ($27\le BMI<30$), moderate obese ($30\le BMI<35$), and severe obese ($BMI\ge 35$). The estimations indicate that when the BMI of employees locates underweight or severe obesity, the salary information or bargaining power they receive is the worst. For example, the net surplus of males (females) with underweight or severe obesity are − 42.72 and − 39.26 (-41.37 and − 43.88), located in the last two grades. In addition, compare with normal weight, overweight, mild obesity, and moderate obesity, the BMI of employees close to normal weight receive more salary information or more bargaining power and net surplus are less robbed during salary negotiation.

Table 5 summarizes the outcomes of the mastery of salary information under different BMIs with or without signing the labor contract. On average, the surplus obtained in bargaining for employees who have the contract makes the salary 32.72% higher than the baseline salary on the total sample. The salary information or bargaining (negotiation) power of the employer reduces the salary by 59.99%, and the employee who signs the labor contract gets the actual salary 27.27% lower than the baseline salary. The surplus obtained in bargaining for employees who has no contract makes the salary 31.03% higher than the baseline salary, and the salary information of the employer reduces the salary by 67.39%, and the employee who does not sign the labor contract gets the actual salary 36.37% lower than the baseline salary.

As the BMI increased, regardless of whether the employee signs a contract, the surplus of the employee's salary information has a trend of first declining and then rising (from underweight to severe obesity). For employees who sign contracts, severely obese ($BMI\ge 35$) employees have the least salary information, which can only increase their salary by 29.25%, and employers have the strongest bargaining power for them, which can reduce their salary by 75.66%. The net surplus is also the smallest among the six categories (-46.41%) so employees can only get a salary of \$53.59 if the fair market return is \$100. For employees who have no contract, moderately obese ($30\le BMI<35$) employees have the lowest salary information, which can only increase the salary by 29.33%, while the employer has the strongest bargaining power on it, which can reduce the salary

Category	Mean (%)	SD (%)	Median (%)
Total			
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.43	9.93	29.25
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	69.06	24.93	72.73
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 36.63	− 31.20	− 43.48
Male			
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.30	9.70	69.70
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	67.04	24.04	29.26
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 34.75	30.04	− 40.45
Female			
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.55	10.12	75.06
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	70.91	25.58	29.25
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 38.35	32.13	− 45.81

Table 3. Surpluses that the employees and the employers get in the transaction process.

	Male		Female	
	Mean (%)	SD (%)	Mean (%)	SD (%)
Underweight (BMI < 18.5)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	31.76	8.72	32.73	11.09
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	74.49	24.00	74.09	25.54
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 42.72	29.66	− 41.37	32.97
Normal-Weight (18.5≦BMI < 24)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.04	9.37	32.37	9.79
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	68.75	24.07	70.71	25.43
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 36.71	29.79	− 38.34	31.64
Overweight (24≦BMI < 27)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	33.05	10.64	32.80	10.23
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	63.06	23.76	69.15	25.64
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 30.01	30.57	− 36.35	32.34
Mild Obesity (27≦BMI < 30)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.10	9.25	32.82	10.38
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	62.51	22.66	69.97	25.50
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 30.40	28.09	− 37.15	32.40
Moderate Obesity(30≦BMI < 35)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.55	10.30	33.40	11.31
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	64.07	21.99	72.67	26.63
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 31.52	28.65	− 39.26	34.64
Severe Obesity (BMI≧35)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	33.10	14.53	32.21	7.85
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	72.36	22.69	76.10	30.94
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	− 39.26	32.85	− 43.88	36.65

Table 4. Surpluses that the male or female employees and the employers get in the transaction process.

by 72.75%. The net market surplus is the smallest of the six categories (− 43.42%). As for employees, they can only get a salary of $56.58 if the fair market return is $100. On the other hand, employees with underweight (BMI < 18.5) who signed the contract and those with overweight (24 ≤ BMI < 27) ones who did not sign the contract received the highest salary. In short, Comparing the two groups with or without signing the contract, the results indicate that no matter which level of BMI, the salary information of the employee who signed the labor contract was higher than those who does not have the contract.

The overall sample estimation in Table 6 shows that the taller the employee, the more information the employee received, and the more net surplus the employee obtained. The net surplus of males (females) is − 58.87 (-42.78) when their height is lower than 150 cm and increases to − 32.75 (-32.84) when the height locates at 170.01–180 cm. Male employees whose height is above 180 (Height ≥ 180) have the most salary information, which can increase their salary by $34.06, while the employer's bargaining power is the weakest, which can only reduce their salary by 61.82 dollars. Female employees with a height of 170 or more (Height ≥ 170) have the most salary information and can Increase the salary by $33.63, and the employer has the weakest bargaining power. It can only reduce the salary by $66.47. The actual salary obtained in salary bargaining is also the highest among the different categories. The results indicate that both males and females of taller height had better bargaining power than others. The estimated result may reflect that the taller male and female laborers are, the more they conform to the public's aesthetics, and they are more likely to be appreciated by employers. They are manifested in the market's stronger salary negotiation ability or sufficient salary information to obtain higher salaries; People who are low have a greater disadvantage, which is manifested as a weaker bargaining ability in the market and ultimately get a lower salary.

Figure 2 illustrates the distribution characteristics of the net surplus between employees and employers, from which it can be seen that more than half of employees are at a disadvantage in the wage negotiation, and the distribution characteristics of the net surplus between employees and employers are right-leaning. On the whole,

	With contract		No contract	
	Mean (%)	SD (%)	Mean (%)	SD (%)
Total				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.72	10.35	31.03	7.06
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	59.99	20.13	67.39	19.98
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−27.27	26.93	−36.37	24.18
Underweight (BMI < 18.5)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	33.64	11.38	32.69	11.42
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	58.38	21.33	68.46	21.10
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−24.74	29.01	−35.77	29.13
Normal-Weight (18.5≦BMI < 24)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.70	10.20	30.78	6.40
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	60.04	20.19	68.29	19.53
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−27.34	26.91	−37.52	23.27
Overweight (24≦BMI < 27)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.97	11.18	31.17	6.59
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	60.23	20.20	64.40	20.96
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−27.26	27.64	−33.23	24.86
Mild Obesity (27≦BMI < 30)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	31.87	8.23	30.66	5.47
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	60.54	19.38	65.54	18.93
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−28.67	24.66	−34.88	22.17
Moderate Obesity(30≦BMI < 35)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	30.16	3.95	29.33	0.49
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	61.80	16.53	72.75	16.80
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−31.64	18.68	−43.42	17.03
Severe Obesity (BMI≧35)				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	29.25	0.21	29.25	10.18
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	75.66	1.39	71.38	26.05
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−46.41	1.39	−42.13	32.58

Table 5. Surpluses that the contract or non-contract employees and the employers get in the transaction process.

we believe that in the process of salary negotiation, employers have greater bargaining power over employees, and ultimately rely on the power to practice the (salary) discrimination.

Conclusion

In this study, we apply the two-tier stochastic frontier model to analyze the salary information of employees in China and to analyze the difference in bargaining power between the employees and the employers. The main results indicate that employees receive more salary information or more bargaining power during salary negotiation if their BMI index locates near the normal level, while severely obese employees receive less salary information, and the net surplus is more plundered. Height also plays a role in determining salary. The taller the employee, the more information the employee received, and the more net surplus the employee obtained. We also found that male employees are more likely to get a fairer market salary than females during salary negotiations. No matter which level of BMI, the salary information of the employee who signed the labor contract was higher than those who does not. We also found that more than half of employees are at a disadvantage in the wage negotiation, and the distribution characteristics of the net surplus between employees and employers are right leaning.

The findings of this paper offer valuable insights for policymakers and employees alike. Given that employers have greater bargaining power over employees and ultimately rely on this power to implement

	Male		Female	
	Mean (%)	SD (%)	Mean (%)	SD (%)
Height < 150				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	29.25	0.44	32.81	10.40
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	88.12	11.64	75.59	27.6
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−58.87	11.64	−42.78	34.39
150.01≦Height < 160				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	30.87	7.39	32.54	10.08
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	79.83	21.52	72.40	25.66
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−48.96	26.12	−39.87	32.30
160.01≦Height < 170				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	31.93	9.19	32.51	10.11
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	68.50	24.03	69.36	25.24
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−36.57	29.54	−36.85	31.63
170.01≦Height < 180				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	32.49	9.93	33.63	11.44
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	65.24	23.71	66.47	26.00
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−32.75	29.90	−32.84	33.68
180≦Height				
Employee $\widehat{E}(1-e^{-w}\|\varepsilon)$	34.06	11.96		
Employer $\widehat{E}(1-e^{-u}\|\varepsilon)$	61.82	24.63		
Net Surplus $\widehat{E}(e^{-u}-e^{-w}\|\varepsilon)$	−27.77	32.61		

Table 6. Surpluses of salary information of the employees and the employers with different heights.

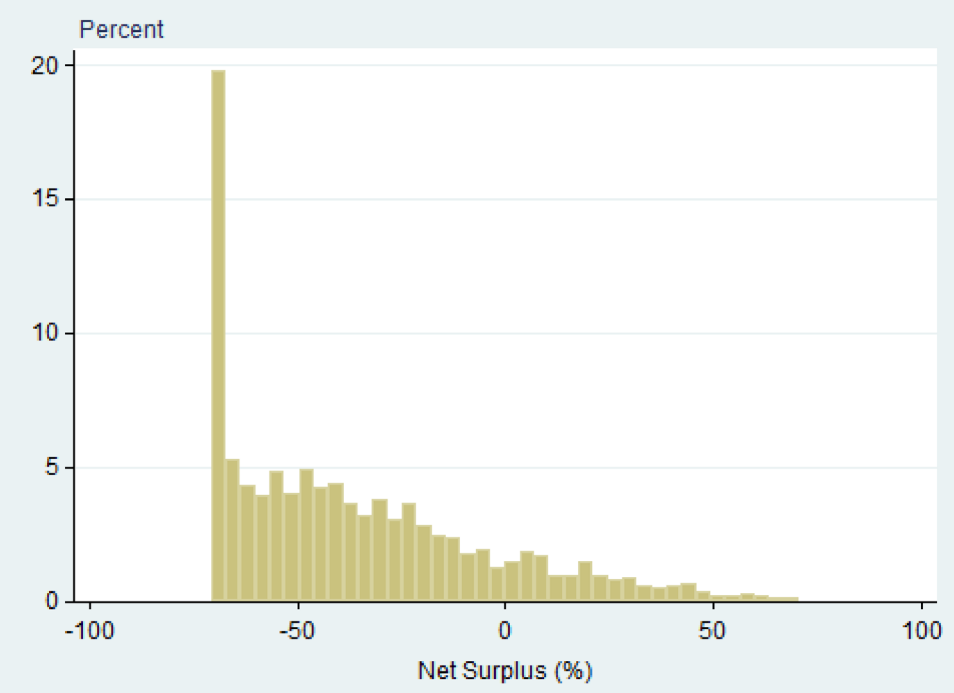

Fig. 2. Net surplus distribution.

salary discrimination, it's imperative for workers to enhance their negotiation skills to safeguard their rights and interests. For instance, workers can proactively gather information before negotiations to enhance their bargaining power and safeguard their interests. Additionally, workers can exert some control over the increase in final net surplus (indicative of information asymmetry) by managing body shape like height and body mass index. The empirical results of this article find that a labor's body shape does have an impact on whether he or she encounters wage discrimination in the market. In other words, if labors can control and maintain their body shape and appearance, they can avoid failure in salary negotiations. Therefore, for college students or graduates who will enter the labor market in the future, maintaining a certain level of physical training will also have a positive impact on their work. On the other hand, schools can also discuss whether the employment status of graduates is the phenomenon found in this article from the perspective of graduates' employment status and body management. Based on the findings of this study, strengthening university sports courses or physical training should be one of the strategic plans to reduce wage discrimination for college students who are about to enter the workplace.

In addition, labors should strengthen their legal awareness and protect their rights and interests by proactively requesting contracts. Policymakers should enact measures to protect workers' interests and regulate employer conduct. This could involve imposing penalties on employers who refuse to sign contracts for employees for a long time, addressing gender discrimination in the workplace, and providing subsidies for certain positions. Such policies are essential to ensure fair labor practices and uphold workers' rights. This paper summarizes data based on CFPS in 2020. China is a developing country, and the applicability of the conclusion to developed countries needs to be investigated to a certain extent. The further prospect of this study is that more data samples will be obtained to further test the conclusions of this study.

Data availability

Data is provided within the manuscript.

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Author contributions

Chao Ye，Qi Wu wrote the main manuscript text and Meng-Ying Wang collected and literature and estimated the main empirical results, Li-Chen Chou set the main theory empirical model, estimated the main empirical results and prepared all figures. All authors reviewed and revised the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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